UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

PLAINTIFF'S EXHIBIT
UC-4925

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Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation Desi... Published by AsbestosClaims.Law
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FUNCTION OF THERMAL INSULATION

The primary function of thermal insulation is to provide substantial resistance to heat flow. For high temperature equipment and piping, the flow is from hot bodies to bodies at a lower temperature or to the ambient air. For low temperature equipment or piping, the heat flow is, of course, in the opposite direction.

Its use in an industrial plant provides the means whereby heat in process pipe and vessels is contained within its boundaries. Conversely, it retards heat from entering low temperature equipment and piping. It is essential not only for economical plant operation, but in some cases it is a basic essential that makes a process possible. In addition to its primary functions, insulation serves to control temperature and condensation and in providing protection from burns to personnel. It also protects pipe and structural steel from external fire.

Because that energy used in processes does have monetary value, and insulation conserves energy, it also conserves money. Properly designed insulation will provide an excellent return on money invested in it.

Besides its use on plant process equipment and piping, thermal insulation is also necessary in buildings. Its functions in buildings are similar to those listed for industrial plants. It serves to conserve energy, control temperature, control condensation, as fire protection and to protect persons from being burned on hot surfaces.

THERMAL INSULATION MANUALS AND STANDARDS

This "THERMAL INSULATION MANUAL - VOLUME 2, DESIGN" presents information to assist in the design of insulation systems for industrial plants of UCC. For convenience it is separated into four sections.

SECTION I presents the theory of heat transfer and mathematical solutions to problems common to industrial plants. It presents the basis for selection of thickness of insulation, information regarding corrosion problem, and information on weather-barrier, vapor barriers, finishes and overcoatings used to protect the insulation from mechanical damage and weather. In addition it contains many tables which are needed by the designer of insulation systems.

SECTION II presents recommendation for selection of one, or more, standard insulation system based on installation requirements. These insulation systems are the individual Material and Application Specifications contained in "THERMAL INSULATION MANUAL - VOLUME 1, SPECIFICATION". They consist of materials specifications for procurement of materials and installation specifications for the application of the materials.

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THERMAL INSULATION MANUALS AND STANDARDS - Continued

SECTION III presents recommended insulation thickness tables. Included are precalculated tables for use of UCC's various locations. Included are tables for insulation thickness to prevent surface condensation, insulation thickness to provide most economical thickness for heat conservation, thickness tables for fire protection, thickness tables to provide safe surface temperature, and thickness tables for steam and electric traced piping.

SECTION IV presents field work sheets for use of field personnel. These work sheets provide space for filling in individual job information, a list of materials needed and a condensed form of application instructions. References to the "THERMAL INSULATION MANUAL - VOLUME 1, SPECIFICATIONS" and "ENGINEERING STANDARDS" are provided so that more detailed information can be obtained from these sources when it is needed.

This "DESIGN MANUAL" provides information necessary for engineering both for new construction and for individual plants needing such information when piping or equipment changes or maintenance requires insulation installations. The "SPECIFICATION MANUAL" provides material specifications for procurement of materials and the application of these materials into an insulated system. The "ENGINEERING STANDARDS" generally supply the information regarding materials and application where the insulation technology must be coordinated with other technologies.

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THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL

Heat is a form of energy. In a state of steady flow, the flow of energy through any medium of transmission is directly proportional to the force causing the flow of the energy, and is inversely proportional to the resistance to the flow.

$$\text{Energy flow: } = = \frac{\text{Force causing flow of energy}}{\text{Resistance to flow of energy}}$$

In terms of heat

$$\text{Heat flow: } = = \frac{\text{Temperature difference}}{\text{Thermal resistance}}$$

The thermal resistance to the flow of energy through a solid is expressed:

$$\text{Thermal resistance} = \frac{\text{Thickness of the solid}}{\text{Conductivity of the solid}}$$

Therefore, the basic heat transfer formula is:

$$\text{Heat flow} = \frac{\text{Temperature difference}}{\frac{\text{Thickness of the solid}}{\text{Conductivity of the solid}}}$$

Substituting symbols for words:

If q_a	= Heat flow rate (Btu per hour per square foot of surface)
t_1	= Temperature of inner surface of insulation in °F
t_2	= Temperature of outer surface of insulation in °F
$t_1 - t_2$	= Temperature difference in °F
L	= Thickness of insulation in inches
k	= Conductivity of insulation in Btu per square foot, inch thickness, hour, degree F temperature difference

Through one single flat material the equation is:

$$q_a = \frac{t_1 - t_2}{\frac{L}{k}} \qquad \text{(Equation 1)}$$

Any surface which is of a different temperature than the surrounding air has a film of air next to it through which the temperature varies from the surface temperature to the ambient air temperature. This film has a resistance of $\frac{1}{h}$ to heat flow through where h is the conductance of the air film.

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THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

In a state of steady heat flow, all heat flowing to a surface must equal the heat flowing from the surface to ambient air temperature (t_a), thus

$$q_a = \frac{t_1 - t_2}{\frac{L}{k}} = \frac{t_2 - t_a}{\frac{1}{h}} \qquad \text{(Equation 2)}$$

Or

$$t_2 = q_a \left(\frac{1}{h}\right) + t_a \qquad \text{(Equation 2A)}$$

When the resistance of insulation is combined with the resistance of an air film, the equation for the heat flow from the inner surface of the insulation to the ambient air is:

$$q_a = \frac{t_1 - t_a}{\frac{L}{k} + \frac{1}{h}} \qquad \text{(Equation 3)}$$

This is illustrated schematically in Figure 1.

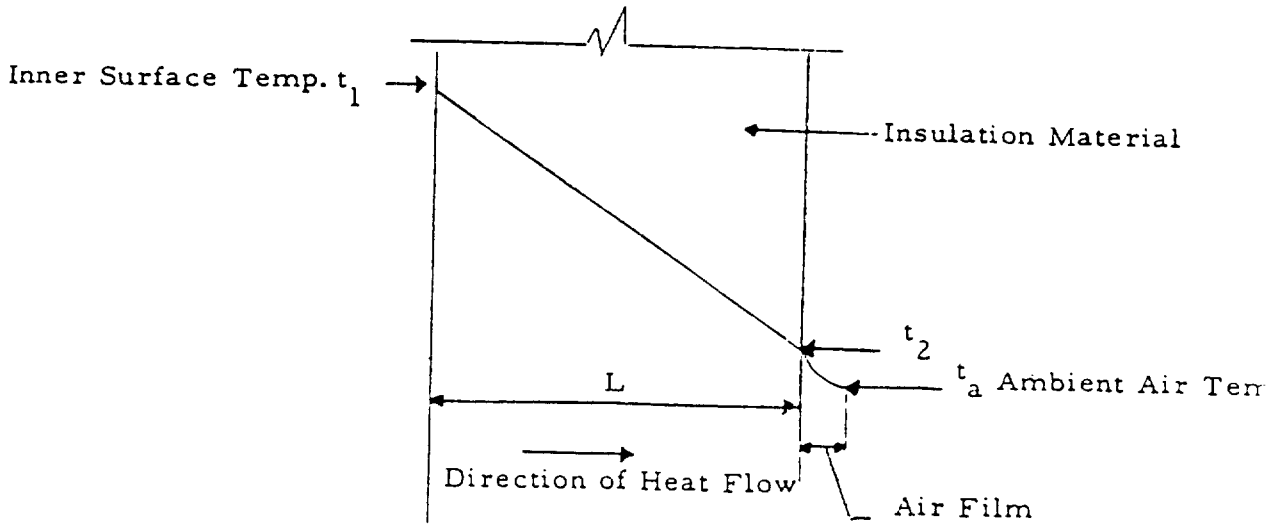


Figure 1
Heat Flow Through One Material and One Air Film

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THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

In a similar manner, an equation can be developed with an air film on both sides of the insulation. Let the resistance of the inner air film be designed at $\frac{1}{h_1}$, and the resistance of the outer film as $\frac{1}{h_2}$, and the air temperature on the inner side as t_i, then

$$q_a = \frac{t_i - t_1}{\frac{1}{h_1}} = \frac{t_1 - t_2}{\frac{L}{k}} = \frac{t_2 - t_a}{\frac{1}{h_2}} \qquad \text{(Equation 4)}$$

Through one single flat material with an air film on each side, the equation is:

$$q_a = \frac{t_i - t_a}{\frac{1}{h_1} + \frac{L}{k} + \frac{1}{h_2}} \qquad \text{(Equation 5)}$$

This is illustrated schematically in Figure 2.

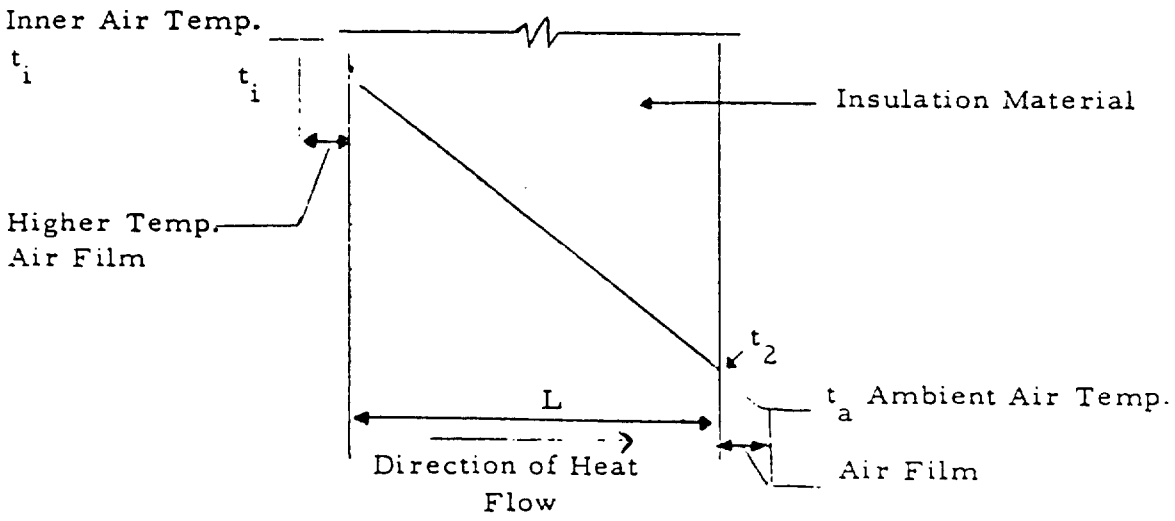


Figure 2
Heat Flow Through One Material and Two Air Films

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THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

Heat Transfer Through Two Materials:

In many instances, more than one insulation material is used. Additional materials are then added to the equation in the same manner as was the additional air film.

When
- t_i The air temperature inside the insulation
- t_1 The temperature of the inner surface of the inner insulation
- t_2 The temperatures of the outer surface of the inner insulation and inner surface of the outer insulation
- t_3 The temperature of the outer surface of the outer insulation
- t_a The outside or ambient air temperature
- L_1 The thickness of the inner insulation
- L_2 The thickness of the outer insulation
- k_1 The conductivity of the inner insulation
- k_2 The conductivity of the outer insulation
- h_1 The conductance of the inner air film
- h_2 The conductance of the outer air film
- q_a The rate of heat transfer per unit area

Then

$$q_a = \frac{t_i - t_1}{\frac{1}{h_1}} = \frac{t_1 - t_2}{\frac{L_1}{k_1}} = \frac{t_2 - t_3}{\frac{L_2}{k_2}} = \frac{t_3 - t_a}{\frac{1}{h_2}} \qquad \text{(Equation 6)}$$

Also

$$q_a = \frac{t_i - t_a}{\frac{1}{h_1} + \frac{L_1}{k_1} + \frac{L_2}{k_2} + \frac{1}{h_2}} \qquad \text{(Equation 7)}$$

The equations so far have all been presented for flat materials with parallel surfaces. Most industrial insulation is applied to cylindrical surfaces. To compensate for the difference between the inner and outer areas, the thickness (L) is converted to "equivalent thickness" in order to obtain the heat transfer per square foot of outer surface. If r_1 equals the inside radius of the insulation material and r_2 equals the outside radius of the insulation, this "equivalent thickness" is represented by the formula

$$r_2 \operatorname{Log}_e \frac{r_2}{r_1}$$

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THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

Substituting the "equivalent thickness" of curved surfaces for the thickness (L) of flat surfaces, the following equations will be developed:

Through one single cylindrical material

$$q_a = \frac{t_1 - t_2}{\frac{r_2 \text{ Log}_e \frac{r_2}{r_1}}{k}} \qquad \text{(Equation 8)}$$

Through one single cylindrical material and one air film

$$q_a = \frac{t_1 - t_a}{\frac{r_2 \text{ Log}_e \frac{r_2}{r_1}}{k} + \frac{1}{h}} \qquad \text{(Equation 9)}$$

Through two cylindrical materials and one air film

$$q_a = \frac{t_1 - t_a}{\frac{r_3 \text{ Log}_e \frac{r_2}{r_1}}{k_1} + \frac{r_3 \text{ Log}_e \frac{r_3}{r_2}}{k_2} + \frac{1}{h}} \qquad \text{(Equation 10)}$$

When r_1 Inside radius of inner layer of insulation

r_2 Outside radius of inner layer of insulation and inside radius of outer layer of insulation

r_3 Outside radius of outer layer of insulation

Through one single cylindrical material and two air films

$$q_a = \frac{t_1 - t_a}{\frac{1}{h_1} + \frac{r_2 \text{ Log}_e \frac{r_2}{r_1}}{k} + \frac{1}{h_2}} \qquad \text{(Equation 11)}$$

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THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

Through two cylindrical materials and two air films

$$q_a = \frac{t_i - t_a}{\frac{1}{h_1} + \frac{r_3 \text{ Log}_e \frac{r_2}{r_1}}{k_1} + \frac{r_3 \text{ Log}_e \frac{r_3}{r_2}}{k_2} + \frac{1}{h_2}} \qquad \text{(Equation 12)}$$

Also

$$q_a = \frac{t_i - t_1}{\frac{1}{h_1}} = \frac{t_i - t_2}{\frac{r_3 \text{ Log}_e \frac{r_2}{r_1}}{k_1}} = \frac{t_2 - t_3}{\frac{r_3 \text{ Log}_e \frac{r_3}{r_2}}{k_2}} = \frac{t_3 - t_a}{\frac{1}{h_2}} \qquad \text{(Equation 13)}$$

For a single cylindrical material and single air film as shown in Equation 9

$$q_a = \frac{t_1 - t_2}{\frac{r_2 \text{ Log}_e \frac{r_2}{r_1}}{k}} = \frac{t_2 - t_a}{\frac{1}{h}} = q_{ra} + q_{ca} \text{ or } q_{ra} + q_{cva} \text{ as the case may be} \qquad \text{(Equation 14)}$$

When = Emittance (the emissive power of a surface compared to a black body)

T_2 = Surface temperature of the insulation, Rankine scale (t_a in °F + 459.6)

T_a = Temperature of ambient air, Rankine scale (t_a in °F + 459.6)

By the Stefan-Boltzmann Law, the equation for radiation is

$$q_{ra} = 0.174 \left[\left(\frac{T_2}{100} \right)^4 - \left(\frac{T_a}{100} \right)^4 \right] \qquad \text{(Equation 15)}$$

The heat transmitted by convection, still air conditions, is determined by Langmuir's equation

$$q_{ca} = 0.296 (t_2 - t_a)^{5/4} \qquad \text{(Equation 16)}$$

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THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

When V = Velocity of air in feet per minute, then the heat transmitted by convection of a velocity (V) is

$$q_{cva} = 0.296 (T_2 - T_a)\, 5/4 \left(\frac{V + 68.9}{68.9}\right) 1/2 \qquad \text{(Equation 17)}$$

Therefore, for a single cylindrical material with one air film

$$q_a = \frac{t_1 - t_2}{\dfrac{r_2 \operatorname{Log}_e \frac{r_2}{r_1}}{k}} = 0.1714 \left[\left(\frac{T_2}{100}\right)^4 - \left(\frac{T_a}{100}\right)^4\right] + 0.296 \left(t_2 - t_a\right) 5/4 \left(\frac{V+68.9}{68.9}\right) 1/2$$

(Equation 18)

For two cylindrical materials with one air film

$$q_a = \frac{t_1 - t_3}{\dfrac{r_3 \operatorname{Log}_e \frac{r_2}{r_1}}{k_1} + \dfrac{r_3 \operatorname{Log}_e \frac{r_3}{r_2}}{k_2}} = 0.1714 \left[\left(\frac{T_3}{100}\right)^4 - \left(\frac{T_a}{100}\right)^4\right] + 0.296 (t_3 - t_a)^{5/4} \left(\frac{V+68.9}{68.9}\right)^{\frac{1}{2}}$$

(Equation 19)

In most instances q_a and t_2 (or t_3), the outer insulation surface temperature, are unknown, so these equations must be solved by trial and error, or by plotting a graph for assumed values of insulation surface temperature. Graphic solution for flat surface and cylindrical surface (18) shown in Figure 3.

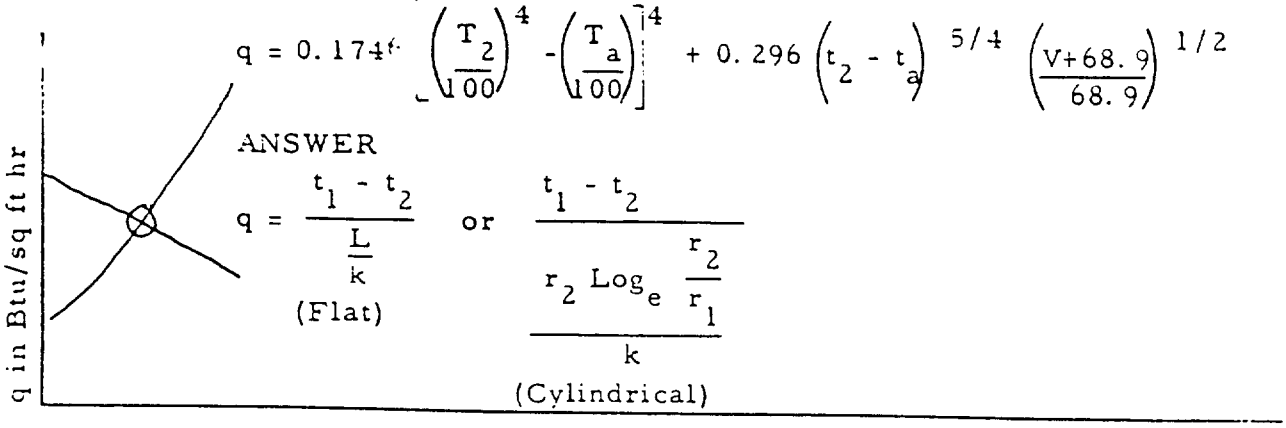


FIGURE 3

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THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

Various factors appear in the preceding equations which are used frequently in the calculation of heat transfer. For rapid calculation, the following factors have been determined and tabulated, and are included:

Factor	
N^4 (N = any number)	(Table 1)
$N^{5/4}$ (N = any number)	(Table 2)
$0.174 \cdot \left(\frac{T}{100}\right)^4$	(Table 3)*
$0.296\,(t_2 - t_a)^{5/4}$ or $0.296\,(t_3 - t_a)^{5/4}$	(Table 4)
$\left(\frac{V+68.9}{68.9}\right)^{1/2}$	(Table 5)
$0.296\,(t_1 - t_a)^{5/4} \left(\frac{V+68.9}{68.9}\right)^{1/2}$	(Table 6)
$r_2 \operatorname{Log}_e \frac{r_2}{r_1}$ for NPS pipe	(Table 7)

* In reference to absolute zero

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THEORY - HEAT TRANSFER

FOURTH POWER OF NUMBERS
N = ANY NUMBER

N	N^4	N	N^4	N	N^4	N	N^4
0.01	0.00000001	0.67	0.20151121	1.33	3.1290072	1.99	15.682592
0.02	0.00000016	0.68	0.21381376	1.34	3.2241793	2.00	16.000000
0.03	0.00000081	0.69	0.22667121	1.35	3.3215062	2.01	16.322408
0.04	0.00000256	0.70	0.24010000	1.36	3.4210201	2.02	16.649664
0.05	0.00000625	0.71	0.25411681	1.37	3.5227536	2.03	16.981816
0.06	0.00001296	0.72	0.26873355	1.38	3.6267393	2.04	17.318914
0.07	0.00002401	0.73	0.28398241	1.39	3.7330104	2.05	17.661006
0.08	0.00004096	0.74	0.29986576	1.40	3.8416000	2.06	18.008140
0.09	0.00006561	0.75	0.31640625	1.41	3.9525416	2.07	18.360348
0.10	0.00010000	0.76	0.33362176	1.42	4.0658589	2.08	18.717736
0.11	0.00014641	0.77	0.35153041	1.43	4.1816160	2.09	19.080297
0.12	0.00020736	0.78	0.37015056	1.44	4.2998159	2.10	19.448100
0.13	0.00028561	0.79	0.38950081	1.45	4.4205062	2.11	19.821194
0.14	0.00038416	0.80	0.40960000	1.46	4.5437185	2.12	20.199631
0.15	0.00050625	0.81	0.43046721	1.47	4.6694888	2.13	20.583461
0.16	0.00065536	0.82	0.45212176	1.48	4.7978521	2.14	20.972736
0.17	0.00083521	0.83	0.47458321	1.49	4.9288440	2.15	21.367506
0.18	0.00104976	0.84	0.49787136	1.50	5.0625000	2.16	21.767825
0.19	0.00130321	0.85	0.52200625	1.51	5.1988560	2.17	22.173739
0.20	0.00160000	0.86	0.54700816	1.52	5.3379481	2.18	22.585305
0.21	0.00194481	0.87	0.57289761	1.53	5.4798128	2.19	23.002575
0.22	0.00234256	0.88	0.59969536	1.54	5.6244865	2.20	23.425600
0.23	0.00279841	0.89	0.62742241	1.55	5.7720062	2.21	23.854432
0.24	0.00331776	0.90	0.65610000	1.56	5.9224089	2.22	24.289126
0.25	0.00390625	0.91	0.68574961	1.57	6.0757320	2.23	24.729734
0.26	0.00456976	0.92	0.71639296	1.58	6.2320129	2.24	25.176309
0.27	0.00531441	0.93	0.74805201	1.59	6.3912896	2.25	25.628906
0.28	0.00614656	0.94	0.78074896	1.60	6.5536000	2.26	26.087577
0.29	0.00707281	0.95	0.81450625	1.61	6.7189824	2.27	26.552378
0.30	0.00810000	0.96	0.84934656	1.62	6.8874753	2.28	27.023362
0.31	0.00923521	0.97	0.88529281	1.63	7.0591176	2.29	27.500584
0.32	0.01048576	0.98	0.92236816	1.64	7.2339481	2.30	27.984100
0.33	0.01185921	0.99	0.96059601	1.65	7.4120062	2.31	28.473963
0.34	0.01336336	1.00	1.0000000	1.66	7.5933313	2.32	28.970229
0.35	0.01500625	1.01	1.0406040	1.67	7.7779632	2.33	29.472955
0.36	0.01679616	1.02	1.0824321	1.68	7.9659417	2.34	29.982195
0.37	0.01874161	1.03	1.1255088	1.69	8.1573072	2.35	30.498006
0.38	0.02085136	1.04	1.1698585	1.70	8.3521000	2.36	31.020444
0.39	0.02313441	1.05	1.2155062	1.71	8.5503608	2.37	31.549565
0.40	0.02560000	1.06	1.2624769	1.72	8.7521305	2.38	32.085427
0.41	0.02825761	1.07	1.3107960	1.73	8.9574504	2.39	32.628086
0.42	0.03111696	1.08	1.3604889	1.74	9.1663517	2.40	33.177600
0.43	0.03418801	1.09	1.4115816	1.75	9.3789062	2.41	33.734025
0.44	0.03748096	1.10	1.4641000	1.76	9.5951257	2.42	34.297420
0.45	0.04100625	1.11	1.5180704	1.77	9.8150624	2.43	34.867844
0.46	0.04477456	1.12	1.5735193	1.78	10.038758	2.44	35.445352
0.47	0.04879681	1.13	1.6304736	1.79	10.266256	2.45	36.030006
0.48	0.05308416	1.14	1.6889601	1.80	10.497600	2.46	36.621862
0.49	0.05764801	1.15	1.7490062	1.81	10.732831	2.47	37.220980
0.50	0.06250000	1.16	1.8106393	1.82	10.971993	2.48	37.827420
0.51	0.06765201	1.17	1.8738872	1.83	11.215131	2.49	38.441240
0.52	0.07311616	1.18	1.9387777	1.84	11.462287	2.50	39.062500
0.53	0.07890481	1.19	2.0053392	1.85	11.713506	2.51	39.691260
0.54	0.08503056	1.20	2.0736000	1.86	11.968832	2.52	40.327580
0.55	0.09150625	1.21	2.1435888	1.87	12.228309	2.53	40.971520
0.56	0.09834496	1.22	2.2153345	1.88	12.491983	2.54	41.623142
0.57	0.10556001	1.23	2.2888664	1.89	12.759898	2.55	42.282506
0.58	0.11316496	1.24	2.3642137	1.90	13.032100	2.56	42.949672
0.59	0.12117361	1.25	2.4414062	1.91	13.308633	2.57	43.624704
0.60	0.12960000	1.26	2.5204737	1.92	13.589544	2.58	44.307660
0.61	0.13845841	1.27	2.6014464	1.93	13.874880	2.59	44.998605
0.62	0.14776336	1.28	2.6843545	1.94	14.164684	2.60	45.697600
0.63	0.15752961	1.29	2.7692288	1.95	14.459006	2.61	46.404706
0.64	0.16777216	1.30	2.8561000	1.96	14.757890	2.62	47.119987
0.65	0.17850625	1.31	2.9449992	1.97	15.061384	2.63	47.843505
0.66	0.18974736	1.32	3.0359577	1.98	15.369536	2.64	48.575324

TABLE I

THEORY - HEAT TRANSFER

FOURTH POWER OF NUMBERS
N = ANY NUMBER

N	N^4	N	N^4	N	N^4	N	N^4
2.65	49.315506	3.30	118.59210	3.95	243.43800	4.60	447.74560
2.66	50.064115	3.31	120.03612	3.96	245.91257	4.61	451.65175
2.67	50.821215	3.32	121.49330	3.97	248.40596	4.62	455.58341
2.68	51.586869	3.33	122.96370	3.98	250.91827	4.63	459.54068
2.69	52.361143	3.34	124.44741	3.99	253.44958	4.64	463.52361
2.70	53.144100	3.35	125.94450	4.00	256.00000	4.65	467.53250
2.71	53.935804	3.36	127.45506	4.01	258.56961	4.66	471.56728
2.72	54.736322	3.37	128.97917	4.02	261.15852	4.67	475.62811
2.73	55.545718	3.38	130.51691	4.03	263.76683	4.68	479.71512
2.74	56.364057	3.39	132.06836	4.04	266.39462	4.69	483.82841
2.75	57.191406	3.40	133.63360	4.05	269.04200	4.70	487.96810
2.76	58.027829	3.41	135.21270	4.06	271.70906	4.71	492.13429
2.77	58.873394	3.42	136.80577	4.07	274.39591	4.72	496.32710
2.78	59.728166	3.43	138.41287	4.08	277.10263	4.73	500.54665
2.79	60.592212	3.44	140.03408	4.09	279.82932	4.74	504.79304
2.80	61.465600	3.45	141.66950	4.10	282.57610	4.75	509.06640
2.81	62.348395	3.46	143.31920	4.11	285.34304	4.76	513.36683
2.82	63.240665	3.47	144.98327	4.12	288.13025	4.77	517.69445
2.83	64.142479	3.48	146.66178	4.13	290.93783	4.78	522.04938
2.84	65.053903	3.49	148.35483	4.14	293.76588	4.79	526.43172
2.85	65.975006	3.50	150.06250	4.15	296.61450	4.80	530.84160
2.86	66.905856	3.51	151.78486	4.16	299.48379	4.81	535.27912
2.87	67.846521	3.52	153.52201	4.17	302.37384	4.82	539.74440
2.88	68.797071	3.53	155.27402	4.18	305.28476	4.83	544.23757
2.89	69.757574	3.54	157.04099	4.19	308.21664	4.84	548.75873
2.90	70.728100	3.55	158.82300	4.20	311.16960	4.85	553.30800
2.91	71.708717	3.56	160.62013	4.21	314.14372	4.86	557.88550
2.92	72.699496	3.57	162.43247	4.22	317.13911	4.87	562.49134
2.93	73.700508	3.58	164.26010	4.23	320.15587	4.88	567.12564
2.94	74.711820	3.59	166.10312	4.24	323.19410	4.89	571.78852
2.95	75.733506	3.60	167.96160	4.25	326.25390	4.90	576.48010
2.96	76.765634	3.61	169.83563	4.26	329.33538	4.91	581.20048
2.97	77.808276	3.62	171.72529	4.27	332.43864	4.92	585.94980
2.98	78.861504	3.63	173.63069	4.28	335.56377	4.93	590.72816
2.99	79.925388	3.64	175.55190	4.29	338.71089	4.94	595.53569
3.00	81.000000	3.65	177.48900	4.30	341.88010	4.95	600.37250
3.01	82.085412	3.66	179.44209	4.31	345.07149	4.96	605.23872
3.02	83.181696	3.67	181.41126	4.32	348.28517	4.97	610.13446
3.03	84.288924	3.68	183.39659	4.33	351.52125	4.98	615.05984
3.04	85.407170	3.69	185.39817	4.34	354.77982	4.99	620.01498
3.05	86.536506	3.70	187.41610	4.35	358.06100	5.00	625.00000
3.06	87.677004	3.71	189.45044	4.36	361.36489	5.01	630.01502
3.07	88.828740	3.72	191.50131	4.37	364.69158	5.02	635.06016
3.08	89.991784	3.73	193.56878	4.38	368.04120	5.03	640.13554
3.09	91.166213	3.74	195.65295	4.39	371.41383	5.04	645.24128
3.10	92.352100	3.75	197.75390	4.40	374.80960	5.05	650.37750
3.11	93.549518	3.76	199.87173	4.41	378.22859	5.06	655.54435
3.12	94.758543	3.77	202.00652	4.42	381.67092	5.07	660.74188
3.13	95.979249	3.78	204.15837	4.43	385.13670	5.08	665.97028
3.14	97.211712	3.79	206.32736	4.44	388.62602	5.09	671.22964
3.15	98.456006	3.80	208.51360	4.45	392.13900	5.10	676.52010
3.16	99.712207	3.81	210.71715	4.46	395.67575	5.11	681.84176
3.17	100.98039	3.82	212.93813	4.47	399.23636	5.12	687.19476
3.18	102.26063	3.83	215.17662	4.48	402.82095	5.13	692.57922
3.19	103.55501	3.84	217.43271	4.49	406.42963	5.14	697.99526
3.20	104.85760	3.85	219.70650	4.50	410.06250	5.15	703.44300
3.21	106.17447	3.86	221.99808	4.51	413.71966	5.16	708.92257
3.22	107.50371	3.87	224.30753	4.52	417.40124	5.17	714.43409
3.23	108.84540	3.88	226.63495	4.53	421.10733	5.18	719.97768
3.24	110.19960	3.89	228.98045	4.54	424.83805	5.19	725.55348
3.25	111.56640	3.90	231.34410	4.55	428.59350	5.20	731.16160
3.26	112.94588	3.91	233.72600	4.56	432.37380	5.21	736.80216
3.27	114.33811	3.92	236.12624	4.57	436.17904	5.22	742.47530
3.28	115.74317	3.93	238.54493	4.58	440.00935	5.23	748.18113
3.29	117.16114	3.94	240.98215	4.59	443.86483	5.24	753.91979

TABLE I (Cont'd)

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THEORY - HEAT TRANSFER

FOURTH POWER OF NUMBERS

N = ANY NUMBER

N	N^4	N	N^4	N	N^4	N	N^4
5.25	759.69140	5.91	1219.9721	6.57	1863.2085	7.23	2732.4560
5.26	765.49608	5.92	1228.2501	6.58	1874.5782	7.24	2747.6047
5.27	771.33397	5.93	1236.5701	6.59	1885.9998	7.25	2762.8164
5.28	777.20518	5.94	1244.9324	6.60	1897.4736	7.26	2778.0910
5.29	783.10985	5.95	1253.3370	6.61	1908.9996	7.27	2793.4290
5.30	789.04810	5.96	1261.7840	6.62	1920.5780	7.28	2808.8304
5.31	795.02005	5.97	1270.2737	6.63	1932.2090	7.29	2824.2953
5.32	801.02584	5.98	1278.8062	6.64	1943.8928	7.30	2839.8241
5.33	807.06559	5.99	1287.3815	6.65	1955.6295	7.31	2855.4167
5.34	813.13944	6.00	1296.0000	6.66	1967.4192	7.32	2871.0735
5.35	819.24750	6.01	1304.6616	6.67	1979.2622	7.33	2886.7946
5.36	825.38991	6.02	1313.3665	6.68	1991.1585	7.34	2902.5802
5.37	831.56680	6.03	1322.1150	6.69	2003.1084	7.35	2918.4305
5.38	837.77829	6.04	1330.9071	6.70	2015.1121	7.36	2934.3455
5.39	844.02451	6.05	1339.7430	6.71	2027.1695	7.37	2950.3256
5.40	850.30560	6.06	1348.6227	6.72	2039.2810	7.38	2966.3708
5.41	856.62167	6.07	1357.5466	6.73	2051.4467	7.39	2982.4814
5.42	862.97287	6.08	1366.5147	6.74	2063.6668	7.40	2998.6576
5.43	869.35932	6.09	1375.5271	6.75	2075.9414	7.41	3014.8994
5.44	875.78116	6.10	1384.5841	6.76	2088.2706	7.42	3031.2071
5.45	882.23850	6.11	1393.6856	6.77	2100.6547	7.43	3047.5809
5.46	888.73149	6.12	1402.8320	6.78	2113.0937	7.44	3064.0210
5.47	895.26025	6.13	1412.0234	6.79	2125.5880	7.45	3080.5275
5.48	901.82492	6.14	1421.2598	6.80	2138.1376	7.46	3097.1005
5.49	908.42562	6.15	1430.5415	6.81	2150.7426	7.47	3113.7404
5.50	915.06250	6.16	1439.8685	6.82	2163.4033	7.48	3130.4472
5.51	921.73567	6.17	1449.2411	6.83	2176.1196	7.49	3147.2212
5.52	928.44527	6.18	1458.6594	6.84	2188.8923	7.50	3164.0625
5.53	935.19144	6.19	1468.1235	6.85	2201.7210	7.51	3180.9712
5.54	941.97431	6.20	1477.6336	6.86	2214.6059	7.52	3197.9477
5.55	948.79400	6.21	1487.1898	6.87	2227.5473	7.53	3214.9920
5.56	955.65066	6.22	1496.7922	6.88	2240.5454	7.54	3232.1044
5.57	962.54442	6.23	1506.4412	6.89	2253.6002	7.55	3249.2850
5.58	969.47540	6.24	1516.1366	6.90	2266.7121	7.56	3266.5339
5.59	976.44375	6.25	1525.8789	6.91	2279.8810	7.57	3283.8515
5.60	983.44960	6.26	1535.6679	6.92	2293.1073	7.58	3301.2379
5.61	990.49307	6.27	1545.5041	6.93	2306.3910	7.59	3318.6931
5.62	997.57432	6.28	1555.3873	6.94	2319.7323	7.60	3336.2176
5.63	1004.6934	6.29	1565.3180	6.95	2333.1315	7.61	3353.8113
5.64	1011.8506	6.30	1575.2961	6.96	2346.5886	7.62	3371.4745
5.65	1019.0460	6.31	1585.3218	6.97	2360.1038	7.63	3389.2074
5.66	1026.2796	6.32	1595.3953	6.98	2373.6773	7.64	3407.0102
5.67	1033.5517	6.33	1605.5167	6.99	2387.3093	7.65	3424.8830
5.68	1040.8624	6.34	1615.6862	7.00	2401.0000	7.66	3442.8260
5.69	1048.2118	6.35	1625.9040	7.01	2414.7494	7.67	3460.8394
5.70	1055.6001	6.36	1636.1701	7.02	2428.5578	7.68	3478.9235
5.71	1063.0273	6.37	1646.4848	7.03	2442.4253	7.69	3497.0783
5.72	1070.4936	6.38	1656.8481	7.04	2456.3521	7.70	3515.3041
5.73	1077.9993	6.39	1667.2603	7.05	2470.3385	7.71	3533.6010
5.74	1085.5443	6.40	1677.7216	7.06	2484.3844	7.72	3551.9692
5.75	1093.1289	6.41	1688.2319	7.07	2498.4902	7.73	3570.4090
5.76	1100.7531	6.42	1698.7916	7.08	2512.6559	7.74	3588.9205
5.77	1108.4171	6.43	1709.4007	7.09	2526.8818	7.75	3607.5039
5.78	1116.1211	6.44	1720.0594	7.10	2541.1681	7.76	3626.1593
5.79	1123.8652	6.45	1730.7680	7.11	2555.5148	7.77	3644.8870
5.80	1131.6496	6.46	1741.5264	7.12	2569.9221	7.78	3663.6872
5.81	1139.4742	6.47	1752.3349	7.13	2584.3904	7.79	3682.5599
5.82	1147.3394	6.48	1763.1936	7.14	2598.9196	7.80	3701.5056
5.83	1155.2453	6.49	1774.1028	7.15	2613.5100	7.81	3720.5242
5.84	1163.1919	6.50	1785.0625	7.16	2628.1617	7.82	3739.6160
5.85	1171.1795	6.51	1796.0728	7.17	2642.8749	7.83	3758.7812
5.86	1179.2081	6.52	1807.1341	7.18	2657.6499	7.84	3778.0199
5.87	1187.2779	6.53	1818.2463	7.19	2672.4867	7.85	3797.3325
5.88	1195.3891	6.54	1829.4097	7.20	2687.3856	7.86	3816.7189
5.89	1203.5418	6.55	1840.6245	7.21	2702.3466	7.87	3836.1795
5.90	1211.7361	6.56	1851.8907	7.22	2717.3700	7.88	3855.7145

TABLE I (Contd)

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THEORY - HEAT TRANSFER

FOURTH POWER OF NUMBERS

N = ANY NUMBER

N	N^4	N	N^4	N	N^4	N	N^4
7.89	3675.3239	8.55	5343.9755	9.21	7195.1279	9.87	9490.0524
7.90	3895.0081	8.56	5369.0204	9.22	7226.4230	9.88	9528.5710
7.91	3914.7671	8.57	5394.1533	9.23	7257.8302	9.89	9567.2069
7.92	3934.6012	8.58	5419.3743	9.24	7289.3345	9.90	9605.9601
7.93	3954.5106	8.59	5444.6837	9.25	7320.9414	9.91	9644.8309
7.94	3974.4955	8.60	5470.0816	9.26	7352.6509	9.92	9683.8195
7.95	3994.5560	8.61	5495.5682	9.27	7384.4633	9.93	9722.9263
7.96	4014.6923	8.62	5521.1438	9.28	7416.3788	9.94	9762.1513
7.97	4034.9047	8.63	5546.8086	9.29	7448.3976	9.95	9801.4950
7.98	4055.1933	8.64	5572.5627	9.30	7480.5201	9.96	9840.9574
7.99	4075.5583	8.65	5598.4065	9.31	7512.7463	9.97	9880.5389
8.00	4096.0000	8.66	5624.3400	9.32	7545.0765	9.98	9920.2396
8.01	4116.5184	8.67	5650.3635	9.33	7577.5109	9.99	9960.0599
8.02	4137.1138	8.68	5676.4772	9.34	7610.0499		
8.03	4157.7864	8.69	5702.6813	9.35	7642.6935		
8.04	4178.5364	8.70	5728.9761	9.36	7675.4420		
8.05	4199.3640	8.71	5755.3616	9.37	7708.2956		
8.06	4220.2693	8.72	5781.8382	9.38	7741.2546		
8.07	4241.2526	8.73	5808.4061	9.39	7774.3192		
8.08	4262.3140	8.74	5835.0654	9.40	7807.4896		
8.09	4283.4537	8.75	5861.8164	9.41	7840.7660		
8.10	4304.6721	8.76	5888.6592	9.42	7874.1486		
8.11	4325.9691	8.77	5915.5941	9.43	7907.6378		
8.12	4347.3451	8.78	5942.6214	9.44	7941.2337		
8.13	4368.8001	8.79	5969.7411	9.45	7974.9365		
8.14	4390.3345	8.80	5996.9536	9.46	8008.7464		
8.15	4411.9485	8.81	6024.2589	9.47	8042.6639		
8.16	4433.6421	8.82	6051.6574	9.48	8076.6887		
8.17	4455.4156	8.83	6079.1493	9.49	8110.8216		
8.18	4477.2692	8.84	6106.7347	9.50	8145.0625		
8.19	4499.2031	8.85	6134.4140	9.51	8179.4116		
8.20	4521.2176	8.86	6162.1872	9.52	8213.8694		
8.21	4543.3126	8.87	6190.0545	9.53	8248.4358		
8.22	4565.4886	8.88	6218.0163	9.54	8283.1113		
8.23	4587.7457	8.89	6246.0728	9.55	8317.8960		
8.24	4610.0840	8.90	6274.2241	9.56	8352.7901		
8.25	4632.5039	8.91	6302.4704	9.57	8387.7939		
8.26	4655.0054	8.92	6330.8120	9.58	8422.9075		
8.27	4677.5887	8.93	6359.2490	9.59	8458.1314		
8.28	4700.2542	8.94	6387.7818	9.60	8493.4656		
8.29	4723.0019	8.95	6416.4105	9.61	8528.9103		
8.30	4745.8321	8.96	6445.1352	9.62	8564.4659		
8.31	4768.7449	8.97	6473.9564	9.63	8600.1326		
8.32	4791.7406	8.98	6502.8741	9.64	8635.9105		
8.33	4814.8194	8.99	6531.8885	9.65	8671.8000		
8.34	4837.9814	9.00	6561.0000	9.66	8707.8012		
8.35	4861.2270	9.01	6590.2086	9.67	8743.9143		
8.36	4884.5561	9.02	6619.5146	9.68	8780.1397		
8.37	4907.9692	9.03	6648.9183	9.69	8816.4775		
8.38	4931.4663	9.04	6678.4199	9.70	8852.9281		
8.39	4955.0477	9.05	6708.0195	9.71	8889.4915		
8.40	4978.7136	9.06	6737.7173	9.72	8926.1680		
8.41	5002.4641	9.07	6767.5137	9.73	8962.9579		
8.42	5026.2995	9.08	6797.4089	9.74	8999.8615		
8.43	5050.2200	9.09	6827.4029	9.75	9036.8789		
8.44	5074.2257	9.10	6857.4961	9.76	9074.0103		
8.45	5098.3170	9.11	6887.6886	9.77	9111.2561		
8.46	5122.4939	9.12	6917.9808	9.78	9148.6164		
8.47	5146.7567	9.13	6948.3727	9.79	9186.0915		
8.48	5171.1054	9.14	6978.8647	9.80	9223.6816		
8.49	5195.5408	9.15	7009.4570	9.81	9261.3869		
8.50	5220.0625	9.16	7040.1497	9.82	9299.2077		
8.51	5244.6708	9.17	7070.9431	9.83	9337.1443		
8.52	5269.3661	9.18	7101.8374	9.84	9375.1968		
8.53	5294.1485	9.19	7132.8328	9.85	9413.3655		
8.54	5319.0182	9.20	7163.9296	9.86	9451.6506		

TABLE I (Cont'd)

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THEORY - HEAT TRANSFER

FOURTH POWER OF NUMBERS

N = ANY NUMBER

N	N^4	N	N^4	N	N^4	N	N^4
10.0	10000.000	16.6	75933.313	23.2	289702.29	29.8	788615.04
10.1	10406.040	16.7	77779.632	23.3	294729.55	29.9	799253.88
10.2	10824.321	16.8	79659.417	23.4	299821.95	30.0	810000.00
10.3	11255.088	16.9	81573.072	23.5	304980.06	30.1	820854.12
10.4	11698.585	17.0	83521.000	23.6	310204.44	30.2	831816.96
10.5	12155.062	17.1	85503.608	23.7	315495.65	30.3	842889.24
10.6	12624.769	17.2	87521.305	23.8	320854.27	30.4	854071.70
10.7	13107.960	17.3	89574.504	23.9	326280.86	30.5	865365.06
10.8	13604.889	17.4	91663.617	24.0	331776.00	30.6	876770.04
10.9	14115.816	17.5	93789.062	24.1	337340.25	30.7	888287.40
11.0	14641.000	17.6	95951.257	24.2	342974.20	30.8	899917.84
11.1	15180.704	17.7	98150.624	24.3	348678.44	30.9	911662.13
11.2	15735.193	17.8	100387.58	24.4	354453.52	31.0	923521.00
11.3	16304.736	17.9	102662.56	24.5	360300.06	31.1	935495.18
11.4	16889.601	18.0	104976.00	24.6	366218.62	31.2	947585.43
11.5	17490.062	18.1	107328.31	24.7	372209.80	31.3	959792.49
11.6	18106.393	18.2	109719.93	24.8	378274.20	31.4	972117.12
11.7	18738.872	18.3	112151.31	24.9	384412.40	31.5	984560.06
11.8	19387.777	18.4	114622.87	25.0	390625.00	31.6	997122.07
11.9	20053.392	18.5	117135.06	25.1	396912.60	31.7	1009803.9
12.0	20736.000	18.6	119688.32	25.2	403275.80	31.8	1022606.3
12.1	21435.888	18.7	122283.09	25.3	409715.20	31.9	1035530.1
12.2	22153.345	18.8	124919.83	25.4	416231.42	32.0	1048576.0
12.3	22888.664	18.9	127598.98	25.5	422825.06	32.1	1061744.7
12.4	23642.137	19.0	130321.00	25.6	429496.72	32.2	1075037.1
12.5	24414.062	19.1	133086.33	25.7	436247.04	32.3	1088454.0
12.6	25204.737	19.2	135895.44	25.8	443076.60	32.4	1101996.0
12.7	26014.454	19.3	138748.80	25.9	449986.05	32.5	1115664.0
12.8	26843.545	19.4	141646.84	26.0	456976.00	32.6	1129458.8
12.9	27692.288	19.5	144590.06	26.1	464047.06	32.7	1143381.1
13.0	28561.000	19.6	147578.90	26.2	471199.87	32.8	1157431.7
13.1	29449.992	19.7	150613.84	26.3	478435.05	32.9	1171611.4
13.2	30359.577	19.8	153695.36	26.4	485753.24	33.0	1185921.0
13.3	31290.072	19.9	156823.92	26.5	493155.06	33.1	1200361.2
13.4	32241.793	20.0	160000.00	26.6	500641.15	33.2	1214933.0
13.5	33215.062	20.1	163224.08	26.7	508212.15	33.3	1229637.0
13.6	34210.201	20.2	166496.64	26.8	515868.69	33.4	1244474.1
13.7	35227.536	20.3	169818.16	26.9	523611.43	33.5	1259445.0
13.8	36267.393	20.4	173189.14	27.0	531441.00	33.6	1274550.6
13.9	37330.104	20.5	176610.06	27.1	539358.04	33.7	1289791.7
14.0	38416.000	20.6	180081.40	27.2	547363.22	33.8	1305169.1
14.1	39525.416	20.7	183603.68	27.3	555457.18	33.9	1320683.6
14.2	40658.689	20.8	187177.36	27.4	563640.57	34.0	1336336.0
14.3	41816.160	20.9	190802.97	27.5	571914.06	34.1	1352127.0
14.4	42998.169	21.0	194481.00	27.6	580278.29	34.2	1368057.7
14.5	44205.062	21.1	198211.94	27.7	588733.94	34.3	1384128.7
14.6	45437.185	21.2	201996.31	27.8	597281.66	34.4	1400340.8
14.7	46694.888	21.3	205834.61	27.9	605922.12	34.5	1416695.0
14.8	47978.521	21.4	209727.36	28.0	614656.00	34.6	1433192.0
14.9	49288.440	21.5	213675.06	28.1	623483.95	34.7	1449832.7
15.0	50625.000	21.6	217678.23	28.2	632406.65	34.8	1466617.8
15.1	51988.560	21.7	221737.39	28.3	641424.79	34.9	1483548.3
15.2	53379.481	21.8	225853.05	28.4	650539.03	35.0	1500625.0
15.3	54798.128	21.9	230025.75	28.5	659750.06	35.1	1517848.6
15.4	56244.865	22.0	234256.00	28.6	669058.56	35.2	1535220.1
15.5	57720.062	22.1	238544.22	28.7	678465.21	35.3	1552740.2
15.6	59224.089	22.2	242891.26	28.8	687970.71	35.4	1570409.9
15.7	60757.320	22.3	247297.34	28.9	697575.74	35.5	1588230.0
15.8	62320.129	22.4	251763.09	29.0	707281.00	35.6	1606201.3
15.9	63912.896	22.5	256289.06	29.1	717087.17	35.7	1624324.7
16.0	65536.000	22.6	260875.77	29.2	726994.96	35.8	1642601.0
16.1	67189.824	22.7	265523.78	29.3	737005.08	35.9	1661031.2
16.2	68874.753	22.8	270233.62	29.4	747118.20	36.0	1679616.0
16.3	70591.176	22.9	275005.84	29.5	757335.06	36.1	1698356.3
16.4	72339.491	23.0	279841.00	29.6	767656.31	36.2	1717252.9
16.5	74120.042	23.1	284739.63	29.7	778082.75	36.3	1736306.9

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THEORY - HEAT TRANSFER

FOURTH POWER OF NUMBERS
N = ANY NUMBER

N	N^4	N	N^4	N	N^4	N	N^4
36.4	1755519.0	43.1	3450714.9	49.8	6150598.4	56.5	10190460.
36.5	1774890.0	43.2	3482851.7	49.9	6200149.8	56.6	10262796.
36.6	1794420.9	43.3	3515212.5	50.0	6250000.0	56.7	10335517.
36.7	1814112.6	43.4	3547798.2	50.1	6300150.2	56.8	10408624.
36.8	1833965.9	43.5	3580610.0	50.2	6350601.6	56.9	10482118.
36.9	1853981.7	43.6	3613648.9	50.3	6401355.4	57.0	10556001.
37.0	1874161.0	43.7	3646915.8	50.4	6452412.8	57.1	10630273.
37.1	1894504.4	43.8	3680412.0	50.5	6503775.0	57.2	10704936.
37.2	1915013.1	43.9	3714138.3	50.6	6555443.3	57.3	10779993.
37.3	1935687.8	44.0	3748096.0	50.7	6607418.8	57.4	10855443.
37.4	1956529.5	44.1	3782285.9	50.8	6659702.8	57.5	10931289.
37.5	1977539.0	44.2	3816709.2	50.9	6712296.4	57.6	11007531.
37.6	1998717.3	44.3	3851367.0	51.0	6765201.0	57.7	11084171.
37.7	2020065.2	44.4	3886260.2	51.1	6818417.6	57.8	11161211.
37.8	2041583.7	44.5	3921390.0	51.2	6871947.6	57.9	11238652.
37.9	2063273.6	44.6	3956757.5	51.3	6925792.2	58.0	11316496.
38.0	2085136.0	44.7	3992363.6	51.4	6979952.6	58.1	11394742.
38.1	2107171.5	44.8	4028209.5	51.5	7034430.0	58.2	11473394.
38.2	2129381.3	44.9	4064296.3	51.6	7089225.7	58.3	11552453.
38.3	2151766.2	45.0	4100625.0	51.7	7144340.9	58.4	11631919.
38.4	2174327.1	45.1	4137196.6	51.8	7199776.8	58.5	11711795.
38.5	2197065.0	45.2	4174012.4	51.9	7255534.8	58.6	11792081.
38.6	2210080.8	45.3	4211073.3	52.0	7311616.0	58.7	11872779.
38.7	2243075.3	45.4	4248380.5	52.1	7368021.6	58.8	11953891.
38.8	2266349.5	45.5	4285935.0	52.2	7424753.0	58.9	12035418.
38.9	2289804.5	45.6	4323738.0	52.3	7481811.3	59.0	12117361.
39.0	2313441.0	45.7	4361790.4	52.4	7539197.9	59.1	12199721.
39.1	2337260.0	45.8	4400093.5	52.5	7596914.0	59.2	12282501.
39.2	2361262.4	45.9	4438648.3	52.6	7654960.8	59.3	12365701.
39.3	2385449.3	46.0	4477456.0	52.7	7713339.7	59.4	12449324.
39.4	2409821.5	46.1	4516517.5	52.8	7772051.8	59.5	12533370.
39.5	2434380.0	46.2	4555834.1	52.9	7831098.5	59.6	12617840.
39.6	2459125.7	46.3	4595406.8	53.0	7890481.0	59.7	12702737.
39.7	2484059.6	46.4	4635236.7	53.1	7950200.5	59.8	12788062.
39.8	2509182.7	46.5	4675325.0	53.2	8010258.4	59.9	12873815.
39.9	2534495.8	46.6	4715672.8	53.3	8070655.9	60.0	12960000.
40.0	2560000.0	46.7	4756281.1	53.4	8131394.4	60.1	13046616.
40.1	2585696.1	46.8	4797151.2	53.5	8192475.0	60.2	13133665
40.2	2611585.2	46.9	4838284.1	53.6	8253899.1	60.3	13221150.
40.3	2637668.3	47.0	4879681.0	53.7	8315668.0	60.4	13309071.
40.4	2663944.2	47.1	4921342.9	53.8	8377782.9	60.5	13397430.
40.5	2690420.0	47.2	4963271.0	53.9	8440245.1	60.6	13486227.
40.6	2717090.6	47.3	5005466.5	54.0	8503056.0	60.7	13575466.
40.7	2743959.1	47.4	5047930.4	54.1	8566216.7	60.8	13665147.
40.8	2771025.3	47.5	5090664.0	54.2	8629728.7	60.9	13755271.
40.9	2798293.2	47.6	5133668.3	54.3	8693593.2	61.0	13845841.
41.0	2825761.0	47.7	5176944.5	54.4	8757811.6	61.1	13936856.
41.1	2853430.4	47.8	5220493.8	54.5	8822385.0	61.2	14028320.
41.2	2881302.5	47.9	5264317.2	54.6	8887314.9	61.3	14120234.
41.3	2909378.3	48.0	5308416.0	54.7	8952602.5	61.4	14212598.
41.4	2937658.8	48.1	5352791.2	54.8	9018249.2	61.5	14305415.
41.5	2966145.0	48.2	5397444.0	54.9	9084256.2	61.6	14398685.
41.6	2994837.9	48.3	5442375.7	55.0	9150625.0	61.7	14492411.
41.7	3023738.4	48.4	5487587.3	55.1	9217356.7	61.8	14586594.
41.8	3052847.6	48.5	5533080.0	55.2	9284452.7	61.9	14681235.
41.9	3082166.4	48.6	5578855.0	55.3	9351914.4	62.0	14776336.
42.0	3111696.0	48.7	5624913.4	55.4	9419743.1	62.1	14871898.
42.1	3141437.2	48.8	5671256.4	55.5	9487940.0	62.2	14967922.
42.2	3171391.1	48.9	5717885.2	55.6	9556506.6	62.3	15064412.
42.3	3201558.7	49.0	5764801.0	55.7	9625444.2	62.4	15161366.
42.4	3231941.0	49.1	5812004.8	55.8	9694754.0	62.5	15258789.
42.5	3262539.0	49.2	5859498.0	55.9	9764437.5	62.6	15356679.
42.6	3293353.8	49.3	5907281.6	56.0	9834496.0	62.7	15455041.
42.7	3324386.4	49.4	5955356.9	56.1	9904930.7	62.8	15553873.
42.8	3355637.7	49.5	6003725.0	56.2	9975743.2	62.9	15653180.
42.9	3387108.9	49.6	6052387.2	56.3	10046934.	63.0	15752961.
43.0	3418801.0	49.7	6101344.6	56.4	10118506.	63.1	15853218.

TABLE 1 (Cont'd)

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THEORY - HEAT TRANSFER

FOURTH POWER OF NUMBERS
N = ANY NUMBER

N	N^4	N	N^4	N	N^4	N	N^4
63.2	15953953.	69.8	23736773.	76.4	34070102.	83.0	47458321.
63.3	16055167.	69.9	23873093.	76.5	34248830.	83.1	47687449.
63.4	16156862.	70.0	24010000.	76.6	34428260.	83.2	47917406.
63.5	16259040.	70.1	24147494.	76.7	34608394.	83.3	48148194.
63.6	16361701.	70.2	24285578.	76.8	34789235.	83.4	48379814.
63.7	16464848.	70.3	24424253.	76.9	34970783.	83.5	48612270.
63.8	16568481.	70.4	24563521.	77.0	35153041.	83.6	48845561.
63.9	16672603.	70.5	24703385.	77.1	35336010.	83.7	49079692.
64.0	16777216.	70.6	24843844.	77.2	35519692.	83.8	49314663.
64.1	16882319.	70.7	24984902.	77.3	35704090	83.9	49550477.
64.2	16987916.	70.8	25126559.	77.4	35889205.	84.0	49787136.
64.3	17094007.	70.9	25268818.	77.5	36075039.	84.1	50024641.
64.4	17200594.	71.0	25411681.	77.6	36261593.	84.2	50262995.
64.5	17307680.	71.1	25555148.	77.7	36448870.	84.3	50502200.
64.6	17415264.	71.2	25699221.	77.8	36636872.	84.4	50742257.
64.7	17523349.	71.3	25843904.	77.9	36825599.	84.5	50983170.
64.8	17631936.	71.4	25989196.	78.0	37015056.	84.6	51224939.
64.9	17741028.	71.5	26135100.	78.1	37205242.	84.7	51467567.
65.0	17850625.	71.6	26281617.	78.2	37396160.	84.8	51711056.
65.1	17960728.	71.7	26428749.	78.3	37587812.	84.9	51955408.
65.2	18071341.	71.8	26576499.	78.4	37780199.	85.0	52200625.
65.3	18182463.	71.9	26724867.	78.5	37973325.	85.1	52446708.
65.4	18294097.	72.0	26873856.	78.6	38167189.	85.2	52693661.
65.5	18406245.	72.1	27023466.	78.7	38361795.	85.3	52941485.
65.6	18518907.	72.2	27173700.	78.8	38557145.	85.4	53190182.
65.7	18632085.	72.3	27324560.	78.9	38753239.	85.5	53439755.
65.8	18745782.	72.4	27476047.	79.0	38950081.	85.6	53690204.
65.9	18859998.	72.5	27628164.	79.1	39147671.	85.7	53941533.
66.0	18974736.	72.6	27780910.	79.2	39346012.	85.8	54193743.
66.1	19089996.	72.7	27934290.	79.3	39545106.	85.9	54446837.
66.2	19205780.	72.8	28088304.	79.4	39744955.	86.0	54700816.
66.3	19322090.	72.9	28242953.	79.5	39945560.	86.1	54955682.
66.4	19438928.	73.0	28398241.	79.6	40146923.	86.2	55211438.
66.5	19556295.	73.1	28554167.	79.7	40349047.	86.3	55468086.
66.6	19674192.	73.2	28710735.	79.8	40551933.	86.4	55725627.
66.7	19792622.	73.3	28867946.	79.9	40755583.	86.5	55984065.
66.8	19911585.	73.4	29025802.	80.0	40960000.	86.6	56243400.
66.9	20031084.	73.5	29184305.	80.1	41165184.	86.7	56503635.
67.0	20151121.	73.6	29343455.	80.2	41371138.	86.8	56764772.
67.1	20271695.	73.7	29503256.	80.3	41577864.	86.9	57026813.
67.2	20392810.	73.8	29663708.	80.4	41785364.	87.0	57289761.
67.3	20514467.	73.9	29824814.	80.5	41993640.	87.1	57553616.
67.4	20636668.	74.0	29986576.	80.6	42202693.	87.2	57818382.
67.5	20759414.	74.1	30148994.	80.7	42412526.	87.3	58084061.
67.6	20882706.	74.2	30313071.	80.8	42623140.	87.4	58350654.
67.7	21006547.	74.3	30475809.	80.9	42834537.	87.5	58618164.
67.8	21130937.	74.4	30640210.	81.0	43046721.	87.6	58886592.
67.9	21255880.	74.5	30805275.	81.1	43259691.	87.7	59155941.
68.0	21381376.	74.6	30971005.	81.2	43473451.	87.8	59426214.
68.1	21507426.	74.7	31137404.	81.3	43688001	87.9	59697411.
68.2	21634033.	74.8	31304472.	81.4	43903345.	88.0	59969536.
68.3	21761198.	74.9	31472212.	81.5	44119485.	88.1	60242589.
68.4	21888923.	75.0	31640625.	81.6	44336421	88.2	60516574.
68.5	22017210.	75.1	31809712.	81.7	44554156.	88.3	60791493.
68.6	22146059.	75.2	31979477.	81.8	44772692.	88.4	61067347.
68.7	22275473.	75.3	32149920.	81.9	44992031.	88.5	61344140.
68.8	22405454.	75.4	32321044.	82.0	45212176.	88.6	61621872.
68.9	22536002.	75.5	32492850.	82.1	45433126.	88.7	61900545.
69.0	22667121.	75.6	32665339.	82.2	45654686.	88.8	62180163.
69.1	22798810.	75.7	32838515.	82.3	45877457.	88.9	62460728.
69.2	22931073.	75.8	33012379.	82.4	46100840.	89.0	62742241.
69.3	23063910.	75.9	33186931.	82.5	46325039.	89.1	63024704.
69.4	23197323.	76.0	33362176.	82.6	46550054.	89.2	63308120.
69.5	23331315.	76.1	33538113.	82.7	46775887.	89.3	63592490.
69.6	23465886.	76.2	33714745.	82.8	47002542.	89.4	63877818.
69.7	23601038.	76.3	33892074.	82.9	47230019.	89.5	64164105.

TABLE I (Contd)

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THEORY - HEAT TRANSFER

FOURTH POWER OF NUMBERS

N = ANY NUMBER

N	N^4	N	N^4	N	N^4	N	N^4
89.6	64451352.	96.2	85644659.	127	260144640.	193	1387488000.
89.7	64739564.	96.3	86001326.	128	268435450.	194	1416468400.
89.8	65028741.	96.4	86359105.	129	276922880.	195	1445900600.
89.9	65318885.	96.5	86718000.	130	285610000.	196	1475789000.
90.0	65610000.	96.6	87078012.	131	294499920.	197	1506138400.
90.1	65902086.	96.7	87439143.	132	303595770.	198	1536953600.
90.2	66195146.	96.8	87801397.	133	312900720.	199	1568239200
90.3	66489183.	96.9	88164775.	134	322417930.	200	1600000000.
90.4	66784199.	97.0	88529281.	135	332150620.	201	1632240800.
90.5	67080195.	97.1	88894915.	136	342102010.	202	1664966400.
90.6	67377173.	97.2	89261680.	137	352275360.	203	1698181600.
90.7	67675137.	97.3	89629579.	138	362673930.	204	1731891400.
90.8	67974088.	97.4	89998615.	139	373301040.	205	1766100600.
90.9	68274029.	97.5	90368789.	140	384160000.	206	1800814000.
91.0	68574961.	97.6	90740103.	141	395254160.	207	1836036800.
91.1	68876886.	97.7	91112561.	142	406586890.	208	1871773600.
91.2	69179808.	97.8	91486164.	143	418161600.	209	1908029700.
91.3	69483727.	97.9	91860915.	144	429981690.	210	1944810000.
91.4	69788647.	98.0	92236816.	145	442050620.	211	1982119400.
91.5	70094570.	98.1	92613869.	146	454371850.	212	2019963100.
91.6	70401497.	98.2	92992077.	147	466948880.	213	2058346100.
91.7	70709431.	98.3	93371443.	148	479785210.	214	2097273600.
91.8	71018374.	98.4	93751968.	149	492884400.	215	2136750600.
91.9	71328328.	98.5	94133655.	150	506250000.	216	2176782300.
92.0	71639296.	98.6	94516506.	151	519885600.	217	2217373900.
92.1	71951279.	98.7	94900524.	152	533794810.	218	2258530500.
92.2	72264280.	98.8	95285710.	153	547981280.	219	2300257500.
92.3	72578302.	98.9	95672069.	154	562448650.	220	2342560000.
92.4	72893345.	99.0	96059601.	155	577200670.	221	2385443200.
92.5	73209414.	99.1	96448309.	156	592240990.	222	2428912600.
92.6	73526509.	99.2	96839195.	157	607573200.	223	2472973400.
92.7	73844633.	99.3	97229263.	158	623201290.	224	2517630900.
92.8	74163788.	99.4	97621513.	159	639128960.	225	2562890600.
92.9	74483976.	99.5	98014950.	160	655360000.	226	2608757700.
93.0	74805201.	99.6	98409574.	161	671898240.	227	2655237800.
93.1	75127463.	99.7	98805389.	162	688747530.	228	2702336200.
93.2	75450765.	99.8	99202396.	163	705911760.	229	2750058400.
93.3	75775109.	99.9	99600599.	164	723394810.	230	2798410000.
93.4	76100499.	100	100000000.	165	741200620.	231	2847396300.
93.5	76426935.	101	104060400.	166	759333130.	232	2897022900.
93.6	76754420.	102	108243210.	167	777796320.	233	2947295500.
93.7	77082956.	103	112550880.	168	796594170.	234	2998219500.
93.8	77412546.	104	116985850.	169	815730720.	235	3049800600.
93.9	77743192.	105	121550620.	170	835210000.	236	3102044400.
94.0	78074896.	106	126247690.	171	855035030.	237	3154956500.
94.1	78407660.	107	131079600.	172	875213050.	238	3208542700.
94.2	78741486.	108	136048890.	173	895745040.	239	3262808600.
94.3	79076378.	109	141158150.	174	916636170.	240	3317760000.
94.4	79412337.	110	146410000.	175	937890670.	241	3373402500.
94.5	79749365.	111	151807040.	176	959512570.	242	3429742000.
94.6	80087464.	112	157351930.	177	981506240.	243	3486784400.
94.7	80425638.	113	163047250.	178	1003875800.	244	3544535200.
94.8	80766887.	114	168896010.	179	1026625600.	245	3603000500.
94.9	81109216.	115	174900620.	180	1049760000.	246	3662186200.
95.0	81450625.	116	181063930.	181	1073283100.	247	3722098000.
95.1	81794116.	117	187388720.	182	1097199300.	248	3782742000.
95.2	82138694.	118	193877770.	183	1121513100.	249	3844124000.
95.3	82484358.	119	200533920.	184	1146228700.	250	3906250000.
95.4	82831113.	120	207360000.	185	1171350600.	251	3969126000.
95.5	83178960.	121	214358880.	186	1196883200.	252	4032758000.
95.6	83527901.	122	221533450.	187	1222830900	253	4097152000.
95.7	83877939.	123	228886640.	188	1249198300.	254	4162314200.
95.8	84229075.	124	236421370.	189	1275989900.	255	4228250600.
95.9	84581314.	125	244140620.	190	1303210000.	256	4294967200.
96.0	84934656.	126	252047370.	191	1330863300.	257	4362470400.
96.1	85289103.			192	1358954400.	258	4430766000.

TABLE I (Cont'd)

THEORY - HEAT TRANSFER

FOURTH POWER OF NUMBERS
N = ANY NUMBER

N	N^4	N	N^4	N	N^4	N	N^4
259	4499360500.	324	11019960000.	389	22898045000.	454	42483805000.
260	4569760000.	325	11156640000.	390	23134410000.	455	42959350000.
261	4640470600.	326	11294518000.	391	23372600000.	456	43237580000.
262	4711998700.	327	11433811000.	392	23612624000.	457	43617904000.
263	4784350500.	328	11574317000.	393	23854493000.	458	44000935000.
264	4857532400.	329	11716114000.	394	24098215000.	459	44386483000.
265	4931550600.	330	11859210000.	395	24343100000.	460	44774560000.
266	5006411500.	331	12003612000.	396	24591257000.	461	45165175000.
267	5032121500.	332	12149330000.	397	24840576000.	462	45558341000.
268	5158686900.	333	12295370000.	398	25091827000.	463	45954068000.
269	5236114300.	334	12444741000.	399	25344958000.	464	46352367000.
270	5314410000.	335	12594450000.	400	25600000000.	465	46753250000.
271	5393580400.	336	12745506000.	401	25856961000.	466	47156723000.
272	5473632200.	337	12897917000.	402	26115852000.	467	47562811000.
273	5554571800.	338	13051691000.	403	26376683000.	468	47971512000.
274	5636405700.	339	13206836000.	404	26639462000.	469	48382841000.
275	5719140600.	340	13363360000.	405	26904200000.	470	48796810000.
276	5802792900.	341	13521270000.	406	27170906000.	471	49213429000.
277	5887339400.	342	13680577000.	407	27439591000.	472	49632710000.
278	5972816600.	343	13841287000.	408	27710263000.	473	50054665000.
279	6059221200.	344	14003408000.	409	27982932000.	474	50479304000.
280	6146560000.	345	14166950000.	410	28257610000.	475	50906640000.
281	6234839500.	346	14331920000.	411	28534304000.	476	51336683000.
282	6324066500.	347	14498327000.	412	28813025000.	477	51769445000.
283	6414247900.	348	14666178000.	413	29093783000.	478	52204938000.
284	6505390300.	349	14835483000.	414	29376588000.	479	52643172000.
285	6597500600.	350	15006250000.	415	29661450000.	480	53084160000.
286	6690585600.	351	15178486000.	416	29948379000.	481	53527912000.
287	6784652100.	352	15352201000.	417	30237384000.	482	53974440000.
288	6879707100.	353	15527402000.	418	30528476000.	483	54423757000.
289	6975757400.	354	15704099000.	419	30821664000.	484	54875873000.
290	7072810000.	355	15882300000.	420	31116960000.	485	55330800000.
291	7170871700.	356	16062013000.	421	31414372000.	486	55788550000.
292	7269949600.	357	16243247000.	422	31713911000.	487	56249134000.
293	7370050800.	358	16426010000.	423	32015587000.	488	56712564000.
294	7471182000.	359	16610312000.	424	32319410000.	489	57178852000.
295	7573350600.	360	16796160000.	425	32625390000.	490	57648010000.
296	7676563400.	361	16983563000.	426	32933536000.	491	58120048000.
297	7780827600.	362	17172529000.	427	33243864000.	492	58594980000.
298	7886150400.	363	17363069000.	428	33556377000.	493	59072816000.
299	7992538800.	364	17555190000.	429	33871089000.	494	59553569000.
300	8100000000.	365	17748900000.	430	34188010000.	495	60037250000.
301	8208541200.	366	17944209000.	431	34507149000.	496	60523872000.
302	8318169600.	367	18141126000.	432	34828517000.	497	61013446000.
303	8429892400.	368	18339659000.	433	35152125000.	498	61505984000.
304	8540717000.	369	18539817000.	434	35477982000.	499	62001498000.
305	8653650600.	370	18741610000.	435	35806100000.	500	62500000000.
306	8767700400.	371	18945044000.	436	36136489000.	501	63001502000.
307	8882874000.	372	19150131000.	437	36469152000.	502	63506016000.
308	8999178400.	373	19356878000.	438	36804130000.	503	64013554000.
309	9116621300.	374	19565295000.	439	37141383000.	504	64524128000.
310	9235210000.	375	19775390000.	440	37480960000.	505	65037750000.
311	9354951800.	376	19987173000.	441	37822859000.	506	65554433000.
312	9475854300.	377	20200652000.	442	38167092000.	507	66074188000.
313	9597924900.	378	20415837000.	443	38513670000.	508	66597028000.
314	9721171200.	379	20632736000.	444	38862602000.	509	67122964000.
315	9845600600.	380	20851360000.	445	39213900000.	510	67652010000.
316	9971220700.	381	21071715000.	446	39567575000.	511	68184176000.
317	10098039000.	382	21293813000.	447	39923636000.	512	68719476000.
318	10226063000.	383	21517662000.	448	40282095000.	513	69257922000.
319	10355301600.	384	21743271000.	449	40642963000.	514	69799526000.
320	10485760000.	385	21970650000.	450	41006250000.	515	70344300000.
321	10617447000.	386	22199808000.	451	41371966000.	516	70892257000.
322	10750371000.	387	24430753000.	452	41740124000.	517	71443409000.
323	10884540000.	388	22663495000.	453	42211033000.	518	71997768000.

TABLE I (Contd)

THEORY - HEAT TRANSFER

FOURTH POWER OF NUMBERS
N = ANY NUMBER

N	N^4	N	N^4	N	N^4	N	N^4
519	72555348000.	585	117117950000.	651	179607280000.	717	264287490000.
520	73116160000.	586	117920810000.	652	180713410000.	718	265764990000.
521	73680216000.	587	118727790000.	653	181824630000.	719	267248670000.
522	74247530000.	588	119538910000.	654	182940970000.	720	268736560000.
523	74818113000.	589	120354180000.	655	184062450000.	721	270234660000.
524	75391979000.	590	121173610000.	656	185189070000.	722	271737000000.
525	75969140000.	591	121997210000.	657	186320850000.	723	273245600000.
526	76549608000.	592	122825010000.	658	187457820000.	724	274760470000.
527	77133397000.	593	123657010000.	659	188599980000.	725	276281640000.
528	77720518000	594	124493240000.	660	189747360000.	726	277809100000.
529	78310985000.	595	125333700000.	661	190899960000.	727	279342900000.
530	78904810000.	596	126178400000.	662	192057800000.	728	280883040000.
531	79502005000.	597	127027370000.	663	193220900000.	729	282429530000.
532	80102584000.	598	127880620000.	664	194389280000.	730	283982410000.
533	80706559000.	599	128738150000.	665	195562950000.	731	285541670000.
534	81313944000.	600	129600000000.	666	196741920000.	732	287107350000.
535	81924750000.	601	130466160000.	667	197926220000.	733	288679450000.
536	82538991000.	602	131336650000.	668	199115850000.	734	290258020000.
537	83156680000.	603	132211500000.	669	200310840000.	735	291843050000.
538	83777829000.	604	133090710000.	670	201511210000.	736	293434550000.
539	84402451000.	605	133974300000.	671	202716950000.	737	295032560000.
540	85030560000.	606	134862270000.	672	203928100000.	738	296637080000.
541	85662167000.	607	135754660000.	673	205144670000.	739	298248140000.
542	86297287000.	608	136651470000.	674	206366680000.	740	299865760000.
543	86935932000.	609	137552710000.	675	207594140000.	741	301489940000.
544	87578116000.	610	138458410000.	676	208827060000.	742	303120710000.
545	88223850000.	611	139368560000.	677	210065470000.	743	304758090000.
546	88873149000.	612	140283200000.	678	211309370000.	744	306402100000.
547	89526025000.	613	141202340000.	679	212558800000.	745	308052750000.
548	90182492000.	614	142125980000.	680	213813760000.	746	309710050000.
549	90842562000.	615	143054150000.	681	215074260000.	747	311374040000.
550	91506250000.	616	143986850000.	682	216340330000.	748	313044720000.
551	92173567000.	617	144924110000.	683	217611980000.	749	314722120000.
552	92844527000.	618	145865940000.	684	218889230000.	750	316406250000.
553	93519144000.	619	146812350000.	685	220172100000.	751	318097120000.
554	94197431000.	620	147763360000.	686	221460590000.	752	319794770000.
555	94879400000.	621	148718980000.	687	222754730000.	753	321499200000.
556	95565066000.	622	149679220000.	688	224054540000.	754	323210440000.
557	96254442000.	623	150644120000.	689	225360020000.	755	324928500000.
558	96947540000.	624	151613650000.	690	226671210000.	756	326653390000.
559	97644375000.	625	152587890000.	691	227988100000.	757	328385150000.
560	98344960000.	626	153566790000.	692	229310730000.	758	330123790000.
561	99049307000.	627	154550410000.	693	230639100000.	759	331869310000.
562	99757432000.	628	155538730000.	694	231973250000.	760	333621760000.
563	100469360000.	629	156531800000.	695	233313150000.	761	335381130000.
564	101185060000.	630	157529610000.	696	234658860000.	762	337147450000.
565	101904600000.	631	158532120000.	697	236010380000.	763	338920740000.
566	102627960000.	632	159539500000.	698	237367730000.	764	340701020000.
567	103355170000.	633	160551670000.	699	238730930000.	765	342488300000.
568	104086240000.	634	161566650000.	700	240100000000.	766	344281600000.
569	104821180000.	635	162590400000.	701	241474940000.	767	346083940000.
570	105560010000.	636	163617010000.	702	242855780000.	768	347892350000.
571	106302750000.	637	164648490000.	703	244242530000.	769	349707830000.
572	107049360000.	638	165684310000.	704	245635210000.	770	351530410000.
573	107799930000.	639	166725050000.	705	247033850000.	771	353360100000.
574	108554450000.	640	167772160000.	706	248438440000.	772	355196920000.
575	109312890000.	641	168823190000.	707	249849000000.	773	357040900000.
576	110075310000.	642	169879150000.	708	251265970000.	774	358892050000.
577	110841710000.	643	170940070000.	709	252688180000.	775	360750390000.
578	111612110000.	644	172005940000.	710	254116810000.	776	362615930000.
579	112386520000.	645	173076900000.	711	255551480000.	777	364488700000.
580	113164960000.	646	174152640000.	712	256992210000.	778	366368720000.
581	113947430000.	647	175233490000.	713	258439040000.	779	368255990000.
582	114733940000.	648	176319360000.	714	259891960000.	780	370150560000.
583	115524500000.	649	177410220000.	715	261351000000.	781	372052420000.
584	116319190000.	650	178506250000.	716	262816170000.	782	373961600000.

TABLE I (Contd)

THEORY - HEAT TRANSFER

FOURTH POWER OF NUMBERS
N = ANY NUMBER

N	N^4	N	N^4	N	N^4	N	N^4
783	3758781 20000.	848	517110560000.	913	694837270000.	978	914861640000.
784	377801990000.	849	519554060000.	914	697886470000.	979	918609150000.
785	379733250000.	850	522006250000.	915	700945700000.	980	922368160000.
786	381671890000.	851	524467080000.	916	704014970000.	981	926138690000.
787	383617950000.	852	526936610000.	917	707094310000.	982	929920770000.
788	385571450000.	853	529414850000.	918	710183740000.	983	933714430000.
789	387532390000.	854	531901820000.	919	713283280000.	984	937519680000.
790	389500810000.	855	534397550000.	920	716392960000.	985	941336550000.
791	391476710000.	856	536902040000.	921	719512780000.	986	945165060000.
792	393460120000.	857	539415330000.	922	722642800000.	987	949005240000.
793	395451060000.	858	541937430000.	923	725783020000.	988	952857100000.
794	397449550000.	859	544468370000.	924	728933450000.	989	956720690000.
795	399455600000.	860	547008160000.	925	732094140000.	990	960596010000.
796	401469230000.	861	549556830000.	926	735265090000.	991	964483090000.
797	403490470000.	862	552114380000.	927	738446330000.	992	968381950000.
798	405519330000.	863	554680860000.	928	741637880000.	993	972292630000.
799	407555830000.	864	557256270000.	929	744839760000.	994	976215130000.
800	409600000000.	865	559840650000.	930	748052010000.	995	980149500000.
801	411651840000.	866	562434000000.	931	751274630000.	996	984095740000.
802	413711380000.	867	565036350000.	932	754507650000.	997	988053890000.
803	415778640000.	868	567647720000.	933	757751090000.	998	992023960000.
804	417853640000.	869	570268130000.	934	761004990000.	999	996005990000.
805	419936400000.	870	572897610000.	935	764269350000.		
806	422026930000.	871	575536160000.	936	767544200000.		
807	424125260000.	872	578183830000.	937	770829560000.		
808	426231400000.	873	580840610000.	938	774125460000.		
809	428345370000.	874	583506540000.	939	777431920000.		
810	430467210000.	875	586181640000.	940	780748960000.		
811	432596910000.	876	588865920000.	941	784076600000.		
812	434734510000.	877	591559410000.	942	787414860000.		
813	436880010000.	878	594262140000.	943	790763780000.		
814	439033450000.	879	596974110000.	944	794123370000.		
815	441194850000.	880	599695360000.	945	797493650000.		
816	443364210000.	881	602425890000.	946	800874640000.		
817	445541560000.	882	605165740000.	947	804266380000.		
818	447726920000.	883	607914930000.	948	807668870000.		
819	449920310000.	884	610673470000.	949	811082160000.		
820	452121760000.	885	613441400000.	950	814506250000.		
821	454331260000.	886	616218720000.	951	817941160000.		
822	456548856000.	887	619005450000.	952	821386940000.		
823	458774570000.	888	621801630000.	953	824843580000.		
824	461008400000.	889	624607250000.	954	828311130000.		
825	463250390000.	890	627422410000.	955	831789600000.		
826	465500540000.	891	630247040000.	956	835279010000.		
827	467758870000.	892	633081200000.	957	838779390000.		
828	470025420000.	893	635924900000.	958	842290750000.		
829	472300190000.	894	638778180000.	959	845813140000.		
830	474583210000.	895	641641050000.	960	849346560000.		
831	476874490000.	896	644513520000.	961	852891030000.		
832	479174060000.	897	647395640000.	962	856446590000.		
833	481481940000.	898	650287410000.	963	860013260000.		
834	483798140000.	899	653188850000.	964	863591050000.		
835	486122700000.	900	656100000000.	965	867180000000.		
836	488455610000.	901	659020880000.	966	870781200000.		
837	490796920000.	902	661951460000.	967	874391430000.		
838	493146630000.	903	664891830000.	968	878013970000.		
839	495504770000.	904	667841990000.	969	881647750000.		
840	497871360000.	905	670801950000.	970	885292810000.		
841	500246410000.	906	673771720000.	971	888949150000.		
842	502629950000.	907	676751370000.	972	892616800000.		
843	505022000000.	908	679740880000.	973	896295790000.		
844	507422570000.	909	682740290000.	974	899986150000.		
845	509831700000.	910	685749610000.	975	903687890000.		
846	512249390000.	911	688768860000.	976	907401030000.		
847	514675670000.	912	691798080000.	977	911125610000.		

TABLE I (Cont'd)

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THEORY - HEAT TRANSFER

TABLE X = N TO THE 5/4 POWER
N = ANY NUMBER

N	0	1	2	3	4	5	6	7	8	9
0	0.0000	1.0000	2.3784	3.9482	5.6569	7.4767	9.3905	11.386	13.454	15.588
10	17.783	20.033	22.335	24.685	27.081	29.520	32.000	34.519	37.076	39.668
20	42.295	44.955	47.646	50.369	53.121	55.902	58.711	61.547	64.409	67.297
30	70.210	73.148	76.109	79.094	82.101	85.130	88.182	91.254	94.347	97.461
40	100.59	103.75	106.92	110.11	113.32	116.55	119.80	123.06	126.34	129.6
50	132.96	136.29	139.64	143.00	146.38	149.78	153.19	156.62	160.06	163.52
60	166.99	170.48	173.98	177.49	181.02	184.56	188.12	191.69	195.27	198.87
70	202.48	206.10	209.73	213.38	217.04	220.71	224.40	228.09	231.80	235.52
80	239.26	243.00	246.76	250.52	254.30	258.09	261.89	265.70	269.53	273.36
90	277.21	281.06	284.93	288.80	292.69	296.59	300.50	304.41	308.34	312.28
100	316.23	320.19	324.15	328.13	332.12	336.11	340.12	344.14	348.16	352.19
110	356.24	360.29	364.35	368.42	372.50	376.59	380.69	384.80	388.91	393.04
120	397.17	401.31	405.46	409.62	413.79	417.96	422.15	426.34	430.55	434.75
130	438.96	443.19	447.42	451.66	455.91	460.17	464.43	468.71	472.99	477.27
140	481.57	485.87	490.19	494.50	498.83	503.16	507.51	511.85	516.21	520.57
150	524.95	529.32	533.71	538.10	542.50	546.91	551.32	555.74	560.17	564.61
160	569.05	573.50	577.95	582.42	586.89	591.36	595.85	600.34	604.83	609.34
170	613.85	618.37	622.89	627.42	631.96	636.50	641.05	645.60	650.17	654.74
180	659.31	663.89	668.48	673.08	677.68	682.28	686.90	691.52	696.14	700.77
190	705.41	710.05	714.70	719.36	724.02	728.69	733.37	738.04	742.73	747.42
200	752.12	756.82	761.53	766.25	770.97	775.70	780.43	785.17	789.91	794.66
210	799.42	804.18	808.95	813.72	818.50	823.28	828.07	832.87	837.67	842.47
220	847.28	852.10	856.92	861.75	866.58	871.42	876.27	881.11	885.97	890.83
230	895.69	900.56	905.44	910.32	915.21	920.10	925.00	929.90	934.81	939.72
240	944.63	949.56	954.48	959.42	964.36	969.30	974.25	979.30	984.16	989.12
250	994.1	999.1	1004.0	1009.0	1014.0	1019.0	1024.0	1029.0	1034.0	1039.0
260	1044.0	1049.1	1054.1	1059.1	1064.2	1069.2	1074.2	1079.3	1084.3	1089.4
270	1094.5	1099.5	1104.6	1109.7	1114.8	1119.9	1125.0	1130.1	1135.2	1140.3
280	1145.4	1150.5	1155.6	1160.7	1165.9	1171.0	1176.1	1181.3	1186.4	1191.6
290	1196.7	1201.9	1207.1	1212.2	1217.4	1222.6	1227.8	1232.9	1238.1	1243.3
300	1248.5	1253.7	1259.0	1264.2	1269.4	1274.6	1279.8	1285.1	1290.3	1295.5
310	1300.8	1306.0	1311.3	1316.5	1321.8	1327.1	1332.3	1337.6	1342.9	1348.2
320	1353.4	1358.7	1364.0	1369.3	1374.6	1379.9	1385.2	1390.5	1395.9	1401.2
330	1406.5	1411.8	1417.2	1422.5	1427.9	1433.2	1438.5	1443.9	1449.3	1454.6
340	1460.0	1465.4	1470.7	1476.1	1481.5	1486.9	1492.3	1497.7	1503.1	1508.5
350	1513.9	1519.3	1524.7	1530.1	1535.5	1540.9	1546.4	1551.8	1557.2	1562.7
360	1568.1	1573.6	1579.0	1584.5	1589.9	1595.4	1600.9	1606.3	1611.8	1617.3
370	1622.8	1628.2	1633.7	1639.2	1644.7	1650.2	1655.7	1661.2	1666.7	1672.2
380	1677.8	1683.3	1688.8	1694.3	1699.9	1705.4	1710.9	1716.5	1722.0	1727.6
390	1733.1	1738.7	1744.2	1749.8	1755.4	1760.9	1766.5	1772.1	1777.7	1783.3
400	1788.9	1794.4	1800.0	1805.6	1811.2	1816.8	1822.5	1828.1	1833.7	1839.3
410	1844.9	1850.6	1856.2	1861.8	1867.5	1873.1	1878.7	1884.4	1890.0	1895.7
420	1901.3	1907.0	1912.7	1918.3	1924.0	1929.7	1935.4	1941.0	1946.7	1952.4
430	1958.1	1963.8	1969.5	1975.2	1980.9	1986.6	1992.3	1998.0	2003.7	2009.5

TABLE 2

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THEORY - HEAT TRANSFER

TABLE X = N TO THE 5/4 POWER
N = ANY NUMBER

N	0	1	2	3	4	5	6	7	8	9
440	2015.2	2020.9	2026.6	2032.4	2038.1	2043.9	2049.6	2055.3	2061.1	2066.8
450	2072.6	2078.4	2084.1	2089.9	2095.7	2101.4	2107.2	2113.0	2118.8	2124.5
460	2130.3	2136.1	2141.9	2147.7	2153.5	2159.3	2165.1	2170.9	2176.7	2182.6
470	2188.4	2194.2	2200.0	2205.9	2211.7	2217.5	2223.4	2229.2	2235.0	2240.9
480	2246.7	2252.6	2258.4	2264.3	2270.2	2276.0	2281.9	2287.8	2293.6	2299.5
490	2305.4	2311.3	2317.2	2323.0	2328.9	2334.8	2340.7	2346.6	2352.5	2358.4
500	2364.4	2370.3	2376.2	2382.1	2388.0	2393.9	2399.9	2405.8	2411.7	2417.7
510	2423.6	2429.5	2435.5	2441.4	2447.4	2453.3	2459.3	2465.3	2471.2	2477.2
520	2483.2	2489.1	2495.1	2501.1	2507.1	2513.0	2519.0	2525.0	2531.0	2537.0
530	2543.0	2549.0	2555.0	2561.0	2567.0	2573.0	2579.0	2585.0	2591.1	2597.1
540	2603.1	2609.1	2616.2	2621.2	2627.2	2633.3	2639.3	2645.4	2651.4	2657.5
550	2663.5	2669.6	2675.6	2681.7	2687.7	2693.8	2699.9	2705.9	2712.0	2718.1
560	2724.2	2730.3	2736.3	2742.4	2748.5	2754.6	2760.7	2766.8	2772.9	2779.0
570	2785.1	2791.2	2797.3	2803.5	2809.6	2815.7	2821.8	2827.9	2834.1	2840.2
580	2846.3	2852.5	2858.6	2864.7	2870.9	2877.0	2883.2	2889.3	2895.5	2901.6
590	2907.8	2914.0	2920.1	2926.3	2932.5	2938.6	2944.8	2951.0	2957.2	2963.4
600	2969.5	2975.7	2981.9	2988.1	2994.3	3000.5	3006.7	3012.9	3019.1	3025.3
610	3031.5	3037.7	3044.0	3050.2	3056.4	3062.6	3068.9	3075.1	3081.3	3087.5
620	3093.8	3100.0	3106.3	3112.5	3118.8	3125.0	3131.3	3137.5	3143.8	3150.0
630	3156.3	3162.5	3168.8	3175.1	3181.4	3187.6	3193.9	3200.2	3206.5	3212.7
640	3219.0	3225.3	3231.6	3237.9	3244.2	3250.5	3256.8	3263.1	3269.4	3275.7
650	3282.0	3288.3	3294.7	3301.0	3307.3	3313.6	3319.9	3326.3	3332.6	3338.9
660	3345.3	3351.6	3357.9	3364.3	3370.6	3377.0	3383.3	3389.7	3396.0	3402.4
670	3408.7	3415.1	3421.5	3427.8	3434.2	3440.6	3446.9	3453.3	3459.7	3466.1
680	3472.5	3478.8	3485.2	3491.6	3498.0	3504.4	3410.8	3517.2	3523.6	3530.0
690	3536.4	3542.8	3549.2	3555.6	3562.0	3568.5	3574.9	3581.3	3587.7	3594.2
700	3600.6	3607.0	3613.4	3619.9	3626.3	3632.8	3639.2	3645.6	3652.1	3658.5
710	3665.0	3671.4	3677.9	3684.4	3690.8	3697.3	3703.7	3710.2	3716.7	3723.2
720	3729.6	3736.1	3742.6	3749.1	3755.5	3762.0	3768.5	3775.0	3781.5	3788.0
730	3794.5	3801.0	3807.5	3814.0	3820.5	3827.0	3833.5	3840.0	3846.5	3853.1
740	3859.6	3866.1	3872.6	3879.1	3885.7	3892.2	3898.7	3905.3	3911.8	3918.3
750	3924.9	3931.4	3938.0	3944.5	3951.1	3957.6	3964.2	3970.7	3977.3	3983.8
760	3990.4	3997.0	4003.5	4010.1	4016.7	4023.2	4029.8	4036.4	4043.0	4049.6
770	4056.1	4062.7	4069.3	4075.9	4082.5	4089.1	4095.7	4102.3	4108.9	4115.5
780	4122.1	4128.7	4135.3	4141.9	4148.5	4155.2	4161.8	4168.4	4175.0	4181.6
790	4188.3	4194.9	4201.5	4208.1	4214.8	4221.4	4228.1	4234.7	4241.3	4248.0
800	4254.6	4261.3	4267.9	4274.6	4281.2	4287.9	4294.6	4301.2	4307.9	4314.5
810	4321.2	4327.9	4334.6	4341.2	4347.9	4354.6	4361.3	4367.9	4374.6	4381.3
820	4388.0	4394.7	4401.4	4408.1	4414.8	4421.5	4428.2	4434.9	4441.6	4448.3
830	4455.0	4461.7	4468.4	4475.1	4481.8	4488.6	4495.3	4502.0	4508.7	4515.5
840	4522.2	4528.9	4535.7	4542.4	4549.1	4555.9	4562.6	4569.3	4576.1	4582.8
850	4589.6	4596.3	4603.1	4609.8	4616.6	4623.4	4630.1	4636.9	4643.6	4650.4
860	4657.2	4663.9	4670.7	4677.5	4684.3	4691.0	4697.8	4704.6	4711.4	4718.2
870	4725.0	4731.8	4738.6	4745.3	4752.1	4758.9	4765.7	4772.5	4779.3	4786.1
880	4793.0	4799.8	4806.6	4813.4	4820.2	4827.0	4833.8	4840.7	4847.5	4854.3

TABLE 2 (Contd)

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THEORY - HEAT TRANSFER

RADIATION HEAT TRANSFER TABLE

Btu/sq ft, hr to Absolute Zero

TEMPERATURE		EMITTANCE									
(F)	(R)	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
-210	250	6.80	6.12	5.44	4.76	4.08	3.40	2.72	2.04	1.36	0.68
-205	255	7.36	6.62	5.89	5.15	4.41	3.68	2.94	2.21	1.47	0.74
-200	260	7.95	7.16	6.36	5.57	4.77	3.98	3.18	2.39	1.59	0.80
-195	265	8.58	7.72	6.86	6.01	5.15	4.29	3.43	2.57	1.72	0.86
-190	270	9.25	8.32	7.40	6.47	5.55	4.62	3.70	2.77	1.85	0.92
-185	275	9.95	8.96	7.96	6.97	5.97	4.98	3.98	2.99	1.99	1.00
-180	280	10.70	9.63	8.56	7.49	6.42	5.35	4.28	3.21	2.14	1.07
-175	285	11.48	10.33	9.18	8.04	6.89	5.74	4.59	3.44	2.30	1.15
-170	290	12.31	11.08	9.85	8.61	7.38	6.15	4.92	3.69	2.46	1.23
-165	295	13.18	11.86	10.54	9.22	7.91	6.59	5.27	3.95	2.64	1.32
-160	300	14.09	12.68	11.28	9.87	8.46	7.05	5.64	4.23	2.82	1.41
-155	305	15.06	13.55	12.05	10.54	9.03	7.53	6.02	4.52	3.01	1.51
-150	310	16.07	14.46	12.86	11.25	9.64	8.03	6.43	4.82	3.21	1.61
-145	315	17.13	15.42	13.71	11.99	10.28	8.57	6.85	5.14	3.43	1.71
-140	320	18.25	16.42	14.60	12.77	10.95	9.12	7.30	5.47	3.65	1.82
-135	325	19.41	17.47	15.53	13.59	11.65	9.71	7.77	5.82	3.88	1.94
-130	330	20.64	18.57	16.51	14.44	12.38	10.32	8.25	6.19	4.13	2.06
-125	335	21.91	19.72	17.53	15.34	13.15	10.96	8.77	6.57	4.38	2.19
-120	340	23.25	20.93	18.60	16.28	13.95	11.63	9.30	6.98	4.65	2.33
-115	345	24.65	22.19	19.72	17.26	14.79	12.33	9.86	7.40	4.93	2.47
-110	350	26.11	23.50	20.89	18.20	15.67	13.06	10.44	7.83	5.22	2.61
-105	355	27.64	24.87	22.11	19.34	16.58	13.82	11.05	8.29	5.53	2.76
-100	360	29.23	26.30	23.38	20.46	17.54	14.16	11.69	8.77	5.85	2.92
-95	365	30.88	27.79	24.71	21.62	18.53	15.44	12.35	9.26	6.18	3.09
-90	370	32.61	29.35	26.09	22.83	19.57	16.31	13.04	9.78	6.52	3.26
-85	375	34.41	30.97	27.53	24.09	20.65	17.20	13.76	10.32	6.88	3.44
-80	380	36.28	32.65	29.03	25.40	21.77	18.14	14.51	10.88	7.26	3.63
-75	385	38.23	34.41	30.58	26.76	22.94	19.11	15.29	11.47	7.65	3.82
-70	390	40.25	36.23	32.20	28.18	24.15	20.13	16.10	12.08	8.05	4.03
-65	395	42.36	38.12	33.89	29.65	25.41	21.18	16.94	12.71	8.47	4.24
-60	400	44.54	40.09	35.64	31.18	26.73	22.27	17.82	13.36	8.91	4.45
-55	405	46.81	42.13	37.45	32.77	28.09	23.41	18.73	14.04	9.36	4.68
-50	410	49.17	44.25	39.33	34.42	29.50	24.58	19.67	14.75	9.83	4.92
-45	415	51.61	46.45	41.29	36.13	30.97	25.81	20.64	15.48	10.32	5.16
-40	420	54.14	48.73	43.31	37.90	32.49	27.07	21.66	16.24	10.83	5.41
-35	425	56.77	51.09	45.41	39.74	34.06	28.38	22.71	17.03	11.35	5.68
-30	430	59.49	53.54	47.59	41.64	35.69	29.74	23.79	17.85	11.90	5.95
-25	435	62.30	56.07	49.84	43.61	37.38	31.15	24.92	18.69	12.46	6.23
-20	440	65.22	58.70	52.17	45.65	39.13	32.61	26.09	19.57	13.04	6.52
-15	445	68.23	61.41	54.59	47.76	40.94	34.12	27.29	20.47	13.65	6.82
-10	450	71.35	64.22	57.08	49.95	42.81	35.68	28.54	21.41	14.27	7.14
-5	455	74.58	67.12	59.66	52.20	44.75	37.29	29.83	22.37	14.92	7.46
0	460	77.91	70.12	62.33	54.54	46.74	38.95	31.16	23.37	15.58	7.79
5	465	81.35	73.22	65.08	56.95	48.81	40.68	32.54	24.41	16.27	8.14
10	470	84.91	76.42	67.93	59.43	50.94	42.45	33.96	25.47	16.98	8.49
15	475	88.58	79.72	70.86	62.00	53.15	44.29	35.43	26.57	17.72	8.86
20	480	92.37	83.13	73.89	64.66	55.42	46.18	36.95	27.71	18.47	9.24
25	485	96.28	86.65	77.02	67.39	57.77	48.14	38.51	28.88	19.26	9.63
30	490	100.31	90.28	80.25	70.22	60.18	50.15	40.12	30.09	20.06	10.03
35	495	104.46	94.02	83.57	73.13	62.68	52.23	41.79	31.34	20.89	10.45
40	500	108.75	97.88	87.00	76.13	65.25	54.38	43.50	32.63	21.75	10.88
45	505	113.17	101.85	90.53	79.22	67.90	56.58	45.27	33.95	22.63	11.32
50	510	117.71	105.94	94.17	82.40	70.63	58.86	47.09	35.31	23.54	11.77
55	515	122.40	110.16	97.92	85.68	73.44	61.20	48.96	36.72	24.48	12.24
60	520	127.22	114.50	101.78	89.06	76.33	63.61	50.89	38.17	25.44	12.72
65	525	132.19	118.97	105.75	92.53	79.31	66.09	52.87	39.66	26.44	13.22

TABLE 3

Note: For conversion to °C use Temperature Conversion Table Page 218

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THEORY - HEAT TRANSFER

RADIATION HEAT TRANSFER TABLE
Btu/sq ft, hr to Absolute Zero

TEMPERATURE		EMITTANCE									
(F)	(R)	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
70	530	137.29	123.56	109.84	96.11	82.38	68.65	54.92	41.19	27.46	13.73
75	535	142.55	128.29	114.04	99.78	85.53	71.27	57.02	42.76	28.51	14.25
80	540	147.95	133.16	118.36	103.57	88.77	73.98	59.18	44.39	29.59	14.80
85	545	153.51	138.16	122.81	107.46	92.11	76.75	61.40	46.05	30.70	15.35
90	550	159.22	143.30	127.38	111.45	95.53	79.61	63.69	47.77	31.84	15.92
95	555	165.09	148.58	132.07	115.56	99.05	82.55	66.04	49.53	33.02	16.51
100	560	171.12	154.01	136.90	119.78	102.67	85.56	68.45	51.34	34.22	17.11
105	565	177.31	159.58	141.85	124.12	106.39	88.66	70.93	53.19	35.46	17.73
110	570	183.67	165.31	146.94	128.57	110.20	91.84	73.47	55.10	36.73	18.37
115	575	190.20	171.18	152.16	133.14	114.12	95.10	76.08	57.06	38.04	19.02
120	580	196.91	177.22	157.53	137.83	118.14	98.45	78.76	59.07	39.38	19.69
125	585	203.79	183.41	163.03	142.65	122.27	101.89	81.51	61.14	40.76	20.38
130	590	210.84	189.76	168.67	147.59	126.51	105.42	84.34	63.25	42.17	21.08
135	595	218.08	196.27	174.46	152.66	130.85	109.04	87.23	65.42	42.62	21.81
140	600	225.50	202.95	180.40	157.85	135.30	112.75	90.20	67.65	45.10	22.55
145	605	233.12	209.80	186.49	163.18	139.87	116.56	93.25	69.93	46.62	23.31
150	610	240.92	216.83	192.73	168.64	144.55	120.46	96.37	72.28	48.18	24.09
155	615	248.91	224.02	199.13	174.24	149.35	124.46	99.57	74.67	49.78	24.89
160	620	257.11	231.40	205.69	179.98	154.26	128.55	102.84	77.13	51.42	25.71
165	625	265.50	238.95	212.40	185.85	159.30	132.75	106.20	79.65	53.10	26.55
170	630	274.10	246.69	219.28	191.87	164.46	137.05	109.64	82.23	54.82	27.41
175	635	282.91	254.62	226.33	198.04	169.74	141.45	113.16	84.87	56.58	28.29
180	640	291.92	262.73	233.54	204.35	175.15	145.96	116.77	87.58	58.38	29.19
185	645	301.15	271.04	240.92	210.81	180.69	150.58	120.46	90.35	60.23	30.12
190	650	310.60	279.54	248.48	217.42	186.36	155.30	124.24	93.18	62.12	31.06
195	655	320.27	288.24	256.21	224.19	192.16	160.13	128.11	96.08	64.05	32.03
200	660	330.16	297.14	264.13	231.11	198.10	165.08	132.06	99.05	66.03	33.02
210	670	350.6	315.6	280.5	245.4	210.4	175.3	140.3	105.2	70.1	35.1
220	680	372.0	334.8	297.6	260.4	223.2	186.0	148.8	111.6	74.4	37.2
230	690	394.4	355.0	315.5	276.1	236.6	197.2	157.8	118.3	78.9	39.4
240	700	417.8	376.0	334.2	292.4	250.7	208.9	167.1	125.3	83.6	41.8
250	710	442.2	397.9	353.7	309.5	265.3	221.1	176.9	132.6	88.4	44.2
260	720	467.6	420.8	374.1	327.3	280.6	233.8	187.0	140.3	93.5	46.8
270	730	494.1	444.7	395.3	345.9	296.5	247.1	197.7	148.2	98.8	49.4
280	740	521.8	469.6	417.4	365.2	313.1	260.9	208.7	156.5	104.4	52.2
290	750	550.5	495.5	440.4	385.4	330.3	275.3	220.2	165.2	110.1	55.1
300	760	580.5	522.5	464.4	406.4	348.3	290.3	232.2	174.2	116.1	58.1
310	770	611.7	550.5	489.3	428.2	367.0	305.8	244.7	183.5	122.3	61.2
320	780	644.1	579.7	515.2	450.8	386.4	322.0	257.6	193.2	128.8	64.4
330	790	677.7	610.0	542.2	474.4	406.6	338.9	271.1	203.3	135.5	67.8
340	800	712.7	641.4	570.2	498.9	427.6	356.4	285.1	213.8	142.5	71.3
350	810	749.0	674.1	599.2	524.3	449.4	374.5	299.6	224.7	149.8	74.9
360	820	786.7	708.0	629.4	550.7	472.0	393.3	314.7	236.0	157.3	78.7
370	830	825.8	743.2	660.6	578.0	495.5	412.9	330.3	247.7	165.2	32.6
380	840	866.3	779.7	693.0	606.4	519.8	433.1	346.5	259.9	173.3	86.6
390	850	908.3	817.5	726.6	635.8	545.0	454.1	363.3	272.5	181.7	90.8
400	860	951.8	856.6	761.6	666.3	571.1	475.9	380.7	285.5	190.4	95.2
410	870	996.8	897.2	797.5	697.8	598.1	498.4	398.7	299.1	199.4	99.7
420	880	1043.5	939.1	834.8	730.4	626.1	521.7	417.4	313.0	208.7	104.3
430	890	1091.7	982.5	873.4	764.2	655.0	545.9	436.7	327.5	218.3	109.2
440	900	1141.6	1027.5	913.3	799.1	685.0	570.8	456.6	342.5	228.3	114.2
450	910	1193.2	1073.9	954.6	835.2	715.9	596.6	477.3	358.0	238.6	119.3
460	920	1246.5	1121.9	997.2	872.6	747.9	623.3	498.6	374.0	249.3	124.7
470	930	1301.6	1171.4	1041.3	911.1	781.0	650.8	520.6	390.5	260.3	130.2
480	940	1358.5	1222.7	1086.8	951.0	815.1	679.3	543.4	407.6	271.7	135.9
490	950	1417.2	1275.5	1133.8	992.1	850.3	708.6	566.9	425.2	283.4	141.7

TABLE 3 (Cont'd)

Note: For conversion to °C use Temperature Conversion Table Page 218

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THEORY - HEAT TRANSFER

RADIATION HEAT TRANSFER TABLE

Btu/sq ft, hr to Absolute Zero

TEMPERATURE		EMITTANCE									
(F)	(R)	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
500	960	1477.9	1330.1	1182.3	1034.5	886.7	738.9	591.1	443.4	295.6	147.8
550	1010	1811.	1630.	1449.	1267.	1086.	905.	543.	543.	362.	181.
600	1060	2197.	1977.	1757.	1538.	1318.	1098.	659.	659.	439.	220.
650	1110	2641.	2377.	2113.	1849.	1585.	1321.	792.	792.	528.	264
700	1160	3151.	2835.	2520.	2205.	1890.	1575.	945.	945.	630.	315.
750	1210	3730.	3357.	2984.	2611.	2238.	1865.	1119.	1119.	746.	373.
800	1260	4386.	3947.	3508.	3070.	2631.	2193.	1316.	1316.	877.	439.
850	1310	5124.	4612.	4099.	3587.	3075.	2562.	1537.	1537.	1025.	512.
900	1360	5953.	5357.	4762.	4167.	3572.	2976.	1786.	1786.	1191.	595.
950	1410	6877.	6190.	5502.	4814.	4126.	3439.	2063.	2063.	1375.	688.
1000	1460	7906.	7115.	6325.	5534.	4744.	3953.	2372.	2372.	1581.	791.
1050	1510	9046.	8141.	7237.	6332.	5428.	4523.	2714.	2714.	1809.	905.
1100	1560	10305.	9274.	8244.	7213.	6183.	5152.	3091.	3091.	2061.	1030.
1150	1610	11691.	105.22.	9353.	8184.	7015.	5846.	3507.	3507.	2338.	1169.
1200	1660	13212.	11891.	10570.	9249.	7927.	6606.	3964.	3964.	2642.	1321.
1250	1710	14878.	13390.	11902.	10414.	8927.	7439.	4463.	4463.	2976.	1488.
1300	1760	16696.	15026.	13356.	11687.	10017.	8348.	5009.	5009.	3339.	1670.
1350	1810	18675.	16808.	14940.	13073.	11205.	9338.	5603.	5603.	3735.	1868.
1400	1860	20826.	18743.	16661.	14578.	12495.	10413.	6248.	6248.	4165.	2083.
1450	1910	23157.	20841.	18526.	16210.	13894.	11579.	6947.	6947.	4631.	2316.
1500	1960	25679.	23111.	20543.	17975.	15407.	12839.	7704.	7704.	5136.	2568.
1550	2010	28401.	25561.	222721.	19881.	17041.	14200.	8520.	8520.	5680.	2840.
1600	2060	31334.	28201.	25067.	21934.	18800.	15667.	9400	9400.	6267.	3133.
1650	2110	34489.	31040.	27591.	24142.	20693.	17244.	10347.	10347.	6898.	3449.
1700	2160	37876.	34088.	30301.	26513.	22726.	18938.	11363.	11363.	7575.	3788.
1750	2210	41507.	37356.	33205.	29055.	24904.	20753.	12452.	12452.	8301.	4151.
1800	2260	45302.	40853.	36314.	31775.	27235.	22696.	13618.	13618.	9078.	4539.
1850	2310	49545.	44590.	39636.	34681.	29727.	24772.	14863.	14863.	9909.	4954.
1900	2360	53976.	48578.	43180.	37783.	32385.	26988.	16193.	16193.	10795.	5398.
1950	2410	58697.	52827.	46958.	41088.	35218.	29349.	17609.	17609.	11739.	5870.
2000	2460	63722.	573.50.	50978.	44605.	38233.	31861.	19117.	19117.	12744.	6372.
2050	2510	69063.	62157.	55250.	48344.	41438.	34531.	20719.	20719.	13813.	6906
2100	2560	74732.	67259.	59786.	52313.	44839.	37366.	22420.	22420.	14946.	7473.
2150	2610	80744.	72670.	64595.	56521.	48447.	40372.	24223.	24223.	16149.	8074.
2200	2660	87112.	78400.	69689.	60978.	52267.	48556.	26133.	26133.	17422.	8711.
2250	2710	93848.	84463.	75079.	65694.	56309.	46924.	28154.	28154.	18770.	9385.
2300	2760	100968.	90872.	80775.	70678.	60581.	50484.	30291.	30291.	20194.	10097.
2350	2810	108486.	97638.	86789.	75940.	65092.	54243.	32546.	32546.	21697.	10849.
2400	2860	116416.	104775.	93133.	81491.	69850.	58208.	34925.	34925.	23283.	11642.
2450	2910	124773.	112296.	99819.	87341.	74864.	62387.	37432.	37432.	24955.	12477.
2500	2960	133572.	120215.	106858.	93501	80143.	66786.	40072.	40072.	26714.	13357.
2550	3010	142829.	128546.	114263.	99980.	85697.	71414.	42849.	42849.	28566.	14283.
2600	3060	152558.	137302.	122046.	106791.	91535.	76279.	45767.	45767.	30512.	15256.
2650	3110	162776.	146499.	130221.	113943.	97666.	81388.	48833.	48833.	32555.	16278.
2700	3160	173499.	156149.	138799.	121449	104100.	86750.	52050.	52050.	34700.	17350.
2750	3210	184744.	166269.	147795.	129320.	110846.	92372.	55423.	55423.	36949.	18474.
2800	3260	196526.	176873.	157221.	137568.	117915.	98263.	58958.	58958.	39305.	19653.
2850	3310	208863.	187977.	167090.	146204.	125318.	104431.	62659.	62659.	41773.	20886
2900	3360	221772	199595.	177417.	155240.	133063.	110886.	66532.	66532.	44354.	22177.
2950	3410	235270.	211743.	188216.	164689.	141162.	117635.	70581.	70581.	47054.	23527.
3000	3460	249375.	224438.	199500.	174563.	149625.	124688.	74813.	74813.	49875.	24938.

TABLE 3 (Contd)

Note: For conversion to °C use Temperature Conversion Table Page 218

THEORY - HEAT TRANSFER

RADIATION HEAT TRANSFER TABLE
INSULATION TO AIR
FOR SURFACE EMITTANCES = 1.0 to 0.1

q_r

Temp. Diff. Sur. To Air	EMITTANCE OF OUTER WEATHER BARRIER OR JACKET IN REFERENCE TO THERMAL BLACK BODY									
	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
2	1.8	1.6	1.4	1.3	1.1	0.9	0.7	0.5	0.4	0.2
4	3.5	3.2	2.8	2.5	2.1	1.8	1.4	1.1	0.7	0.4
6	5.6	5.0	4.5	3.9	3.4	2.8	2.2	1.7	1.1	0.6
8	7.5	6.8	6.0	5.2	4.5	3.8	3.0	2.3	1.5	0.8
10	9.5	8.6	7.6	6.6	5.7	4.8	3.8	2.9	1.9	1.0
15	14.4	13.0	11.5	10.1	8.6	7.2	5.8	4.3	2.9	1.4
20	19.6	17.6	15.7	13.7	11.8	9.8	7.8	5.9	3.9	2.0
25	24.7	22.2	19.8	17.3	14.8	12.4	9.9	7.4	4.9	2.5
30	30.2	27.2	24.2	21.1	18.1	15.1	12.1	9.1	6.1	3.0
35	35.8	32.2	28.6	25.1	21.5	17.9	14.4	10.8	7.2	3.6
40	41.5	37.4	33.2	28.0	24.9	20.8	16.6	12.4	8.3	4.2
45	47.4	42.6	37.9	31.5	28.4	23.7	19.0	14.2	9.5	4.7
50	53.1	47.8	42.4	37.2	31.9	26.6	21.2	15.9	10.6	5.3
60	65.9	59.4	52.7	46.1	39.5	33.0	26.4	19.8	13.2	6.6
70	79.2	71.3	63.3	55.5	47.5	39.6	31.6	23.8	15.8	7.9
80	93.1	83.9	74.4	65.2	55.8	46.6	37.2	27.9	18.6	9.3
90	107.8	97.2	86.3	75.5	64.7	53.9	43.2	32.3	21.6	10.8
100	123.2	111.1	95.5	87.2	73.9	61.6	49.3	37.0	24.6	12.3
110	139.4	125.6	111.5	95.5	83.6	69.7	55.8	41.8	27.9	13.9
120	156.4	141.0	125.1	109.0	93.2	78.2	62.6	46.9	31.3	15.6
130	174.2	157.1	139.3	122.0	104.5	87.1	69.8	52.4	34.8	17.4
140	192.9	173.7	154.0	135.0	115.8	96.5	77.2	57.8	38.6	19.3
150	212.4	191.3	169.9	148.7	127.7	106.2	85.1	63.8	42.6	21.2
160	232.9	209.0	185.5	163.0	139.8	116.5	93.3	70.0	46.7	23.3
170	254.3	229.1	203.5	178.0	152.6	127.2	101.9	76.4	50.8	25.4
180	276.7	249.3	221.1	192.9	166.0	138.4	110.8	83.1	55.4	27.7
190	300.1	270.0	240.0	210.0	180.0	150.0	120.0	90.0	60.0	30.0
200	324.5	292.5	259.5	227.5	194.8	162.3	130.0	97.5	64.8	32.4

TABLE 4

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THEORY - HEAT TRANSFER

CONVECTION HEAT TRANSFER FROM HOT SURFACE TO AMBIENT AIR STILL AIR (NATURAL CONVECTION)

Temp. Diff. F	Heat Trans. q_c Btu/s.f., hr.	Temp. Diff.	Heat Trans. q_c Btu/s.f., hr.	Temp. Diff.	Heat Trans. q_c Btu/s.f., hr.	Temp. Diff.	Heat Trans. q_c Btu/s.f., hr.
t_s-t_a	$0.296(t_s-t_a)\frac{5}{4} \times C_s$	t_s-t_a F	$0.296(t_s-t_a)\frac{5}{4} \times C_s$	t_s-t_a F	$0.296(t_s-t_a)\frac{5}{4} \times C_s$	t_s-t_a F	$0.296(t_s-t_a)\frac{5}{4} \times C_s$
2	0.70	56	45.50	300	369.2	900	1459
4	1.67	58	47.38	320	400.5	925	1510
6	2.78	60	49.40	340	432.3	950	1561
8	3.92	70	59.90	360	464.3	975	1612
10	5.26	80	70.80	380	496.5	1000	1665
12	6.61	90	82.10	400	529.0	1050	1769
14	8.02	100	93.60	420	562.5	1100	1875
16	9.47	110	105.5	440	596.5	1150	1982
18	10.97	120	117.50	460	630.5	1200	2091
20	12.52	130	130.0	480	664.5	1250	2200
22	14.10	140	142.5	500	700.0	1300	2311
24	15.72	150	155.4	525	744.0	1350	2422
26	17.37	160	168.5	550	788.0	1400	2535
28	19.06	170	181.6	575	833.0	1450	2645
30	20.78	180	195.1	600	879.0	1500	2763
32	22.51	190	208.6	625	925.0	1550	2889
34	24.32	200	222.4	650	971.0	1600	2995
36	26.09	210	236.5	675	10.19	1650	3113
40	27.92	220	250.8	700	1066	1700	3231
42	29.78	230	265.3	725	1113	1750	3350
44	31.62	240	279.3	750	1162	1800	3470
46	33.42	250	294.1	775	1211	1850	3591
48	37.38	260	307.0	800	1259	1900	3713
50	39.32	270	323.8	825	1310	1950	3834
52	41.33	280	337.0	850	1358	2000	3959
54	42.25	290	354.2	875	1407		

C_s = A constant upon size and shape of the surface

C_s = For horizontal cylinders = 1.016

C_s = For long vertical cylinders = 1.235

C_s = For vertical plates 1.394

C_s = For horizontal plates facing upward = 1.79

C_s = For horizontal plates facing downward = 0.89

(Symbols and Abbreviations on Pages 208-10)

TABLE 5

THEORY - HEAT TRANSFER

CONVECTION HEAT TRANSFER TABLE - SLOW CONVECTION CURRENTS

Btu/sq ft, hr

q_{cu}

CONVECTION VELOCITY

T-t° F	176 Ft/Min 2 Mi/Hr	352 Ft/Min 4 Mi/Hr	440 Ft/Min 5 Mi/Hr	528 Ft/Min 6 Mi/Hr	704 Ft/Min 8 Mi/Hr	880 Ft/Min 10 Mi/Hr	1056 Ft/Min 12 Mi/Hr	1232 Ft/Min 14 Mi/Hr	1320 Ft/Min 15 Mi/Hr	1408 Ft/Min 16 Mi/Hr
2	1.32	1.74	1.91	2.07	2.35	2.61	2.84	3.05	3.15	3.26
4	3.15	4.14	4.54	4.92	5.60	6.21	6.75	7.29	7.50	7.74
6	5.23	6.86	7.54	8.17	9.31	10.30	11.20	12.06	12.43	12.85
8	7.50	9.84	10.81	11.72	13.35	14.74	16.09	17.32	17.85	18.45
10	9.90	13.00	14.27	15.48	17.60	19.50	21.20	22.84	23.57	24.31
15	16.45	21.60	23.70	25.70	29.27	32.42	35.24	37.97	39.18	40.43
20	23.41	30.73	33.75	36.62	41.76	46.20	50.60	53.98	55.70	57.60
25	31.15	40.83	44.80	48.65	55.40	61.35	66.65	71.80	74.0	76.50
30	39.13	51.30	56.45	61.17	69.64	77.10	83.90	90.30	93.1	96.12
35	47.40	62.25	68.38	74.13	84.40	93.04	101.5	109.3	112.7	116.5
40	56.04	73.58	80.85	87.50	99.70	110.5	120.1	129.3	133.3	137.8
45	65.30	85.30	93.70	101.5	115.5	128.0	139.2	150.0	154.6	159.6
50	74.20	97.30	106.7	115.7	131.8	145.9	158.6	171.0	176.2	181.9
60	93.3	122.1	134.1	145.5	165.5	183.3	199.3	214.9	221.3	228.5
70	112.0	147.0	161.3	175.0	199.1	220.8	239.9	258.3	266.5	275.0
80	133.4	174.9	192.4	208.3	237.1	262.8	285.8	308.0	317.5	327.5
90	154.6	202.9	222.8	241.7	274.9	304.6	331.0	356.8	368.0	379.8
100	176.2	231.9	253.8	275.3	313.2	347.4	377.5	406.5	419.0	433.0
110	198.6	260.7	286.1	310.5	353.2	391.5	425.3	457.0	472.0	487.9
120	220.1	290.4	319.0	346.0	393.7	436.0	474.1	510.0	527.0	544.0
130	243.5	321.0	352.9	382.0	435.4	482.1	524.2	564.0	583.0	601.5
140	268.5	352.0	386.8	419.3	477.2	529.0	575.0	619.0	638.5	659.2
150	292.7	384.0	421.9	457.5	520.7	577.3	627.0	675.0	696.3	719.5
160	317.2	416.4	457.0	496.0	564.2	625.5	680.0	731.0	754.5	779.7
170	342.0	448.4	493.0	534.7	608.3	674.0	733.0	789.0	813.5	838.5
180	367.5	482.1	530.0	574.8	653.3	724.5	787.5	848.0	875.0	903.0
190	393.2	516.0	566.5	615.0	699.6	774.5	843.0	906.5	935.0	966.0
200	409.5	55.05	604.5	655.7	746.0	826.5	899.0	966.5	998.0	1030.0

(Symbols and Abbreviations on Page 208-10)

TABLE 6

THEORY - HEAT TRANSFER

CONVECTION HEAT TRANSFER TABLE - SLOW CONVECTION CURRENTS

Btu/sq ft, hr

q_{cv}

CONVECTION VELOCITY

t-to °F	10 Ft/Min .1136 Mi/Hr	20 Ft/Min .2272 Mi/Hr	30 Ft/Min .3408 Mi/Hr	40 Ft/Min .4544 Mi/Hr	50 Ft/Min .5680 Mi/Hr	60 Ft/Min .6816 Mi/Hr	70 Ft/Min .7952 Mi/Hr	80 Ft/Min .9088 Mi/Hr	90 Ft/Min .0224 Mi/Hr	100 Ft/Min 1.1360 Mi/Hr
2	.752	.798	.842	.884	.922	.961	.996	1.033	1.068	1.100
4	1.790	1.900	2.001	2.101	2.195	2.285	2.370	2.457	2.537	2.617
6	2.971	3.157	3.327	3.490	3.648	3.798	3.926	4.081	4.217	4.350
8	4.262	4.530	4.775	5.010	5.233	5.450	5.655	5.860	6.050	6.240
10	5.63	5.98	6.31	6.62	6.90	7.19	7.47	7.74	7.99	8.23
15	9.35	9.94	10.47	10.98	11.45	11.94	12.38	12.83	13.25	13.67
20	13.61	14.44	15.23	16.00	16.70	17.40	18.04	18.70	19.20	19.90
25	17.68	18.78	19.80	20.77	21.70	22.60	23.43	24.28	25.08	25.85
30	22.20	23.61	24.90	26.12	27.29	28.42	29.50	30.54	31.55	32.52
35	26.95	28.62	30.16	31.65	33.05	33.67	35.70	37.00	38.20	39.40
40	31.90	33.85	35.72	37.50	39.13	40.76	42.30	43.80	45.24	46.61
45	36.93	39.22	41.33	43.40	45.30	47.20	48.92	50.70	52.40	54.02
50	42.10	44.70	47.19	49.48	51.68	53.80	55.82	57.83	59.76	61.58
60	52.90	56.18	59.23	62.21	64.93	67.60	70.18	72.70	75.08	77.37
70	64.10	68.05	71.80	75.35	78.70	81.95	85.00	88.10	91.00	93.70
80	75.90	80.50	84.05	90.40	93.10	96.90	100.0	104.0	107.4	110.7
90	87.95	93.30	95.84	103.1	107.7	112.2	116.4	120.6	124.5	128.4
100	100.2	106.2	112.0	117.5	122.8	127.8	132.6	137.5	141.9	146.3
110	112.7	119.7	126.3	132.5	137.1	144.1	149.5	154.9	160.0	164.8
120	125.7	133.5	140.8	147.7	154.4	160.6	166.7	172.8	178.4	183.8
130	139.1	147.7	155.8	163.5	170.7	177.7	184.5	191.1	197.4	203.3
140	152.5	161.9	170.8	179.2	187.0	194.8	202.1	209.5	216.3	223.0
150	166.3	176.5	186.2	195.3	204.0	212.3	220.5	228.2	236.0	243.0
160	180.2	191.3	201.9	211.8	221.0	230.1	239.0	247.5	255.7	263.3
170	194.3	206.3	217.5	228.3	238.4	248.2	257.5	267.0	275.8	284.2
180	208.9	221.8	234.0	245.5	256.3	266.9	277.0	286.9	296.4	305.3
190	222.3	237.1	250.1	262.3	273.9	285.2	296.2	306.9	317.0	326.7
200	238.2	253.0	266.9	280.0	292.2	304.2	315.9	327.2	338.0	348.2

TABLE 6 (Continued)

(Symbols and Abbreviations on Pages 208-210

THEORY - HEAT TRANSFER

CONVECTION HEAT TRANSFER TABLE - SLOW CONVECTION CURRENTS

Btu/sq ft, hr

q_{cv}

CONVECTION VELOCITY

t-to °F	110 Ft/Min 1.2375 Mi/Hr	120 Ft/Min 1.3632 Mi/Hr	130 Ft/Min 1.4768 Mi/Hr	140 Ft/Min 1.5904 Mi/Hr	150 Ft/Min 1.7040 Mi/Hr	160 Ft/Min 1.8176 Mi/Hr	170 Ft/Min 1.9312 Mi/Hr	180 Ft/Min 2.0448 Mi/Hr	190 Ft/Min 2.1584 Mi/Hr	200 Ft/Min 2.2720 Mi/Hr
2	1.132	1.164	1.194	1.224	1.251	1.280	1.309	1.335	1.361	1.388
4	2.695	2.766	2.839	2.910	2.977	3.047	3.112	3.176	3.240	3.302
6	4.531	4.598	4.718	4.840	4.962	5.060	5.171	5.280	5.380	5.480
8	6.420	6.610	6.770	6.940	7.100	7.262	7.420	7.570	7.722	7.878
10	8.47	8.71	8.95	9.16	9.36	9.58	9.79	9.99	10.19	10.39
15	14.07	14.45	14.82	15.20	15.55	15.91	16.25	16.60	16.91	17.25
20	20.62	21.05	21.60	22.15	22.63	23.15	23.67	24.15	24.62	25.10
25	26.62	27.35	28.07	28.79	29.41	30.11	30.75	31.40	32.01	32.64
30	33.50	34.39	35.30	36.18	37.00	37.87	38.70	39.50	40.25	41.05
35	40.60	41.65	42.75	43.83	44.81	45.89	46.87	47.82	48.80	49.76
40	48.00	49.30	50.64	51.90	53.02	54.28	55.45	56.64	57.75	58.82
45	55.60	57.18	58.60	60.13	61.45	62.90	64.20	65.57	66.78	68.13
50	63.40	65.13	66.85	68.53	70.02	71.20	73.24	74.80	76.30	77.70
60	79.62	81.75	84.00	86.05	88.00	90.10	92.00	94.00	95.80	97.60
70	96.50	99.15	101.6	104.2	106.5	109.1	111.4	114.4	116.0	119.2
80	114.0	117.2	120.2	123.3	126.0	129.0	131.7	134.5	137.2	139.8
90	132.2	135.7	139.3	142.9	146.1	149.5	152.7	156.0	158.3	162.0
100	150.7	154.7	158.8	162.9	166.5	170.3	174.0	177.8	180.3	184.7
110	169.7	174.4	179.0	183.5	187.6	191.9	196.1	198.3	204.1	206.0
120	189.3	194.5	199.7	204.5	209.1	214.1	218.7	223.1	227.8	232.0
130	209.3	215.1	220.9	226.2	231.3	236.9	241.9	247.0	251.9	256.8
140	229.5	235.9	242.1	248.0	253.8	259.7	265.2	270.9	276.1	281.3
150	250.2	257.1	264.0	270.5	276.5	283.0	289.0	295.2	301.1	306.8
160	271.2	278.5	286.2	293.1	299.8	306.8	313.5	320.0	326.3	332.5
170	292.7	300.5	307.7	316.1	323.2	330.9	338.0	345.1	341.8	358.5
180	314.3	323.1	331.8	340.0	347.6	358.8	353.3	370.9	378.1	385.5
190	336.2	345.2	354.8	353.2	371.5	380.2	388.3	396.5	404.4	412.2
200	358.5	368.4	378.2	387.5	396.1	402.8	414.0	422.8	431.3	439.6

(Symbols and Abbreviations on Pages 208-210

TABLE 6 (Continued)

THEORY - HEAT TRANSFER

CONVECTION HEAT TRANSFER TABLE - FAST CONVECTION CURRENTS

Btu/sq ft, hr

CONVECTION VELOCITY

Δt° F	1584 Ft/Min 18 Mi/Hr	1760 Ft/Min 20 Mi/Hr	1933 Ft/Min 22 Mi/Hr	2112 Ft/Min 24 Mi/Hr	2200 Ft/Min 25 Mi/Hr	2288 Ft/Min 26 Mi/Hr	2464 Ft/Min 28 Mi/Hr	2640 Ft/Min 30 Mi/Hr	3080 Ft/Min 35 Mi/Hr	3520 Ft/Min 40 Mi/Hr	4400 Ft/Min 50 Mi/Hr
2	3.44	3.62	3.79	3.95	4.03	4.11	4.26	4.40	4.75	5.07	5.66
4	8.19	8.61	9.02	9.41	9.60	9.78	10.13	10.47	11.29	12.18	13.45
6	13.57	14.30	14.95	15.67	15.91	16.24	16.81	17.39	18.75	20.02	22.20
8	19.50	20.52	21.50	22.40	22.88	23.30	24.15	25.00	26.94	28.77	32.10
10	25.73	27.08	28.32	29.58	30.20	30.75	31.85	32.93	35.53	37.95	42.30
15	42.60	45.00	47.10	49.12	50.15	51.08	53.00	54.70	59.00	63.10	70.40
20	60.90	64.10	67.10	70.00	71.30	72.70	75.40	78.00	83.90	89.60	100.10
25	81.00	85.20	89.15	93.00	94.90	96.70	101.8	103.5	111.6	119.3	133.0
30	101.8	107.0	112.0	116.90	119.3	121.5	125.9	129.2	140.3	150.0	167.3
35	123.2	129.6	135.8	141.6	144.5	147.2	152.7	157.5	170.0	181.7	202.6
40	145.8	153.4	160.6	167.5	170.8	174.0	180.5	186.6	201.0	214.8	239.4
45	169.0	177.7	186.0	194.2	198.3	201.8	209.2	216.1	233.0	248.7	277.8
50	192.5	202.4	211.9	221.2	225.8	230.0	238.3	246.2	265.9	283.7	316.5
60	242.0	254.4	266.6	278.0	283.7	288.8	299.7	310.0	333.8	356.5	397.8
70	291.1	306.2	320.8	334.4	341.7	347.6	360.2	372.4	401.8	429.0	478.7
80	346.5	364.8	381.5	398.2	406.8	414.0	429.4	443.9	478.3	510.8	570.2
90	402.0	422.6	442.4	461.7	471.3	480.0	497.9	514.0	554.3	592.0	660.5
100	457.9	481.9	504.9	526.2	537.0	547.0	567.3	586.2	632.3	674.5	753.0
110	516.0	543.0	568.3	593.2	605.0	616.3	639.9	680.8	711.5	761.0	849.0
120	575.8	605.3	633.7	661.2	674.5	687.0	712.5	736.3	793.5	848.0	946.0
130	637.0	670.0	701.0	731.5	746.0	760.0	788.0	814.0	878.0	938.0	1046.0
140	697.7	734.0	768.0	801.0	813.0	833.5	864.5	893.0	963.0	1028.0	1146.0
150	761.0	801.0	838.5	874.5	891.0	908.0	942.5	974.5	1049.0	1121.0	1251.0
160	825.5	867.5	909.0	947.5	966.5	985.0	1021.0	1055.0	1136.0	1215.0	1355.0
170	889.0	936.0	979.0	1021.0	1041.0	1061.0	1110.0	1137.0	1226.0	1310.0	1462.0
180	955.0	981.0	1052.0	1097.0	1120.0	1141.0	1184.0	1223.0	1318.0	1408.0	1572.0
190	1021.0	1074.0	1125.0	1174.0	1193.0	1221.0	1265.0	1307.0	1410.0	1505.0	1680.0
200	1090.0	1145.0	1201.0	1252.0	1278.0	1302.0	1350.0	1394.0	1503.0	1605.0	1790.0

TABLE 6 (Continued)

(Symbols and Abbreviations on Pages 208-210)

THEORY - HEAT TRANSFER

SURFACE HEAT LOSS TABLE - HOT SERVICE

Heat Transfer From Surface To Lower Temperature Air - Btu/Hour, Sq. Ft.

$q_r + q_{cv}$

Temp. Dif. Sur. to Air °F (t-to)	∈ = 1.0						∈ = 0.9						∈ = 0.8					
	Air Movement In Miles Per Hour						Air Movement In Miles Per Hour						Air Movement In Miles Per Hour					
	0	2	4	8	12	20	0	2	4	8	12	20	0	2	4	8	12	20
2	2.5	3.1	3.5	4.2	4.6	5.4	2.3	2.9	3.3	4.0	4.4	5.2	2.1	2.7	3.1	3.8	4.2	5.0
4	5.2	6.6	7.6	9.1	10.3	12.1	4.9	6.3	7.1	8.8	10.0	11.8	4.5	5.9	6.9	8.4	9.6	11.4
6	8.4	10.8	12.5	13.8	16.8	19.9	7.8	10.2	11.9	14.3	16.2	19.3	7.3	9.7	11.4	13.8	15.7	18.8
8	11.5	15.0	16.9	19.2	24.4	28.0	10.8	14.3	16.6	20.1	23.7	27.3	10.0	13.5	15.8	19.3	22.9	26.5
10	14.8	19.4	22.5	27.4	30.7	36.6	13.9	18.5	21.6	26.2	29.8	35.7	12.9	17.5	20.6	25.2	28.8	34.7
15	23.2	30.9	36.0	43.7	49.6	59.4	21.7	29.	34.6	42.3	48.2	58.0	20.2	27.9	33.1	40.8	46.7	56.5
20	32.0	44.4	50.5	61.4	70.2	83.7	30.0	41.0	48.3	59.4	68.2	81.7	28.1	39.1	46.4	57.5	66.3	79.8
25	41.2	55.8	65.5	80.1	91.4	109.9	38.7	53.4	63.0	77.6	88.9	107.4	36.3	51.0	60.6	75.2	86.5	105.0
30	51.0	69.3	81.5	99.8	112.1	137.2	48.0	66.3	78.5	96.8	110.1	134.2	45.0	63.3	75.5	93.8	107.1	131.2
35	61.0	83.2	98.1	120.2	137.3	165.4	57.4	79.6	94.5	116.6	133.7	161.8	53.8	76.0	90.9	113.0	130.1	158.2
40	71.3	97.5	115.1	141.2	161.6	194.9	67.2	93.4	111.0	137.1	157.5	191.8	63.0	89.2	106.8	132.9	153.3	186.6
45	81.9	112.7	132.7	162.9	166.6	225.1	77.1	107.9	127.9	158.1	181.8	220.3	72.4	103.2	123.2	153.4	177.1	215.6
50	92.5	127.3	150.4	184.9	211.7	265.5	87.2	122.0	145.1	179.6	206.4	259.2	81.8	116.6	139.7	194.2	201.0	248.8
60	115.3	159.2	188.0	231.4	265.2	319.3	108.8	152.7	181.5	224.9	258.7	313.8	102.1	146.0	174.8	218.2	252.0	307.1
70	138.7	191.3	226.2	278.3	391.1	385.4	130.8	183.	219.2	270.4	311.2	377.5	122.8	175.3	211.2	262.4	303.2	369.5
80	164.0	226.5	268.1	330.2	378.9	457.9	154.8	217.1	258.8	321.0	369.7	448.7	145.3	207.8	249.1	311.5	360.2	439.2
90	189.9	262.4	310.7	382.7	438.8	530.4	179.3	251.8	299.6	372.1	428.2	519.8	168.4	240.9	289.2	361.2	417.3	508.9
100	216.8	299.5	355.1	436.4	500.7	605.1	204.7	287.3	343.0	424.3	488.6	594.0	189.1	271.7	327.4	408.7	473.0	577.4
110	244.8	338.0	400.1	492.6	564.7	682.4	231.0	324.2	386.3	478.8	550.9	668.6	216.9	310.1	372.2	464.7	536.8	654.5
120	273.9	376.5	446.8	550.1	630.5	761.7	258.3	361.1	431.4	534.7	615.1	746.3	242.6	345.2	415.5	518.8	599.2	730.4
130	304.2	417.7	493.2	609.6	698.4	844.2	287.1	400.6	478.1	592.5	681.3	827.1	269.3	382.8	460.3	574.7	663.5	809.4
140	335.4	461.4	544.9	670.1	767.9	926.9	316.2	442.2	525.7	650.9	748.7	907.7	296.5	422.5	506.0	631.2	729.0	888.0
150	367.8	510.1	396.4	733.1	849.4	1013.4	346.7	484.0	575.3	712.0	828.3	992.3	323.3	462.6	553.9	690.6	806.9	970.9
160	400.4	550.1	649.3	797.1	912.9	1100.4	377.1	521.2	625.0	771.2	889.9	1076.5	353.6	502.7	601.5	749.7	865.5	1052.0
170	435.9	596.3	702.7	862.6	987.3	1190.4	410.7	571.1	677.1	827.4	932.1	1165.1	385.1	545.5	651.5	811.8	936.5	1139.5
180	471.9	644.2	758.8	930.0	1064.2	1257.2	445.5	616.8	731.3	902.6	1037.8	230.3	416.3	588.6	703.1	874.4	1008.6	1202.1
190	508.9	693.3	861.1	999.7	1143.1	1374.2	478.8	663.2	768.0	969.6	1113.0	1344.0	448.8	633.2	756.0	939.6	1083.0	1314.0
200	547.2	734.0	885.0	1070.5	1223.5	1470.5	515.2	702.0	843.0	1038.5	1191.5	1438.5	482.2	669.0	810.0	1003.5	1158.5	1403.5

(Symbols and Aobreviations given on Pages 208-210)

TABLE 7

SURFACE HEAT LOSS TABLE - HOT SERVICE
Heat Transfer From Surface To Lower Temperature Air - Btu/Hour, Sq. Ft.
$q_r + q_{cv}$

Temp. Diff. Sur. to Air °F (t s-ta)	ε = 0.7					ε = 0.6					ε = 0.5				
	Air Movement In Miles Per Hour					Air Movement In Miles Per Hour					Air Movement In Miles Per Hour				
	0	2	4	8	12	20	0	2	4	8	12	20	0	2	4	8	12	20
2	2.0	2.6	3.0	3.7	4.1	4.9	1.8	2.4	2.8	3.5	3.9	4.7	1.6	2.2	2.6	3.3	3.7	4.5
4	4.2	5.6	6.6	8.1	9.3	11.1	3.8	5.2	6.2	7.7	8.9	10.7	3.5	4.9	6.9	7.4	8.6	10.4
6	6.7	9.1	10.8	13.2	15.1	19.2	6.2	8.6	10.3	12.7	14.6	17.7	5.6	8.0	9.7	12.1	14.0	17.1
8	9.2	12.7	15.0	18.5	22.1	25.7	8.5	12.0	14.3	17.8	21.4	25.0	7.8	11.3	13.6	17.1	20.7	24.3
10	11.9	16.3	19.6	24.2	27.8	33.7	11.0	15.6	18.7	23.3	26.9	32.8	10.1	14.7	17.8	22.4	26.0	31.9
15	18.8	26.3	31.7	39.4	45.3	55.1	17.3	25.0	30.2	37.9	43.8	53.6	15.9	23.6	28.8	36.5	42.4	52.2
20	26.1	37.1	44.4	53.5	64.3	77.8	24.2	35.2	42.5	53.6	62.4	75.9	22.2	33.2	40.5	51.6	60.4	73.9
25	33.8	48.5	58.1	72.7	84.0	102.5	31.3	46.0	55.6	70.2	81.5	100.0	28.9	43.6	53.2	67.8	79.1	97.6
30	41.9	60.2	72.4	90.7	104.0	128.1	38.9	57.2	69.4	87.7	101.0	125.1	35.9	54.2	66.4	84.7	98.0	122.1
35	50.3	72.5	87.4	109.5	126.4	154.7	46.7	68.9	83.8	105.9	123.0	151.1	43.1	65.3	80.2	102.3	119.2	147.5
40	57.8	84.0	101.6	127.7	148.1	181.4	54.7	80.9	98.5	129.6	145.0	178.3	50.6	76.8	94.4	120.5	140.9	174.2
45	66.0	96.8	116.8	147.0	170.7	209.2	62.9	93.7	113.7	143.9	167.6	205.1	58.2	89.0	109.0	139.2	162.9	201.4
50	76.7	111.4	134.5	169.0	195.8	239.6	71.3	106.1	129.2	163.7	190.5	234.1	66.0	100.8	123.9	158.4	185.2	229.0
60	95.5	139.4	168.2	211.6	245.4	300.5	85.9	132.8	161.6	205.0	238.8	293.9	82.4	126.3	155.1	198.5	232.3	287.4
80	136.1	198.6	240.1	302.3	351.0	429.0	126.7	189.0	230.7	292.9	341.6	420.6	117.5	180.0	221.5	283.7	332.4	411.4
90	159.6	230.1	278.4	350.4	406.5	498.1	146.8	219.3	267.6	339.6	395.7	487.3	136.0	208.5	256.8	328.8	384.9	476.5
100	180.8	263.4	319.1	400.4	464.7	569.1	167.5	250.1	305.8	387.1	451.4	555.8	155.2	237.8	293.5	374.8	439.1	543.5
110	200.9	294.1	366.2	448.7	520.8	638.5	189.0	282.2	344.3	436.8	518.9	626.6	175.1	268.3	330.4	422.9	495.0	612.7
120	226.5	322.1	399.4	502.7	583.1	714.3	210.7	313.3	383.6	486.9	567.3	698.5	195.7	298.3	368.6	471.9	552.3	683.5
130	252.0	365.5	443.0	557.4	646.2	792.0	234.5	348.0	425.5	539.9	628.7	774.5	217.1	330.6	408.1	522.5	611.3	757.1
140	277.5	403.5	487.0	612.2	710.0	869.0	258.3	384.3	467.8	593.0	690.8	849.8	239.0	365.0	448.5	573.7	671.5	830.5
150	302.1	441.1	532.7	669.4	785.7	949.7	283.1	420.4	511.7	648.4	764.7	928.7	264.6	398.9	490.2	626.9	743.2	907.2
160	331.1	480.2	579.0	727.2	843.0	1030.5	307.9	457.0	553.8	704.0	819.8	1007.3	284.6	433.7	532.5	680.7	796.5	983.0
170	359.6	520.0	626.0	786.3	911.0	1114.0	334.2	494.6	600.6	760.9	883.6	1088.6	309.2	469.2	575.2	735.5	860.2	1063.2
180	388.1	560.4	674.9	846.2	980.4	1173.9	361.2	533.5	648.0	819.3	953.5	1147.0	333.6	506.9	620.4	791.7	925.8	1119.4
190	418.8	603.2	726.0	909.6	1033.0	1284.0	388.8	573.2	696.0	876.6	1023.0	1254.0	358.8	543.2	666.0	849.6	993.0	1224.0
200	637.0	778.0	973.5	1126.5	1373.5	416.5	604.3	745.3	940.8	1093.8	1093.8	1340.8	395.0	571.8	712.8	908.3	1061.3	1308.3

TABLE 7 (Continued)

THEORY - HEAT TRANSFER

SURFACE HEAT LOSS TABLE - HOT SERVICE
Heat Transfer From Surface to Lower Temperature Air - Btu/Hour, Sq. Ft.
$q_r + q_{cv}$

Temp. Diff. Sur. to Air °F (t-t$_a$)	ε = 0.4					ε = 0.3					ε = 0.2				
	Air Movement In Miles Per Hour					Air Movement In Miles Per Hour					Air Movement In Miles Per Hour				
	0	2	4	8	12	20	0	2	4	8	10	20	0	2	4	8	12	20
2	1.4	2.0	2.4	3.1	3.5	4.3	1.2	1.8	2.2	2.9	3.3	4.1	1.1	1.7	2.1	2.8	3.2	4.0
4	3.1	4.5	5.5	7.0	8.2	10.0	2.8	4.2	5.2	6.7	7.9	9.7	2.4	3.8	4.8	6.3	7.5	9.3
6	5.0	7.4	9.1	11.5	13.4	16.5	4.5	6.9	8.6	11.0	12.9	16.0	3.9	6.3	8.0	10.4	12.3	15.4
8	7.0	10.5	12.8	16.3	19.9	23.5	6.3	9.8	12.1	15.6	19.2	22.8	5.5	9.0	11.3	14.8	18.4	22.0
10	9.1	13.7	16.8	21.4	25.0	30.9	8.2	12.8	15.9	20.5	24.1	30.0	7.2	11.8	14.9	19.5	23.1	29.0
15	14.5	22.2	26.4	35.1	41.0	50.8	13.0	20.7	25.9	33.6	39.5	49.3	11.6	19.3	24.5	32.1	38.1	47.9
20	20.2	31.2	38.5	49.6	58.4	71.9	18.3	29.3	36.6	47.7	56.3	70.0	16.3	27.3	34.6	45.7	54.5	68.0
25	26.4	41.1	50.7	65.3	76.6	95.1	23.9	38.6	48.2	62.8	74.1	92.6	21.4	36.1	45.7	60.3	71.6	90.1
30	32.9	51.2	63.4	81.7	93.0	119.1	29.9	48.2	60.4	78.7	92.0	116.1	26.9	45.2	57.4	75.7	89.0	113.1
35	39.6	61.8	76.7	98.8	115.9	144.0	36.0	58.2	73.1	95.2	112.3	140.4	32.4	54.6	69.5	91.6	108.7	136.8
40	46.4	72.6	90.2	116.3	136.7	170.0	42.2	68.4	86.0	111.1	132.5	165.8	38.1	64.3	81.9	108.0	128.4	161.7
45	53.5	84.3	104.3	134.5	158.2	196.7	48.7	79.5	99.5	129.7	153.4	191.9	44.0	74.8	94.8	125.0	148.7	187.2
50	60.6	95.4	118.5	153.0	179.8	223.6	55.3	90.1	113.2	147.7	174.5	218.3	50.0	84.8	107.9	142.4	169.2	213.0
60	75.8	119.7	148.5	191.9	223.7	280.8	69.2	113.6	141.9	185.3	219.1	274.2	62.6	106.5	135.3	178.7	212.5	267.6
70	91.9	144.5	179.5	230.7	272.5	337.8	83.3	135.8	173.7	222.9	262.7	330.0	75.3	127.8	163.7	214.9	255.7	322.0
80	108.1	170.6	212.1	274.3	323.0	401.8	98.8	161.3	202.8	265.0	313.7	392.7	89.4	152.0	193.5	255.7	304.4	383.4
90	125.3	197.8	245.1	317.1	374.2	465.8	114.4	186.9	235.2	307.2	363.3	454.9	103.7	176.2	224.5	296.5	352.6	444.2
100	142.9	225.5	281.2	362.5	426.8	531.2	130.6	213.2	268.9	350.2	414.5	516.9	118.2	201.2	256.5	337.8	402.1	506.5
110	161.2	254.4	316.5	409.0	486.6	598.8	146.2	240.4	302.5	395.0	466.1	584.8	133.3	226.5	288.6	381.1	453.2	570.9
120	180.1	282.6	353.0	456.3	536.7	667.9	164.4	267.0	337.3	440.6	521.0	652.2	148.8	251.4	321.7	425.0	505.4	636.6
130	199.8	312.5	390.8	505.2	594.0	747.8	182.4	295.9	373.4	487.8	576.6	722.4	164.8	278.3	359.8	470.2	712.8	
140	219.7	345.7	429.2	554.4	652.2	821.2	199.3	325.3	409.8	534.0	632.8	791.8	181.1	307.1	390.6	515.8	613.6	772.6
150	240.5	377.8	469.1	605.8	712.1	886.1	217.2	356.5	447.8	584.5	690.8	864.8	195.0	335.3	426.6	573.3	679.6	843.6
160	261.4	410.6	509.3	657.5	773.3	960.8	238.1	387.1	486.0	634.2	750.0	937.5	214.8	363.9	462.7	611.8	726.7	914.2
170	283.5	443.9	549.9	710.2	834.9	1037.9	258.0	418.4	525.4	684.7	809.4	1012.4	232.4	392.8	498 8	659.1	783.8	986.8
180	306.0	488.3	592.8	764.1	898.3	1091.8	278.3	450.6	565.1	736.4	870.6	1064.1	250.5	422.9	537.4	708.7	842.9	1036.4
190	328.8	513.2	638.0	819.6	963.0	1194.0	298.8	483.2	608.0	769.6	933.0	1164.0	268.8	453.2	576.0	759.6	903.0	1134.0
200	352.7	539.5	680.5	876.0	1024.0	1276.0	320.2	507.0	648.0	843.5	996.5	1243.5	287.5	474.3	515.3	810.8	963.8	1212.8

(Symbols and Abbreviations given on Pages 208-210)

THEORY - HEAT TRANSFER

SURFACE HEAT LOSS TABLE - HOT SERVICE
Heat Transfer From Surface To Lower Temperature Air - Btu/Hour, Sq. Ft.
$q_r + q_{cv}$

Temp. Diff. Sur. to Air °F (t-to)	ε = 0.1						ε = 0.05					
	Air Movement In Miles Per Hour						Air Movement In Miles Per Hour					
	0	2	4	8	12	20	0	2	4	8	12	20
2	0.9	1.5	1.9	2.6	3.0	3.8	0.8	1.4	1.8	2.5	2.9	3.7
4	2.1	3.5	4.5	6.0	7.2	9.0	1.9	3.3	4.3	5.8	7.0	8.8
6	3.4	5.8	7.5	9.9	11.8	14.9	3.1	5.5	7.2	9.6	11.5	14.6
8	4.8	8.3	10.6	14.1	17.7	21.3	4.4	7.9	10.2	13.7	17.3	20.9
10	6.3	10.9	14.0	18.6	22.2	28.1	5.8	10.4	13.5	18.1	21.7	27.6
15	10.1	17.8	23.0	30.7	36.6	46.4	9.4	17.1	22.3	30.0	35.9	45.7
20	14.4	25.4	32.7	43.8	52.6	65.1	13.4	24.4	31.7	42.8	51.6	65.1
25	19.0	33.7	43.3	57.9	69.2	87.7	17.8	32.5	42.1	56.7	68.0	85.5
30	23.8	42.1	54.3	72.6	85.9	110.0	22.3	40.6	52.8	71.1	84.4	108.5
35	28.8	51.0	65.9	88.0	104.9	133.2	27.0	49.2	64.1	86.2	103.1	131.4
40	34.0	60.2	78.2	103.9	124.3	157.6	31.9	58.1	75.7	101.8	122.2	155.5
45	39.2	70.0	90.0	120.2	143.9	182.4	36.9	67.7	87.7	117.9	141.6	180.1
50	44.7	79.5	102.6	137.1	163.9	205.7	42.1	76.9	100.0	134.5	161.3	205.1
60	56.0	99.9	128.7	172.1	205.9	261.0	52.7	96.6	125.4	168.8	202.6	257.7
70	67.4	119.9	155.8	207.0	247.8	314.1	63.5	116.0	151.9	203.1	243.9	310.2
80	80.2	142.7	184.2	246.4	295.1	374.1	75.6	138.1	179.6	241.8	290.5	369.5
90	92.9	165.4	213.7	285.7	341.8	433.4	87.5	160.0	208.3	280.3	336.4	428.0
100	105.9	188.5	244.2	325.5	389.8	494.2	99.8	182.4	238.1	319.4	383.7	488.1
110	119.1	212.5	274.6	367.1	439.2	556.9	112.4	205.6	267.7	360.2	432.3	550.0
120	133.1	235.7	306.0	409.3	489.7	620.9	125.3	227.9	298.2	401.5	481.9	613.1
130	147.4	260.9	338.4	452.8	541.6	687.4	138.7	252.2	329.7	444.1	532.9	678.7
140	161.8	287.8	371.3	496.5	594.3	753.3	152.2	278.2	361.7	486.9	584.7	743.7
150	174.6	313.9	405.2	541.9	658.2	822.2	164.0	303.3	394.6	531.3	637.6	811.6
160	191.4	340.5	439.3	587.5	703.3	890.8	179.8	328.9	427.7	575.9	691.7	879.2
170	207.0	367.4	473.4	633.7	758.4	961.4	194.3	354.7	460.7	621.0	745.7	948.7
180	222.9	395.2	509.7	681.0	815.2	1008.2	209.1	381.4	495.9	667.2	801.4	994.9
190	238.8	423.2	545.0	729.6	873.0	1104.0	223.8	408.2	531.0	714.6	858.0	1069.0
200	255.1	441.9	582.9	778.4	931.4	1178.4	239.9	435.7	566.7	762.2	915.2	1142.2

(Symbols and Abbreviations on Pages 208-210)

TABLE 7 (Continued)

THEORY - HEAT TRANSFER

THICKNESS OF FLAT INSULATION EQUIVALENT TO NOMINAL PIPE INSULATION THICKNESS

Based on IPS Pipe and A S T M Dimensional Standard Pipe Insulation

Values of $r_2 \log_e \frac{r_2}{r_1}$

NOMINAL PIPE SIZE	NOMINAL PIPE INSULATION THICKNESS									
	½	1	1½	2	2½	3	3½	4	4½	5
½	0.76	1.74	3.08	4.41	6.78	8.24	9.96	11.65	13.60	15.39
¾	0.55	1.43	2.65	3.86	6.05	7.50	9.02	10.59	12.42	14.10
1	0.69	1.69	2.74	3.98	5.32	6.65	8.06	9.52	11.22	12.79
1¼	0.78	1.29	2.73	3.34	4.55	5.78	7.07	8.41	9.99	11.44
1½	0.58	1.47	2.40	4.11	5.27	6.49	7.77	9.27	10.66	12.08
2	0.66	1.41	2.33	3.36	4.40	5.51	6.67	8.05	9.32	10.63
2½	0.64	1.36	2.73	3.68	4.69	5.77	7.03	8.21	9.43	11.01
3	0.55	1.26	2.08	2.94	3.85	4.83	5.98	7.06	8.18	9.64
3½	0.54	1.65	2.43	3.28	4.19	5.27	6.28	7.34	8.71	8.71
4	0.57	1.26	1.98	2.78	3.63	4.64	5.60	6.59	7.90	8.98
6	0.49	1.09	1.74	2.54	3.30	4.10	5.16	6.04	6.96	7.91
8			1.76	2.43	3.33	4.08	4.87	5.69	6.54	7.42
10			1.80	2.44	3.12	3.83	4.57	5.34	6.14	6.96
12			1.76	2.38	3.04	3.72	4.43	5.16	5.92	6.70
14			1.59	2.20	2.84	3.50	4.19	4.90	5.63	6.39
16			1.57	2.17	2.79	3.44	4.11	4.80	5.51	6.24
18			1,56	2.15	2.76	3.39	4.04	4.71	5.40	6.11
20			1.55	2.13	2.73	3.35	3.99	4.65	5.32	6.01
24			1.54	2.10	2.69	3.29	3.91	4.54	5.19	5.86
30			1.52	2.08	2.64	3.23	3.82	4.43	5.06	5.69
36			1.51	2.06	2.61	3.18	3.76	4.36	4.96	5.58

Note: Find nominal pipe insulation thickness for the particular pipe size which has an equivalent thickness equal to the required flat insulation thickness.

THICKNESS OF FLAT INSULATION EQUIVALENT TO NOMINAL PIPE INSULATION THICKNESS

Values of $r_2 \log_e \frac{r_2}{r_1}$

NOMINAL PIPE SIZE	NOMINAL PIPE INSULATION THICKNESS									
	5½	6	6½	7	7½	8	8½	9	9½	10
½	17.22	19.56								
¾	15.82	18.03								
1	14.40	16.47	18.16	19.89						
1¼	12.94	14.86	16.44	18.05						
1½	13.92	13.92	15.43	16.97						
2	12.33	13.73	15.16	16.62						
2½	11.01	12.31	13.65	15.02						
3	10.85	12.09	13.36	14.66	15.99	17.34	18.72	20.12	21.55	22.99
3½	9.85	11.03	12.23	13.47	14.73	16.02	17.33	18.67	20.02	21.41
4	10.09	11.24	12.41	13.62	14.85	16.10	17.38	18.68	20.00	21.35
6	8.89	9.90	10.93	11.99	13.07	14.18	15.30	16.45	17.62	18.81
8	8.32	9.25	10.20	11.18	12.17	13.19	14.23	15.28	16.36	17.45
10	7.80	8.66	9.55	10.46	11.39	12.34	13.30	14.29	15.29	16.30
12	7.50	8.33	9.17	10.03	10.91	11.81	12.73	13.66	14.61	15.57
14	7.16	7.96	8.78	9.61	10.46	11.33	12.22	13.12	14.04	14.97
16	6.99	7.75	8.54	9.34	10.16	11.00	11.85	12.72	13.60	14.49
18	6.84	7.58	8.35	9.12	9.92	10.72	11.55	12.38	13.23	14.10
20	6.72	7.45	8.19	8.94	9.71	10.50	11.29	12.11	12.93	13.77
24	6.53	7.23	7.94	8.66	9.39	10.14	10.90	11.67	12.45	13.25
30	6.34	7.00	7.67	8.36	9.05	9.76	10.48	11.21	11.94	12.69
36	6.21	6.84	7.49	8.15	8.82	9.49	10.19	10.88	11.58	12.30

TABLE 8

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THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

CALCULATION BY PREDETERMINED AIR FILM RESISTANCE

By the use of predetermined film resistances, $\frac{1}{h}$, a simplified method for calculating insulation in hot service is possible which eliminates need for plotting as shown in Figure 3. This method is not as accurate as can be obtained by the simultaneous plot method, but it is quicker, easier, and, in most instances, provides answers as to heat transfer within 3%. When used to determine surface temperature, it is inaccurate as the $\frac{1}{h}$ values given are based on an average correction factor in respect to shape, size and position of surface, and ambient air temperatures.

The heat transfer equation for flat surfaces, in which these film resistances appear, is Equation 3, and for curved surfaces is Equation 9.

The following examples illustrate the manner in which these film resistances can be used to determine heat transfer of insulated hot surface.

Flat Surface

Given: Operating temperature 600F, t_1
Ambient air temperature 70F, t_a
Wind 20 mph
Surface flat
Conductivity of insulation at 335F = 0.45 Btu/sq ft, hr, in, F, k
Thickness of insulation 2 inches, L

Emittance of outer jacket surface = 0.9
q_a = Btu heat transfer per sq ft of insulation surface
Equation 3 states

$$q_a = \frac{t_1 - t_a}{\frac{L}{k} + \frac{1}{h}}$$

$$q_a = \frac{600 - 70}{\frac{2}{.45} + \frac{1}{h}}$$

The insulation resistance $\frac{L}{k} = \frac{2}{.45} = 4.45$

From $\frac{1}{h}$ table at emittance = .9 Resistance 5 to 10 at 20 mph wind and operating temp. = 600 $\frac{1}{h}$ = .25

$$q_a = \frac{600-70}{4.45 + .25} = \frac{530}{4.7} = 113 \text{ Btu/sq ft, hr}$$

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THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

CALCULATION BY PREDETERMINED AIR FILM RESISTANCE
Continued

Curved Surfaces

Identical problem with insulation on 6" NPS pipe instead of flat surface.

Given: $t_1 = 600$ $t_a = 70$, wind = 20 mph

k of insulation at 335F = 0.45, thickness L = 2

Emittance of surface = .9

Equation 9 states

$$q_a = \frac{t_1 - t_a}{\frac{r_2 \text{ Log}_e \frac{r_2}{r_1}}{k} + \frac{1}{h}}$$

$$q_a = \frac{600 - 70}{\frac{r_2 \text{ Log}_e \frac{r_2}{r_1}}{0.45} + \frac{1}{h}}$$

From Table 8 $r_2 \text{ Log}_e \frac{r_2}{r_1}$

For 2" insulation on 6" NPS pipe = 2.54

or $$q_a = \frac{600 - 70}{\frac{2.54}{0.45} + \frac{1}{h}}$$

From air film resistance table $\frac{1}{h} = 0.25$, same as in first problem which illustrates correction factor for shape and position was averaged and that neither value of $\frac{1}{h}$ is exactly correct.

$$q_a = \frac{530}{5.64 + 0.25} = \frac{530}{5.89} = 90 \text{ Btu/sq ft, hr}$$

Similar calculation can be made to determine the heat transfer from insulated cold service by use of tables of value for $\frac{1}{h}$ - cold service

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THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

CALCULATION BY PREDETERMINED AIR FILM RESISTANCE
Continued

Curved Surfaces - Continued

Table No. 10. Again, the use of these $\frac{1}{h}$ valves will provide relatively close determinations for heat transfer, but they are unsuitable for calculation of surface temperature. This method of calculation should not be used to determine thickness of insulation to prevent outer surface compensation.

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THEORY - HEAT TRANSFER

AIR FILM RESISTANCE
Values of $\frac{1}{h}$

ε Emittance	Wind Velocity MPH	Insulation Resistance Min.	Insulation Resistance Max.	Operating Temperature (t_f) Degree F 200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
1.0	0 Natural Convection	1.0	2.5	0.61	0.58	0.55	0.54	0.51	0.48	0.46	0.44	0.42								
		2.5	5.0	0.65	0.63	0.60	0.58	0.55	0.54	0.52	0.49	0.47	0.46	0.45						
		5.0	10.0	0.69	0.65	0.63	0.61	0.59	0.58	0.56	0.54	0.52	0.51	0.50	0.50	0.49				
		10.0	15.0	0.72	0.72	0.69	0.67	0.65	0.63	0.62	0.61	0.60	0.59	0.55	0.54	0.53	0.52	0.51		
		15.0	20.0	0.77	0.74	0.69	0.67	0.65	0.63	0.62	0.61	0.60	0.59	0.58	0.58	0.57	0.56	0.55	0.55	0.54
		20.0	25.0	0.80	0.75	0.72	0.69	0.66	0.65	0.64	0.63	0.61	0.60	0.59	0.59	0.59	0.58	0.58	0.57	0.56
	2	1.0	2.5	0.48	0.46	0.44	0.43	0.41	0.39	0.37	0.36	0.35								
		2.5	5.0	0.50	0.48	0.46	0.45	0.42	0.41	0.40	0.39	0.38	0.37	0.37						
		5.0	10.0	0.56	0.52	0.50	0.49	0.47	0.45	0.44	0.43	0.42	0.41	0.40	0.40	0.39				
		10.0	15.0	0.60	0.56	0.53	0.52	0.50	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.42	0.41	0.40		
		15.0	20.0	0.62	0.60	0.57	0.56	0.54	0.52	0.50	0.48	0.47	0.46	0.45	0.45	0.44	0.44	0.43	0.43	0.43
		20.0	25.0	0.64	0.62	0.60	0.58	0.56	0.54	0.52	0.50	0.48	0.48	0.47	0.47	0.46	0.46	0.45	0.45	0.45
	4	1.0	2.5	0.41	0.38	0.37	0.36	0.34	0.32	0.31	0.30	0.29								
		2.5	5.0	0.44	0.42	0.41	0.39	0.37	0.36	0.35	0.33	0.32	0.32	0.31						
		5.0	10.0	0.48	0.46	0.44	0.43	0.41	0.40	0.38	0.37	0.36	0.35	0.35	0.34	0.34				
		10.0	15.0	0.53	0.51	0.48	0.47	0.45	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.37	0.36	0.35		
		15.0	20.0	0.55	0.53	0.51	0.49	0.47	0.45	0.43	0.42	0.42	0.41	0.40	0.39	0.38	0.38	0.38	0.37	0.37
		20.0	25.0	0.56	0.54	0.53	0.51	0.48	0.46	0.44	0.43	0.43	0.42	0.42	0.41	0.40	0.40	0.39	0.39	0.38
	8	1.0	2.5	0.34	0.33	0.31	0.30	0.28	0.27	0.26	0.25	0.25								
		2.5	5.0	0.38	0.36	0.34	0.33	0.31	0.30	0.29	0.28	0.27	0.27	0.26						
		5.0	10.0	0.43	0.40	0.38	0.36	0.34	0.33	0.32	0.31	0.30	0.30	0.29	0.29	0.29				
		10.0	15.0	0.45	0.43	0.41	0.39	0.37	0.36	0.35	0.34	0.33	0.33	0.32	0.31	0.31	0.30	0.30		
		15.0	20.0	0.46	0.44	0.43	0.41	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.33	0.33	0.32	0.32	0.31	0.31
		20.0	25.0	0.48	0.46	0.45	0.43	0.41	0.39	0.38	0.37	0.36	0.36	0.35	0.34	0.34	0.33	0.33	0.33	0.32
	12	1.0	2.5	0.30	0.29	0.28	0.27	0.25	0.24	0.24	0.23	0.23								
		2.5	5.0	0.33	0.32	0.30	0.29	0.28	0.26	0.26	0.25	0.24	0.24	0.23						
		5.0	10.0	0.38	0.36	0.33	0.32	0.31	0.29	0.29	0.29	0.28	0.28	0.27	0.27	0.27				
		10.0	15.0	0.41	0.39	0.37	0.36	0.33	0.32	0.31	0.30	0.30	0.29	0.29	0.29	0.28	0.28	0.28		
		15.0	20.0	0.42	0.40	0.39	0.38	0.36	0.34	0.33	0.31	0.31	0.30	0.30	0.30	0.29	0.29	0.29	0.29	0.28
		20.0	25.0	0.43	0.41	0.40	0.39	0.37	0.35	0.34	0.32	0.32	0.32	0.31	0.31	0.30	0.30	0.30	0.30	0.29
	20	1.0	2.5	0.26	0.25	0.24	0.23	0.22	0.21	0.20	0.20	0.19								
		2.5	5.0	0.29	0.27	0.26	0.25	0.24	0.23	0.22	0.21	0.21	0.20	0.20						
		5.0	10.0	0.33	0.31	0.29	0.28	0.26	0.25	0.25	0.24	0.24	0.23	0.23	0.23	0.23				
		10.0	15.0	0.36	0.34	0.32	0.31	0.29	0.28	0.27	0.26	0.25	0.25	0.24	0.24	0.24	0.24	0.23		
		15.0	20.0	0.38	0.36	0.34	0.33	0.31	0.29	0.28	0.27	0.26	0.26	0.25	0.25	0.25	0.24	0.24	0.24	0.24
		20.0	25.0	0.40	0.38	0.36	0.34	0.32	0.30	0.29	0.28	0.27	0.27	0.27	0.26	0.26	0.26	0.25	0.25	0.25

(Symbols and Abbreviations on Pages 208-210)

TABLE 9

THEORY - HEAT TRANSFER

AIR FILM RESISTANCE
Values of $\frac{1}{h}$

Emittance ε	Wind Velocity MPH	Convection	Insulation Resistance Min.	Max.	Operating Temperature (t_1) Degree F: 200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
0.9	0	Natural	1.0	2.5	0.65	0.61	0.58	0.56	0.53	0.50	0.48	0.47	0.46								
			2.5	5.0	0.68	0.63	0.61	0.59	0.56	0.54	0.52	0.51	0.50	0.49	0.48						
			5.0	10.0	0.72	0.69	0.68	0.63	0.62	0.60	0.58	0.57	0.56	0.55	0.54	0.53	0.52				
			10.0	15.0	0.77	0.75	0.72	0.69	0.67	0.66	0.64	0.63	0.61	0.59	0.58	0.57	0.57	0.56	0.55		
			15.0	20.0	0.80	0.77	0.74	0.72	0.70	0.68	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57
			20.0	25.0	0.83	0.79	0.76	0.74	0.72	0.70	0.69	0.68	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59
	2		1.0	2.5	0.50	0.47	0.45	0.43	0.41	0.39	0.37	0.36	0.36	0.38	0.38						
			2.5	5.0	0.52	0.50	0.49	0.47	0.44	0.43	0.41	0.40	0.39	0.43	0.42	0.41	0.40				
			5.0	10.0	0.58	0.54	0.52	0.51	0.49	0.47	0.46	0.45	0.44	0.46	0.45	0.44	0.43	0.42	0.41		
			10.0	15.0	0.63	0.59	0.56	0.54	0.52	0.51	0.49	0.48	0.47	0.48	0.47	0.46	0.45	0.45	0.44	0.44	0.44
			15.0	20.0	0.63	0.61	0.58	0.56	0.54	0.53	0.51	0.50	0.49	0.48	0.47	0.48	0.45	0.45	0.44	0.44	0.44
			20.0	25.0	0.67	0.64	0.61	0.59	0.56	0.55	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.47	0.46	0.46	0.46
	4		1.0	2.5	0.42	0.40	0.38	0.36	0.34	0.32	0.31	0.31	0.30								
			2.5	5.0	0.45	0.43	0.41	0.40	0.38	0.37	0.35	0.34	0.33	0.32	0.32						
			5.0	10.0	0.50	0.48	0.46	0.44	0.42	0.41	0.40	0.39	0.38	0.37	0.36	0.35	0.35				
			10.0	15.0	0.56	0.53	0.49	0.48	0.44	0.43	0.42	0.41	0.41	0.40	0.39	0.38	0.38	0.37	0.36		
			15.0	20.0	0.60	0.56	0.52	0.50	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.40	0.39	0.39	0.38	0.38
			20.0	25.0	0.63	0.59	0.55	0.53	0.49	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.41	0.41	0.40	0.40	0.40
	8		1.0	2.5	0.35	0.34	0.32	0.30	0.28	0.27	0.26	0.26	0.26								
			2.5	5.0	0.39	0.37	0.35	0.34	0.32	0.31	0.30	0.29	0.28	0.27	0.27						
			5.0	10.0	0.44	0.41	0.39	0.37	0.35	0.34	0.33	0.32	0.31	0.31	0.30	0.30	0.29				
			10.0	15.0	0.46	0.44	0.42	0.41	0.38	0.37	0.36	0.35	0.34	0.33	0.33	0.32	0.32	0.31	0.31		
			15.0	20.0	0.48	0.46	0.45	0.43	0.41	0.39	0.38	0.37	0.36	0.35	0.35	0.34	0.33	0.33	0.32	0.32	0.32
			20.0	25.0	0.50	0.48	0.47	0.45	0.42	0.40	0.39	0.38	0.37	0.36	0.36	0.35	0.35	0.34	0.34	0.34	0.33
	12		1.0	2.5	0.31	0.29	0.28	0.27	0.25	0.24	0.24	0.24	0.25								
			2.5	5.0	0.35	0.33	0.31	0.30	0.28	0.27	0.26	0.25	0.25	0.24	0.24						
			5.0	10.0	0.39	0.37	0.35	0.34	0.32	0.31	0.30	0.29	0.28	0.28	0.27	0.27	0.27				
			10.0	15.0	0.42	0.40	0.38	0.37	0.35	0.34	0.33	0.32	0.31	0.30	0.30	0.29	0.29	0.28	0.28		
			15.0	20.0	0.44	0.42	0.40	0.39	0.37	0.35	0.34	0.33	0.32	0.32	0.31	0.31	0.30	0.30	0.29	0.29	0.29
			20.0	25.0	0.45	0.43	0.42	0.40	0.38	0.36	0.35	0.34	0.34	0.33	0.32	0.32	0.31	0.31	0.30	0.30	0.30
	20		1.0	2.5	0.27	0.26	0.24	0.23	0.22	0.21	0.20	0.20	0.20								
			2.5	5.0	0.30	0.28	0.27	0.26	0.25	0.24	0.23	0.22	0.22	0.21	0.21						
			5.0	10.0	0.34	0.32	0.30	0.29	0.27	0.26	0.25	0.24	0.24	0.24	0.23	0.23	0.23				
			10.0	15.0	0.37	0.35	0.33	0.32	0.30	0.29	0.28	0.27	0.26	0.25	0.25	0.24	0.24	0.24	0.23		
			15.0	20.0	0.39	0.37	0.35	0.33	0.32	0.30	0.29	0.28	0.27	0.27	0.26	0.26	0.25	0.25	0.25	0.24	0.24
			20.0	25.0	0.41	0.38	0.36	0.35	0.33	0.32	0.30	0.29	0.28	0.28	0.28	0.27	0.27	0.26	0.26	0.26	0.26

(Symbols and Abbreviations shown on Pages 208-210)

TABLE 9 (Continued)

THEORY - HEAT TRANSFER

AIR FILM RESISTANCE
Values of $\frac{1}{f_o}$

ε Emittance	Wind Velocity MPH	Convection / Natural	Insulation Resistance Min.	Insulation Resistance Max.	Operating Temperature (t) Degree F 200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
0.8	0	Natural	1.0	2.5	0.69	0.65	0.62	0.60	0.55	0.52	.51	0.50	0.49								
			2.5	5.0	0.73	0.69	0.67	0.65	0.62	0.60	0.58	0.56	0.54	0.53	0.52						
			5.0	10.0	0.78	0.75	0.73	0.71	0.69	0.66	0.64	0.62	0.60	0.59	0.58	0.57	0.56				
			10.0	15.0	0.82	0.79	0.77	0.75	0.73	0.70	0.69	0.67	0.65	0.64	0.63	0.62	0.61	0.60	0.58		
			15.0	20.0	0.87	0.83	0.79	0.78	0.77	0.74	0.72	0.70	0.68	0.67	0.65	0.65	0.64	0.63	0.62	0.61	0.61
			20.0	25.0	0.89	0.85	0.81	0.80	0.77	0.76	0.74	0.72	0.70	0.69	0.68	0.67	0.66	0.65	0.64	0.63	0.63
	2		1.0	2.5	0.51	0.49	0.46	0.45	0.43	0.40	0.38	0.37	0.37								
			2.5	5.0	0.54	0.52	0.51	0.49	0.46	0.45	0.43	0.41	0.40	0.39	0.38						
			5.0	10.0	0.60	0.57	0.54	0.53	0.51	0.49	0.48	0.46	0.45	0.44	0.43	0.44	0.44				
			10.0	15.0	0.65	0.61	0.57	0.55	0.53	0.51	0.50	0.48	0.47	0.45	0.45	0.45	0.45	0.45	0.44		
			15.0	20.0	0.69	0.65	0.62	0.60	0.58	0.54	0.54	0.52	0.51	0.50	0.49	0.47	0.47	0.47	0.46	0.46	0.45
			20.0	25.0	0.70	0.68	0.65	0.62	0.60	0.58	0.56	0.54	0.53	0.52	0.51	0.50	0.49	0.49	0.48	0.47	0.47
	4		1.0	2.5	0.43	0.41	0.40	0.38	0.36	0.34	0.32	0.32	0.31	0.34	0.33	0.37	0.36				
			2.5	5.0	0.47	0.45	0.43	0.41	0.40	0.38	0.36	0.35	0.34	0.38	0.37	0.40	0.39				
			5.0	10.0	0.52	0.50	0.48	0.46	0.44	0.42	0.41	0.40	0.39	0.41	0.40	0.43	0.42				
			10.0	15.0	0.57	0.54	0.52	0.50	0.48	0.46	0.44	0.43	0.42	0.43	0.42	0.42	0.41	0.39	0.39		
			15.0	20.0	0.61	0.57	0.54	0.52	0.50	0.48	0.46	0.45	0.44	0.45	0.44	0.43	0.42	0.41	0.40	0.40	0.39
			20.0	25.0	0.64	0.59	0.56	0.54	0.52	0.50	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.42	0.41	0.41	0.41
	8		1.0	2.5	0.36	0.35	0.33	0.31	0.29	0.28	0.27	0.27	0.27								
			2.5	5.0	0.40	0.38	0.36	0.35	0.33	0.32	0.31	0.30	0.29	0.28	0.28						
			5.0	10.0	0.45	0.42	0.40	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.31	0.30				
			10.0	15.0	0.48	0.46	0.44	0.42	0.40	0.38	0.37	0.36	0.35	0.34	0.34	0.34	0.33	0.32	0.32		
			15.0	20.0	0.50	0.48	0.46	0.44	0.42	0.40	0.39	0.38	0.37	0.36	0.36	0.35	0.35	0.34	0.34	0.33	0.33
			20.0	25.0	0.52	0.50	0.48	0.46	0.44	0.42	0.40	0.39	0.38	0.37	0.37	0.36	0.36	0.36	0.35	0.35	0.34
	12		1.0	2.5	0.32	0.30	0.29	0.28	0.26	0.25	0.24	0.24	0.24								
			2.5	5.0	0.36	0.34	0.31	0.31	0.29	0.28	0.27	0.26	0.25	0.25	0.25						
			5.0	10.0	0.40	0.38	0.36	0.35	0.33	0.32	0.31	0.30	0.29	0.29	0.28	0.28					
			10.0	15.0	0.44	0.41	0.39	0.38	0.36	0.35	0.34	0.32	0.31	0.30	0.30	0.29	0.29				
			15.0	20.0	0.46	0.44	0.42	0.40	0.38	0.36	0.35	0.34	0.33	0.32	0.32	0.31	0.30	0.30	0.30		
			20.0	25.0	0.48	0.46	0.44	0.42	0.40	0.38	0.36	0.35	0.34	0.33	0.33	0.32	0.32	0.31	0.31	0.31	0.31
	20		1.0	2.5	0.29	0.26	0.25	0.24	0.22	0.21	0.20	0.20	0.20								
			2.5	5.0	0.33	0.29	0.28	0.27	0.25	0.24	0.23	0.22	0.22	0.22	0.22						
			5.0	10.0	0.34	0.33	0.31	0.30	0.28	0.27	0.26	0.25	0.25	0.24	0.24	0.24	0.24				
			10.0	15.0	0.33	0.35	0.34	0.32	0.30	0.29	0.28	0.28	0.27	0.26	0.26	0.25	0.25	0.24	0.24		
			15.0	20.0	0.40	0.38	0.36	0.34	0.32	0.31	0.30	0.29	0.28	0.28	0.27	0.27	0.26	0.26	0.25	0.25	0.25
			20.0	25.0	0.42	0.40	0.38	0.36	0.34	0.32	0.31	0.30	0.29	0.29	0.28	0.28	0.28	0.27	0.27	0.27	0.26

(Symbols and Abbreviations shown on Pages 208-210)

TABLE 9 (Continued)

THEORY - HEAT TRANSFER

AIR FILM RESISTANCE
Values of $\frac{1}{h}$

ε Emittance	Wind Velocity MPH	Insulation Resistance Min.	Insulation Resistance Max.	Operating Temperature (t_1) Degrees F: 200	250	300	350	400	500	600	700	800	900	1000	1200	1300	1400	1500	1600
0.7	0 Natural Convection	1.0	2.5	0.73	0.69	0.66	0.64	0.59	0.56	0.53	0.52	0.51							
		2.5	5.0	0.78	0.74	0.71	0.68	0.66	0.63	0.60	0.58	0.56	0.55	0.54					
		5.0	10.0	0.83	0.81	0.78	0.76	0.73	0.70	0.68	0.65	0.63	0.62	0.61	0.60				
		10.0	15.0	0.88	0.85	0.82	0.80	0.77	0.74	0.72	0.70	0.69	0.68	0.67	0.65	0.63	0.62		
		15.0	20.0	0.93	0.90	0.86	0.84	0.81	0.78	0.76	0.74	0.73	0.71	0.70	0.69	0.67	0.66	0.65	0.64
		20.0	25.0	0.95	0.92	0.88	0.86	0.83	0.80	0.78	0.76	0.75	0.73	0.72	0.70	0.69	0.68	0.67	0.66
	2	1.0	2.5	0.53	0.50	0.48	0.47	0.43	0.41	0.39	0.38	0.38	0.41	0.40					
		2.5	5.0	0.57	0.54	0.53	0.51	0.49	0.47	0.45	0.43	0.42	0.42	0.42	0.45				
		5.0	10.0	0.63	0.61	0.58	0.56	0.54	0.52	0.50	0.49	0.48	0.47	0.46	0.48	0.47	0.46		
		10.0	15.0	0.69	0.66	0.63	0.61	0.57	0.55	0.54	0.52	0.51	0.50	0.49	0.49	0.49	0.49	0.49	0.48
		15.0	20.0	0.71	0.69	0.65	0.63	0.60	0.58	0.57	0.56	0.54	0.53	0.52	0.51	0.51	0.50	0.50	0.50
		20.0	25.0	0.74	0.71	0.69	0.67	0.63	0.60	0.59	0.57	0.56	0.55	0.54	0.53	0.52	0.52		
	4	1.0	2.5	0.44	0.42	0.41	0.39	0.37	0.35	0.33	0.32	0.32	0.35	0.34					
		2.5	5.0	0.50	0.47	0.45	0.44	0.41	0.39	0.38	0.37	0.36	0.39	0.38	0.38				
		5.0	10.0	0.54	0.51	0.49	0.47	0.45	0.44	0.42	0.41	0.40	0.39	0.42	0.41	0.40	0.40		
		10.0	15.0	0.61	0.58	0.54	0.52	0.49	0.47	0.46	0.45	0.44	0.43	0.44	0.43	0.42	0.41	0.40	0.40
		15.0	20.0	0.63	0.59	0.57	0.55	0.52	0.50	0.48	0.47	0.46	0.43	0.44	0.43	0.44	0.43	0.43	0.42
		20.0	25.0	0.66	0.64	0.61	0.57	0.55	0.52	0.50	0.48	0.47	0.46	0.45	0.45	0.44	0.43		
	9	1.0	2.5	0.37	0.36	0.34	0.42	0.30	0.29	0.28	0.28	0.28	0.29	0.29					
		2.5	5.0	0.41	0.39	0.37	0.36	0.34	0.33	0.32	0.31	0.30	0.29	0.32	0.32				
		5.0	10.0	0.46	0.43	0.41	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.34	0.34	0.33			
		10.0	15.0	0.49	0.47	0.45	0.43	0.41	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.33	0.33	0.34	0.33
		15.0	20.0	0.52	0.50	0.48	0.46	0.44	0.42	0.40	0.39	0.38	0.37	0.37	0.36	0.35	0.34	0.35	0.35
		20.0	25.0	0.54	0.52	0.50	0.48	0.46	0.44	0.42	0.40	0.39	0.39	0.38	0.37	0.36	0.36		
	12	1.0	2.5	0.33	0.31	0.30	0.29	0.27	0.26	0.25	0.25	0.25	0.26	0.26					
		2.5	5.0	0.37	0.35	0.33	0.32	0.30	0.29	0.28	0.27	0.26	0.26	0.26	0.29				
		5.0	10.0	0.41	0.39	0.37	0.36	0.34	0.33	0.32	0.31	0.30	0.29	0.29	0.29	0.30	0.30		
		10.0	15.0	0.45	0.42	0.41	0.39	0.36	0.35	0.34	0.33	0.32	0.31	0.31	0.30	0.30	0.30	0.30	0.30
		15.0	20.0	0.47	0.45	0.43	0.41	0.39	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.31	0.31	0.30	0.31
		20.0	25.0	0.49	0.47	0.45	0.43	0.41	0.39	0.37	0.36	0.35	0.34	0.33	0.33	0.32	0.32		
	20	1.0	2.5	0.28	0.26	0.25	0.25	0.23	0.22	0.21	0.21	0.21	0.22	0.22					
		2.5	5.0	0.31	0.30	0.29	0.27	0.26	0.25	0.23	0.23	0.22	0.22	0.24	0.24				
		5.0	10.0	0.35	0.33	0.31	0.30	0.29	0.27	0.27	0.26	0.26	0.25	0.24	0.24	0.25	0.25		
		10.0	15.0	0.38	0.36	0.35	0.33	0.31	0.30	0.29	0.28	0.27	0.27	0.26	0.26	0.26	0.26	0.26	0.26
		15.0	20.0	0.40	0.38	0.37	0.35	0.33	0.31	0.31	0.30	0.29	0.28	0.27	0.27	0.27	0.27	0.27	0.27
		20.0	25.0	0.42	0.40	0.38	0.37	0.35	0.33	0.32	0.31	0.30	0.30	0.29	0.29	0.28	0.28		

(Symbols and Abbreviations shown on Pages 208-210)

TABLE 9 (Continued)

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THEORY - HEAT TRANSFER

AIR FILM RESISTANCE
Values of $\frac{1}{h}$

ε Emittance	Wind Velocity MPH	Insulation Resistance Min.	Insulation Resistance Max.	Operating Temperature (t_1) Degree F 200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
0.6	0 (Natural Convection)	1.0	2.5	0.78	0.73	0.69	0.66	0.33	0.60	0.57	0.56	0.55								
		2.5	5.0	0.83	0.80	0.76	0.75	0.70	0.68	0.75	0.63	0.61	0.60	0.59						
		5.0	10.0	0.91	0.87	0.84	0.82	0.77	0.75	0.72	0.70	0.68	0.67	0.65	0.64	0.63				
		10.0	15.0	0.95	0.91	0.89	0.87	0.83	0.80	0.77	0.75	0.73	0.71	0.70	0.69	0.68	0.67	0.66		
		15.0	20.0	0.99	0.95	0.92	0.90	0.87	0.84	0.82	0.80	0.78	0.76	0.74	0.73	0.72	0.71	0.70	0.69	0.68
		20.0	25.0	1.04	0.98	0.95	0.93	0.90	0.87	0.85	0.83	0.81	0.79	0.77	0.76	0.75	0.74	0.73	0.72	0.71
	2	1.0	2.5	0.55	0.52	0.50	0.48	0.45	0.42	0.41	0.40	0.40								
		2.5	5.0	0.60	0.58	0.55	0.53	0.50	0.48	0.47	0.45	0.44	0.43	0.42						
		5.0	10.0	0.66	0.63	0.61	0.59	0.56	0.53	0.51	0.50	0.49	0.48	0.47	0.47	0.46	0.46			
		10.0	15.0	0.71	0.68	0.66	0.63	0.60	0.58	0.56	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47		
		15.0	20.0	0.76	0.71	0.68	0.67	0.63	0.61	0.59	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.50	0.50
		20.0	25.0	0.79	0.73	0.72	0.69	0.66	0.63	0.61	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.51
	4	1.0	2.5	0.45	0.43	0.42	0.40	0.38	0.36	0.35	0.34	0.34								
		2.5	5.0	0.52	0.49	0.47	0.45	0.42	0.41	0.39	0.38	0.37	0.36	0.35						
		5.0	10.0	0.57	0.53	0.51	0.50	0.47	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38				
		10.0	15.0	0.64	0.58	0.56	0.53	0.51	0.49	0.48	0.46	0.45	0.44	0.43	0.42	0.42	0.41	0.41		
		15.0	20.0	0.68	0.63	0.58	0.56	0.53	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.43	0.42	0.42
		20.0	25.0	0.71	0.68	0.64	0.60	0.57	0.54	0.52	0.50	0.50	0.49	0.48	0.47	0.46	0.45	0.45	0.44	0.43
	8	1.0	2.5	0.38	0.36	0.34	0.33	0.31	0.30	0.29	0.29	0.29								
		2.5	5.0	0.42	0.40	0.38	0.37	0.35	0.34	0.33	0.32	0.31	0.30	0.30						
		5.0	10.0	0.47	0.44	0.42	0.40	0.39	0.38	0.37	0.36	0.35	0.34	0.33	0.32	0.32				
		10.0	15.0	0.50	0.48	0.46	0.44	0.42	0.40	0.39	0.38	0.37	0.36	0.35	0.35	0.34	0.34	0.34		
		15.0	20.0	0.54	0.52	0.49	0.47	0.45	0.43	0.41	0.40	0.39	0.38	0.38	0.37	0.37	0.36	0.36	0.35	0.34
		20.0	25.0	0.56	0.54	0.52	0.50	0.47	0.45	0.43	0.41	0.40	0.40	0.39	0.39	0.38	0.37	0.37	0.36	0.36
	12	1.0	2.5	0.34	0.32	0.31	0.30	0.28	0.26	0.25	0.25	0.25								
		2.5	5.0	0.38	0.36	0.34	0.33	0.31	0.30	0.29	0.28	0.27	0.27	0.27						
		5.0	10.0	0.42	0.40	0.38	0.37	0.35	0.33	0.32	0.31	0.31	0.30	0.30	0.30	0.29				
		10.0	15.0	0.46	0.44	0.42	0.40	0.38	0.36	0.35	0.34	0.33	0.32	0.32	0.31	0.31	0.30	0.30		
		15.0	20.0	0.48	0.46	0.44	0.42	0.40	0.38	0.37	0.36	0.35	0.34	0.33	0.33	0.32	0.32	0.32	0.31	0.31
		20.0	25.0	0.50	0.48	0.46	0.44	0.42	0.40	0.38	0.37	0.36	0.35	0.34	0.34	0.34	0.33	0.33	0.32	0.32
	20	1.0	2.5	0.28	0.27	0.25	0.25	0.23	0.22	0.21	0.21	0.21								
		2.5	5.0	0.32	0.30	0.29	0.28	0.26	0.25	0.24	0.23	0.22	0.22	0.22						
		5.0	10.0	0.35	0.34	0.33	0.32	0.30	0.28	0.27	0.26	0.26	0.25	0.24	0.24	0.24				
		10.0	15.0	0.39	0.37	0.35	0.34	0.32	0.30	0.29	0.29	0.28	0.28	0.26	0.26	0.26	0.25	0.25		
		15.0	20.0	0.41	0.39	0.37	0.36	0.34	0.33	0.32	0.31	0.30	0.29	0.28	0.28	0.27	0.27	0.26	0.26	0.26
		20.0	25.0	0.43	0.41	0.39	0.37	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.29	0.28	0.28	0.28	0.28	0.27

(Symbols and Abbreviations shown on Pages 208-210)

TABLE 9 (Continued)

THEORY - HEAT TRANSFER

AIR FILM RESISTANCE
Values of $\frac{1}{h}$

ε Emittance	Wind Velocity MPH	Insulation Resistance Min.	Insulation Resistance Max.	Operating Temperature (t_1) Degrees F 200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
0.5	0 Convection																			
	2 Natural	1.0	2.5	0.82	0.77	0.74	0.71	0.67	0.64	0.61	0.60	0.59								
		2.5	5.0	0.88	0.84	0.81	0.79	0.76	0.71	0.68	0.66	0.64	0.65	0.64						
		5.0	10.0	0.98	0.95	0.90	0.87	0.83	0.79	0.77	0.75	0.73	0.70	0.68	0.67	0.66				
		10.0	15.0	1.03	1.00	0.97	0.94	0.89	0.85	0.82	0.80	0.78	0.77	0.76	0.75	0.74	0.73	0.72		
		15.0	20.0	1.07	1.03	1.00	0.97	0.92	0.87	0.85	0.83	0.81	0.80	0.79	0.78	0.77	0.76	0.75	0.74	0.73
		20.0	25.0	1.11	1.06	1.03	1.00	0.95	0.90	0.88	0.87	0.84	0.83	0.82	0.81	0.80	0.79	0.78	0.77	0.76
	4	1.0	2.5	0.57	0.54	0.51	0.48	0.46	0.44	0.42	0.41	0.41								
		2.5	5.0	0.64	0.60	0.57	0.55	0.52	0.50	0.48	0.46	0.45	0.44	0.43						
		5.0	10.0	0.70	0.66	0.64	0.62	0.58	0.55	0.54	0.52	0.51	0.50	0.49	0.48	0.48				
		10.0	15.0	0.75	0.71	0.68	0.66	0.63	0.60	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.51	0.50		
		15.0	20.0	0.80	0.75	0.72	0.69	0.66	0.64	0.62	0.60	0.58	0.57	0.56	0.55	0.54	0.54	0.53	0.52	0.51
		20.0	25.0	0.83	0.78	0.75	0.72	0.69	0.66	0.64	0.62	0.60	0.59	0.58	0.57	0.56	0.55	0.55	0.54	0.54
	8	1.0	2.5	0.48	0.45	0.43	0.31	0.39	0.37	0.36	0.35	0.35	0.37	0.36						
		2.5	5.0	0.54	0.51	0.49	0.47	0.44	0.42	0.40	0.39	0.38	0.42	0.31	0.40	0.40				
		5.0	10.0	0.60	0.56	0.54	0.52	0.49	0.47	0.46	0.44	0.43	0.46	0.45	0.44	0.43	0.42	0.42		
		10.0	15.0	0.67	0.61	0.59	0.56	0.53	0.51	0.49	0.48	0.47	0.48	0.47	0.47	0.46	0.46	0.45	0.45	0.44
		15.0	20.0	0.72	0.67	0.62	0.59	0.56	0.54	0.52	0.50	0.49	0.50	0.49	0.48	0.47	0.47	0.47	0.46	0.45
		20.0	25.0	0.75	0.72	0.67	0.62	0.59	0.56	0.54	0.52	0.51	0.50	0.49	0.48	0.47	0.47	0.47	0.46	0.45
	12	1.0	2.5	0.39	0.37	0.35	0.34	0.32	0.30	0.29	0.29	0.29								
		2.5	5.0	0.42	0.40	0.38	0.37	0.35	0.34	0.33	0.32	0.31	0.31	0.31						
		5.0	10.0	0.49	0.47	0.45	0.43	0.41	0.39	0.37	0.36	0.35	0.35	0.34	0.34	0.33				
		10.0	15.0	0.54	0.52	0.49	0.47	0.44	0.42	0.41	0.40	0.39	0.38	0.37	0.36	0.35	0.35	0.35		
		15.0	20.0	0.57	0.54	0.52	0.50	0.47	0.45	0.43	0.42	0.40	0.40	0.39	0.39	0.38	0.38	0.37	0.36	0.35
		20.0	25.0	0.59	0.56	0.54	0.52	0.49	0.47	0.45	0.43	0.42	0.41	0.40	0.40	0.39	0.39	0.39	0.38	0.37
	20	1.0	2.5	0.35	0.34	0.32	0.31	0.28	0.27	0.26	0.26	0.25								
		2.5	5.0	0.38	0.36	0.35	0.34	0.32	0.31	0.29	0.28	0.28	0.28	0.27						
		5.0	10.0	0.44	0.41	0.39	0.38	0.35	0.34	0.34	0.33	0.33	0.33	0.30	0.30	0.30				
		10.0	15.0	0.48	0.45	0.43	0.41	0.38	0.37	0.36	0.35	0.34	0.34	0.33	0.32	0.32	0.31	0.31		
		15.0	20.0	0.52	0.49	0.46	0.45	0.42	0.36	0.38	0.37	0.36	0.34	0.34	0.34	0.34	0.34	0.33	0.32	0.32
		20.0	25.0	0.54	0.51	0.48	0.46	0.43	0.41	0.39	0.38	0.37	0.36	0.35	0.35	0.35	0.34	0.34	0.34	0.33
	0 Convection																			
	2 Natural	1.0	2.5	0.29	0.27	0.26	0.25	0.23	0.22	0.21	0.21	0.21								
		2.5	5.0	0.33	0.31	0.29	0.28	0.27	0.26	0.25	0.24	0.23	0.23	0.22						
		5.0	10.0	0.37	0.35	0.33	0.32	0.30	0.29	0.28	0.27	0.26	0.26	0.25	0.25	0.25				
		10.0	15.0	0.40	0.38	0.36	0.35	0.33	0.31	0.30	0.29	0.29	0.28	0.27	0.27	0.26	0.26	0.26		
		15.0	20.0	0.42	0.40	0.38	0.37	0.35	0.33	0.32	0.31	0.30	0.29	0.29	0.29	0.28	0.28	0.27	0.27	0.27
		20.0	25.0	0.45	0.43	0.41	0.39	0.37	0.35	0.34	0.32	0.31	0.31	0.30	0.30	0.29	0.29	0.29	0.28	0.28

(Symbols and Abbreviations shown on Pages 208-210)

TABLE 9 (Continued)

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THEORY - HEAT TRANSFER

AIR FILM RESISTANCE
Values of $\frac{1}{h}$

Emittance ε	Wind Velocity MPH		Insulation Resistance Min.	Max.	Operating Temperature Degree F 200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
0.4	0	Natural Convection	1.0	2.5	0.87	0.83	0.79	0.75	0.71	0.68	0.65	0.64	0.63								
			2.5	5.0	0.96	0.90	0.87	0.84	0.79	0.76	0.74	0.71	0.69	0.68	0.67						
			5.0	10.0	1.07	1.01	0.98	0.95	0.91	0.85	0.83	0.81	0.79	0.77	0.75	0.74	0.73				
			10.0	15.0	1.13	1.08	1.04	1.01	0.96	0.90	0.88	0.86	0.84	0.82	0.80	0.79	0.78	0.77	0.76		
			15.0	20.0	1.18	1.13	1.08	1.05	1.01	0.97	0.94	0.91	0.88	0.86	0.85	0.84	0.83	0.82	0.81	0.80	0.79
			20.0	25.0	1.24	1.17	1.12	1.09	1.04	1.00	0.97	0.94	0.91	0.89	0.88	0.87	0.86	0.85	0.84	0.83	0.82
	2		1.0	2.5	0.60	0.57	0.54	0.51	0.48	0.46	0.45	0.44	0.43	0.46	0.45						
			2.5	5.0	0.68	0.64	0.61	0.59	0.55	0.52	0.50	0.48	0.47	0.46	0.51	0.50					
			5.0	10.0	0.74	0.71	0.68	0.65	0.61	0.59	0.57	0.55	0.53	0.52	0.51	0.50	0.50				
			10.5	15.0	0.81	0.75	0.73	0.71	0.68	0.64	0.62	0.60	0.58	0.57	0.56	0.55	0.54	0.53			
			15.0	20.0	0.85	0.80	0.75	0.73	0.70	0.68	0.66	0.64	0.62	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53
			20.0	25.0	0.90	0.84	0.81	0.77	0.73	0.70	0.68	0.66	0.64	0.62	0.61	0.60	0.59	0.59	0.58	0.57	0.57
	4		1.0	2.5	0.50	0.47	0.45	0.43	0.40	0.39	0.38	0.37	0.36	0.38	0.37						
			2.5	5.0	0.57	0.53	0.50	0.48	0.46	0.44	0.43	0.41	0.39	0.44	0.43	0.42	0.42				
			5.0	10.0	0.63	0.60	0.58	0.56	0.53	0.49	0.47	0.46	0.45	0.44	0.43	0.42	0.42				
			10.0	15.0	0.69	0.63	0.61	0.59	0.56	0.53	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43		
			15.0	20.0	0.73	0.68	0.65	0.62	0.59	0.57	0.54	0.52	0.51	0.50	0.49	0.48	0.47	0.47	0.46	0.46	0.45
			20.0	25.0	0.77	0.72	0.69	0.65	0.61	0.59	0.57	0.55	0.53	0.52	0.51	0.50	0.49	0.49	0.48	0.47	0.47
	8		1.0	2.5	0.40	0.38	0.36	0.35	0.33	0.31	0.30	0.29	0.29	0.31	0.31						
			2.5	5.0	0.44	0.42	0.40	0.38	0.35	0.34	0.33	0.32	0.32	0.31	0.35	0.34	0.34				
			5.0	10.0	0.51	0.48	0.46	0.44	0.42	0.40	0.38	0.37	0.36	0.35	0.38	0.38	0.37	0.36			
			10.0	15.0	0.56	0.53	0.50	0.48	0.45	0.43	0.42	0.41	0.40	0.39	0.40	0.40	0.39	0.38	0.38	0.37	0.36
			15.0	20.0	0.60	0.57	0.53	0.51	0.48	0.46	0.44	0.43	0.41	0.41	0.40	0.40	0.39	0.39	0.38	0.38	0.38
			20.0	25.0	0.63	0.59	0.56	0.54	0.51	0.49	0.47	0.45	0.44	0.43	0.42	0.41	0.40	0.40	0.39		
	12		1.0	2.5	0.36	0.34	0.33	0.31	0.29	0.28	0.27	0.26	0.25	0.28	0.27						
			2.5	5.0	0.40	0.38	0.37	0.35	0.33	0.31	0.30	0.29	0.28	0.32	0.31	0.31	0.31				
			5.0	10.0	0.46	0.42	0.40	0.39	0.37	0.35	0.34	0.33	0.32	0.34	0.33	0.33	0.33	0.32			
			10.0	15.0	0.50	0.47	0.45	0.42	0.40	0.38	0.37	0.36	0.35	0.37	0.36	0.35	0.34	0.33	0.32		
			15.0	20.0	0.54	0.51	0.48	0.46	0.43	0.40	0.39	0.38	0.37	0.39	0.38	0.37	0.36	0.34	0.33	0.33	0.32
			20.0	25.0	0.56	0.53	0.50	0.43	0.45	0.42	0.40	0.40	0.39	0.38	0.37	0.37	0.36	0.34	0.34	0.34	0.34
	20		1.0	2.5	0.30	0.28	0.25	0.23	0.25	0.23	0.23	0.22	0.22	0.24	0.23						
			2.5	5.0	0.34	0.32	0.30	0.29	0.28	0.26	0.25	0.24	0.24	0.26	0.25	0.25	0.25				
			5.0	10.0	0.38	0.35	0.34	0.32	0.31	0.30	0.29	0.28	0.27	0.28	0.28	0.28	0.27	0.26	0.26		
			10.0	15.0	0.42	0.40	0.38	0.38	0.34	0.32	0.33	0.32	0.31	0.30	0.30	0.30	0.29	0.28	0.28	0.27	0.27
			15.0	20.0	0.44	0.42	0.40	0.38	0.35	0.34	0.34	0.33	0.32	0.31	0.31	0.31	0.30	0.30	0.29	0.29	0.29
			20.0	25.0	0.47	0.45	0.43	0.40	0.38	0.35	0.34	0.33	0.32	0.32	0.31	0.31	0.30	0.30	0.29	0.29	0.29

(Symbols and Abbreviations on Pages 208-210)

TABLE 9 (Continued)

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THEORY - HEAT TRANSFER

AIR FILM RESISTANCE
Values of $\frac{1}{h}$

ε Emittance	Wind Velocity MPH	Insulation Resistance Min.	Max.	Operating Temperature Degree F 200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
0.3	0 Natural Convection	1.0	2.5	0.95	0.89	0.86	0.81	0.76	0.72	0.69	0.67	0.66		0.73						
		2.5	5.0	1.08	1.00	0.96	0.92	0.88	0.83	0.80	0.77	0.75	0.74	0.80	0.79	0.78				
		5.0	10.0	1.17	1.12	1.05	1.02	0.97	0.92	0.88	0.86	0.84	0.82	0.87	0.85	0.84	0.83	0.82		
		10.0	15.0	1.25	1.19	1.15	1.11	1.05	1.00	0.96	0.94	0.91	0.89	0.91	0.91	0.89	0.88	0.87	0.86	0.85
		15.0	20.0	1.31	1.25	1.21	1.16	1.07	1.04	1.02	0.99	0.96	0.94	0.92	0.91	0.89	0.88	0.90	0.89	0.88
		20.0	25.0	1.34	1.28	1.25	1.20	1.15	1.10	1.07	1.04	1.01	0.98	0.96	0.94	0.92	0.91			
	2	1.0	2.5	0.64	0.60	0.57	0.54	0.51	0.48	0.47	0.46	0.45	0.49	0.48						
		2.5	5.0	0.71	0.67	0.64	0.61	0.58	0.55	0.53	0.51	0.50	0.49	0.53	0.52	0.52				
		5.0	10.0	0.78	0.75	0.72	0.68	0.66	0.62	0.60	0.58	0.56	0.54	0.59	0.58	0.56	0.55	0.54		
		10.0	15.0	0.85	0.81	0.77	0.75	0.71	0.67	0.66	0.63	0.61	0.60	0.62	0.60	0.59	0.59	0.58	0.57	0.57
		15.0	20.0	0.90	0.85	0.82	0.78	0.75	0.72	0.69	0.67	0.66	0.64	0.66	0.64	0.61	0.60	0.60	0.60	0.59
		20.0	25.0	0.95	0.88	0.85	0.82	0.77	0.75	0.73	0.70	0.68	0.67	0.66						
	4	1.0	2.5	0.53	0.50	0.48	0.45	0.42	0.40	0.39	0.38	0.37	0.39	0.38						
		2.5	5.0	0.59	0.56	0.53	0.51	0.48	0.45	0.43	0.42	0.40	0.45	0.44	0.44	0.43				
		5.0	10.0	0.65	0.62	0.59	0.57	0.54	0.52	0.50	0.48	0.47	0.50	0.49	0.48	0.47	0.46	0.45		
		10.0	15.0	0.72	0.68	0.65	0.62	0.58	0.56	0.54	0.52	0.51	0.52	0.52	0.51	0.50	0.49	0.48	0.48	0.47
		15.0	20.0	0.77	0.73	0.68	0.66	0.62	0.59	0.57	0.55	0.53	0.52	0.52	0.51	0.50	0.49	0.48	0.48	0.47
		20.0	25.0	0.81	0.76	0.72	0.68	0.65	0.62	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49
	8	1.0	2.5	0.42	0.40	0.38	0.37	0.34	0.32	0.31	0.30	0.30	0.33	0.32						
		2.5	5.0	0.47	0.45	0.43	0.41	0.39	0.37	0.35	0.34	0.33	0.37	0.36	0.35	0.35				
		5.0	10.0	0.53	0.50	0.48	0.46	0.43	0.41	0.40	0.39	0.38	0.40	0.40	0.39	0.38	0.37	0.37		
		10.0	15.0	0.58	0.55	0.52	0.50	0.48	0.45	0.43	0.42	0.41	0.40	0.42	0.41	0.40	0.40	0.39	0.39	0.38
		15.0	20.0	0.62	0.59	0.56	0.53	0.50	0.48	0.46	0.45	0.44	0.43	0.43	0.41	0.40	0.40	0.39	0.40	0.39
		20.0	25.0	0.68	0.61	0.58	0.56	0.53	0.50	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40		
	12	1.0	2.5	0.37	0.35	0.34	0.32	0.30	0.29	0.27	0.26	0.26	0.29	0.28						
		2.5	5.0	0.41	0.39	0.38	0.36	0.34	0.32	0.31	0.30	0.29	0.32	0.31	0.31	0.31				
		5.0	10.0	0.46	0.43	0.41	0.40	0.38	0.36	0.35	0.34	0.33	0.35	0.34	0.33	0.33	0.33	0.33		
		10.0	15.0	0.51	0.48	0.45	0.43	0.41	0.39	0.38	0.37	0.36	0.37	0.36	0.35	0.35	0.34	0.34	0.34	0.33
		15.0	20.0	0.55	0.52	0.49	0.47	0.44	0.42	0.40	0.39	0.38	0.39	0.38	0.37	0.36	0.36	0.35	0.35	0.35
		20.0	25.0	0.57	0.54	0.51	0.49	0.46	0.43	0.42	0.41	0.40	0.39	0.38						
	20	1.0	2.5	0.30	0.29	0.28	0.27	0.26	0.24	0.24	0.23	0.23	0.23	0.24						
		2.5	5.0	0.34	0.33	0.30	0.29	0.28	0.27	0.26	0.25	0.24	0.24	0.26	0.26	0.25				
		5.0	10.0	0.40	0.37	0.35	0.33	0.32	0.30	0.29	0.29	0.28	0.27	0.29	0.28	0.28	0.27	0.27		
		10.0	15.0	0.44	0.42	0.39	0.38	0.35	0.33	0.32	0.30	0.30	0.29	0.30	0.30	0.29	0.29	0.29	0.28	0.28
		15.0	20.0	0.46	0.44	0.42	0.40	0.37	0.35	0.34	0.33	0.32	0.31	0.32	0.31	0.30	0.29	0.29	0.29	0.29
		20.0	25.0	0.49	0.47	0.45	0.41	0.40	0.37	0.35	0.36	0.33	0.33	0.32						

(Symbols and Abbreviations on Pages 208-210)

TABLE 9 (Continued)

THEORY - HEAT TRANSFER

AIR FILM RESISTANCE
Values of $\frac{1}{h}$

ε Emittance	Wind Velocity MPH	Insulation Resistance Min.	Max.	Operating Temperature (t_1) Degree F 200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
0.2	0 Natural Convection	1.0	2.5	1.02	0.96	0.93	0.88	0.81	0.78	0.74	0.71	0.69								
		2.5	5.0	1.17	1.10	1.05	1.01	0.95	0.91	0.87	0.85	0.81	0.78	0.76	0.75					
		5.0	10.0	1.29	1.23	1.17	1.12	1.06	1.01	0.99	0.95	0.93	0.90	0.87	0.85	0.83				
		10.0	15.0	1.39	1.30	1.26	1.23	1.15	1.09	1.04	1.02	1.00	0.97	0.95	0.93	0.91	0.90	0.89		
		15.0	20.0	1.45	1.39	1.34	1.29	1.22	1.17	1.12	1.08	1.05	1.03	1.01	0.99	0.97	0.96	0.95	0.94	0.93
		20.0	25.0	1.52	1.43	1.38	1.33	1.26	1.21	1.17	1.13	1.10	1.07	1.05	1.02	1.01	1.00	0.99	0.98	0.97
	2	1.0	2.5	0.67	0.63	0.59	0.57	0.55	0.52	0.51	0.50	0.49								
		2.5	5.0	0.75	0.71	0.67	0.64	0.61	0.58	0.56	0.54	0.52	0.51	0.50						
		5.0	10.0	0.84	0.80	0.76	0.73	0.69	0.65	0.62	0.60	0.58	0.57	0.56	0.55	0.54				
		10.0	15.0	0.92	0.87	0.82	0.79	0.76	0.71	0.68	0.66	0.64	0.62	0.61	0.60	0.59	0.58	0.57		
		15.0	20.0	0.98	0.93	0.88	0.84	0.79	0.76	0.73	0.70	0.68	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59
		20.0	25.0	1.03	0.96	0.92	0.89	0.84	0.80	0.77	0.74	0.77	0.69	0.68	0.67	0.66	0.65	0.64	0.63	0.62
	4	1.0	2.5	0.55	0.52	0.49	0.47	0.44	0.42	0.40	0.39	0.38								
		2.5	5.0	0.62	0.58	0.55	0.53	0.50	0.47	0.45	0.44	0.43	0.42	0.41						
		5.0	10.0	0.69	0.65	0.62	0.59	0.57	0.54	0.51	0.49	0.48	0.47	0.46	0.45	0.44				
		10.0	15.0	0.76	0.73	0.69	0.65	0.61	0.59	0.57	0.55	0.53	0.51	0.50	0.49	0.48	0.47	0.46		
		15.0	20.0	0.80	0.76	0.72	0.69	0.65	0.62	0.60	0.58	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48
		20.0	25.0	0.85	0.80	0.75	0.72	0.68	0.64	0.62	0.60	0.59	0.58	0.56	0.55	0.54	0.53	0.52	0.51	0.50
	8	1.0	2.5	0.44	0.41	0.39	0.38	0.35	0.33	0.32	0.31	0.30								
		2.5	5.0	0.50	0.47	0.44	0.42	0.40	0.38	0.36	0.35	0.34	0.34	0.33						
		5.0	10.0	0.56	0.52	0.50	0.48	0.45	0.42	0.41	0.40	0.39	0.38	0.37	0.36	0.36				
		10.0	15.0	0.62	0.58	0.53	0.52	0.49	0.47	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.38		
		15.0	20.0	0.66	0.61	0.59	0.56	0.52	0.50	0.48	0.47	0.45	0.44	0.43	0.42	0.41	0.40	0.40	0.40	0.39
		20.0	25.0	0.68	0.64	0.62	0.59	0.55	0.52	0.50	0.49	0.48	0.46	0.45	0.44	0.43	0.42	0.42	0.41	0.40
	12	1.0	2.5	0.38	0.36	0.34	0.32	0.30	0.29	0.28	0.27	0.27								
		2.5	5.0	0.42	0.40	0.38	0.37	0.35	0.33	0.31	0.30	0.30	0.29	0.29						
		5.0	10.0	0.48	0.46	0.43	0.41	0.39	0.37	0.36	0.35	0.34	0.33	0.32	0.32	0.31				
		10.0	15.0	0.53	0.50	0.47	0.45	0.43	0.41	0.39	0.38	0.37	0.36	0.35	0.35	0.34	0.34	0.33		
		15.0	20.0	0.57	0.53	0.50	0.48	0.45	0.43	0.42	0.40	0.39	0.38	0.37	0.37	0.36	0.36	0.35	0.35	0.34
		20.0	25.0	0.60	0.56	0.53	0.51	0.48	0.45	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.37	0.36	0.36	0.36
	20	1.0	2.5	0.31	0.29	0.28	0.27	0.26	0.25	0.25	0.24	0.24								
		2.5	5.0	0.35	0.34	0.32	0.31	0.29	0.28	0.27	0.26	0.25	0.25	0.24						
		5.0	10.0	0.41	0.38	0.36	0.34	0.33	0.31	0.30	0.29	0.28	0.28	0.27	0.27	0.26				
		10.0	15.0	0.46	0.43	0.41	0.39	0.37	0.34	0.32	0.31	0.30	0.30	0.29	0.29	0.28	0.28	0.27		
		15.0	20.0	0.48	0.46	0.44	0.42	0.39	0.36	0.35	0.34	0.33	0.32	0.31	0.31	0.30	0.30	0.29	0.29	0.28
		20.0	25.0	0.50	0.48	0.46	0.44	0.41	0.38	0.36	0.35	0.34	0.33	0.33	0.32	0.32	0.31	0.30	0.30	0.29

(Symbols and Abbreviations on Pages 208-210)

TABLE 9 (Continued)

THEORY - HEAT TRANSFER

AIR FILM RESISTANCE
Values of $\frac{1}{h}$

ε Emittance	Wind Velocity MPH	Insulation Resistance Min.	Max.	Operating Temperature (t) Degree F 200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
0.1	0 Convection / 2 Natural	1.0	2.5	1.15	1.07	1.02	0.98	0.91	0.87	0.83	0.80	0.78								
		2.5	5.0	1.30	1.21	1.17	1.12	1.05	1.00	0.95	0.92	0.89	0.87	0.85						
		5.0	10.0	1.47	1.36	1.30	1.24	1.17	1.12	1.07	1.04	1.01	0.98	0.96	0.94	0.92				
		10.0	15.0	1.57	1.42	1.43	1.35	1.27	1.21	1.17	1.12	1.10	1.07	1.05	1.03	1.01	0.99	0.97		
		15.0	20.0	1.65	1.57	1.51	1.46	1.35	1.27	1.22	1.19	1.15	1.13	1.10	1.08	1.06	1.05	1.04	1.02	1.01
		20.0	25.0	1.71	1.62	1.57	1.51	1.43	1.35	1.29	1.25	1.21	1.19	1.16	1.14	1.12	1.10	1.08	1.07	1.06
	2 Natural	1.0	2.5	0.71	0.66	0.63	0.61	0.57	0.54	0.52	0.51	0.50	0.53	0.52						
		2.5	5.0	0.81	0.75	0.71	0.69	0.64	0.60	0.58	0.56	0.54	0.53	0.59	0.58	0.57	0.56	0.55	0.54	0.53
		5.0	10.0	0.90	0.84	0.80	0.77	0.73	0.69	0.66	0.64	0.62	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53
		10.0	15.0	0.99	0.92	0.88	0.84	0.80	0.76	0.73	0.71	0.68	0.66	0.64	0.63	0.62	0.61	0.60	0.59	0.58
		15.0	20.0	1.05	0.99	0.94	0.89	0.84	0.80	0.77	0.74	0.72	0.70	0.68	0.67	0.66	0.65	0.64	0.63	0.62
		20.0	25.0	1.11	1.03	0.98	0.93	0.88	0.84	0.81	0.79	0.76	0.74	0.72	0.71	0.70	0.69	0.68	0.67	0.66
	4 Natural	1.0	2.5	0.58	0.54	0.51	0.49	0.46	0.43	0.42	0.41	0.40	0.44	0.43						
		2.5	5.0	0.65	0.61	0.58	0.55	0.52	0.50	0.48	0.46	0.45	0.49	0.48	0.47	0.46				
		5.0	10.0	0.74	0.69	0.65	0.62	0.59	0.56	0.54	0.52	0.51	0.54	0.53	0.52	0.51	0.50	0.49		
		10.0	15.0	0.80	0.75	0.71	0.67	0.64	0.61	0.59	0.57	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.51	0.50
		15.0	20.0	0.85	0.80	0.76	0.73	0.69	0.66	0.63	0.61	0.59	0.58	0.56	0.55	0.54	0.53	0.52	0.54	0.53
		20.0	25.0	0.90	0.84	0.80	0.76	0.72	0.68	0.65	0.63	0.61	0.60	0.59	0.58	0.57	0.56	0.55		
	8 Natural	1.0	2.5	0.45	0.42	0.40	0.39	0.36	0.34	0.33	0.32	0.31	0.33	0.34						
		2.5	5.0	0.52	0.49	0.46	0.44	0.41	0.39	0.37	0.36	0.35	0.39	0.38	0.38	0.37				
		5.0	10.0	0.58	0.54	0.52	0.50	0.47	0.44	0.42	0.41	0.40	0.43	0.42	0.41	0.40	0.39	0.39		
		10.0	15.0	0.65	0.61	0.57	0.54	0.51	0.49	0.47	0.45	0.44	0.47	0.45	0.44	0.43	0.42	0.41	0.41	0.40
		15.0	20.0	0.69	0.64	0.61	0.58	0.54	0.51	0.49	0.48	0.47	0.49	0.47	0.46	0.45	0.44	0.43	0.42	0.41
		20.0	25.0	0.72	0.67	0.64	0.61	0.57	0.54	0.52	0.51	0.50	0.49	0.48						
	12 Natural	1.0	2.5	0.39	0.37	0.35	0.33	0.31	0.29	0.28	0.28	0.27	0.30	0.29						
		2.5	5.0	0.44	0.42	0.40	0.38	0.36	0.34	0.32	0.31	0.30	0.32	0.31	0.33	0.32				
		5.0	10.0	0.50	0.48	0.45	0.43	0.40	0.38	0.37	0.36	0.35	0.34	0.33	0.34	0.33	0.32			
		10.0	15.0	0.55	0.52	0.49	0.47	0.45	0.43	0.41	0.39	0.38	0.37	0.36	0.36	0.35	0.34	0.34		
		15.0	20.0	0.60	0.56	0.53	0.51	0.48	0.45	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.36	0.36	0.35	0.35
		20.0	25.0	0.63	0.59	0.56	0.53	0.50	0.48	0.46	0.44	0.42	0.41	0.40	0.39	0.38	0.38	0.37	0.37	0.36
	20 Natural	1.0	2.5	0.32	0.30	0.29	0.27	0.26	0.25	0.24	0.24	0.24	0.25	0.25						
		2.5	5.0	0.37	0.35	0.32	0.31	0.29	0.28	0.27	0.26	0.25	0.25	0.27	0.27	0.27				
		5.0	10.0	0.42	0.40	0.38	0.36	0.33	0.31	0.30	0.29	0.29	0.28	0.27	0.29	0.29	0.29	0.28		
		10.0	15.0	0.47	0.45	0.42	0.40	0.38	0.36	0.34	0.32	0.31	0.30	0.30	0.29	0.30	0.30	0.30	0.29	0.29
		15.0	20.0	0.50	0.47	0.45	0.43	0.39	0.37	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.30	0.30	0.31	0.30
		20.0	25.0	0.52	0.50	0.48	0.45	0.43	0.40	0.38	0.36	0.35	0.34	0.33	0.32	0.32	0.32	0.31		

(Symbols and Abbreviations on Pages 208-210)

TABLE 9 (Continued)

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THEORY - HEAT TRANSFER

AIR FILM RESISTANCE
Values of $\frac{1}{h}$

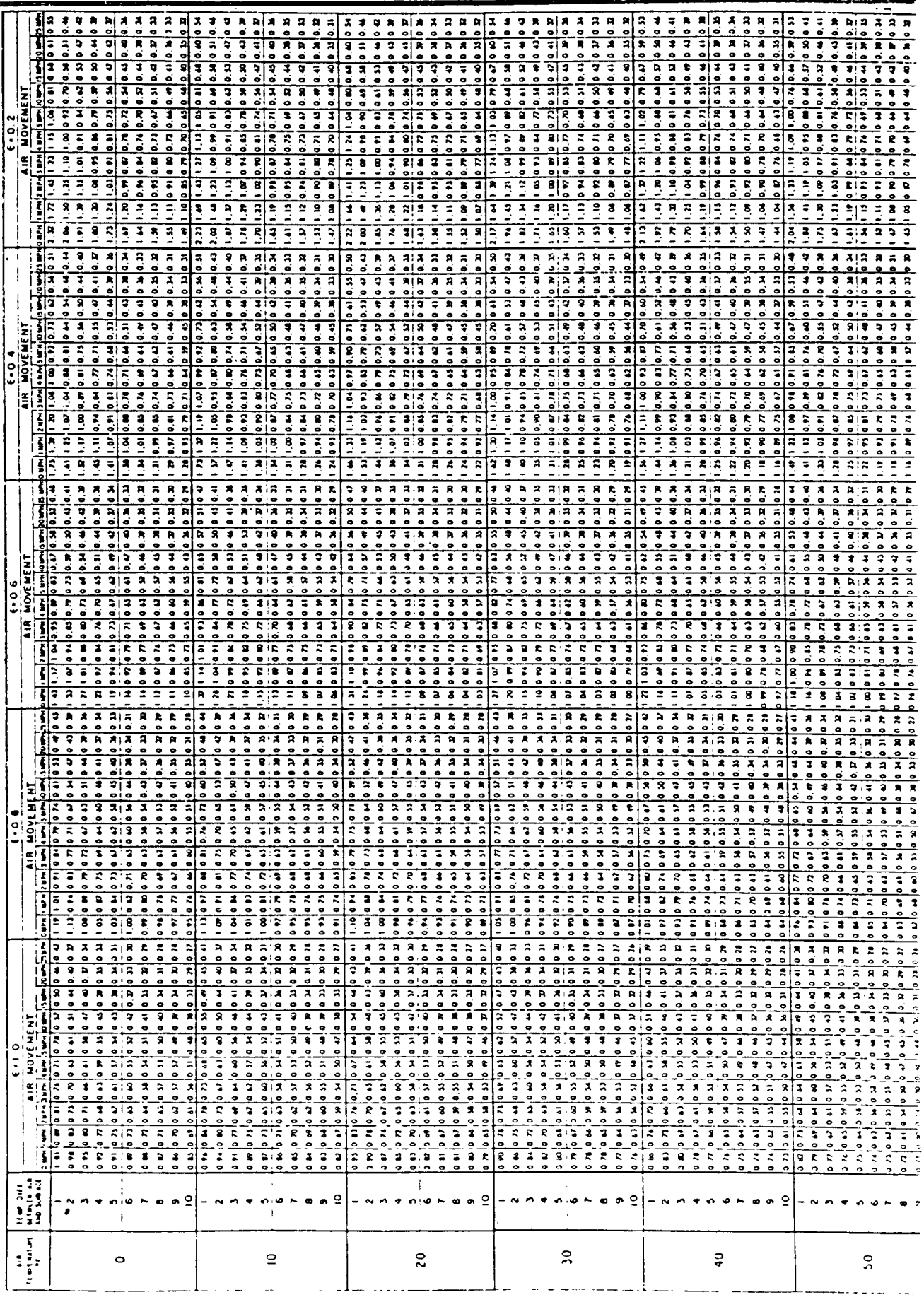
ε Emittance	Wind Velocity MPH	Insulation Resistance Min.	Insulation Resistance Max.	Operating Temperature (t_1) Degree F 200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
0.05	0 (Convection)	1.0	2.5	1.24	1.16	1.10	1.06	0.98	0.94	0.89	0.85	0.82								
		2.5	5.0	1.37	1.31	1.22	1.18	1.10	1.05	1.00	0.96	0.94	0.92	0.91						
		5.0	10.0	1.55	1.43	1.36	1.32	1.22	1.17	1.12	1.08	1.05	1.03	1.00	0.98	0.96				
		10.0	15.0	1.68	1.58	1.50	1.43	0.35	1.28	1.22	1.19	1.15	1.11	1.08	1.06	1.04	1.03	1.02		
		15.0	20.0	1.74	1.66	1.60	1.54	1.42	1.36	1.31	1.26	1.22	1.19	1.16	1.14	1.12	1.10	1.08	1.06	1.04
		20.0	25.0	1.83	1.72	1.66	1.60	1.49	1.42	1.36	1.33	1.29	1.24	1.21	1.19	1.16	1.14	1.12	1.11	1.10
	2	1.0	2.5	0.74	0.70	0.66	0.63	0.58	0.55	0.54	0.53	0.52	0.55	0.54						
		2.5	5.0	0.84	0.78	0.74	0.71	0.65	0.62	0.60	0.58	0.56	0.62	0.61	0.60	0.59				
		5.0	10.0	0.94	0.88	0.83	0.80	0.75	0.71	0.68	0.65	0.63	0.68	0.66	0.65	0.64	0.63	0.62		
		10.0	15.0	1.02	0.96	0.91	0.88	0.82	0.77	0.74	0.72	0.70	0.73	0.71	0.70	0.69	0.68	0.67	0.66	0.65
		15.0	20.0	1.09	1.01	0.97	0.94	0.88	0.83	0.79	0.77	0.75	0.78	0.74	0.72	0.71	0.70	0.69	0.68	0.67
		20.0	25.0	1.15	1.07	1.01	0.98	0.92	0.88	0.84	0.81	0.78	0.76	0.74	0.72	0.71	0.70	0.69	0.68	0.67
	4	1.0	2.5	0.60	0.55	0.52	0.50	0.46	0.44	0.42	0.41	0.41	0.45	0.44						
		2.5	5.0	0.67	0.63	0.60	0.57	0.53	0.50	0.48	0.47	0.46	0.50	0.49	0.48	0.47				
		5.0	10.0	0.76	0.71	0.67	0.64	0.61	0.57	0.55	0.53	0.51	0.55	0.54	0.53	0.52	0.51	0.50		
		10.0	15.0	0.82	0.78	0.74	0.71	0.66	0.63	0.61	0.59	0.57	0.60	0.59	0.57	0.56	0.55	0.54	0.53	0.52
		15.0	20.0	0.87	0.82	0.79	0.76	0.71	0.67	0.65	0.62	0.61	0.60	0.60	0.59	0.58	0.57	0.56	0.55	0.54
		20.0	25.0	0.93	0.86	0.82	0.78	0.75	0.71	0.67	0.65	0.63	0.61	0.60						
	8	1.0	2.5	0.46	0.43	0.41	0.39	0.37	0.35	0.34	0.33	0.32	0.36	0.35						
		2.5	5.0	0.53	0.50	0.47	0.44	0.42	0.40	0.38	0.37	0.36	0.39	0.38	0.38	0.38				
		5.0	10.0	0.59	0.56	0.53	0.51	0.47	0.45	0.43	0.41	0.40	0.39	0.42	0.42	0.41	0.41	0.40		
		10.0	15.0	0.66	0.61	0.58	0.56	0.52	0.50	0.48	0.46	0.44	0.45	0.42	0.42	0.41	0.43	0.42	0.42	0.41
		15.0	20.0	0.70	0.65	0.62	0.59	0.56	0.53	0.51	0.49	0.48	0.47	0.46	0.45	0.44	0.45	0.44	0.43	0.42
		20.0	25.0	0.74	0.69	0.65	0.63	0.58	0.55	0.53	0.51	0.50	0.49	0.48	0.47	0.46	0.45			
	12	1.0	2.5	0.40	0.37	0.36	0.34	0.32	0.30	0.29	0.29	0.28	0.31	0.30						
		2.5	5.0	0.45	0.42	0.40	0.39	0.37	0.35	0.33	0.32	0.31	0.34	0.33	0.33	0.33	0.35	0.35		
		5.0	10.0	0.51	0.47	0.44	0.42	0.41	0.39	0.37	0.36	0.35	0.37	0.36	0.36	0.36	0.35	0.37	0.36	0.36
		10.0	15.0	0.56	0.53	0.49	0.46	0.44	0.42	0.41	0.40	0.39	0.38	0.39	0.38	0.38	0.37	0.37	0.36	0.36
		15.0	20.0	0.61	0.56	0.53	0.50	0.46	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.39	0.39	0.38	0.38	0.37
		20.0	25.0	0.64	0.60	0.56	0.53	0.49	0.46	0.44	0.43	0.42	0.42	0.41	0.40	0.39				
	24	1.0	2.5	0.33	0.31	0.29	0.28	0.26	0.25	0.24	0.24	0.24	0.25	0.25						
		2.5	5.0	0.37	0.35	0.33	0.32	0.30	0.28	0.27	0.26	0.25	0.28	0.28	0.28	0.27				
		5.0	10.0	0.43	0.41	0.39	0.37	0.34	0.32	0.31	0.30	0.29	0.31	0.31	0.30	0.29	0.29	0.29		
		10.0	15.0	0.48	0.45	0.42	0.41	0.38	0.36	0.34	0.33	0.32	0.33	0.32	0.32	0.31	0.31	0.30	0.30	0.29
		15.0	20.0	0.51	0.48	0.46	0.44	0.40	0.38	0.36	0.35	0.34	0.35	0.34	0.33	0.32	0.32	0.31	0.31	0.31
		20.0	25.0	0.53	0.51	0.49	0.47	0.44	0.41	0.39	0.37	0.36								

(Symbols and Abbreviations on Pages 208-210)

TABLE 9 (Continued)

AIR FILM SURFACE RESISTANCE VALUES OF ' 1/h" OR "Rs"

Heat Transfer From Air To Lower Temperature Surface (Cold Service)



Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation De...
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UNION CARBIDE

STANDARD

CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

AIR FILM SURFACE RESISTANCE VALUES OF 'h' OR 'Rs'

Heat Transfer From Air To Lower Temperature Surface (Cold Service)

TABLE 10 (Contd)

(Symbols and Abbreviations on Page ____)

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THEORY - HEAT TRANSFER

1. HEAT TRANSFER - GENERAL - Continued

CALCULATION OF HEAT TRANSFER BY COMPUTER

The six most used heat transfer problems have been programmed on the UCC Time-Sharing Computer System. These programs are now operational and are set up so that all plants or departments connected to the Time-Sharing Computer can use these six programs.

The following is a brief review of the equations, the purpose of the calculation, instructions for use of these programs, and sample solutions.

In addition, tables of dimensions for inside and outside radii for pipe and tubing (R1 and R2); thermal conductivities for commonly used insulation materials (EK); surface emittance factors for weather barriers commonly used over insulation (EPS); and a table of conversions for change in wind velocity from miles per hour to feet per minute (V) are included. It should be noticed the symbols used are different than those previously used. This was necessary due to limitations of entering in symbols in the computer.

INTRODUCTION - Except in rare cases, certain equations employed by process and project design personnel for calculating heat transfer, cannot be solved directly. The solution of these equations is usually arrived at by a trial and error technique, a procedure which can be both tedious and time consuming. However, this type of problem is ideally suited to computerization, particularly on the UCC Time Sharing System.

The following heat transfer equations are in continuous use by UCC personnel, and their solution normally is both time consuming and certainly tedious, depending on how good the first assumptions are:

$$QA=\frac{(T1-T2)EK}{R2\ \mathrm{Log}_e(R2/R1)} = 0.174 \times EPS \left[\left(\frac{T2+460}{100}\right)^4 - \left(\frac{TA+460}{100}\right)^4\right] + 0.296(T2-TA)^{5/4}\left(\frac{V+68.9}{68.9}\right)^{1/2} \quad (1) \text{ for pipe}$$

$$QA=\frac{(T1-T2)EK}{EL} = 0.174 \times EPS \left[\left(\frac{T2+460}{100}\right)^4 - \left(\frac{TA+460}{100}\right)^4\right] + 0.296\,(T2-TA)^{5/4}\left(\frac{V+68.9}{68.9}\right)^{1/2} \quad (2) \text{ for flat surfaces}$$

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Where:

QA	=	HEAT LOSS OR GAIN, BTU/SQ. FT, HR.
T1	=	OPERATING TEMPERATURE, DEG. F
T2	=	SURFACE TEMP OF INSULATION PROTECTIVE COVER, DEG F
TA	=	AMBIENT AIR TEMPERATURE, DEG F
R1	=	INSIDE RADIUS OF INSULATION, INCHES
R2	=	OUTSIDE RADIUS OF INSULATION, INCHES
EL	=	THICKNESS OF INSULATION, INCHES
EK	=	CONDUCTIVITY OF INSULATION, BTU/SQ. FT., HR, INCHES
EPS	=	SURFACE EMITTANCE, RATIO TO BLACK BODY
V	=	VELOCITY OF WIND, FT./MIN.

As noted, equation (1) pertains to insulated pipe, and equation (2) to insulated flat surfaces.* The middle term in the three part equation calculates the heat transfer through an insulated wall by conduction, whereas the right hand terms calculate the same heat flow to or from the atmosphere by a combination of radiation and convection. For a specific problem, the input data for all terms in the formulas will be known or can be obtained, but two. The two unknowns are then obtained by simultaneous solution of the two heat flow equations.

There are three typical problems normally encountered in process or project design that employ equations (1) or (2).

Solutions are needed to define:

1. The heat loss or gain for a given thickness of insulation. Numerical values for all terms in the equations are known except for QA and T2.

2. The required thickness of insulation for a specified heat loss or gain. Numerical values for all terms are known except for R2** and T2.

3. The required thickness of insulation to limit the outside surface temperature, T2, of the insulation jacket or covering to some predetermined amount. Numerical values for all terms are known except for R2** and QA.

The computer programs listed in the following table are operational on the UCC Time Sharing System, and are filed under User Number C693:

* The walls of process vessels over 36 inches in diameter may be considered as flat surfaces.

** For flat surfaces, the required insulation thickness is defined by the term "EL".

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A - Insulated Pipe (Formula 1)

Program Name	Purpose	Formula Terms: Known	Formula Terms: To Be Calculated
INSQAP	For calculation of heat loss or gain.	T1, TA, R1, R2, EK, EPS, V	QA, T2
INSTHP	For calculation of the required insulation thickness for a specified heat loss or gain.	T1, TA, R1, QA, EK, EPS, V	R2, T2
INST2P	For calculation of the required insulation thickness to assure a specified maximum temperature at the outer surface of the insulation jacket.	T1, TA, R1, T2, EK, EPS, V	R2, QA

B - Insulated Flat Surfaces (Formula 2)

INSQAF	For calculation of heat loss or gain.	T1, TA, EL, EK, EPS, V	QA, T2
INSTHF	For calculation of required insulation thickness for a specified heat loss or gain.	T1, TA, QA, EK, EPS, V	EL, T2
INST2F	For calculation of required insulation thickness to assure a specified maximum temperature at the outer surface of the insulation.	T1, TA, T2 EK, EPS, V	EL, QA

Operating Peocedure - The operating procedure may be outlined as follows:

1. Call computer using assigned USER NUMBER.
2. After the computer acknowledges the "USER NUMBER", it will ask, "NEW OR OLD".
3. Computer will ask for Program Name. Type in name of the desired program (INSQAP, INSTHP, INST2P, INSQAF, INSTHF, INST2F, C-693). For example, INSQAP, C-693. Note that it is necessary to type "C-693", preceded by comma after the program name each time.

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4. After computer responds with "READY", type in "RUN".

5. The computer will type out the program title, then will ask whether definition of variables is wanted. After the question mark appears, print "YES" if definitions are wanted; otherwise type "NO".

6. After the definitions are typed in following "YES"; or immediately after "NO", the computer will print a line number followed by another question mark. This is an invitation to type in the data.

7. The data for each program must be typed in the exact order as listed in the proceding table. Any variation in order will result in erroneous answers.

8. The numerical value of each known term, must be typed in the correct sequence on the same line, and each term must be separated by a comma.

9. After all data has been typed in, the "return" key is punched.

10. The computer will first print out the input data. This permits the operator to check the accuracy of his input.

11. The calculated results will then be printed by the computer.

12. Following solution of a problem, the computer is programmed to request data for a second problem without going thru the routine of inquiring whether definitions are wanted.

13. If there is no second problem, type "STOP".

14. After print-out of running time, the computer will print "READY".

15. Type "BYE" to release the computer.

NOTE: After each typed direction by the Operator, it is necessary to punch the "Return" key, returning the teletypewriter carriage to the extreme right.

REPRESENTATIVE EXAMPLES

1 - EXAMPLE NO. 1

UNION CARBIDE TIME SHARING

ON AT -- 08:14 TTY: 24

USER NUMBER: Assigned User Number

TCH-2000-4613 (Terminal identification typed in by computer)

TYPE OLD OR NEW: Old

PROGRAM NAME: INSTHP, C-693

```
READY
RUN

INSTHP   08:15        UCC   TUESDAY   02/11/69

    CALCULATION OF INSULATION THICKNESS FOR A SPECIFIED HEAT
    LOSS OR GAIN, QA - INSULATED PIPE

    DO YOU WANT DEFINITIONS OF THE VARIABLES?
    TYPE YES OR NO
INPUT: 00150
?YES

    DEFINITIONS

    QA = HEAT LOSS OR GAIN, BTU/SQ FT, HR
    T1  = OPERATING TEMPERATURE, DEG. F
    T2  = SURFACE TEMP OF OUTER INSULATION JACKET, DEG F
    TA  = AMBIENT AIR TEMPERATURE, DEG. F
    R1  = INSIDE RADIUS OF INSULATION, INCHES
    R2  = OUTSIDE RADIUS OF INSULATION, INCHES
    EK  = CONDUCTIVITY OF INSULATION , BTU/SQ FT, HR IN
    EPS = SURFACE EMITTANCE, RATIO TO BLACK BODY
    V   = VELOCITY OF WIND, FT/MIN

    WHEN QUESTION MARK APPEARS, TYPE IN DATA
INPUT: 00320 (Example 1A)
? 500, 90, 3, 29.3, .3, .8, 1760

    T1=   500.0        TA=   90.0        R1=   3.000        QA=   29.3

    EK=   0.3000       EPS=  0.8000      V=    1760.0

    T2=   98.3 DEGREES                   R2=   5.974 INCHES

INPUT: 00320 (Example 1B)
? -150, 90, 3, 17.1, .3, .8, 1760.

    T1=   -150.0       TA=   90.0        R1=   3.000        QA=   17.1

    EK=   0.3000       EPS=  0.8000      V=    1760.0

    T2=   84.7 DEGREES                   R2=   5.976 INCHES
```

```
INPUT: 00320
? STOP

RT802  00320

RUNNING TIME:  06.9 SECS    I/O TIME:  09.6 SECS

READY
BYE
OFF AT 08:19
```

2 - EXAMPLE NO. 2

```
INSOAF  08:20        UCC    FRIDAY  02/07/69

    CALCULATION OF HEAT LOSS OR GAIN
        INSULATED FLAT SURFACES

    DO YOU WANT DEFINITIONS OF THE VARIABLES?
    TYPE YES OR NO
INPUT: 00150
? NO

INPUT: 00320 (Example 2A)
? 750, 80, 4, .4, .9, 880.

    T1=   750.0          TA=   80.0          EL=   4.000

    EK=   0.4000         EPS=  0.9000        V=    880.0

    T2=   99.5 DEGREES                       QA=   65.3 BTU

INPUT: 00320 (Example 2B)
? -200, 80, 4, .4, .9, 880.

    T1=   -200.0         TA=   80.0          EL=   4.000

    EK=   0.4000         EPS=  0.9000        V=    880.0

    T2=   70.6 DEGREES                       QA=   27.1 BTU
```

3 - EXAMPLE NO. 3

INST2F 09:13 UCC FRIDAY 02/07/69

CALCULATION OF REQUIRED INSULATION THICKNESS TO ASSURE A SPECIFIED OUTSIDE SURFACE TEMPERATURE, T2 - INSULATED FLAT SURFACES

DO YOU WANT DEFINITIONS OF THE VARIABLES?
TYPE YES OR NO
INPUT: 00160
? NO

INPUT: 00330 (Example 3A)
? 750, 80, 99.5, .4, .9, 880.

T1= 750.0 TA= 80.0 T2= 99.5

EK= 0.4000 EPS= 0.9000 V= 880.0

QA= 65.3 BTU EL= 3.984 INCHES

INPUT: 00330 (Example 3B)
? -200, 80, 70.6, .4, .9, 880.

T1= -200.0 TA= 80.00 T2= 70.6

EK= 0.4000 EPS= 0.9000 V= 880.0

QA= 27.1 BTU EL= 3.992 INCHES

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APPENDIX

Derivation of Program Names

INSQAP

INS-QA-P

Insulation - Heat Transfer - Pipe

INSQAF

INS-QA-F

Insulation - Heat Transfer - Flat Surface

INSTHP

INS-TH-P

Insulation - Thickness - Pipe

INSTHF

INS-TH-F

Insulation - Thickness - Flat Surface

INST2P

INS-T2-P

Insulation - Term for Surface Temp. - Pipe

INST2F

INS-T2-F

Insulation - Term for Surface Temp. - Flat Surface

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INNER AND OUTER RADII OF INSULATION FOR NPS PIPE

BASED ON AVERAGE TOLERANCE

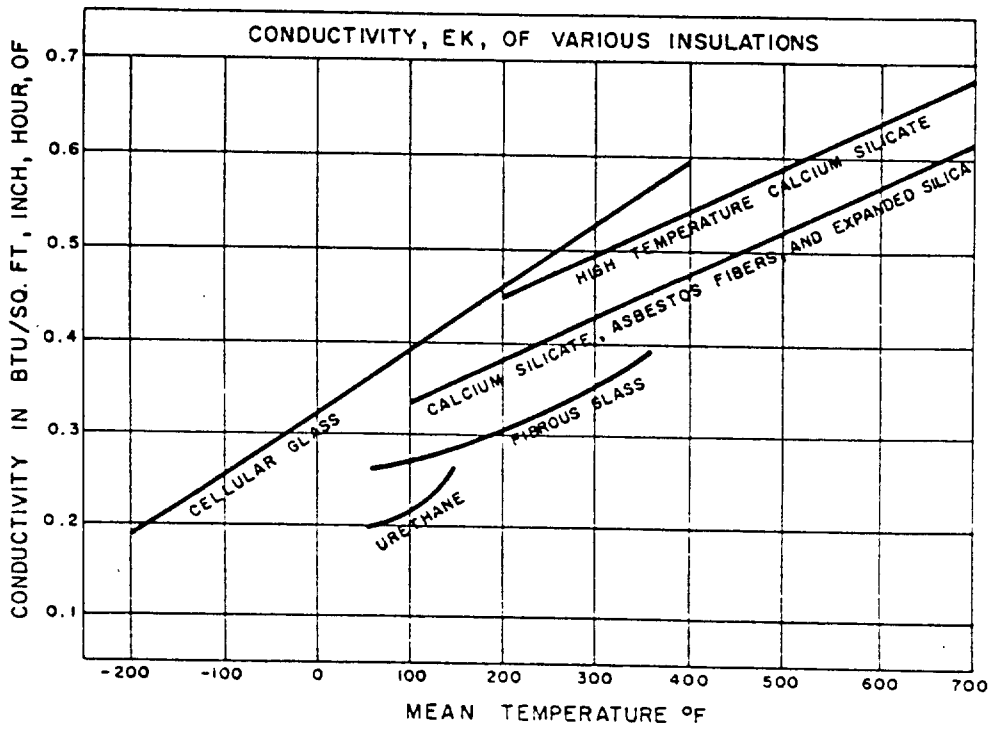
NPS Pipe Size	Inside Radius of Insul. R1	Outer Radius Inches R2 — Nominal Insulation Thickness												
		1	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7
3/8	0.39	1.44	2.00	2.50	2.78	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50
½	0.45	1.44	2.00	2.50	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00
3/4	0.56	1.44	2.00	2.50	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00
1	0.69	1.75	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00
1¼	0.86	1.75	2.50	2.78	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00
1½	0.98	2.00	2.50	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00	8.50
2	1.24	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00	8.50
2½	1.49	2.50	3.31	3.81	4.31	4.81	5.37	5.82	6.37	6.37	7.00	7.50	8.00	8.50
3	1.80	2.78	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00	8.50	9.00
3½	2.05	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.00	7.50	8.00	8.50	9.00
4	2.30	3.31	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00	8.50	9.00	9.50
4½	2.55	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00	8.50	9.00	9.50	10.00
5	2.83	3.81	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00	8.50	9.00	9.50	10.00
6	3.37	4.31	4.81	5.37	5.82	6.37	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50
7	3.87		5.37	5.82	6.37	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50	11.00
8	4.37		5.82	6.37	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50	11.00	11.50
9	4.87		6.37	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50	11.00	11.50	12.00
10	5.40		7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50	11.00	11.50	12.00	12.50
11	5.90		7.50	8.00	8.50	9.00	9.50	10.00	10.50	11.00	11.50	12.00	12.50	13.00
12	6.40		8.00	8.50	9.00	9.50	10.00	10.50	11.00	11.50	12.00	12.50	13.00	13.50
14	7.08		8.50	9.00	9.50	10.00	10.50	11.00	11.50	12.00	12.50	13.00	13.50	14.00
16	8.08		9.50	10.00	10.50	11.00	11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00
18	9.08		10.50	11.00	11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00	15.50	16.00
20	10.08		11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00	15.50	16.00	16.50	17.00
22	11.08		12.50	13.00	13.50	14.00	14.50	15.00	15.50	16.00	16.50	17.00	17.50	18.00
24	12.08		13.50	14.00	14.50	15.00	15.50	16.00	16.50	17.00	17.50	18.00	18.50	19.00
30	15.08		16.50	17.00	17.50	18.00	18.50	19.00	19.50	20.00	20.50	21.00	21.50	22.00
36	18.06		19.50	20.00	20.50	21.00	21.50	22.00	22.50	23.00	23.50	24.00	24.50	25.00

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INNER AND OUTER RADII OF INSULATION FOR TUBES

BASED ON AVERAGE TOLERANCE

Nom. Tube Size	Outside Diameter of Tube Inches	Inside Radius of Insul. Inches, R1	Outside Radius of Insulation - Inches R2										
			Nominal Insulation Thickness										
			1	1½	2	2½	3	3½	4	4½	5	5½	6
¼	0.250	0.15	1.44	1.75	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37
3/8	0.375	0.21	1.44	1.75	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37
½	0.500	0.28	1.44	1.75	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37
½	0.625	0.34	1.44	1.75	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37
3/4	0.750	0.40	1.44	2.00	2.50	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00
3/4	0.875	0.46	1.44	2.00	2.50	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00
1	1.000	0.53	1.44	2.00	2.50	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00
1	1.125	0.59	1.44	2.00	2.50	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00
1¼	1.250	0.65	1.75	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00
1½	1.500	0.78	1.75	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00
1½	1.625	0.84	1.75	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00
2	2.000	1.03	2.00	2.50	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50
2	2.125	1.09	2.00	2.50	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50
2½	2.500	1.28	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50
2½	2.625	1.34	2.25	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50
3	3.000	1.53	2.50	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50	8.00
3	3.125	1.59	2.50	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50	8.00
3⅝	3.625	1.84	2.78	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50	8.00
4	4.000	2.05	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50	8.00	8.50
4	4.125	2.11	3.31	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50	8.00	8.50
5	5.000	2.55	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50	8.00	8.50	9.00
5	5.125	2.61	3.81	4.31	4.81	5.37	5.87	6.37	7.00	7.50	8.00	8.50	9.00
6	6.000	3.05	4.31	4.81	5.37	5.87	6.37	7.00	7.50	8.00	8.50	9.00	9.50
6	6.125	3.11	4.31	4.81	5.37	5.87	6.37	7.00	7.50	8.00	8.50	9.00	9.50
8	8.000	4.05		5.87	6.37	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50
8	8.125	4.11		5.87	6.37	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50
10	10.000	5.05		6.37	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50	11.00
10	10.125	5.11		7.00	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50	11.00



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APPROXIMATE VALUES OF EMITTANCE, EPS, OF MASTICS AND JACKETS

MATERIAL	EMITTANCE, EPS NEW	EMITTANCE, EPS OLD
Aluminum Jacket	.05	.08 to .10
Stainless Steel Jacket	.30	.45 to .50
Treated Steel Jacket (Medium Gray Painted Surface)	.75	.65 to .75
Treated Steel Jacket (Painted with Gloss White)	.25	.40 to .50
Mastic (Acrylic or PVA) Dark Gray	.80	.85 to .90
Mastic (Acrylic or PVA) White	.50	.65 to .75
Mastic (Asphalt)	.90	.93 to .97

CONVERSION TABLE OF WIND VELOCITY FROM MILES PER HOUR TO FEET PER MINUTE, V

WIND (OR AIR) VELOCITY					
MILES PER HOUR	FEET PER MIN. V	MILES PER HOUR	FEET PER MIN. V	MILES PER HOUR	FEET PER MIN. V
1	88	11	968	21	1848
2	176	12	1056	22	1936
3	264	13	1144	23	2024
4	352	14	1232	24	2112
5	440	15	1320	25	2200
6	528	16	1408	30	2640
7	616	17	1496	35	3080
8	704	18	1584	40	3520
9	792	19	1672	45	3960
10	880	20	1760	50	4400

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THEORY - ECONOMIC THICKNESS

II. ECONOMIC EQUATIONS

As the thickness of insulation is increased, the cost of heat loss per year of insulation is increased. The thickness at which the sum of these two costs is a minimum is obviously the most economical.

For flat surfaces this may be determined

When C — Cost constant (this is eliminated in final derivation)
When L — Most economical thickness
When B — Cost of insulation factor
When R — The sum of all thermal resistances, including film resistance, other than the insulation
When k — Conductivity of the insulation
When Y — Hours of operation per year
When t_o — Operating temperature
When t_{av} — Average temperature of surrounding air
When M — Value of heat, in dollars per 1,000,000 Btu
When B_p — Cost factor for pipes in $/lin ft, yr, in
When B_s — Cost factor for flat surfaces $/sq ft, yr, in

Then

$$L = \left(\frac{Y (t_o - t_{av}) M}{\frac{1,000,000}{B}} \times k \right)^{1/2} - Rk \qquad \text{(Equation 20)}$$

For one layer cylindrical material (including one air film)

From the cost per linear foot, B is determined by the following equation

$$B = (B_p - C) \frac{12}{2\pi r_2} (r_2 - r_1) \qquad \text{(Equation 21)}$$

When R_s = Surface resistance
k_1 = Conductivity of insulation

Then solve for r_2 by trial and error, which determines (L)

$$\left(r_2 \operatorname{Log}_e \frac{r_2}{r_1} + R_s k_1 \right) \left(\frac{2r_2 - r_1}{r_2 - R_s k_1} \right)^{1/2} = \left(\frac{Y (t_a - t_{av}) M}{\frac{1,000,000}{B}} \times k_1 \right)^{1/2} \qquad \text{(Equation 22)}$$

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THEORY - ECONOMIC THICKNESS

II. ECONOMIC EQUATIONS - Continued

For two-layer cylindrical material (including one air film) the equation when r_s is outer radius and k_2 conductivity of other insulation, is

$$\left[r_s \operatorname{Log}_e \frac{r_s}{r_2} + \frac{r_s}{r_1} \left(\frac{r_s \operatorname{Log}_e \frac{r_2}{r_1}}{k_2} \right) k_1 + R_s k_1 \right] \left(\frac{2r_s - r_2}{r_s - R_s k_1} \right)^{1/2} = \left(\frac{Y (t_o - t_{av}) M}{\frac{1,000,000}{V}} \times k_1 \right)^{1/2}$$

(Equation 23)

These equations have been electronically calculated for most conditions on high temperature insulation, and are published in manual "Economic Thickness of Insulation for Flat Surfacesand Pipes".

Using this "Economic Thickness" manual, and specific cost at each plant, the economic thickness tables of UCC plants for steam lines and steam heated process equipment and lines have been calculated. These are in Section III of this manual.

These tables are correct only when the basic heat medium is steam.

The economic thickness for Dowtherm heated equipment and lines were not calculated for various plants for it was found the Dowtherm heated process costs differed considerably from one unit to another within a single plant. In general, Dowtherm heat is higher than steam cost so it justifies greater insulation thickness, but any economic thickness table must be based on the heat cost of the unit being considered.

The same holds true for any process heated by direct fire, electric, or hot water. The correct insulation thickness must be based on the individual unit in question.

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THEORY - THICKNESS TO PREVENT CONDENSATION

III. THICKNESS TO PREVENT CONDENSATION

On low temperature service it is frequently necessary to calculate the thickness of the insulation so that its surface temperature is above dew point.

The insulation thickness to prevent condensation is only one consideration in final choice of insulation thickness. Another consideration may be the economic thickness of insulation based on conservation of energy and investment in refrigeration equipment. In cases of storage of expensive liquefied gases the rate of boil-off of gas determines the required insulation thickness, or safety requirements may dictate that insulation thickness must be sufficient to protect contents of vessels or pipes for given length of time. Therefore, the problem must be considered in all its aspects to assure a properly engineered installation.

This section presents the reasons for maintaining the outer weather-vapor barrier above dew point, the factors involved in determining dew point, the basic formulas for calculating thickness of insulation whose outer surface temperature will be above dew point, tables for the solution of the problem, and illustrative examples.

The method presented, as compared to other methods, considers all of the factors which have a bearing on the determination of the thickness. Although the system is complex, an accurate answer can be obtained by use of the tables and a simple computation.

When dry, most insulations are quite effective. When insulation becomes wet, its effectiveness is impaired. The conductivity of wet insulation can be from 16 to 20 times greater than dry insulation. It is thus apparent why insulation must be kept dry.

Insulation must be protected from two forms of moisture: (1) in the liquid state and, (2) in the vapor state. The protection from moisture in liquid state, such as rain, is provided by a weather barrier. The protection from moisture in the vapor state is provided by a vapor barrier. In many instances both are provided by a single material -- a weather-vapor barrier.

The above points out the importance of weather and vapor barriers. However, to protect the insulation, the vapor barrier must remain effective.

Many experiments have shown that when the surface of a vapor barrier is wet with liquid water its transmission of moisture is approximately four times that than when the surface is dry. This more rapid transmission of moisture shortens the effective life of the insulation.

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THEORY - THICKNESS TO PREVENT CONDENSATION

III. THICKNESS TO PREVENT CONDENSATION - Continued

In addition to protection of the insulation from moisture, there are other practical reasons why the surface snould be above design dew point. These are:

1. Water dripping or flowing onto steel columns, beams or equipment causes excessive rusting.

2. Continually wetted surfaces become moldy and slippery.

3. Continually wetted surfaces are impossible to coat with mastic or to paint.

4. The weather-vapor barrier deteriorates more rapidly when continually wetted.

Unfortunately, no thickness of insulation installed on a low temperature surface can prevent condensation on its weather-vapor barrier wnen ambient relative humidity reaches 100%. However, periods of 100% relative humidity are generally short so that insulation thickness can be provided which can prevent excessive condensation until the relative humidity drops to a more reasonable percentage. Selection of design conditions of air temperature and relative humidity should be such that they are not expected to be exceeded for any extended length of time.

Due to the variables in weather conditions and other factors surrounding a given installation, no general recommendation of "design" conditions can be made in this manual. The engineer must analyze the conditions to which the installation is to be subjected. Expected maximum temperature; proximity to moisture producing equipment, such as steam discharge or cooling towers; ventilation; location, such as above decorative ceilings; will need to be considered in determining the ambient air temperature and relative humidity to which he must design.

Good judgment must be exercised in selecting realistic conditions. Conditions that are too severe require an excess of insulation and conditions that are too mild result in insufficient insulation, allowing surface condensation too much of the time.

After design ambient air dry-bulb and wet-bulb temperatures have been selected, this method can be used to arrive at required insulation thickness to prevent condensation under those conditions.

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THEORY - THICKNESS TO PREVENT CONDENSATION

MATHEMATICAL SOLUTION

Previous approaches to this problem depended upon equating the temperature difference across the insulation, divided by the insulation resistance, to the temperature difference across the air film divided by the air film resistance. The air film resistance was assumed. Any error in the assumed value of the air film resistance caused a corresponding error in the calculated insulation thickness. Using the assumed air film resistance method, errors of insulation thickness can range from 50% more insulation than needed to 33% of the thickness of insulation required.

The mathematical method of solving the problem is based on calculating the heat gain from the ambient air to the lower temperature surface. It eliminates the need for guessing at the air film resistance.

Solution to this problem is divided into three basic steps:

Step 1. Determination of Design Surface Temperature
Step 2. Determination of Surface Heat Gain
Step 3. Determination of Insulation Thickness

A. Step 1 is no different from any other method of determining insulation thickness to prevent condensation. The surface temperature to which the installation must be designed depends upon the conditions to which the installation is subjected. Tables I and II are provided in this manual to eliminate the need for a psychometric chart. To prevent condensation the insulation surface temperature must be slightly above dew point.

B. Step 2 is the key to the solution of the problem. The heat gain from ambient air to the lower temperature surface by radiation and convection determines the maximum allowable heat flow through the insulation if the design surface temperature is to be maintained. The radiation heat gain and convection heat gain must be found separately, then added together to obtain total heat gain.

When q_a = Total heat gain to surface

q_{ra} = Heat gain due to radiation

q_{ca} = Heat gain due to convection

$q_a = q_{ra} + q_{ca}$

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THEORY - THICKNESS TO PREVENT CONDENSATION

MATHEMATICAL SOLUTION - Continued

B. Step 2 - Continued

Table III gives the values of radiation heat transfer rates in reference to absolute zero. It is based on Stefan - Boltzmann Formula:

When q_r = Radiation heat transfer rate from a body at temperature to a body at absolute zero

ϵ = Absorptance which is 1.00 (black body conditions)

t = Temperature of body °F

$q_{ra} = 0.174 \times 10^{-8} \therefore (t + 460)^4$

Since we are concerned with radiation between the surface and ambient air and absorptance other than 1.00

When q_{ra} = Radiation heat transfer rate from ambient air and surrounding bodies at temperature t_a to the insulation surface at a temperature t_2

ϵ = Absorptance of the insulation surface or its outer barrier

Then $q_{ra} = \left\{\left[0.174 \times 10^{-8} (t_a + 460)^4\right] - \left[0.174 \times 10^{-8} (t_2 + 460)^4\right]\right\} \epsilon$

The values of the expression $0.174 \times 10^{-8} (t + 460)^4$ have been calculated for different values of t_a and are tabulated in Table III. Using the temperature of $t_a = t$ the value of the expression $0.174 \times 10^{-8} (t_a + 460)^4$ can be determined. In similar manner the value of the expression $0.174 \times 10^{-8} (t_2 + 460)^4$ can be determined using temperature $t_2 = t$. Multiplying the difference of these values by the correct value of ϵ will determine q_{ra}. This multiplication has been precalculated in Table IV.

As surface heat gain due to solar radiation lessens the possibility of condensation, the heat gain to insulated vessels and pipes located outdoors where they are exposed to solar heat is not included in this manual. If for reasons other than condensation control, the maximum heat gain rate must be known, solar radiation must be taken into consideration.

The cooling effect of radiation from the insulation surface into space during darkness also has not been considered because it is not practical to attempt to insulate for this condition.

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THEORY - THICKNESS TO PREVENT CONDENSATION

MATHEMATICAL SOLUTION - Continued

B. Step 2 - Continued

Table V gives values of convection heat transfer rates for various conditions of shape, size and position of surfaces. The proper table and correction factor, dictated by installation conditions, must be selected. In case the installation has several conditions and it is impractical to have various insulation thicknesses, then the most severe condition is the controlling factor. These tables are based on the Heilman Formula:

When q_{ca} = Convection heat gain for Δt

C = A constant depending on shape of surface (horizontal cylinders, C = 1.016, etc.)

D = Outside diameter of cylindrical surface or height of vertical flat surface. (For anything 24 inches or more use values listed for 24)

T = Average absolute temperature. For this study this was taken as 540R (80F).
Note: A change to 500R would produce an error of slightly more than 1%

Δt_1 = Dry bulb ambient air temperature (t_a) less design insulation surface temperature (t_2)

Then $$q_{ca} = C \left(\frac{1}{D}\right)^{02} \left(\frac{1}{T}\right)^{0.181} \left(\Delta t_1\right)^{1.266}$$

The effect of a forced air velocity has not been considered, as air velocity most often will tend to retard condensation due to faster evaporation. If for other reasons other than condensation control, the maximum heat rate must be known, then air velocity must be considered. To obtain convection loss for a certain forced air velocity, all that is necessary is to multiply q_{ca} by $\sqrt{\frac{V + 68.9}{68.9}}$ when V equals air velocity in feet per minute.

The insulation (or its outer barrier) surface heat gain rate q_a is found by:

$$q_a = q_{ra} + q_{ca}$$

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THEORY - THICKNESS TO PREVENT CONDENSATION

MATHEMATICAL SOLUTION - Continued

B. Step 2 - Continued

This q_a is the key factor for design of insulation to prevent condensation. It is the maximum allowable surface heat gain rate if the design surface temperature is to be maintained. Under static conditions the heat gain to a surface must equal the heat loss from that surface, thus, all that remains is to determine the thickness of insulation which provides sufficient resistance so that the heat flow from the outer surface, of "design" temperature t_2, to inner surface, of temperature t_1 (operating) is equal or less than q_a.

C. Step 3 - The required resistance to heat flow is determined. Table VI gives the values of resistance R. This table is based on the following formula:

When q_a = Heat gain to the surface of the insulation and through insulation

Δt_2 = Design surface temperature t_2 less operating temperature t_1 of pipe or equipment

R = Thermal resistance

Then $q_a = \dfrac{\Delta t_2}{R}$

Table VII gives the flat surface (or equivalent) thickness. This table is based on the following formula:

When L = Insulation thickness, flat surface (or equivalent)

k = Conductivity of insulation, Btu/sq ft, hr, in °F

Then $L = Rk$

The thickness L is the minimum thickness of insulation on flat surfaces to prevent condensation. However, L is equivalent thickness of insulation to prevent condensation on curved surfaces. Table VII provides the conversion from equivalent thickness to nominal thicknesses of pipe covering, and actual insulation thickness for small diameter equipment. This formula is based on the formula:

$$L = r_2 \operatorname{Log}_e \frac{r_2}{r_1}$$

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THEORY - THICKNESS TO PREVENT CONDENSATION

MATHEMATICAL SOLUTION - Continued

C. Step 3 - Continued

When r_1 = Inner radius of insulation

r_2 = Outer radius of insulation

The above r_1 and r_2 were used to calculate Table VIII, but do not appear in the tabulation, as tabulation is presented in NPS pipe diameters and nominal thicknesses are those manufactured for certain combinations of $r_2 - r_1$.

The curved thickness is selected so that its equivalent thickness is equal to or more than required thickness L for flat surface.

A diagram of this method for selection of insulation thickness to prevent condensation is shown on Page 7.

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THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEET

Although the mathematical solution appears relatively complex, the actual solution to a problem is easy. Selection of proper design wet and dry bulb temperatures is based on installation requirements. After this selection is made, determination of insulation thickness to prevent condensation can be made by using the tables in this manual.

A. Step 1 - Determination of Design Surface Temperature

Using the selected dry-bulb (t_a) and wet-bulb temperatures, the percent relative humidity is found in Table I.

Using the selected dry bulb (t_a) and determined relative humidity, the dew-point temperature is found in Table II.

The design surface temperature (t_2) must be slightly higher than dew point. Add 1°F to dew-point temperature to obtain design surface temperature.

B. Step 2 - Determination of Surface Heat Gain

The total heat gain by radiation (q_{ra}) and convection (q_{ca}) to the surface at temperature t_2 from ambient air at temperature t_a must be determined.

Radiation gain is found by determining the difference in radiation levels of surface temperature t_2 and ambient temperature t_a in reference to absolute zero.

Determine radiation level of ambient temperature t_a using Table III. From this, subtract the radiation level of surface temperature t_2. The result is radiation from t_a to t_2 if the surface has black body absorptance (ϵ) equal to one. Should surface absorptance be a ratio less than one, the previous determined result is multiplied by the proper absorptance ratio ϵ. This multiplication is found in Table IV. This final result is the heat gain by radiation q_{ra}.

Convection heat gain (q_{ca}) is found using the proper column in Table V. The heat gain by convection (q_{ca}) is found opposite the proper temperature difference, t_1 ($t_1 = t_a - t_2$) between air and surface. In some instances this result must be multiplied by a correction factor as shown at bottom of table.

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THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEET - Continued

B. Step 2 - Determination of Surface Heat Gain - Continued

Add radiation heat gain (q_{ra}) and convection heat gain (q_{ca}) to obtain total heat gain (q_a). This is also maximum allowable heat transfer through the insulation (q_1).

C. Step 3 - Determination of Insulation Thickness

Using maximum allowable heat transfer through the insulation q and the temperature difference across the insulation Δt_2 (which equals the operating temperature t_1 subtracted from the outer surface temperature t_2) the required thermal resistance (R) of the insulation is found in Table VI.

Using required thermal resistance, R, and the conductivity of insulation (k) the flat surface (or equivalent) thickness of insulation (L) is found in Table VII. This thickness table gives thickness, L, in decimals. The insulation's actual thickness must be that which is commercially available and is equal to or slightly larger than the figure given. This is the thermal insulation thickness required to prevent condensation for flat surfaces.

Using the flat surface thickness, L, for various pipe sizes, the nominal thickness required can be found in Table VIII. This is the thermal insulation thickness for pipe, or curved surfaces, required to prevent condensation.

To assist in the use of these tables, a work sheet has been prepared and several illustrative examples are given.

D. Illustrative Examples

Three design problems applying different ambient air conditions, different installation requirements and different insulations are presented to illustrate the use of the tables to determine the insulation thickness to prevent condensation.

1. Example 1

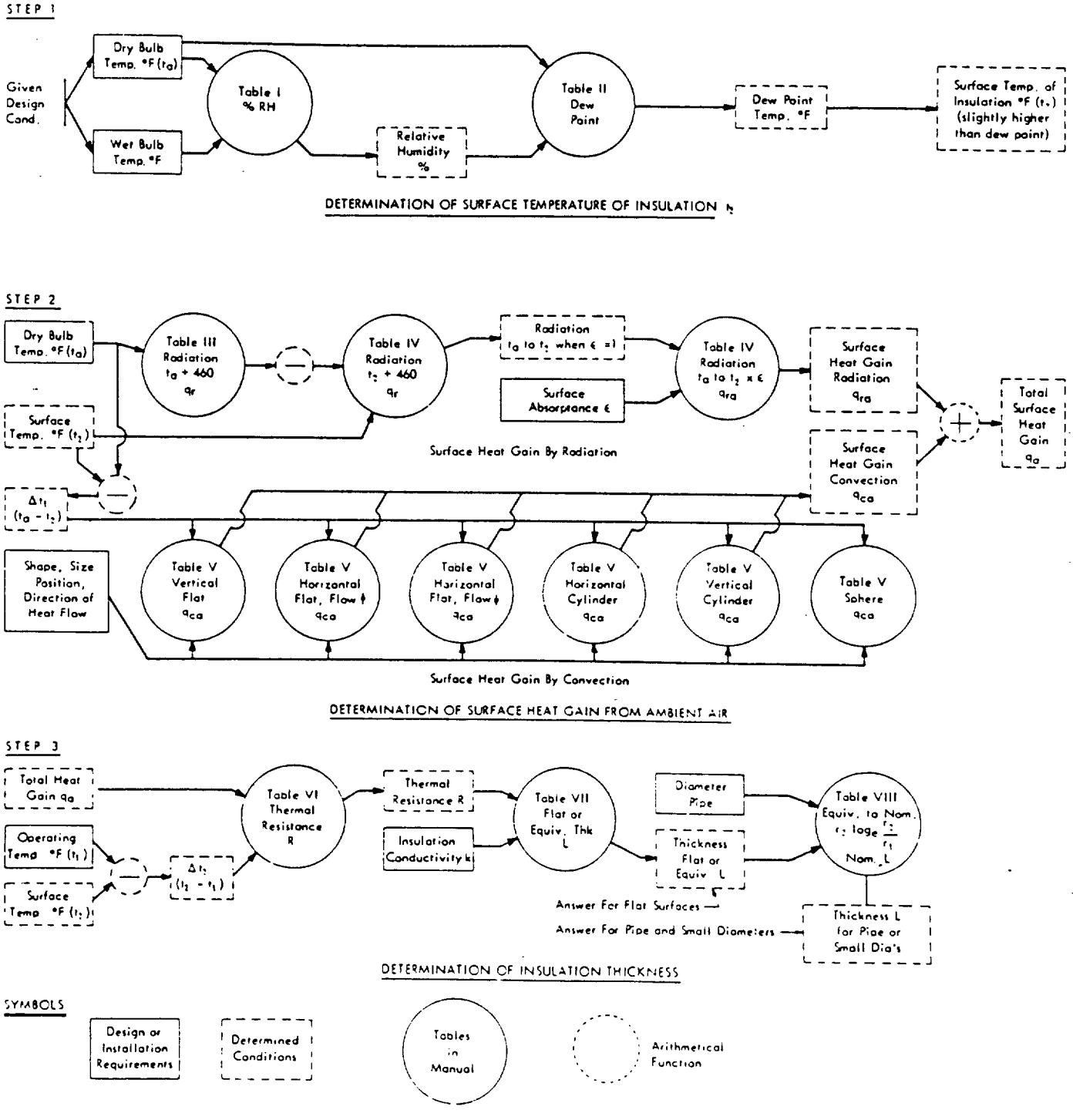
DATA

Brine lines 2", 4", and 6" IPS in both horizontal and vertical positions
Ambient air, high mean average is 90F dry-bulb, 80F wet bulb
Operating temperature - 20F
Black outer weather-vapor surface, absorptance = .9
Insulation - Cellular glass, conductivity k = .35

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THEORY - THICKNESS TO PREVENT CONDENSATION

DIAGRAM OF SOLUTION



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THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEET - Continued

D. Illustrative Examples - Continued

1. Example 1 - Continued

Enter data on work sheet

Description - Work order - Example 1
Pipe or vessel - Pipe
Description of surface - cylindrical, vertical and horizontal 2", 4", and 6" NPS.
Heat flow - does not apply

Dry bulb temperature in column a		90F
Wet bulb temperature in column b		80F
Surface absorptance in column i	=	.9
Operating temperature in column q		-20F
Conductivity of insulation in column t	k =	0.35

Step 1

Determine relative humidity from Table 1, 90F dry bulb 80F wet bulb = 65% RH.
Enter in column c.

Determine dew point from Table II, 90F dry bulb - 65% RH = 77F dew point.
Enter in column d.

Add 1°F to dew point temperature 77 + 1 = 78 is surface temperature above, and at which condensation will not occur.
Enter in column e.

Step 2

From Table III determine radiation from absolute zero to ambient dry bulb temperature t_a of 90F, this equals 159.2 Btu.
Enter in column f.

From Table III determine radiation from absolute zero to surface t_2 of 78F, this equals 145.8 Btu.
Enter in column g.

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THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEET - Continued

D. Illustrative Examples - Continued

1. Example 1 - Continued

Step 2 - Continued

Subtract amount of Btu in column g from that in column f, this equals 13.4. Enter in column h.

Multiply amount in column h by column i (given in Table IV). Enter in column j.

Enter Δt_1 which is t_a (column a) less t_2 (column e) which is 12F in column k.

Selection of proper convection from Table V is necessary to obtain Btu heat gain for column 1.

In this case, as the problem is with piping, the answer will be in column 5 or 6 of Table V. Also in this case the pipes are installed both in horizontal and vertical position and, as it is impractical to change insulation thickness for various positions, the most severe conditions must be used; thus, column 6 for vertical cylinders and pipes is selected. For 12F Δt_1 this equals 4.87.

At the bottom of the same table are correction factors for outside diameters of insulation. An assumed thickness of the insulation must be made at this point. Assuming the insulation thickness to be about 2", then the outside diameter of the 2" NPS by 2" thick insulation would be approximately 6" OD. These figures are entered in column m.

The correction factors of the OD of insulation are entered in column n. These are 1.32, 1.25, and 1.22. As can be seen, an error of 1" thickness in assumed to actual thickness of insulation makes a relatively small difference in the correction factor.

Total convection heat gain is obtained by the multiplication of column 1 by n. These results, which are 6.43, 6.08, and 5.93, are entered in column o.

Total heat gain to surface is obtained by adding Btu by radiation q_{ra}, column j, to Btu by convection q_{ca}, column o. These, which are 18.62, 18.28, and 18.13, are entered in column p.

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THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEET - Continued

SELECTION OF INSULATION THICKNESS TO PREVENT CONDENSATION - WORK SHEET
DESIGN AND CONSTRUCTION
UNION CARBIDE CORPORATION
OLEFINS DIVISION

EXAMPLE 1

DATE 1-15-64
JOB NUMBER 936-4901
CALCULATED BY HENSON

PIPE OR VESSEL NUMBER	DESCRIPTION OF SURFACE HORIZONTAL VERTICAL FLAT CYLINDER SPHERE SIZE, LENGTH	HEAT FLOW	STEP 1 SELECT DESIGN SURFACE TEMPERATURE: ATMOSPHERIC DESIGN CONDITIONS: MAX. AMBIENT DESIGN TEMP. t_a °F (a)	MAX. RELATIVE HUMIDITY % (b)	DESIGN SURFACE TEMP. t_s °F (c)	DESIGN DEW POINT t_d °F (d)	STEP 2 DETERMINE SURFACE HEAT GAIN RATE: HEAT GAIN RATE DUE TO RADIATION: AMBIENT TEMP. t_a °F (e)	SURFACE TEMP. t_s °F (f)	HEAT GAIN COLUMN (f-e) (g)	STANDARD FILM COEFF. f_1 (h)	Δt_1 $(t_a - t_s)$ (i)	HEAT GAIN (j)	MAX. (k)	CORRECTION FACTOR (l)	TOTAL CORRECTED HEAT GAIN q_1 (m)	TOTAL CALCULATED HEAT GAIN q_t (n)	STEP 3 DETERMINATION OF THICKNESS OF INSULATION: OPERATING TEMP. t_s °F (o)	Δt_2 $(t_a - t_s)$ (p)	THERMAL RESIST. R (q)	INSULATION THICKNESS (r)	FROM TABLE III (s)	FROM TABLE IV (t)
P-127	4" H CYL 2" NPS	—	90	80	65	77	78	159	2	1458	13.4	.9	12.2	12	4.87	6"OD	1.32	6.43	18.62	-20	98	5.45	.35	1.925	2"	1½"
P-115	" " 4"	—	"	"	"	"	"	"	"	"	"	"	"	"	"	8"OD	1.25	6.08	18.28	"	"	5.45	"	1.925	4"	1½"
P-116	" " 6"	—	"	"	"	"	"	"	"	"	"	"	"	"	"	10"OD	1.22	5.93	18.13	"	"	5.45	"	1.925	6"	2"

THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEET - Continued

D. Illustrative Examples - Continued

1. Example 1 - Continued

Step 3

Operating temperature t_1 in column q is given.

The Δt_2 is surface temperature t_2 column e minus operating temperature t_i or 78 - (-20) = 98. Enter in column r.

Insulation resistance is found in Table VI. Using 18 Btu as heat flow to surface at 98 Δt_2, resistance R would be approximately 5.45. Enter in column s. Note total differences in column p are so small in this case that they have litttle effect on thickness.

Flat or equivalent thickness L is found in Table VII. Using resistance of 5.5 with insulation k of .35, L equals 1.925.

From Table VIII find the nominal pipe insulation thickness equivalent to a flat thickness of 1.925. 2" NPS pipe requires 1 1/2" nominal thickness. 4" IPS pipe requires 1 1/2" nominal thickness, and 6" IPS pipe requires 2" nominal thickness of pipe insulation.

2. Example II

Less explanation is provided in solving this problem.

DATA

Large duct 48" x 47" passing through high humidity space.
Ambient air temperature dry bulb = 70F, relative humidity = 90%.
Operating temperature of duct 40F.
Outer coating on duct insulation - light gray = .7.
Insulation, glass fiber, conductivity (published) = .25 + 20% = 0.3.
(20% safety factor to allow for some moisture in the insulation)

Enter data on work sheet

Description - Example II
Duct
Flat surfaces, one horizontal - heat upward, one horizontal heat downward, one vertical

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THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEET - Continued

D. Illustrative Examples - Continued

2. Example II - Continued

column a	= dry bulb temperature 70F
column b	not needed - RH given
column c	= 90% RH
column i	= surface absorptance = .7.
column q	= operating temperature t_1 = 40F
column t	= conductivity of insulation k = 0.3

Step 1

column d, From Table II	dew point = 67F
column e	surface temperature = 68F

Step 2

column f, From Table III	absolute 0 to 70 = 137.3 Btu
column g, From Table III	absolute 0 to 68 = 135.2 Btu
column h	137.3 - 135.2 = 2.1
column j	2.1 x .7 = 1.47
column k	$t_a - t_2$ 70 - 68 = 2
column l	horizontal flat, facing down, Table V 0.73 horizontal flat, facing up, Table V 0.36 vertical flat, Table V 0.57
column m	horizontal flat, facing down, no correction factor
column n	horizontal flat, facing up, no correction factor
column o	vertical flat, above 24", no correction required
column p	columns j and l = 2.20, 1.83, and 2.04
column q	given as 40F
column r	$t_2 - t_1$ = 68 - 40 = 28F
column s	In this case of small differences, it is more accurate to divide results in column r by results in column p 28/2.20 = 12.3 28/1.83 = 15.3 28/2.04 = 13.7
column t	k = 0.3 given

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THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEET - Continued

EXAMPLE 11

SELECTION OF INSULATION THICKNESS TO PREVENT CONDENSATION – WORK SHEET
DESIGN AND CONSTRUCTION
UNION CARBIDE CORPORATION
OLEFINS DIVISION

DATE 1-15-64
WORK ORDER 936-4891
CALCULATED BY JONES

PIPE OR VESSEL NUMBER	DESCRIPTION OF SURFACE HORIZONTAL, VERTICAL, FLAT, CYLINDER, SPHERE, SIZE, LENGTH	HEAT FLOW	STEP 1 SELECT DESIGN SURFACE TEMPERATURE: ATMOSPHERIC DESIGN CONDITIONS: DRY BULB TEMP °F a	DESIGN DRY BULB TEMP °F b	DESIGN WET BULB TEMP °F c	DESIGN DEW POINT TEMP °F d	DESIGN SURFACE TEMP °F e	STEP 2 DETERMINE SURFACE HEAT GAIN RATE: HEAT GAIN RATE DUE TO RADIATION: DESIGN SURFACE TEMP °F f	DESIGN SURFACE EMITTANCE g	DESIGN SURFACE HEAT GAIN RATE BTU/HR-SQ FT h	RADIATION HEAT GAIN RATE BTU/HR-SQ FT i	TOTAL SURFACE HEAT GAIN RATE BTU/HR-SQ FT j	Δt_1 $(t_a - t_s)$ k	HEAT GAIN RATE TABLE 1 l	USE m	CORRECTION FACTOR TABLE 2 n	TOTAL HEAT GAIN RATE BTU/HR-SQ FT o	TOTAL HEAT GAIN RATE BTU/HR-SQ FT p	STEP 3 DETERMINATION OF THICKNESS OF INSULATION: DESIGN SURFACE TEMP °F q	Δt_2 $(t_a - t_s)$ r	THERMAL RESISTANCE "R" TABLE 3 s	INSULATION THICKNESS REQUIRED t	FOR HORIZONTAL CYLINDRICAL PIPES SIZE OF NEXT LARGER STANDARD PIPE u	FOR REQUIRED CONDITIONS ON FLAT SURFACES AND ON PIPES OVER 24" DIA. v	FOR REQUIRED CONDITIONS ON SMALL VESSELS w
	HOR. FLAT	UP	70		90	67	68	137.3		135.2	2.1		.7	1.47	2	0.73	—	—	0.73	2.20	40	28	12.3	0.30	3.7	FLAT	
	HOR. FLAT	DN	70		90	67	68	137.3		135.2	2.1		.7	1.47	2	0.36	—	—	0.36	1.83	40	28	15.3	0.30	4.6	"	
	VERT. FLAT	—	70		90	67	68	137.3		135.2	2.1		.7	1.47	2	0.57	OVER 24"	—	0.57	2.04	40	28	13.7	0.30	4.0	"	

THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEET - Continued

D. Illustrative Examples - Continued

2. Example II - Continued

column u, From Table VII
L = 3.7
L = 4.6
L = 4.0
Or in practical thickness
horizontal flat, surface facing down, requires 4" thickness
horizontal flat, surface facing up, requires 5" thickness
vertical flat, requires 4" thickness

Note: With relatively small temperature difference, air to operating temperatures, if in a very humid atmosphere, heavy thicknesses of insulation are required to prevent condensation.

3. Example III

DATA

Heat exchanger, horizontal, 310" diameter with dished heads.
Ambient air, high mean average of 100F dry bulb 85F wet bulb.
Operating temperature - 100F
White outer weather barrier surface, absorptance ϵ = .5
Insulation - Cellular glass, conductivity k = .33.

Enter data on work sheet

Body is horizontal cylinder
Ends being over 24" will be considered as vertical flat
Surface facing up or down does not apply

Column	Given	Found
a	100	
b	85	
c		From Table I = 50
d		From Table II = 78
e		78 + 1 = 79
f		From Table III = 171.1
g		From Table III = 146.9

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THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEET - Continued

D. Illustrative Examples - Continued

3. Example III - Continued

Column	Given	Found
h		171.1 - 146.9 = 24.2
i	.5	
j		24.2 x .5 = 12.1
k		100 - 79 = 21
l		Hor - cyl (Table V) = 8.13, Vert - flat (Table V) = 11.2
m		Greater than 24"
n		None (above 24")
o		8.13, 11.2
p		12.1 + 8.13 = 20.23, 12.1 + 11.2 = 23.3
q	-100	
r		79 - (-100) = 179
s		179/20.3 = 8.83, 179/23.3 = 7.68
t	.33	
u		8.83 x .33 = 2.91, 7.68 x .33 = 2.54

Therefore, 3" thickness would be required.

Note: The resultant thickness of only 3" is the direct result of the basic ambient condition that 50% RH would be highest relative humidity.

E. Discussion on Illustrative Examples

After using this method of determining insulation thickness to prevent condensation, it becomes apparent that accurate answers can be obtained in just a few minutes. As can be observed, the thickness is directly affected by the ambient conditions to which the installation is exposed. The three illustrative examples show this.

In Example I where dry-bulb temperature and wet-bulb temperature dictate a maximum relative humidity of only 65%, only 1 1/2, and 2 inches of insulation, with a conductivity of .35 are required to prevent condensation at an operating temperature of -20F.

In Example II where the relative humidity is 90% at 70F dry bulb 4 and 5 inches of insulation are required to prevent condensation with an insulation conductivity equal to .3 and operating temperature being only 40F.

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THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEET - Continued

EXAMPLE III

SELECTION OF INSULATION THICKNESS TO PREVENT CONDENSATION - WORK SHEET
DESIGN AND CONSTRUCTION
UNION CARBIDE CORPORATION
OLEFINS DIVISION

DATE 1-15-64
WORK ORDER 936-4632
CALCULATED BY CARSON

PIPE OR VESSEL NUMBER	DESCRIPTION OF SURFACE HORIZONTAL VERTICAL FLAT CYLINDER SPHERE SIZE LENGTH	HEAT FLOW	STEP 1 SELECT DESIGN SURFACE TEMPERATURE: ATMOSPHERIC DESIGN CONDITIONS a DEW POINT TEMP. °F	b DESIGN AIR TEMP. °F	c RELATIVE HUMIDITY %	d AIR TEMP. °F	e DESIGN SURFACE TEMP. t_s °F	STEP 2 DETERMINE SURFACE HEAT GAIN RATE: HEAT GAIN RATE DUE TO RADIATION f DEW POINT TEMP. °F	g SURFACE TEMP. °F	h HEAT GAIN (FIGURE 2)	i ASSUMED TEMP. °F	j Δt_1 $(t_2 - t_s)$	k HEAT GAIN (FIGURE 1)	m SIZE	n CONDUCTION SECTION (TABLE 2)	o TOTAL HEAT GAIN BTU/HR.	p TOTAL HEAT GAIN BTU/HR./Sq.Ft.	STEP 3 DETERMINATION OF THICKNESS OF INSULATION: q DEPARTURE TEMP. t_1 °F	r Δt_1 $(t_2 - t_1)$	s THERMAL CONDUCTANCE C (TABLE 3)	t INSULATION THICKNESS L	u THE PROPER THICKNESS TO PREVENT CONDENSATION	v PIPE SIZE OR WALL THICKNESS
E-101	HOR 3'0 CD CYL ENDS VERT OVER 3' (FLAT)	—	100	85	50	78	79			171.1	1469	242	.5	12.1	21	8.13	3'-0"	—	8.13	2023	-100	179	8.83	.33	2.91	
"	"	—	100	85	50	78	79			171.1	1469	242	.5	12.1	21	11.2	3'-0"	—	11.2	2333	-100	179	7.68	.33	2.54	

THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEET - Continued

E. Discussion on Illustrative Examples - Continued

In Example III with a very dry condition of 50% maximum relative humidity 3 inches of insulation will prevent condensation even when the operating temperature is -100F.

The above shows the importance of an accurate analysis of conditions to which the installation will be subjected. In most instances design conditions should be selected which are seldom exceeded for more than a few hours per year.

Film Resistance

$$q_a = \frac{t_a - t_2}{R_s} \qquad \text{or} \qquad R_s = \frac{t_a - t_2}{q_a}$$

For Example I the film resistances for the three different surfaces would be:

$$R_s = \frac{12}{18.62} = 0.644$$

$$R_s = \frac{12}{18.28} = 0.657$$

$$R_s = \frac{12}{18.13} = 0.662$$

For Example II the film resistances for the three different surfaces would be:

$$R_s = \frac{2}{2.20} = 0.91$$

$$R_s = \frac{2}{1.83} = 1.09$$

$$R_s = \frac{2}{2.04} = 0.97$$

For Example III the film resistances for the two different surfaces would be:

$$R_s = \frac{21}{20.3} = 1.09$$

$$R_s = \frac{21}{23.3} = 0.90$$

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THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEET - Continued

E. Discussion on Illustrative Examples - Continued

Had the surface been black instead of white then the film resistances would have been:

$$R_s = \frac{21}{32.33} = 0.65$$

$$R = \frac{21}{35.5} = 0.59$$

From just these three examples the surface resistances ranged from 0.59 to 1.04, which shows that a single assumed surface resistance cannot be used to determine insulation thickness to prevent condensation, as it leads to considerable error. As shown in the following:

If q_a is determined by $\frac{t_a - t_2}{R_s}$ by an assumed R_s, then R for insulation is determined by $R\,\frac{t_2 - t_1}{q_{ca}}$ the R is no more accurate than assumed R_s. Thus, in assuming R_s the R which determines insulation thickness basically is also assumed. Unless the values of R_s are known for each particular condition of wet-bulb temperature, dry-bulb temperature, surface shape, size, position, and emittance. As such tabulation for values of R_s does not exist, the use of R_s to determine insulation thickness to prevent condensation is not recommended

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THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEETS - Continued

RELATIVE HUMIDITY

Dry-Bulb Temp °F	DIFFERENCE BETWEEN READINGS OF WET-BULB AND DRY-BULB TEMPERATURE °F																																												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
0	70	40	10																																													
5	75	50	26	4																																												
10	80	60	40	22	4																																											
15	84	68	52	34	20	5																																										
20	86	72	59	46	33	20	7																																								
21	86	73	60	48	34	22	11																																								
22	87	74	61	50	36	25	13	2																																							
23	87	75	62	51	38	27	16	5																																							
24	88	76	64	53	41	30	19	8																																							
25	88	77	65	54	42	32	22	11																																							
26	88	77	66	55	44	34	24	14	4																																						
27	88	78	67	56	46	36	26	16	6																																						
28	89	78	68	57	48	37	28	18	9																																						
29	89	78	69	58	49	39	30	20	12	3																																						
30	89	80	70	60	51	41	32	23	14	6																																						
31	90	80	71	61	52	43	34	26	17	8																																						
32	90	81	72	62	53	44	36	27	19	10	3																																						
33	90	82	73	63	55	46	38	29	21	13	5																																						
34	90	82	74	65	56	48	40	32	24	16	8																																						
35	90	82	73	66	58	50	42	34	26	18	10	4																																					
36	91	82	74	65	59	51	44	36	28	20	13	6																																					
37	91	83	75	66	58	53	45	38	30	22	16	8																																					
38	91	83	75	67	59	51	47	39	32	24	17	10	4																																				
39	91	83	76	68	60	53	46	41	34	27	20	13	6																																				
40	92	84	77	68	61	53	47	39	36	28	22	15	8																																				
41	92	84	77	69	62	54	47	40	33	31	24	17	11	5																																			
42	92	84	77	70	62	55	48	41	34	28	26	19	13	6																																			
43	93	84	78	70	63	56	49	43	36	29	23	22	15	9	3																																		
44	93	85	78	71	64	57	50	44	37	31	24	18	17	12	5																																		
45	93	86	78	72	65	58	52	45	39	32	26	20	14	13	8	3																																	
46	93	86	79	72	65	58	53	46	40	33	27	22	16	11	11	5																																	
47	93	86	79	72	66	59	54	47	41	35	29	23	17	12	7	7	2																															
48	93	86	80	73	67	60	54	48	42	36	30	24	19	14	8	4	4																															
49	93	86	80	74	67	61	55	49	43	38	32	26	20	16	10	5	2																															
50	93	87	81	75	68	62	56	50	45	39	33	28	23	18	13	7	3																															
51	94	87	81	75	68	62	56	50	45	39	34	29	23	19	14	8	4																															
52	94	87	81	75	69	63	57	51	46	40	35	30	24	20	15	10	5	2																														
53	94	87	81	75	69	63	58	52	47	41	36	31	25	21	17	12	8	3.																														
54	94	88	82	76	70	64	58	53	47	42	37	32	27	23	18	14	9	4																														
55	94	88	82	76	70	65	59	54	49	44	39	34	29	24	20	15	11	5	2																													
56	94	88	82	76	71	66	60	55	50	45	40	35	30	25	21	17	13	8	4																													
57	94	88	83	77	71	66	61	56	51	46	41	36	31	27	23	18	14	9	6	2																												
58	94	88	83	77	72	67	62	57	52	47	42	37	32	28	24	20	15	11	7	4																												
59	94	89	84	77	73	68	62	57	53	48	43	38	34	29	25	21	16	13	8	5	2																											
60	94	89	84	78	73	68	63	58	53	48	44	39	35	31	27	22	18	14	10	6	3																											
61	94	89	84	79	74	69	63	59	54	49	45	41	36	32	28	24	20	15	12	8	4																											
62	94	89	84	79	74	69	64	59	54	50	46	42	37	33	29	25	21	17	13	9	6	3																										
63	95	90	84	79	74	70	65	60	55	51	47	43	38	34	30	26	22	19	14	11	8	4																										
64	95	90	85	80	75	70	65	61	56	52	48	44	39	34	31	27	23	20	16	12	9	6	2																									
65	95	90	85	80	75	71	66	61	57	53	49	45	40	36	32	28	25	21	17	13	11	7	4																									
66	95	90	85	80	75	71	66	62	57	53	49	46	41	37	33	30	26	22	19	15	12	8	5	2																							
67	95	90	85	80	76	71	67	63	58	55	50	47	42	39	34	30	27	23	20	17	13	10	7	4																							
68	95	90	86	81	76	72	67	63	58	55	51	48	43	39	35	31	28	24	21	18	14	11	8	5	2																					
69	95	90	86	81	76	72	68	64	59	56	52	48	44	40	36	32	29	25	22	19	15	12	9	6	3																					
70	95	90	86	81	76	72	68	64	60	56	52	48	45	41	37	33	30	27	23	20	17	14	10	7	5	2																				
71	95	90	86	81	76	72	69	64	60	56	53	49	46	41	38	34	31	28	24	21	18	15	12	8	5	3																				
72	95	91	86	82	77	73	69	65	61	57	54	50	46	43	39	35	32	28	25	22	19	16	13	10	7	4	2																			
73	95	91	86	82	77	73	70	66	62	58	55	52	48	45	41	38	34	31	28	25	22	19	16	13	11	8	5	3																		
74	95	91	86	82	78	74	70	66	62	58	54	51	47	43	40	36	33	30	27	24	21	18	15	12	9	6	4	2																		
75	95	91	87	82	78	74	70	66	62	59	55	52	48	45	41	37	34	31	28	25	22	19	16	13	11	8	6	3																		
76	95	91	87	83	78	75	70	66	63	59	55	52	49	45	42	38	35	32	29	26	23	20	17	15	12	9	7	4	2																	
77	95	91	87	83	79	75	71	67	64	59	56	53	49	46	42	39	36	33	30	27	24	21	18	16	13	11	8	6	4	2																
78	96	91	87	83	79	75	71	67	64	60	57	53	50	46	43	40	37	34	31	27	25	22	19	17	14	12	9	6	4																	
79	96	91	87	83	79	75	71	67	64	60	57	54	50	47	44	40	37	34	32	29	26	23	20	18	16	13	10	7	5	3																
80	96	91	87	83	79	75	72	68	64	61	57	54	50	47	44	41	38	35	32	29	27	24	21	19	17	14	11	8	6	4	2															
82	96	92	88	84	80	76	72	69	65	62	58	55	51	48	45	42	39	37	34	31	28	25	23	21	18	16	13	11	9	7	4															
84	96	92	88	84	80	76	73	69	66	63	59	57	53	50	47	44	41	38	35	32	30	28	25	22	20	17	15	12	11	8	5	4	2													
86	96	92	88	84	80	77	73	70	66	63	60	57	54	51	48	45	42	39	37	34	32	29	26	24	22	19	17	14	13	11	8	6	4	2												
88	96	92	88	85	81	78	74	70	67	64	61	58	55	52	49	46	43	41	38	35	33	31	28	26	24	21	18	17	15	13	11	8	6	4	2											
90	96	92	89	85	81	78	74	71	68	65	61	59	55	53	50	47	44	42	39	37	34	32	29	27	25	22	20	18	16	14	12	10	8	6	4	2										
92	96	92	89	85	82	79	75	72	68	65	62	59	56	54	51	48	46	43	41	38	36	33	31	28	26	24	22	20	18	16	14	12	11	8	7	5	3									
94	96	93	89	85	82	79	75	72	69	66	63	60	57	55	52	49	47	44	42	39	37	34	32	30	28	26	24	21	19	17	15	14	12	10	8	6	4	2								
96	96	93	89	86	82	79	76	73	70	67	64	61	58	56	53	50	48	45	43	40	38	35	33	31	29	27	25	23	21	19	17	15	14	12	10	8	6	4	3							
98	96	93	89	86	82	79	77	73	70	67	64	62	59	57	54	51	49	46	44	41	39	36	34	32	30	28	26	24	22	20	18	16	15	13	11	9	8	6	4	3						
100	96	93	89	86	83	80	77	74	71	68	65	62	60	57	54	51	49	47	44	42	40	37	35	33	31	29	27	25	23	22	19	18	16	14	13	11	9	8	6	5	3					
102	96	93	90	86	83	80	77	74	71	68	65	63	60	58	55	52	50	48	45	42	41	38	36	34	32	30	28	26	24	23	20	19	17	15	14	13	10	10	7	7	5	2				
104	97	93	90	87	83	81	77	74	71	69	66	63	61	58	55	53	51	48	46	43	42	39	37	35	33	31	29	27	25	24	21	21	20	18	16	14	12	11	8	8	7	4	2			
106	97	93	90	87	84	81	78	75	72	69	66	63	62	59	56	53	51	49	46	44	43	40	38	36	34	32	30	28	26	25	22	21	19	17	17	16	13	12	10	10	8	5	4	3		
108	97	93	90	87	84	81	78	75	72	70	67	64	62	60	57	54	52	50	47	45	44	41	39	37	35	33	31	29	27	26	23	22	20	18	18	17	14	14	11	11	10	7	5	4	3	
110	97	93	90	87	84	81	78	75	72	70	67	64	63	60	57	55	53	50	48	45	45	42	40	38	36	34	32	30	28	27	24	23	21	19	19	18	16	15	12	12	11	8	7	6	4	3
112	97	94	90	87	84	81	79	76	73	70	68	65	63	61	58	56	53	51	47	46	45	43	41	39	37	35	33	31	30	28	26	24	23	20	20	19	18	16	14	13	12	9	8	7	5	4
114	97	94	91	88	85	82	79	76	74	71	68	65	64	61	58	56	54	52	49	47	46	44	42	40	38	36	34	32	31	29	27	25	24	22	21	20	19	17	16	14	13	12	9	8	7	6
116	97	94	91	88	85	82	79	76	74	71	69	66	64	62	59	57	54	52	50	48	47	45	43	41	39	37	35	33	32	30	28	27	25	23	22	21	20	18	17	15	14	13	12	10	9	7
118	97	94	91	88	85	82	79	77	74	72	69	67	65	62	60	58	55	53	51	49	48	46	44	42	40	38	36	34	33	31	29	28	26	24	23	22	21	19	18	16	15	14	13	12	10	9
120	97	94	91	88	85	82	80	77	74	72	69	67	65	63	60	58	56	53	51	50	48	46	44	42	41	39	37	35	34	32	30	29	27	26	24	23	22	20	19	18	16	15	14	13	12	10

NOTE:
Values above heavy line are for ice, while those below line are for water.

TABLE I

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THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEETS - Continued

DEW POINT TEMPERATURE

Dry Bulb Temp °F	PER CENT RELATIVE HUMIDITY																	
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
5	-35	-30	-25	-21	-17	-14	-12	-10	- 8	- 6	- 5	- 4	- 2	- 1	1	2	3	4
10	-31	-25	-20	-16	-13	-10	- 7	- 5	- 3	- 2	0	2	3	4	5	7	8	9
15	-28	-21	-16	-12	- 8	- 5	- 3	- 1	1	3	5	6	8	9	10	12	13	14
20	-24	-16	-11	- 8	- 4	- 2	2	4	6	8	10	11	13	14	15	16	18	19
25	-20	-15	- 8	- 4	0	3	6	8	10	12	15	16	18	19	20	21	23	24
30	-15	- 4	- 3	2	5	8	11	13	15	17	20	22	23	24	25	27	28	29
35	-12	- 5	1	5	9	12	15	18	20	22	24	26	27	28	30	32	33	34
40	- 7	0	5	9	14	16	19	22	24	26	28	29	31	33	35	36	38	39
45	- 4	3	9	13	17	20	23	25	28	30	32	34	36	38	39	41	43	44
50	- 1	7	13	17	21	24	27	30	32	34	37	39	41	42	44	45	47	49
55	3	11	16	21	25	28	32	34	37	39	41	43	45	47	49	50	52	53
60	6	14	20	25	29	32	35	39	42	44	46	48	50	52	54	55	57	59
65	10	18	24	28	33	38	40	43	46	49	51	53	55	57	59	60	62	63
70	13	21	28	33	37	41	45	48	50	53	55	57	60	62	64	65	67	68
75	17	25	32	37	42	46	49	52	55	57	60	62	64	66	69	70	72	74
80	20	29	35	41	46	50	54	57	60	62	65	67	69	72	74	75	77	78
85	23	32	40	45	50	54	58	61	64	67	69	72	74	76	78	80	82	83
90	27	36	44	99	54	58	62	66	69	72	74	77	79	81	83	85	87	89
95	30	40	48	54	59	63	67	70	73	76	79	82	84	86	88	90	91	93
100	34	44	52	58	63	68	71	75	78	81	84	86	88	91	92	94	96	98
105	38	48	56	62	67	72	76	79	82	85	88	90	93	95	97	99	101	103
110	41	52	60	66	71	77	80	84	87	90	92	95	98	100	102	104	106	108
115	45	56	64	70	75	80	84	88	91	94	97	100	102	105	107	109	111	113
120	48	60	68	74	79	85	88	92	96	99	102	105	107	109	112	114	116	118
125	52	63	72	78	84	89	93	97	100	104	107	109	111	114	117	119	121	123

TABLE II

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THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEETS - Continued

RADIATION HEAT TRANSFER RATE FOR BLACK-BODY CONDITIONS (To Absolute Zero)

Values of $q_r = 0.174 \epsilon (t + 460)^4$ When $\epsilon = 1.0$

t Temp °F	q_r, Btu/ hr, sq ft	t Temp °F	q_r, Btu/ hr, sq ft	t Temp °F	q_r, Btu/ hr, sq ft	t Temp °F	q_r, Btu/ hr, sq ft	t Temp °F	q_r, Btu/ hr, sq ft
-35	56.77	- 3	75.90	29	99.49	61	128.2	93	162.7
-34	57.30	- 2	76.56	30	100.3	62	129.2	94	163.9
-33	57.84	- 1	77.23	31	101.1	63	130.2	95	165.1
-32	58.39	0	77.91	32	102.0	64	131.2	96	166.3
-31	58.94	1	78.59	33	102.8	65	132.2	97	167.5
-30	59.49	2	79.27	34	103.6	66	133.2	98	168.7
-29	60.04	3	79.96	35	104.5	67	134.2	99	169.9
-28	60.60	4	80.65	36	105.3	68	135.2	100	171.1
-27	61.17	5	81.35	37	106.2	69	136.3	101	172.4
-26	61.73	6	82.05	38	107.0	70	137.3	102	173.6
-25	62.30	7	82.76	39	107.9	71	138.3	103	174.8
-24	62.88	8	83.47	40	108.8	72	139.4	104	176.1
-23	63.46	9	84.19	41	109.6	73	140.4	105	177.3
-22	64.04	10	84.91	42	110.5	74	141.5	106	178.6
-21	64.63	11	85.63	43	111.4	75	142.6	107	179.8
-20	65.22	12	86.36	44	112.3	76	143.6	108	181.1
-19	65.81	13	87.10	45	113.2	77	144.7	109	182.4
-18	66.41	14	87.83	46	114.1	78	145.8	110	183.7
-17	67.01	15	88.58	47	115.0	79	146.9	111	185.0
-16	67.62	16	89.33	48	115.9	80	148.0	112	186.3
-15	68.23	17	90.08	49	116.8	81	149.1	113	187.6
-14	68.85	18	90.84	50	117.7	82	150.2	114	188.9
-13	69.47	19	91.60	51	118.6	83	151.3	115	190.2
-12	70.09	20	92.37	52	119.6	84	152.4	116	191.5
-11	70.72	21	93.14	53	120.5	85	153.5	117	192.9
-10	71.35	22	93.92	54	121.5	86	154.6	118	194.2
- 9	71.99	23	94.70	55	122.4	87	155.8	119	195.6
- 8	72.63	24	95.48	56	123.4	88	156.9	120	196.9
- 7	73.27	25	96.28	57	124.3	89	158.1		
- 6	73.92	26	97.07	58	125.3	90	159.2		
- 5	74.58	27	97.87	59	126.3	91	160.4		
- 4	75.23	28	98.68	60	127.2	92	161.6		

TABLE III

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THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEETS - Continued

RADIATION HEAT TRANSFER RATE TO SURFACE WITH ABSORPTANCE ε LISTED

$$[0.174 \times 10^{-8}(t_a + 460)^4] - [0.174 \times 10^{-8}(t_s + 460)^4]$$

NOTE: In cases of radiation of low level with a decimal in the term such as 8.3 use 83 in table and shift answer decimal point one figure to left

ΔT	ABSORPTANCE ε																			
	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
1	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
2	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00
3	0.15	0.30	0.45	0.60	0.75	0.90	1.05	1.20	1.35	1.50	1.65	1.80	1.95	2.10	2.25	2.40	2.55	2.70	2.85	3.00
4	0.20	0.40	0.60	0.80	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	3.00	3.20	3.40	3.60	3.80	4.00
5	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00
6	0.30	0.60	0.90	1.20	1.50	1.80	2.10	2.40	2.70	3.00	3.30	3.60	3.90	4.20	4.50	4.80	5.10	5.40	5.70	6.00
7	0.35	0.70	1.05	1.40	1.75	2.10	2.45	2.80	3.15	3.50	3.85	4.20	4.55	4.90	5.25	5.60	5.95	6.30	6.65	7.00
8	0.40	0.80	1.20	1.60	2.00	2.40	2.80	3.20	3.60	4.00	4.40	4.80	5.20	5.60	6.00	6.40	6.80	7.20	7.60	8.00
9	0.45	0.90	1.35	1.80	2.25	2.70	3.15	3.60	4.05	4.50	4.95	5.40	5.85	6.30	6.75	7.20	7.65	8.10	8.55	9.00
10	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00
11	0.55	1.10	1.65	2.20	2.75	3.30	3.85	4.40	4.95	5.50	6.05	6.60	7.15	7.70	8.25	8.80	9.35	9.90	10.45	11.00
12	0.60	1.20	1.80	2.40	3.00	3.60	4.20	4.80	5.40	6.00	6.60	7.20	7.80	8.40	9.00	9.60	10.20	10.80	11.40	12.00
13	0.65	1.30	1.95	2.60	3.25	3.90	4.55	5.20	5.85	6.50	7.15	7.80	8.45	9.10	9.75	10.40	11.05	11.70	12.35	13.00
14	0.70	1.40	2.10	2.80	3.50	4.20	4.90	5.60	6.30	7.00	7.70	8.40	9.10	9.80	10.50	11.20	11.90	12.60	13.30	14.00
15	0.75	1.50	2.25	3.00	3.75	4.50	5.25	6.00	6.75	7.50	8.25	9.00	9.75	10.50	11.25	12.00	12.75	13.50	14.25	15.00
16	0.80	1.60	2.40	3.20	4.00	4.80	5.60	6.40	7.20	8.00	8.80	9.60	10.40	11.20	12.00	12.80	13.60	14.40	15.20	16.00
17	0.85	1.70	2.55	3.40	4.25	5.10	5.95	6.80	7.65	8.50	9.35	10.20	11.05	11.90	12.75	13.60	14.45	15.30	16.15	17.00
18	0.90	1.80	2.70	3.60	4.50	5.40	6.30	7.20	8.10	9.00	9.90	10.80	11.70	12.60	13.50	14.40	15.30	16.20	17.10	18.00
19	0.95	1.90	2.85	3.80	4.75	5.70	6.65	7.60	8.55	9.50	10.45	11.40	12.35	13.30	14.25	15.20	16.15	17.10	18.05	19.00
20	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00
21	1.05	2.10	3.15	4.20	5.25	6.30	7.35	8.40	9.45	10.50	11.55	12.60	13.65	14.70	15.75	16.80	17.85	18.90	19.95	21.00
22	1.10	2.20	3.30	4.40	5.50	6.60	7.70	8.80	9.90	11.00	12.10	13.20	14.30	15.40	16.50	17.60	18.70	19.80	20.90	22.00
23	1.15	2.30	3.45	4.60	5.75	6.90	8.05	9.20	10.35	11.50	12.65	13.80	14.95	16.10	17.25	18.40	19.55	20.70	21.85	23.00
24	1.20	2.40	3.60	4.80	6.00	7.20	8.40	9.60	10.80	12.00	13.20	14.40	15.60	16.80	18.00	19.20	20.40	21.60	22.80	24.00
25	1.25	2.50	3.75	5.00	6.25	7.50	8.75	10.00	11.25	12.50	13.75	15.00	16.25	17.50	18.75	20.00	21.25	22.50	23.75	25.00
26	1.30	2.60	3.90	5.20	6.50	7.80	9.10	10.40	11.70	13.00	14.30	15.60	16.90	18.20	19.50	20.80	22.10	23.40	24.70	26.00
27	1.35	2.70	4.05	5.40	6.75	8.10	9.45	10.80	12.15	13.50	14.85	16.20	17.55	18.90	20.25	21.60	22.95	24.30	25.65	27.00
28	1.40	2.80	4.20	5.60	7.00	8.40	9.80	11.20	12.60	14.00	15.40	16.80	18.20	19.60	21.00	22.40	23.80	25.20	26.60	28.00
29	1.45	2.90	4.35	5.80	7.25	8.70	10.15	11.60	13.05	14.50	15.95	17.40	18.85	20.30	21.75	23.20	24.65	26.10	27.55	29.00
30	1.50	3.00	4.50	6.00	7.50	9.00	10.50	12.00	13.50	15.00	16.50	18.00	19.50	21.00	22.50	24.00	25.50	27.00	28.50	30.00
31	1.55	3.10	4.65	6.20	7.75	9.30	10.85	12.40	13.95	15.50	17.05	18.60	20.15	21.70	23.25	24.80	26.35	27.90	29.45	31.00
32	1.60	3.20	4.80	6.40	8.00	9.60	11.20	12.80	14.40	16.00	17.60	19.20	20.80	22.40	24.00	25.60	27.20	28.80	30.40	32.00
33	1.65	3.30	4.95	6.60	8.25	9.90	11.55	13.20	14.85	16.50	18.15	19.80	21.45	23.10	24.75	26.40	28.05	29.70	31.35	33.00
34	1.70	3.40	5.10	6.80	8.50	10.20	11.90	13.60	15.30	17.00	18.70	20.40	22.10	23.80	25.50	27.20	28.90	30.60	32.30	34.00
35	1.75	3.50	5.25	7.00	8.75	10.50	12.25	14.00	15.75	17.50	19.25	21.00	22.75	24.50	26.25	28.00	29.75	31.50	33.25	35.00
36	1.80	3.60	5.40	7.20	9.00	10.80	12.60	14.40	16.20	18.00	19.80	21.60	23.40	25.20	27.00	28.80	30.60	32.40	34.20	36.00
37	1.85	3.70	5.55	7.40	9.25	11.10	12.95	14.80	16.65	18.50	20.35	22.20	24.05	25.90	27.75	29.60	31.45	33.30	35.15	37.00
38	1.90	3.80	5.70	7.60	9.50	11.40	13.30	15.20	17.10	19.00	20.90	22.80	24.70	26.60	28.50	30.40	32.30	34.20	36.10	38.00
39	1.95	3.90	5.85	7.80	9.75	11.70	13.65	15.60	17.55	19.50	21.45	23.40	25.35	27.30	29.25	31.20	33.15	35.10	37.05	39.00
40	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	32.00	34.00	36.00	38.00	40.00
41	2.05	4.10	6.15	8.20	10.25	12.30	14.35	16.40	18.45	20.50	22.55	24.60	26.65	28.70	30.75	32.80	34.85	36.90	38.95	41.00
42	2.10	4.20	6.30	8.40	10.50	12.60	14.70	16.80	18.90	21.00	23.10	25.20	27.30	29.40	31.50	33.60	35.70	37.80	39.90	42.00
43	2.15	4.30	6.45	8.60	10.75	12.90	15.05	17.20	19.35	21.50	23.65	25.80	27.95	30.10	32.25	34.40	36.55	38.70	40.85	43.00
44	2.20	4.40	6.60	8.80	11.00	13.20	15.40	17.60	19.80	22.00	24.20	26.40	28.60	30.80	33.00	35.20	37.40	39.60	41.80	44.00
45	2.25	4.50	6.75	9.00	11.25	13.50	15.75	18.00	20.25	22.50	24.75	27.00	29.25	31.50	33.75	36.00	38.25	40.50	42.75	45.00
46	2.30	4.60	6.90	9.20	11.50	13.80	16.10	18.40	20.70	23.00	25.30	27.60	29.90	32.20	34.50	36.80	39.10	41.40	43.70	46.00
47	2.35	4.70	7.05	9.40	11.75	14.10	16.45	18.80	21.15	23.50	25.85	28.20	30.55	32.90	35.25	37.60	39.95	42.30	44.65	47.00
48	2.40	4.80	7.20	9.60	12.00	14.40	16.80	19.20	21.60	24.00	26.40	28.80	31.20	33.60	36.00	38.40	40.80	43.20	45.60	48.00
49	2.45	4.90	7.35	9.80	12.25	14.70	17.15	19.60	22.05	24.50	26.95	29.40	31.85	34.30	36.75	39.20	41.65	44.10	46.55	49.00
50	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00	27.50	30.00	32.50	35.00	37.50	40.00	42.50	45.00	47.50	50.00
51	2.55	5.10	7.65	10.20	12.75	15.30	17.85	20.40	22.95	25.50	28.05	30.60	33.15	35.70	38.25	40.80	43.35	45.90	48.45	51.00
52	2.60	5.20	7.80	10.40	13.00	15.60	18.20	20.80	23.40	26.00	28.60	31.20	33.80	36.40	39.00	41.60	44.20	46.80	49.40	52.00
53	2.65	5.30	7.95	10.60	13.25	15.90	18.55	21.20	23.85	26.50	29.15	31.80	34.45	37.10	39.75	42.40	45.05	47.70	50.35	53.00
54	2.70	5.40	8.10	10.80	13.50	16.20	18.90	21.60	24.30	27.00	29.70	32.40	35.10	37.80	40.50	43.20	45.90	48.60	51.30	54.00
55	2.75	5.50	8.25	11.00	13.75	16.50	19.25	22.00	24.75	27.50	30.25	33.00	35.75	38.50	41.25	44.00	46.75	49.50	52.25	55.00
56	2.80	5.60	8.40	11.20	14.00	16.80	19.60	22.40	25.20	28.00	30.80	33.60	36.40	39.20	42.00	44.80	47.60	50.40	53.20	56.00
57	2.85	5.70	8.55	11.40	14.25	17.10	19.95	22.80	25.65	28.50	31.35	34.20	37.05	39.90	42.75	45.60	48.45	51.30	54.15	57.00
58	2.90	5.80	8.70	11.60	14.50	17.40	20.30	23.20	26.10	29.00	31.90	34.80	37.70	40.60	43.50	46.40	49.30	52.20	55.10	58.00
59	2.95	5.90	8.85	11.80	14.75	17.70	20.65	23.60	26.55	29.50	32.45	35.40	38.35	41.30	44.25	47.20	50.15	53.10	56.05	59.00
60	3.00	6.00	9.00	12.00	15.00	18.00	21.00	24.00	27.00	30.00	33.00	36.00	39.00	42.00	45.00	48.00	51.00	54.00	57.00	60.00
61	3.05	6.10	9.15	12.20	15.25	18.30	21.35	24.40	27.45	30.50	33.55	36.60	39.65	42.70	45.75	48.80	51.85	54.90	57.95	61.00
62	3.10	6.20	9.30	12.40	15.50	18.60	21.70	24.80	27.90	31.00	34.10	37.20	40.30	43.40	46.50	49.60	52.70	55.80	58.90	62.00
63	3.15	6.30	9.45	12.60	15.75	18.90	22.05	25.20	28.35	31.50	34.65	37.80	40.95	44.10	47.25	50.40	53.55	56.70	59.85	63.00
64	3.20	6.40	9.60	12.80	16.00	19.20	22.40	25.60	28.80	32.00	35.20	38.40	41.60	44.80	48.00	51.20	54.40	57.60	60.80	64.00
65	3.25	6.50	9.75	13.00	16.25	19.50	22.75	26.00	29.25	32.50	35.75	39.00	42.25	45.50	48.75	52.00	55.25	58.50	61.75	65.00
66	3.30	6.60	9.90	13.20	16.50	19.80	23.10	26.40	29.70	33.00	36.30	39.60	42.90	46.20	49.50	52.80	56.10	59.40	62.70	66.00
67	3.35	6.70	10.05	13.40	16.75	20.10	23.45	26.80	30.15	33.50	36.85	40.20	43.55	46.90	50.25	53.60	56.95	60.30	63.65	67.00
68	3.40	6.80	10.20	13.60	17.00	20.40	23.80	27.20	30.60	34.00	37.40	40.80	44.20	47.60	51.00	54.40	57.80	61.20	64.60	68.00
69	3.45	6.90	10.35	13.80	17.25	20.70	24.15	27.60	31.05	34.50	37.95	41.40	44.85	48.30	51.75	55.20	58.65	62.10	65.55	69.00
70	3.50	7.00	10.50	14.00	17.50	21.00	24.50	28.00	31.50	35.00	38.50	42.00	45.50	49.00	52.50	56.00	59.50	63.00	66.50	70.00
71	3.55	7.10	10.65	14.20	17.75	21.30	24.85	28.40	31.95	35.50	39.05	42.60	46.15	49.70	53.25	56.80	60.35	63.90	67.45	71.00
72	3.60	7.20	10.80	14.40	18.00	21.60	25.20	28.80	32.40	36.00	39.60	43.20	46.80	50.40	54.00	57.60	61.20	64.80	68.40	72.00
73	3.65	7.30	10.95	14.60	18.25	21.90	25.55	29.20	32.85	36.50	40.15	43.80	47.45	51.10	54.75	58.40	62.05	65.70	69.35	73.00
74	3.70	7.40	11.10	14.80	18.50	22.20	25.90	29.60	33.30	37.00	40.70	44.40	48.10	51.80	55.50	59.20	62.90	66.60	70.30	74.00
75	3.75	7.50	11.25	15.00	18.75	22.50	26.25	30.00	33.75	37.50	41.25	45.00	48.75	52.50	56.25	60.00	63.75	67.50	71.25	75.00
76	3.80	7.60	11.40	15.20	19.00	22.80	26.60	30.40	34.20	38.00	41.80	45.60	49.40	53.20	57.00	60.80	64.60	68.40	72.20	76.00
77	3.85	7.70	11.55	15.40	19.25	23.10	26.95	30.80	34.65	38.50	42.35	46.20	50.05	53.90	57.75	61.60	65.45	69.30	73.15	77.00
78	3.90	7.80	11.70	15.60	19.50	23.40	27.30	31.20	35.10	39.00	42.90	46.80	50.70	54.60	58.50	62.40	66.30	70.20	74.10	78.00
79	3.95	7.90	11.85	15.80	19.75	23.70	27.65	31.60	35.55	39.50	43.45	47.40	51.35	55.30	59.25	63.20	67.15	71.10	75.05	79.00
80	4.00	8.00	12.00	16.00	20.00	24.00	28.00	32.00	36.00	40.00	44.00	48.00	52.00	56.00	60.00	64.00	68.00	72.00	76.00	80.00
81	4.05	8.10	12.15	16.20	20.25	24.30	28.35	32.40	36.45	40.50	44.55	48.60	52.65	56.70	60.75	64.80	68.85	72.90	76.95	81.00
82	4.10	8.20	12.30	16.40	20.50	24.60	28.70	32.80	36.90	41.00	45.10	49.20	53.30	57.40	61.50	65.60	69.70	73.80	77.90	82.00
83	4.15	8.30	12.45	16.60	20.75	24.90	29.05	33.20	37.35	41.50	45.65	49.80	53.95	58.10	62.25	66.40	70.55	74.70	78.85	83.00
84	4.20	8.40	12.60	16.80	21.00	25.20	29.40	33.60	37.80	42.00	46.20	50.40	54.60	58.80	63.00	67.20	71.40	75.60	79.80	84.00
85	4.25	8.50	12.75	17.00	21.25	25.50	29.75	34.00	38.25	42.50	46.75	51.00	55.25	59.50	63.75	68.00	72.25	76.50	80.75	85.00
86	4.30	8.60	12.90	17.20	21.50	25.80	30.10	34.40	38.70	43.00	47.30	51.60	55.90	60.20	64.50	68.80	73.10	77.40	81.70	86.00
87	4.35	8.70	13.05	17.40	21.75	26.10	30.45	34.80	39.15	43.50	47.85	52.20	56.55	60.90	65.25	69.60	73.95	78.30	82.65	87.00
88	4.40	8.80	13.20	17.60	22.00	26.40	30.80	35.20	39.60	44.00	48.40	52.80	57.20	61.60	66.00	70.40	74.80	79.20	83.60	88.00
89	4.45	8.90	13.35	17.80	22.25	26.70	31.15	35.60	40.05	44.50	48.95	53.40	57.85	62.30	66.75	71.20	75.65	80.10	84.55	89.00
90	4.50	9.00	13.50	18.00	22.50	27.00	31.50	36.00	40.50	45.00	49.50	54.00	58.50	63.00	67.50	72.00	76.50	81.00	85.50	90.00
91	4.55	9.10	13.65	18.20	22.75	27.30	31.85	36.40	40.95	45.50	50.05	54.60	59.15	63.70	68.25	72.80	77.35	81.90	86.45	91.00
92	4.60	9.20	13.80	18.40	23.00	27.60	32.20	36.80	41.40	46.00	50.60	55.20	59.80	64.40	69.00	73.60	78.20	82.80	87.40	92.00
93	4.65	9.30	13.95	18.60	23.25	27.90	32.55	37.20	41.85	46.50	51.15	55.80	60.45	65.10	69.75	74.40	79.05	83.70	88.35	93.00
94	4.70	9.40	14.10	18.80	23.50	28.20	32.90	37.60	42.30	47.00	51.70	56.40	61.10	65.80	70.50	75.20	79.90	84.60	89.30	94.00
95	4.75	9.50	14.25	19.00	23.75	28.50	33.25	38.00	42.75	47.50	52.25	57.00	61.75	66.50	71.25	76.00	80.75	85.50	90.25	95.00
96	4.80	9.60	14.40	19.20	24.00	28.80	33.60	38.40	43.20	48.00	52.80	57.60	62.40	67.20	72.00	76.80	81.60	86.40	91.20	96.00
97	4.85	9.70	14.55	19.40	24.25	29.10	33.95	38.80	43.65	48.50	53.35	58.20	63.05	67.90	72.75	77.60	82.45	87.30	92.15	97.00
98	4.90	9.80	14.70	19.60	24.50	29.40	34.30	39.20	44.10	49.00	53.90	58.80	63.70	68.60	73.50	78.40	83.30	88.20	93.10	98.00
99	4.95	9.90	14.85	19.80	24.75	29.70	34.65	39.60	44.55	49.50	54.45	59.40	64.35	69.30	74.25	79.20	84.15	89.10	94.05	99.00
100	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00	55.00	60.00	65.00	70.00	75.00	80.00	85.00	90.00	95.00	100.00

TABLE IV

THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEETS - Continued

CONVECTION HEAT GAIN RATE (q_{ca})
Free Convection

Temp Diff Δt_1	HEAT GAIN RATE, BTU/HR, SQ FT					
	Vertical Flat Surfaces[1]	Horizontal Flat Surfaces, Facing Upward[2]	Horizontal Flat Surfaces, Facing Downward[2]	Horizontal Cylinders and Pipes[1]	Vertical Cylinders and Pipes[1,3]	Spheres
1	0 24	0.15	0.30	0.17	0.21	0.31
2	0.57	0.36	0.73	0.41	0.50	0.74
3	0.95	0.61	1.22	0.69	0.84	1.24
4	1 37	0.87	1.76	1.00	1.21	1.79
5	1.81	1.16	2.33	1.32	1.61	2.37
6	2.29	1.46	2.93	1.67	2.02	2.98
7	2 78	1.77	3.56	2.02	2.46	3.63
8	3.29	2.10	4.22	2.40	2.91	4.29
9	3.82	2.44	4.90	2.78	3.38	4.98
10	4.36	2.79	5.60	3.18	3.86	5.69
11	4.92	3.14	6.31	3.58	4.36	6.43
12	5.49	3.51	7.06	4.00	4.87	7.17
13	6.08	3.88	7.80	4.43	5.39	7.94
14	6.68	4.26	8.57	4.86	5.92	8.72
15	7.29	4.65	9.36	5.31	6.46	9.52
16	7.91	5.05	10.2	5.76	7.01	10.3
17	8.54	5.45	11.0	6.22	7.57	11.1
18	9.18	5.86	11.8	6.69	8.13	12.0
19	9.83	6.28	12.6	7.17	8.71	12.8
20	10.4	6.70	13.5	7.65	9.29	13.7
21	11 2	7.12	14.3	8.13	9 89	14.6
22	11 8	7.56	15.2	8 63	10.5	15.5
23	12 5	7 99	16.1	9.13	11.1	16.4
24	13 2	8 44	17 0	9.63	11.7	17.3
25	13 9	8 88	17 9	10.1	12.3	18.2
26	14 6	9 34	18 8	10 7	13.0	19.1
27	15 3	9.79	19.7	11 2	13.6	20.1
28	16 1	10 3	20.6	11.7	14 2	21.0
29	16 8	10 7	21 6	12.2	14.9	21.9
30	17 5	11.2	22.5	12.8	15.5	22.9
31	18.3	11.7	23.5	13.3	16.2	23.9
32	19 0	12 1	24.4	13.9	16.8	24.8
33	19.8	12.6	25.4	14 4	17.5	25.8
34	20 5	13.1	26.4	15.0	18.2	26.8
35	21 3	13.6	27.4	15 5	18.9	27.8
36	22 1	14 1	28 4	16 1	19.6	28 8

Temp Diff Δt_1	HEAT GAIN RATE, BTU/HR, SQ FT					
	Vertical Flat Surfaces[1]	Horizontal Flat Surfaces, Facing Upward[2]	Horizontal Flat Surfaces, Facing Downward[2]	Horizontal Cylinders and Pipes[1]	Vertical Cylinders and Pipes[1,3]	Spheres
37	22.9	14.6	29.4	16.7	20.3	29.8
38	23.6	15.1	30.4	17.2	20.9	30.9
39	24.4	15.6	31.4	17.8	21.7	31.9
40	25.2	16.1	32.4	18.4	22.4	32.9
41	26.0	16.6	33.4	19.0	23.1	34.0
42	26.8	17.1	34 5	19.6	23.8	35.0
43	27.7	17.7	35.5	20.2	24.5	36.1
44	28.5	18.2	36.6	20.7	25.2	37.2
45	29.3	18.7	37.6	21.3	25.9	38.2
46	30.1	19.2	38.7	22.0	26.7	39.3
47	30.9	19.7	39.7	22.6	27.4	40.4
48	31.8	20.3	40.8	23.2	28 2	41.5
49	32.6	20.8	41.9	23.8	28.9	42.6
50	33.5	21.4	43.0	24.4	29.7	43 7
51	34.3	21.9	44.1	25.0	30.4	44.8
52	35.2	22.5	45.2	25.6	31.2	45.9
53	36.0	23.0	46.3	26.3	31.9	47.0
54	36.9	23.5	47.4	26.9	32.7	48.2
55	37.8	24.1	48.5	27.5	33.5	49.3
56	38.6	24.7	49.6	28.2	34.2	50 4
57	39.5	25.2	50.7	28.8	35.0	51 6
58	40.4	25.8	51.9	29.4	35.8	52.7
59	41.3	26.3	53.0	30.1	36.6	53 9
60	42.2	26 9	54.1	30.7	37 3	55 0
61	43.0	27.5	55.3	31.4	38.1	56 2
62	43.9	28.1	56 4	32.0	38 9	57 4
63	44 8	28 6	57.6	32 7	39 7	58.5
64	45.7	29.2	58 7	33 3	40.5	59 7
65	46.7	29.8	59 9	34.0	41 3	60 9
66	47.6	30.4	61.1	34.7	42 1	62 1
67	48.5	31.0	62.2	35.3	42 9	63 3
68	49.4	31.5	63.4	36.0	43 8	64 5
69	50.3	32.1	64 6	36.7	44 6	65 7
70	51.2	32.7	65 8	37.3	45 4	66.9
71	52.2	33.3	67 0	38.0	46 2	68 1
72	53.1	33.9	68 2	38.7	47 0	69 3

[1] See table at right for correction factors for surface height or diameter.

[2] Figures in this column are more accurate for surfaces having dimensions of 24 inches or greater.

[3] Figures in this column are more accurate for vertical heights over 24 inches

CORRECTION FACTORS FOR SURFACE HEIGHT OR DIAMETER OF INSULATION

Approx. Height or OD, In.	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20	22
Correction Factor C_s	1.89	1.64	1.52	1.43	1.37	1.32	1.28	1.25	1 22	1.19	1 15	1.11	1 08	1 06	1 04	1 02

No correction needed for heights or diameters 24 inches and greater.

TABLE V

THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEETS - Continued

VALUES OF RESISTANCE R ($R = \Delta t_2 / q_a$)

Note: $q_a = q_{cr} + q_{ca}$

Δt_1 °F	SURFACE HEAT GAIN q_a in Btu/sf hr																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
5	5.0	2.5	1.67	1.25	1.0	0.83	0.71	0.63	0.56	0.5	0.45	0.42	0.39	0.36	0.33	0.31	0.29	0.28	0.26	0.2
10	10.0	5.0	3.33	2.50	2.0	1.67	1.43	1.25	1.11	1.0	0.91	0.83	0.77	0.71	0.66	0.63	0.59	0.56	0.53	0.5
15	15.0	7.5	5.00	3.75	3.0	2.50	2.14	1.88	1.67	1.5	1.36	1.25	1.15	1.07	1.00	0.94	0.88	0.83	0.79	0.7
20	20.0	10.0	6.67	5.00	4.0	3.33	2.86	2.50	2.22	2.0	1.82	1.67	1.54	1.43	1.33	1.25	1.18	1.11	1.05	1.0
25	25.0	12.5	8.33	6.25	5.0	4.17	3.57	3.13	2.78	2.5	2.27	2.08	1.92	1.79	1.66	1.56	1.47	1.39	1.32	1.2
30	30.0	15.0	10.00	7.50	6.0	5.00	4.29	3.75	3.33	3.0	2.73	2.50	2.31	2.14	2.00	1.88	1.76	1.67	1.57	1.5
35	35.0	17.5	11.67	8.75	7.0	5.83	5.00	4.38	3.89	3.5	3.18	2.92	2.69	2.50	2.33	2.19	2.06	1.94	1.84	1.7
40	40.0	20.0	13.33	10.00	8.0	6.67	5.71	5.00	4.44	4.0	3.64	3.33	3.08	2.86	2.66	2.50	2.35	2.22	2.11	2.0
45	45.0	22.5	15.00	11.25	9.0	7.50	6.43	5.63	5.00	4.5	4.09	3.75	3.46	3.21	3.00	2.81	2.65	2.50	2.37	2.2
50	50.0	25.0	16.67	12.50	10.0	8.33	7.14	6.25	5.56	5.0	4.55	4.17	3.85	3.57	3.33	3.13	2.94	2.78	2.63	2.5
55	55.0	27.5	18.33	13.75	11.0	9.17	7.86	6.88	6.11	5.5	5.00	4.58	4.23	3.93	3.66	3.44	3.24	3.06	2.89	2.7
60	60.0	30.0	20.00	15.00	12.0	10.00	8.57	7.50	6.67	6.0	5.46	5.00	4.62	4.29	4.00	3.75	3.53	3.33	3.16	3.0
65	65.0	32.5	21.67	16.25	13.0	10.83	9.29	8.13	7.22	6.5	5.91	5.42	5.00	4.64	4.33	4.06	3.82	3.61	3.42	3.2
70	70.0	35.0	23.33	17.50	14.0	11.67	10.00	8.75	7.78	7.0	6.37	5.83	5.39	5.00	4.66	4.38	4.12	3.89	3.68	3.5
75	75.0	37.5	25.00	18.75	15.0	12.00	10.71	9.38	8.33	7.5	6.82	6.25	5.77	5.36	5.00	4.69	4.41	4.17	3.95	3.7
80	80.0	40.0	26.67	20.00	16.0	13.33	11.43	10.00	8.89	8.0	7.27	6.67	6.15	5.71	5.33	5.00	4.71	4.44	4.21	4.0
85	85.0	42.5	28.33	21.25	17.0	14.17	12.14	10.63	9.44	8.5	7.73	7.08	6.54	6.07	5.66	5.31	5.00	4.72	4.47	4.2
90	90.0	45.0	30.00	22.50	18.0	15.00	12.86	11.25	10.00	9.0	8.19	7.50	6.92	6.43	6.00	5.63	5.29	5.00	4.74	4.5
95	95.0	47.5	31.67	23.75	19.0	15.83	13.57	11.88	10.56	9.5	8.64	7.92	7.31	6.79	6.33	5.94	5.59	5.28	5.00	4.7
100	100.0	50.0	33.33	25.00	20.0	16.67	14.29	12.50	11.11	10.0	9.09	8.33	7.69	7.14	6.66	6.25	5.88	5.56	5.26	5.0
110	110.0	55.0	36.67	27.50	22.0	18.33	15.71	13.75	12.22	11.0	10.00	9.17	8.46	7.86	7.33	6.88	6.47	6.11	5.79	5.5
120	120.0	60.0	40.00	30.00	24.0	20.00	17.14	15.00	13.33	12.0	10.91	10.00	9.23	8.57	8.00	7.50	7.06	6.67	6.32	6.0
130	130.0	65.0	43.33	32.50	26.0	21.67	18.57	16.25	14.44	13.0	11.82	10.83	10.00	9.29	8.66	8.13	7.65	7.22	6.84	6.5
140	140.0	70.0	46.67	35.00	28.0	23.33	20.00	17.50	15.56	14.0	12.73	11.67	10.77	10.00	9.30	8.75	8.24	7.78	7.37	7.0
150	150.0	75.0	50.00	37.50	30.0	25.00	21.43	18.75	16.67	15.0	13.64	12.50	11.54	10.71	10.00	9.38	8.82	8.33	7.89	7.5
160	160.0	80.0	53.33	40.00	32.0	26.67	22.86	20.00	17.78	16.0	14.55	13.33	12.31	11.42	10.66	10.00	9.41	8.89	8.42	8.0
170	170.0	85.0	56.67	42.50	34.0	28.33	24.29	21.25	18.89	17.0	15.46	14.17	13.08	12.14	11.33	10.63	10.00	9.44	8.95	8.5
180	180.0	90.0	60.00	45.00	36.0	30.00	25.71	22.50	20.00	18.0	16.37	15.00	13.85	12.86	12.00	11.25	10.59	10.00	9.47	9.0
190	190.0	95.0	63.33	47.50	38.0	31.67	27.14	23.75	21.11	19.0	17.27	15.83	14.62	13.57	12.66	11.88	11.18	10.56	10.00	9.5
200	200.0	100.0	66.67	50.00	40.0	33.33	28.57	25.00	22.22	20.0	18.19	16.67	15.39	14.29	13.33	12.50	11.76	11.11	10.53	10.0
210	210.0	105.0	70.00	52.50	42.0	35.00	30.00	26.25	23.33	21.0	19.09	17.50	16.15	15.00	14.00	13.13	12.35	11.67	11.05	10.5
220	220.0	110.0	73.33	55.00	44.0	36.67	31.43	27.50	24.44	22.0	20.00	18.33	16.92	15.71	14.66	13.75	12.94	12.22	11.57	11.0
230	230.0	115.0	76.67	57.50	46.0	38.33	32.86	28.75	25.56	23.0	20.91	19.17	17.69	16.43	15.33	14.38	13.53	12.78	12.11	11.5
240	240.0	120.0	80.00	60.00	48.0	40.00	34.29	30.00	26.67	24.0	21.82	20.00	18.46	17.14	16.00	15.00	14.12	13.33	12.63	12.0
250	250.0	125.0	83.33	62.50	50.0	41.67	35.71	31.25	27.78	25.0	22.73	20.83	19.23	17.86	16.66	15.63	14.71	13.89	13.16	12.5
260	260.0	130.0	86.67	65.00	52.0	43.33	37.14	32.50	28.89	26.0	23.64	21.67	20.00	18.57	17.33	16.25	15.29	14.44	13.68	13.0
270	270.0	135.0	90.00	67.50	54.0	45.00	38.57	33.75	30.00	27.0	24.55	22.50	20.77	19.29	18.00	16.88	15.88	15.00	14.21	13.5
280	280.0	140.0	93.33	70.00	56.0	46.67	40.00	35.00	31.11	28.0	25.46	23.33	21.54	20.00	18.66	17.50	16.47	15.56	14.74	14.0
290	290.0	145.0	96.67	72.50	58.0	48.33	41.43	36.25	32.22	29.0	26.37	24.17	22.31	20.71	19.33	18.13	17.06	16.11	15.26	14.5
300	300.0	150.0	100.00	75.00	60.0	50.00	42.86	37.50	33.33	30.0	27.27	25.00	23.08	21.43	20.00	18.75	17.65	16.67	15.79	15.0

Δt_1 °F	SURFACE HEAT GAIN q_a in Btu/sf hr																			
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
5	0.24	0.23	0.22	0.21	0.20	0.20	0.19	0.18	0.17	0.17	0.16	0.16	0.15	0.15	0.14	0.14	0.14	0.13	0.13	0.1
10	0.48	0.46	0.44	0.42	0.40	0.39	0.37	0.36	0.35	0.33	0.32	0.31	0.30	0.30	0.29	0.28	0.27	0.26	0.26	0.2
15	0.71	0.68	0.65	0.63	0.60	0.58	0.56	0.54	0.52	0.50	0.48	0.47	0.46	0.44	0.43	0.42	0.41	0.40	0.39	0.3
20	0.95	0.91	0.87	0.83	0.80	0.77	0.74	0.71	0.69	0.67	0.65	0.63	0.61	0.59	0.57	0.56	0.54	0.53	0.51	0.5
25	1.19	1.14	1.09	1.04	1.00	0.96	0.93	0.89	0.86	0.83	0.81	0.78	0.76	0.74	0.72	0.70	0.68	0.66	0.64	0.6
30	1.43	1.36	1.30	1.25	1.20	1.15	1.11	1.07	1.04	1.00	0.97	0.94	0.91	0.88	0.86	0.83	0.81	0.79	0.77	0.7
35	1.67	1.59	1.52	1.46	1.40	1.35	1.30	1.25	1.21	1.17	1.13	1.09	1.06	1.03	1.00	0.97	0.95	0.92	0.90	0.8
40	1.91	1.82	1.74	1.67	1.60	1.54	1.48	1.43	1.38	1.33	1.29	1.25	1.21	1.18	1.14	1.11	1.08	1.05	1.03	1.0
45	2.14	2.05	1.96	1.88	1.80	1.73	1.67	1.61	1.55	1.50	1.45	1.41	1.36	1.32	1.29	1.25	1.22	1.18	1.15	1.1
50	2.38	2.27	2.17	2.08	2.00	1.92	1.85	1.79	1.72	1.67	1.61	1.56	1.52	1.47	1.43	1.39	1.35	1.32	1.28	1.2
55	2.62	2.50	2.39	2.29	2.20	2.12	2.04	1.96	1.90	1.83	1.77	1.72	1.67	1.62	1.57	1.53	1.49	1.45	1.41	1.3
60	2.86	2.73	2.61	2.50	2.40	2.31	2.22	2.14	2.07	2.00	1.94	1.88	1.82	1.77	1.71	1.67	1.62	1.58	1.54	1.5
65	3.10	2.96	2.83	2.71	2.60	2.50	2.41	2.32	2.24	2.17	2.10	2.03	1.97	1.91	1.86	1.81	1.76	1.71	1.67	1.6
70	3.33	3.18	3.04	2.92	2.80	2.69	2.59	2.50	2.41	2.33	2.26	2.19	2.12	2.06	2.00	1.94	1.89	1.84	1.80	1.75
75	3.57	3.41	3.26	3.13	3.00	2.89	2.78	2.68	2.59	2.50	2.42	2.34	2.27	2.21	2.14	2.08	2.03	1.97	1.92	1.8
80	3.81	3.64	3.48	3.33	3.20	3.08	2.96	2.86	2.76	2.67	2.58	2.50	2.42	2.35	2.29	2.22	2.16	2.11	2.11	2.0
85	4.05	3.86	3.70	3.54	3.40	3.27	3.15	3.04	2.93	2.83	2.74	2.66	2.58	2.50	2.43	2.36	2.29	2.24	2.18	2.1
90	4.29	4.09	3.91	3.75	3.60	3.46	3.33	3.21	3.10	3.00	2.90	2.81	2.73	2.65	2.57	2.50	2.43	2.37	2.31	2.2
95	4.52	4.32	4.13	3.96	3.80	3.65	3.52	3.39	3.28	3.17	3.07	2.97	2.88	2.79	2.71	2.64	2.57	2.50	2.44	2.3
100	4.76	4.55	4.35	4.17	4.00	3.85	3.70	3.57	3.45	3.33	3.23	3.13	3.03	2.94	2.86	2.78	2.70	2.63	2.56	2.5
110	5.24	5.00	4.78	4.58	4.40	4.23	4.07	3.93	3.79	3.67	3.55	3.44	3.33	3.24	3.14	3.06	2.97	2.90	2.82	2.7
120	5.71	5.46	5.22	5.00	4.80	4.62	4.44	4.29	4.14	4.00	3.87	3.75	3.64	3.53	3.43	3.33	3.24	3.16	3.08	3.0
130	6.19	5.91	5.65	5.42	5.20	5.00	4.82	4.64	4.48	4.33	4.19	4.06	3.94	3.82	3.71	3.61	3.51	3.42	3.33	3.2
140	6.67	6.36	6.09	5.83	5.60	5.39	5.19	5.00	4.83	4.67	4.52	4.38	4.24	4.12	4.00	3.89	3.78	3.68	3.59	3.5
150	7.14	6.82	6.52	6.25	6.00	5.77	5.56	5.36	5.17	5.00	4.84	4.69	4.55	4.41	4.29	4.17	4.05	3.95	3.85	3.7
160	7.62	7.27	6.95	6.67	6.40	6.15	5.93	5.71	5.52	5.33	5.16	5.00	4.85	4.71	4.57	4.44	4.32	4.21	4.0	4.0
170	8.10	7.73	7.39	7.08	6.80	6.54	6.30	6.07	5.86	5.66	5.48	5.31	5.15	5.00	4.86	4.72	4.60	4.47	4.36	4.2
180	8.57	8.18	7.83	7.50	7.20	6.92	6.67	6.43	6.21	6.00	5.81	5.63	5.46	5.29	5.14	5.00	4.87	4.74	4.62	4.5
190	9.05	8.64	8.26	7.92	7.60	7.31	7.04	6.79	6.55	6.33	6.13	5.94	5.76	5.59	5.43	5.28	5.14	5.00	4.87	4.7
200	9.52	9.09	8.70	8.33	8.00	7.69	7.41	7.14	6.90	6.67	6.45	6.25	6.06	5.88	5.71	5.56	5.41	5.26	5.13	5.0
210	10.00	9.55	9.13	8.75	8.40	8.08	7.78	7.50	7.24	7.00	6.77	6.56	6.36	6.18	6.00	5.83	5.68	5.53	5.39	5.2
220	10.48	10.00	9.57	9.17	8.80	8.46	8.15	7.86	7.59	7.33	7.10	6.88	6.67	6.47	6.29	6.11	5.95	5.79	5.64	5.5
230	10.95	10.46	10.00	9.58	9.20	8.85	8.52	8.21	7.93	7.67	7.42	7.19	6.97	6.77	6.57	6.39	6.22	6.05	5.90	5.7
240	11.43	10.91	10.44	10.00	9.60	9.23	8.89	8.57	8.28	8.00	7.74	7.50	7.27	7.06	6.86	6.67	6.49	6.32	6.15	6.0
250	11.91	11.36	10.87	10.42	10.00	9.62	9.26	8.93	8.62	8.33	8.07	7.82	7.58	7.36	7.14	6.94	6.76	6.58	6.41	6.2
260	12.38	11.82	11.30	10.83	10.40	10.00	9.63	9.29	8.97	8.67	8.39	8.13	7.88	7.65	7.43	7.22	7.03	6.84	6.67	6.5
270	12.86	12.27	11.74	11.25	10.80	10.39	10.00	9.64	9.31	9.00	8.71	8.44	8.18	7.94	7.71	7.50	7.30	7.11	6.92	6.7
280	13.33	12.73	12.17	11.67	11.20	10.77	10.37	10.00	9.66	9.33	9.03	8.75	8.49	8.24	8.00	7.78	7.57	7.37	7.18	7.0
290	13.81	13.18	12.61	12.08	11.60	11.15	10.74	10.36	10.00	9.67	9.36	9.06	8.79	8.53	8.29	8.06	7.84	7.63	7.44	7.2
300	14.29	13.64	13.04	12.50	12.00	11.54	11.11	10.71	10.35	10.00	9.68	9.38	9.09	8.82	8.57	8.33	8.11	7.90	7.69	7.5

TABLE VI

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THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEETS - Continued

FLAT (OR EQUIVALENT) THICKNESS OF INSULATION, L (L = Rk)

	k OF INSULATION IN Btu/sf, hr, °F, INCH																			
R	0.10	0.12	0.14	0.16	0.18	0.20	0.22	0.24	0.26	0.28	0.30	0.35	0.40	0.45	0.50	0.60	0.70	0.80	0.90	1.00
0.5	0.05	0.06	0.07	0.08	0.09	0.10	0.11	0.12	0.13	0.14	0.15	0.18	0.20	0.23	0.25	0.30	0.35	0.40	0.45	0.50
1.0	0.10	0.12	0.14	0.16	0.18	0.20	0.22	0.24	0.26	0.28	0.30	0.35	0.40	0.45	0.50	0.60	0.70	0.80	0.90	1.00
1.5	0.15	0.18	0.21	0.24	0.27	0.30	0.33	0.36	0.39	0.42	0.45	0.53	0.60	0.68	0.75	0.90	1.05	1.20	1.35	1.50
2.0	0.20	0.24	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00
2.5	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.88	1.00	1.13	1.25	1.50	1.75	2.00	2.25	2.50
3.0	0.30	0.36	0.42	0.48	0.54	0.60	0.66	0.72	0.78	0.84	0.90	1.05	1.20	1.35	1.50	1.80	2.10	2.40	2.70	3.00
3.5	0.35	0.42	0.49	0.56	0.63	0.70	0.77	0.84	0.91	0.98	1.05	1.23	1.40	1.58	1.75	2.10	2.45	2.80	3.15	3.50
4.0	0.40	0.48	0.56	0.64	0.72	0.80	0.88	0.96	1.04	1.12	1.20	1.40	1.60	1.80	2.00	2.40	2.80	3.20	3.60	4.00
4.5	0.45	0.54	0.63	0.72	0.81	0.90	0.99	1.08	1.17	1.26	1.35	1.58	1.80	2.03	2.25	2.70	3.15	3.60	4.05	4.50
5.0	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.75	2.00	2.25	2.50	3.00	3.50	4.00	4.50	5.00
5.5	0.55	0.66	0.77	0.88	0.99	1.10	1.21	1.32	1.43	1.54	1.65	1.93	2.20	2.48	2.75	3.30	3.85	4.40	4.95	5.50
6.0	0.60	0.72	0.84	0.96	1.08	1.20	1.32	1.44	1.56	1.68	1.80	2.10	2.40	2.70	3.00	3.60	4.20	4.80	5.40	6.00
6.5	0.65	0.78	0.91	1.04	1.17	1.30	1.43	1.56	1.69	1.82	1.95	2.28	2.60	2.93	3.25	3.90	4.55	5.20	5.85	6.50
7.0	0.70	0.84	0.98	1.12	1.26	1.40	1.54	1.68	1.82	1.96	2.10	2.45	2.80	3.15	3.50	4.20	4.90	5.60	6.30	7.00
7.5	0.75	0.90	1.05	1.20	1.35	1.50	1.65	1.80	1.95	2.10	2.25	2.63	3.00	3.38	3.75	4.50	5.25	6.00	6.75	7.50
8.0	0.80	0.96	1.12	1.28	1.44	1.60	1.76	1.92	2.08	2.24	2.40	2.80	3.20	3.60	4.00	4.80	5.60	6.40	7.20	8.00
8.5	0.85	1.02	1.19	1.36	1.53	1.70	1.87	2.04	2.21	2.38	2.55	2.98	3.40	3.83	4.25	5.10	5.95	6.80	7.65	8.50
9.0	0.90	1.08	1.26	1.44	1.62	1.80	1.98	2.16	2.34	2.52	2.70	3.15	3.60	4.05	4.50	5.40	6.30	7.20	8.10	9.00
9.5	0.95	1.14	1.33	1.52	1.71	1.90	2.09	2.28	2.47	2.66	2.85	3.33	3.80	4.28	4.75	5.70	6.65	7.60	8.55	9.50
10.0	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	3.00	3.50	4.00	4.50	5.00	6.00	7.00	8.00	9.00	10.00
11.0	1.10	1.32	1.54	1.76	1.98	2.20	2.42	2.64	2.86	3.08	3.30	3.85	4.40	4.95	5.50	6.60	7.70	8.80	9.90	11.00
12.0	1.20	1.44	1.68	1.92	2.16	2.40	2.64	2.88	3.12	3.36	3.60	4.20	4.80	5.40	6.00	7.20	8.40	9.60	10.80	12.00
13.0	1.30	1.56	1.82	2.08	2.34	2.60	2.86	3.12	3.38	3.64	3.90	4.55	5.20	5.85	6.50	7.80	9.10	10.40	11.70	13.00
14.0	1.40	1.68	1.96	2.24	2.52	2.80	3.08	3.36	3.64	3.92	4.20	4.90	5.60	6.30	7.00	8.40	9.80	11.20	12.60	14.00
15.0	1.50	1.80	2.10	2.40	2.70	3.00	3.30	3.60	3.90	4.20	4.50	5.25	6.00	6.75	7.50	9.00	10.50	12.00	13.50	15.00
16.0	1.60	1.92	2.24	2.56	2.88	3.20	3.52	3.84	4.16	4.48	4.80	5.60	6.40	7.20	8.00	9.60	11.20	12.80	14.40	16.00
17.0	1.70	2.04	2.38	2.72	3.06	3.40	3.74	4.08	4.42	4.76	5.10	5.95	6.80	7.65	8.50	10.20	11.90	13.60	15.30	17.00
18.0	1.80	2.16	2.52	2.88	3.24	3.60	3.96	4.32	4.68	5.04	5.40	6.30	7.20	8.10	9.00	10.80	12.60	14.40	16.20	18.00
19.0	1.90	2.28	2.66	3.04	3.42	3.80	4.18	4.56	4.94	5.32	5.70	6.65	7.60	8.55	9.50	11.40	13.30	15.20	17.10	19.00
20.0	2.00	2.40	2.80	3.20	3.60	4.00	4.40	4.80	5.20	5.60	6.00	7.00	8.00	9.00	10.00	12.00	14.00	16.00	18.00	20.00
21.0	2.10	2.52	2.94	3.36	3.78	4.20	4.62	5.04	5.46	5.88	6.30	7.35	8.40	9.45	10.50	12.60	14.70	16.80	18.90	21.00
22.0	2.20	2.64	3.08	3.52	3.96	4.40	4.84	5.28	5.72	6.16	6.60	7.70	8.80	9.90	11.00	13.20	15.40	17.60	19.80	22.00
23.0	2.30	2.76	3.22	3.68	4.14	4.60	5.06	5.52	5.98	6.44	6.90	8.05	9.20	10.35	11.50	13.80	16.10	18.40	20.70	23.00
24.0	2.40	2.88	3.36	3.84	4.32	4.80	5.28	5.76	6.24	6.72	7.20	8.40	9.60	10.80	12.00	14.40	16.80	19.20	21.60	24.00
25.0	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.75	10.00	11.25	12.50	15.00	17.50	20.00	22.50	25.00
26.0	2.60	3.12	3.64	4.16	4.68	5.20	5.72	6.24	6.76	7.28	7.80	9.10	10.40	11.70	13.00	15.60	18.20	20.80	23.40	26.00
27.0	2.70	3.24	3.78	4.32	4.86	5.40	5.94	6.48	7.02	7.56	8.10	9.45	10.80	12.15	13.50	16.20	18.90	21.60	24.30	27.00
28.0	2.80	3.36	3.92	4.48	5.04	5.60	6.16	6.72	7.28	7.84	8.40	9.80	11.20	12.60	14.00	16.80	19.60	22.40	25.20	28.00
29.0	2.90	3.48	4.06	4.64	5.22	5.80	6.38	6.96	7.54	8.12	8.70	10.15	11.60	13.05	14.50	17.40	20.30	23.20	26.10	29.00
30.0	3.00	3.60	4.20	4.80	5.40	6.00	6.60	7.20	7.80	8.40	9.00	10.50	12.00	13.50	15.00	18.00	21.00	24.00	27.00	30.00
31.0	3.10	3.72	4.34	4.96	5.58	6.20	6.82	7.44	8.06	8.68	9.30	10.85	12.40	13.95	15.50	18.60	21.70	24.80	27.90	31.00
32.0	3.20	3.84	4.48	5.12	5.76	6.40	7.04	7.68	8.32	8.96	9.60	11.20	12.80	14.40	16.00	19.20	22.40	25.60	28.80	32.00
33.0	3.30	3.96	4.62	5.28	5.94	6.60	7.26	7.92	8.58	9.24	9.90	11.55	13.20	14.85	16.50	19.80	23.10	26.40	29.70	33.00
34.0	3.40	4.08	4.76	5.44	6.12	6.80	7.48	8.16	8.84	9.52	10.20	11.90	13.60	15.30	17.00	20.40	23.80	27.20	30.60	34.00
35.0	3.50	4.20	4.90	5.60	6.30	7.00	7.70	8.40	9.10	9.80	10.50	12.25	14.00	15.75	17.50	21.00	24.50	28.00	31.50	35.00
36.0	3.60	4.32	5.04	5.76	6.48	7.20	7.92	8.64	9.36	10.08	10.80	12.60	14.40	16.20	18.00	21.60	25.20	28.80	32.40	36.00
37.0	3.70	4.44	5.18	5.92	6.66	7.40	8.14	8.88	9.62	10.36	11.10	12.95	14.80	16.65	18.50	22.20	25.90	29.60	33.30	37.00
38.0	3.80	4.56	5.32	6.08	6.84	7.60	8.36	9.12	9.88	10.64	11.40	13.30	15.20	17.10	19.00	22.80	26.60	30.40	34.20	38.00
39.0	3.90	4.68	5.46	6.24	7.02	7.80	8.58	9.36	10.14	10.92	11.70	13.65	15.60	17.55	19.50	23.40	27.30	31.20	35.10	39.00
40.0	4.00	4.80	5.60	6.40	7.20	8.00	8.80	9.60	10.40	11.20	12.00	14.00	16.00	18.00	20.00	24.00	28.00	32.00	36.00	40.00
41.0	4.10	4.92	5.74	6.56	7.38	8.20	9.02	9.84	10.66	11.48	12.30	14.35	16.40	18.45	20.50	24.60	28.70	32.80	36.90	41.00
42.0	4.20	5.04	5.88	6.72	7.56	8.40	9.24	10.08	10.92	11.76	12.60	14.70	16.80	18.90	21.00	25.20	29.40	33.60	37.80	42.00
43.0	4.30	5.16	6.02	6.88	7.74	8.60	9.46	10.32	11.18	12.04	12.90	15.05	17.20	19.35	21.50	25.80	30.10	34.40	38.70	43.00
44.0	4.40	5.28	6.16	7.04	7.92	8.80	9.68	10.56	11.44	12.32	13.20	15.40	17.60	19.80	22.00	26.40	30.80	35.20	39.60	44.00
45.0	4.50	5.40	6.30	7.20	8.10	9.00	9.90	10.80	11.70	12.60	13.50	15.75	18.00	20.25	22.50	27.00	31.50	36.00	40.50	45.00
46.0	4.60	5.52	6.44	7.36	8.28	9.20	10.12	11.04	11.96	12.88	13.80	16.10	18.40	20.70	23.00	27.60	32.20	36.90	41.40	46.00
47.0	4.70	5.64	6.58	7.52	8.46	9.40	10.34	11.28	12.22	13.16	14.10	16.45	18.80	21.15	23.50	28.20	32.90	37.60	42.30	47.00
48.0	4.80	5.76	6.72	7.68	8.64	9.60	10.56	11.52	12.48	13.44	14.40	16.80	19.20	21.60	24.00	28.80	33.60	38.40	43.20	48.00
49.0	4.90	5.88	6.86	7.84	8.82	9.80	10.78	11.76	12.74	13.72	14.70	17.15	19.60	22.05	24.50	29.40	34.30	39.20	44.10	49.00
50.0	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	17.50	20.00	22.50	25.00	30.00	35.00	40.00	45.00	50.00
52.0	5.20	6.24	7.28	8.32	9.36	10.40	11.44	12.48	13.52	14.56	15.60	18.20	20.80	23.40	26.00	31.20	36.40	41.60	46.80	52.00
54.0	5.40	6.48	7.56	8.64	9.72	10.80	11.88	12.96	14.04	15.12	16.20	18.90	21.60	24.30	27.00	32.40	37.80	43.20	48.60	54.00
56.0	5.60	6.72	7.84	8.96	10.04	11.20	12.32	13.44	14.56	15.68	16.80	19.60	22.40	25.20	28.00	33.60	39.20	44.80	50.40	56.00
58.0	5.80	6.96	8.12	9.28	10.44	11.60	12.76	13.92	15.08	16.24	17.40	20.30	23.20	26.10	29.00	34.80	40.60	46.40	52.20	58.00
60.0	6.00	7.20	8.40	9.60	10.80	12.00	13.20	14.40	15.60	16.80	18.00	21.00	24.00	27.00	30.00	36.00	42.00	48.00	54.00	60.00
62.0	6.20	7.44	8.68	9.92	11.16	12.40	13.64	14.88	16.12	17.36	18.60	21.70	24.80	27.90	31.00	37.20	43.40	49.60	55.80	62.00
64.0	6.40	7.68	8.96	10.24	11.52	12.80	14.08	15.36	16.64	17.92	19.20	22.40	25.60	28.80	32.00	38.40	44.80	51.40	57.60	64.00
66.0	6.60	7.92	9.24	10.56	11.88	13.20	14.52	15.84	17.16	18.48	19.80	23.10	26.40	29.70	33.00	39.60	46.20	53.20	59.40	66.00
68.0	6.80	8.16	9.52	10.88	12.24	13.60	14.96	16.32	17.68	19.04	20.40	23.80	27.20	30.60	34.00	40.40	47.60	54.80	61.20	68.00
70.0	7.00	8.40	9.80	11.20	12.60	14.00	15.40	16.80	18.20	19.60	21.00	24.50	28.00	31.50	35.00	42.00	49.00	56.00	63.00	70.00
75.0	7.50	9.00	10.50	12.00	13.50	15.00	16.50	18.00	19.50	21.00	22.50	26.25	30.00	33.75	37.50	45.00	52.50	60.00	67.50	75.00
80.0	8.00	9.60	11.20	12.80	14.40	16.00	17.60	19.20	20.80	22.40	24.00	28.00	32.00	36.00	40.00	48.00	56.00	64.00	72.00	80.00
85.0	8.50	10.20	11.90	13.60	15.30	17.00	18.70	20.40	22.10	23.80	25.50	29.75	34.00	38.25	42.50	51.00	59.50	68.00	76.50	85.00
90.0	9.00	10.80	12.60	14.40	16.20	18.00	19.80	21.60	23.40	25.20	27.00	31.50	36.00	40.50	45.00	54.00	63.00	72.00	81.00	90.00
95.0	9.50	11.40	13.30	15.20	17.10	19.00	20.90	22.80	24.70	26.60	28.50	33.25	38.00	42.75	47.50	57.00	66.50	76.00	85.50	95.00
100.0	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	35.00	40.00	45.00	50.00	60.00	70.00	80.00	90.00	100.00

TABLE VII

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THEORY - THICKNESS TO PREVENT CONDENSATION

SOLUTION BY USE OF TABLES AND WORK SHEETS - Continued

NOMINAL PIPE INSULATION THICKNESS EQUIVALENT TO FLAT INSULATION THICKN

Nom. Pipe Size	NOMINAL PIPE INSULATION THICKNESS																		
	1/2	1	1-1/2	2	2-1/2	3	3-1/2	4	4-1/2	5	5-1/2	6	6-1/2	7	7-1/2	8	8-1/2	9	9-1/2
1/2	0.76	1.74	3.08	4.41	6.78	8.34	9.96	11.65	13.60	15.39	17.22	19.56							
3/4	0.55	1.43	2.65	3.86	6.05	7.50	9.02	10.59	12.42	14.10	15.82	18.03							
1	0.69	1.69	2.74	3.98	5.32	6.65	8.06	9.52	11.22	12.79	14.40	16.47	18.16	19.89					
1-1/4	0.78	1.29	2.73	3.34	4.55	5.78	7.07	8.41	9.99	11.44	12.94	14.86	16.44	18.05					
1-1/2	0.58	1.47	2.40	4.11	5.27	6.49	7.77	9.27	10.66	12.08	13.92	13.92	15.43	16.97					
2	0.66	1.41	2.33	3.36	4.40	5.51	6.67	8.05	9.32	10.63	12.33	13.73	15.16	16.62					
2-1/2	0.64	1.36	2.73	3.68	4.69	5.77	7.03	8.21	9.43	11.01	11.01	12.31	13.65	15.02					
3	0.55	1.26	2.08	2.94	3.85	4.83	5.98	7.06	8.18	9.64	10.85	12.09	13.36	14.66	15.99	17.34	18.72	20.12	21.55
3-1/2	0.54	1.65	2.43	3.28	4.19	5.27	6.28	7.34	8.71	8.71	9.85	11.03	12.23	13.47	14.73	16.02	17.33	18.67	20.02
4	0.57	1.26	1.98	2.78	3.63	4.64	5.60	6.59	7.90	8.98	10.09	11.24	12.41	13.62	14.85	16.10	17.38	18.68	20.00
6	0.49	1.09	1.74	2.54	3.30	4.10	5.16	6.04	6.96	7.91	8.89	9.90	10.93	11.99	13.07	14.18	15.30	16.45	17.62
8			1.76	2.43	3.33	4.08	4.87	5.69	6.54	7.42	8.32	9.25	10.20	11.18	12.17	13.19	14.23	15.28	16.36
10			1.80	2.44	3.12	3.83	4.57	5.34	6.14	6.96	7.80	8.66	9.55	10.46	11.39	12.34	13.30	14.29	15.29
12			1.76	2.38	3.04	3.72	4.43	5.16	5.92	6.70	7.50	8.33	9.17	10.03	10.91	11.81	12.73	13.66	14.61
14			1.59	2.20	2.84	3.50	4.19	4.90	5.63	6.39	7.16	7.96	8.78	9.61	10.46	11.33	12.22	13.12	14.04
16			1.57	2.17	2.79	3.44	4.11	4.80	5.51	6.24	6.99	7.75	8.54	9.34	10.16	11.00	11.85	12.72	13.60
18			1.56	2.15	2.76	3.39	4.04	4.71	5.40	6.11	6.84	7.58	8.35	9.12	9.92	10.72	11.55	12.38	13.23
20			1.55	2.13	2.73	3.35	3.99	4.65	5.32	6.01	6.72	7.45	8.19	8.94	9.71	10.50	11.29	12.11	12.93
24			1.54	2.10	2.69	3.29	3.91	4.54	5.19	5.86	6.53	7.23	7.94	8.66	9.39	10.14	10.90	11.67	12.45
30			1.52	2.08	2.64	3.23	3.82	4.43	5.06	5.69	6.34	7.00	7.67	8.35	9.05	9.76	10.48	11.21	11.94
36			1.51	2.06	2.61	3.18	3.76	4.36	4.96	5.58	6.21	6.84	7.49	8.15	8.82	9.49	10.18	10.88	11.58

NOTE: Find nominal pipe size in first column and read across table until you find required flat insulation thickness (or greater), then read equi nominal pipe insulation thickness at top of column.

Dimensions given in table for pipe sizes 14-in. OD and larger can be used for equipment of same diameters.

TABLE VIII

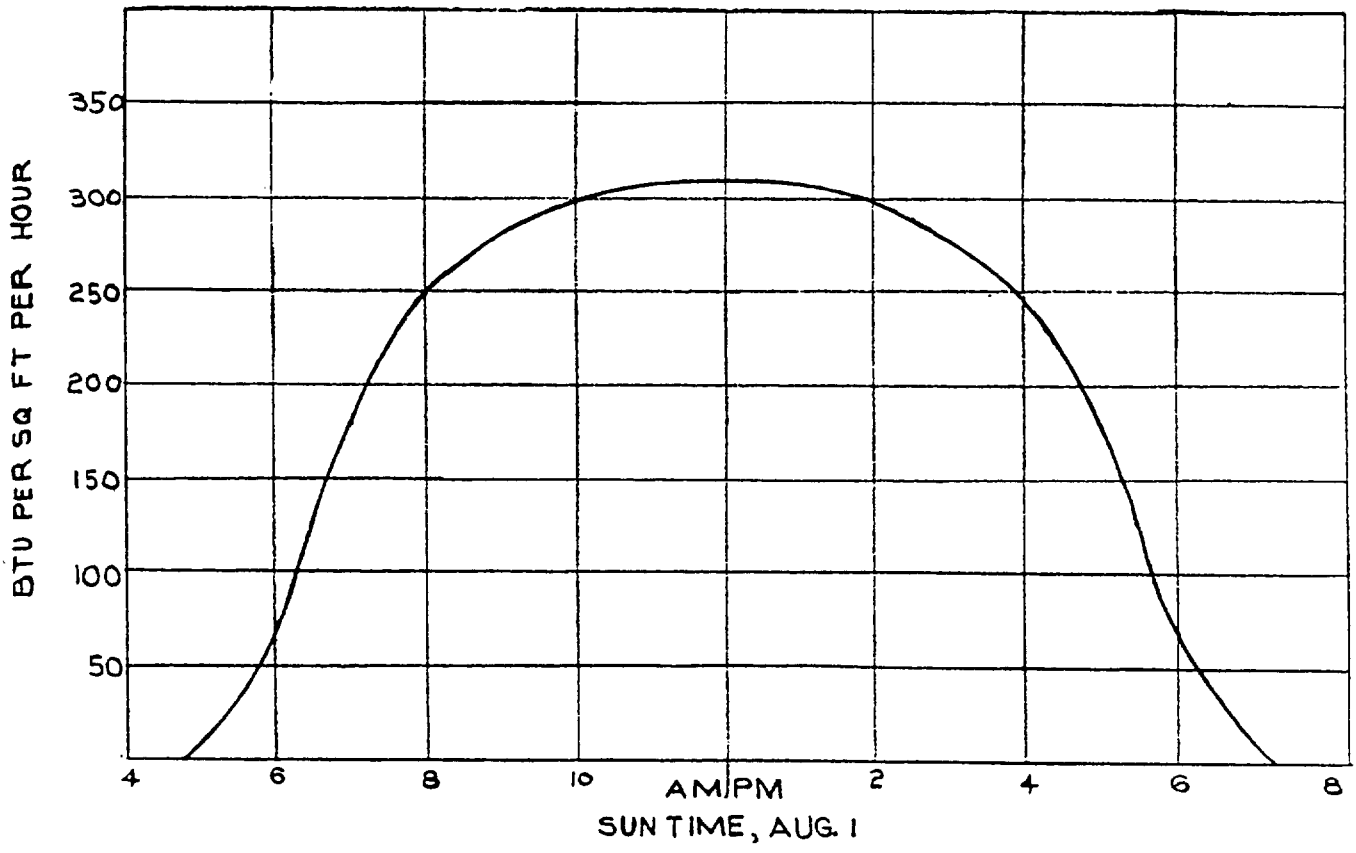
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THEORY - SOLAR RADIATION

IV. RADIATION PROBLEMS - Continued

A. Solar Radiation to Insulated Vessels - Continued

2. Continued



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THEORY - SOLAR RADIATION

IV. RADIATION PROBLEMS

A. Solar Radiation to Insulated Vessels - Continued

2. Continued

The heat transferred by radiation is based on absolute temperature T, but when heat radiation from above graph is used in the following equations, ordinary temperature t in °F may be used as the radiation affect has already been determined. As the heat gain is given in Btu's per sq ft, hr on surface normal to the sun, the total heat gain will be this value times the projected area of vessel in relation to the sun's rays. Although there will be differences existing in the rate of heat transfer for any one particular surface in accordance with angle from normal, if total heat input is the major importance it will be obtained by using the projected area.

3. To illustrate this operation, the following example is presented:

Sphere is exposed to sun 40° latitude
is insulated with 2" thickness (L) cellular glass
is coated with black asphalt mastic $\epsilon = .97$
is operated at 70°F (t_o)
is 225 feet in diameter
Ambient air temperature is 90°F t_a
What savings in heat gain would be obtained if vessel was overcoated with aluminum paint with absorption $\epsilon = 0.26$ instead of asphalt $\epsilon = .97$. In this instance for asphalt mastic ϵ and α have identical values.

Solution:

Projected sun area A_1 of sphere $\pi \left(\frac{225}{2}\right)^2 = 39,850$

Solar intensity normal to sun at 12 noon, August 1, 40°N latitude = 310 Btu/sq ft/hr (from ASHVE guide) = Value of $H_s \alpha$ when $\alpha = 1.0$

Total surface absorption (max. conditions) $A_1 \alpha H_s$ would be for black asphalt. .97 (39850 x 310) = 12,010,000 Btu's per hour.

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THEORY - SOLAR RADIATION

IV. RADIATION PROBLEMS - Continued

A. Solar Radiation to Insulated Vessels - Continued

3. Solution: - Continued

For aluminum painted. .26 (39850 x 310) = 3,285,000 Btu/hr

The heat of solar radiation will raise the surface temperature t_2 above ambient temperature t_a and above the operating temperature t_o. Thus, it will be split, part reversing direction and going to the air and the other part going into the vessel.

$$\text{or} \quad \left(\frac{t_2 - t_o}{\frac{L}{k}}\right) \frac{A_2}{2} + \left(\frac{t_2 - t_a}{\frac{1}{h}}\right) \frac{A_2}{2} = q$$

(temperatures in °F)

When A_2 = surface area of sphere.

The film resistance $\frac{1}{h} = \frac{1}{2}$, L is given as 2, the conductivity k=.42

$$A_2 = 4\pi r^2 = 4\pi (112.50)^2 = 159,400 \text{ sq ft}$$

$\frac{A_2}{2}$ the area on sun side = 79,700 sq ft

t_o = 70F, t_a = 90F

To find t_2 for black asphalt surface, the average surface on sun side

$$\left(\frac{t_2 - 70}{\frac{2}{0.42}}\right) 79,700 + \left(\frac{t_2 - 90}{\frac{1}{2}}\right) 79,700 = 12,010,000 \text{ Btu, therefore } t_2 = 156\text{F}$$

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THEORY - SOLAR RADIATION

IV. RADIATION PROBLEMS - Continued

A. Solar Radiation to Insulated Vessels - Continued

3. Continued

To find t_2 for aluminum overcoated surface

$$\left(\frac{t_2 - 70}{\frac{2}{0.42}}\right) 79,700 + \left(\frac{t_2 - 90}{\frac{1}{2}}\right) 79,700 = 3,285,000 \text{ Btu}$$

$t_2 = 107$

Heat gain sun side per hour

For black asphalt surface

$$q_{rb} = \frac{t_2 - t_o}{\frac{L}{k}} = \frac{156 - 70}{\frac{2}{0.42}} = 18.1 \text{ Btu/sq ft, hr}$$

For aluminum overcoated

$$q_{ra} = \frac{t_2 - t_o}{\frac{L}{k}} = \frac{107 - 70}{\frac{2}{0.42}} = 7.8 \text{ Btu/sq ft, hr}$$

Heat gain shade side (either asphalt or aluminum overcoated)

$\frac{1}{h}$ = .9 still air conditions

$$q_{rs} = \frac{t_a - t_o}{\frac{L}{k} + \frac{1}{h}} = \frac{90 - 70}{\frac{2}{0.42} + .9} = \frac{20}{5.66} = 3.53 \text{ Btu/sq ft, hr}$$

Total maximum gain per hour caused by maximum sun load

Asphalt black

$$\left(\frac{A_1}{2} \times q_{rb}\right) + \left(\frac{A_1}{2} \times q_{rs}\right) = \text{Btu/hr}$$

$(79700 \times 18.1) + (79700 \times 3.53) = 1,440,000 + 286,000 = 1,726,000$ Btu/hr

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THEORY - SOLAR RADIATION

IV. RADIATION PROBLEMS - Continued

A. Solar Radiation to Insulated Vessels - Continued

3. Continued

Aluminum overcoated

$$\left(\frac{A_1}{2} \times q_{ra}\right) + \left(\frac{A_1}{2} \times q_{rs}\right) = \text{Btu/hr}$$

$$(79700 \times 7.8) + (79700 \times 3.53) = 620,000 + 286,000 = 906,000 \text{ Btu/hr}$$

V. TIME-TEMPERATURE CALCULATIONS

A. Temperature Drop of Liquids From Inlet to Outlet of Line

Such problems are frequent, as it is necessary that many materials be above a certain temperature for proper flow.

The allowance for Btu loss is determined by the amount of allowable temperature drop of the liquid as shown below.

$$Q = \Delta t \times W \times c$$

When Δt = Allowable temperature drop
W = Weight of material in lbs
c = Specific heat

This gives amount of allowable heat loss of the material passing from one end of the pipe to the other. To obtain maximum allowable heat loss per hour from the pipe, time required for the material to pass through the line must be established in hours.

Thus q (Btu/hr) = $\frac{Q}{\text{hrs}}$, which is the allowable heat loss for the entire length of line per hour, and $\frac{q}{\text{linear ft of pipe}}$

From previously stated formulas for determining heat loss through cylindrical insulation, the required insulation thickness can be determined.

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THEORY - MISCELLANEOUS

V. TIME-TEMPERATURE CALCULATIONS - Continued

B. Temperature Drop of Stored Liquids

Another frequent problem is: If a vessel is filled with a liquid at a given temperature, what is the length of time before it arrives at certain lower (or higher) temperature closer to ambient temperature?

The solution is to determine the number of Btu's available for transfer from (or to) the material and the vessel, based on the temperature difference ($\Delta_1 t$) between material and vessel temperature and ambient temperature.

$$\text{Btu's} = (\Delta_1 t \times W_m \times c_m) + (\Delta_1 t \times W_v \times c_v)$$

When $\Delta_1 t$ = Temperature difference of material and vessel in relation to ambient temperature
W_m = Weight of material in lbs
c_m = Specific heat of material
W_v = Weight of vessel in lbs
c_v = Specific heat of vessel metal

Next is to determine Btu's of material and the vessel at difference between final allowable temperature and ambient temperature.

When $\Delta_2 t$ = Temperature difference of material and vessel at final allowable temperature in relation to ambient temperature

$$\text{Btu's} = (\Delta_2 t \times W_m \times c_m) + (\Delta_2 t \times W_v \times c_v)$$

Subtracting one from the other will give allowable Btu's heat gain or loss to the ambient air.

The heat loss (or gain) per hour per sq ft is calculcated based on expected temperature differences between vessel temperature and ambient temperatures in accordance with formulas previously presented. Total loss (or gain) per hour is obtained by multiplying this result by insulation outside surface area.

Allowable Btu's divided by Btu loss per hour will give number of hours to reach allowable temperature.

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THEORY - MISCELLANEOUS

VI. MISCELLANEOUS EQUATIONS

A number of equations are used to determine the transfer of heat to the pipe or tube on which insulation is installed. Some of the most used equations follow:

A. Reynolds Number, R

$$R = \frac{VD\rho}{\mu}$$

When V = Velocity of stream, ft/hr
ρ = Density of fluid, lb/ft^3
D = Inside diameter of tube (or pipe) ft
μ = Viscosity of fluid, lb/ft, hr

Note: Laminar flow is stable only below value R = 2320 and turbulent flow above this critical value.

B. Critical Velocity, V_{cr}

$$V_{cr} = \frac{0.643\mu}{D\rho_o} \quad \frac{ft}{sec}$$

When density of fluid, lb/ft^3 (at 32F and 29.92" of Hg)

C. Surface Conductance of Superheated Steam to a Pipe (with temperature above saturation point)

$$h = \left(0.432 + 0.151\,\frac{t}{1000}\right) \frac{V_o^{0.79}}{D^{0.16} L^{0.03}} \quad \frac{Btu}{sq\ ft,\ hr\ °F}$$

When t = Temperature of steam °F (V = 3 ft/sec as per Nusselt)
V_o = Velocity of steam at standard conditions

$$V_0 = 33.53\,\frac{pV}{460t} \quad \frac{ft}{sec}$$

V = Velocity in ft/sec
p = Steam pressure lb/in^2 absolute
t = Temperature of steam F
D = Equivalent inside diameter of cross sectional area of gas stream F_t
L = 8.7 + 8.9 D = length of pipe required to reach minimum surface conductance.

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THEORY - MISCELLANEOUS

VI. MISCELLANEOUS EQUATIONS - Continued

D. Surface Conductance of Water in Pipe, h

$$h = 163\ V^{0.83}\ (1 + 0.0104\ t_w)\ \frac{\text{Btu}}{\text{sq ft, hr, °F}}$$

When t_w = Temperature of water, F
V = Velocity of water, ft/sec

E. Surface Conductance of Condensing Saturated Steam, h_v or h_H

Vertical pipe

$$h_v = \frac{1590 + 4.07\ (t_s + t_w)}{\left[H\ (t_s - t_w)\right]\ 1/4}\ \frac{\text{Btu}}{\text{sq ft, hr, °F}}$$

Horizontal pipe

$$h_h = \frac{1225 + 3.15\ (t_s + t_w)}{\left[D\ (t_s - t_w)\right]\ 1/4}\ \frac{\text{Btu}}{\text{sq ft, hr, °F}}$$

Where t_s = Steam temperature, F
t_w = Wall temperature
D = Diameter of pipe, ft
H = Height in ft of vertical run

F. Conductance of Condensate Film, h_v or h_H

Vertical pipe

$$h_v = k \left(\frac{\rho^2 g}{\mu^3_c}\right)^{1/3}\ \frac{\text{Btu}}{\text{sq ft, hr, °F}}$$

Horizontal pipe

$$h_H = 0.78\ K \left(\frac{\rho^2 g}{1.5 D \alpha \mu}\right)^{1/3}\ \frac{\text{Btu}}{\text{sq ft, hr, °F}}$$

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THEORY - MISCELLANEOUS

VI. MISCELLANEOUS EQUATIONS - Continued

F. Conductance of Condensate Film - Continued

When k = Thermal conductivity of condensate $\frac{\text{Btu}}{\text{sq ft, hr, °F}}$

p = Density of condensate lb/ft^3

g = Acceleration of gravity $\text{ft/hr}^2 = 4.18 \times 10^8$

c = Rate of flow of condensate per unit length of perimeter $\frac{\text{lbs}}{\text{ft, hr}}$

D = Diameter of pipe, ft

a = Rate of condensation per unit area $\frac{\text{lbs}}{\text{cu ft, hr}}$

μ = Absolute viscosity of condensate $\frac{\text{lbs}}{\text{ft, hr}}$

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THEORY - HEAT TRACING

VII. HEAT TRACING

A. General

Transfer and storage of materials which freeze or become highly viscous at normal ambient temperatures, frequently require heat from an external source to keep them liquid. This source of heat can be obtained from heated liquids, steam, or electricity.

Heated liquids are sometimes used to furnish heat to process lines and equipment containing material having a critically high temperature. Heated liquid systems have certain disadvantages, such as the problem of controlling the temperature of the liquid, cycling the liquid, and preventing the liquid itself from freezing. For these reasons, we seldom use this system, and when it is necessary, it is a special design problem.

Steam or electric tracing systems are generally used as sources of external heat. The basic heat transfer equations for applying these sources of external heat are presented. This manual provides only heat transfer information which affects design of insulation. Information for the design of steam piping or electrical systems is provided in the appropriate manual.

B. Steam Heating

1. Steam Jacketing

The heat from steam can be transferred to a pipe or vessel in a number of ways. One is the use of jackets which enclose the pipe or vessel. Where jackets are used, the temperature of the metal of the pipe or vessel encased by the jacket is within a few degrees of the steam temperature. In the past, where maintenance of high temperatures only has been required, jackets have been used. However, steam jacketing of vessels, lines and fittings is undesirable from an initial cost and maintenance viewpoint and limits flexibility of design.

2. Steam Tracing

Another way to maintain high temperature in pipe is the close wrapping of steam tracers around a pipe. When installed on horizontal lines, this system has a trapping problem. The condensate pocket at the bottom of each loop creates excessive

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THEORY - HEAT TRACING

VII. HEAT TRACING - Continued

B. Steam Heating - Continued

2. Steam Tracing - Continued

pressure drop, thus requiring frequent trapping. As the installed cost of a trapping station is $150 to $300, this system is very expensive.

Because of the excessive cost of the spirally wrapped system, the parallel system of steam tracing is recommended. This way of heat tracing is used both with steam and electricity as the heat source; however, it can be installed with two methods of heat transfer: one is the air convection heat transfer method and the other is the high-conductive cement method.

Each of the methods presented provides an equation for determining line temperature based on static conditions and no flow in the pipe. Thus, they are independent of velocity, density, specific heat, and conductivity of the material in the pipe or vessel. Heat input of the tracer provides only for loss of heat through the insulation, and provides no heat for the process material.

a. Air Convection Method

In most instances where it is necessary to add only moderate heat to the process pipe, the air convection system is the least costly. Also, it is more economical to use one larger tracer size than two smaller tracers. In cases where heat requirements indicate that more than one large tracer is needed to supply the heat, it is more efficient to use the high-conductive cement method and use only one tracer. Under such conditions care should be taken in using the high-conductive cement method to be certain that this does not give too high a maintained temperature.

It should be noted that there is a broad range between the maximum temperatures possible with conventional air conduction tracing and the minimum temperatures possible with the high-conductive cement method. Where temperature levels fall within this range, it is suggested that electric tracing be considered.

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THEORY - HEAT TRACING

VII. HEAT TRACING - Continued

B. Steam Heating - Continued

2. Steam Tracing - Continued

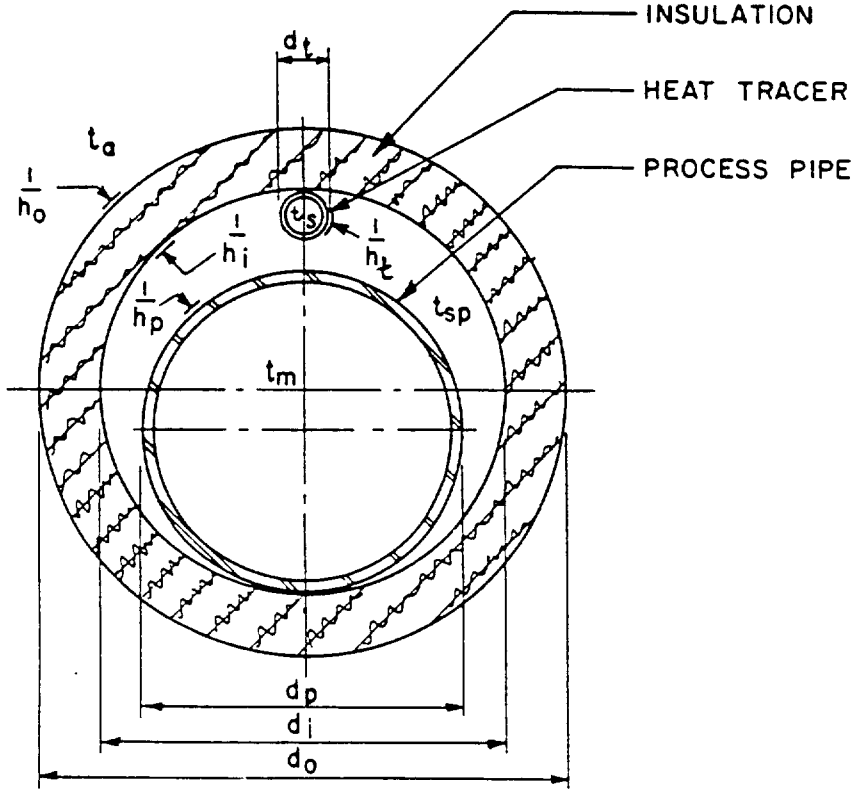
a. Air Convection Method - Continued

The formulas presented are based on certain assumptions. The first is that the insulation is oversize, and eccentric for cylindrical pipe.

If contour insulation is used, correction must be made in the factor $\frac{d_o}{d_i}$

Two other assumptions are present. One is the conductivity of the insulation and the other is the air film resistance. Although these assumptions are made as mean averages in the range of temperatures involved, they do change slightly with temperature. If the conductivity of the insulation to be used differs over 15% from the assumption, or if surrounding conditions are dissimilar, the constants in the equations must be altered to obtain correct results.

When, as shown in Figure 1



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THEORY - HEAT TRACING

VII. HEAT TRACING - Continued

B. Steam Heating - Continued

2. Steam Tracing - Continued

a. Air Convection Method - Continued

d_o = Outside diameter of insulation in inches

d_i = Inside diameter of insulation in inches

d_p = Outside diameter of process pipe in inches

d_t = Outside diameter of heat tracer in inches

t_s = Temperature of heat tracer °F

n = Number of heat tracers

t_a = Temperature of ambient air °F

$\frac{1}{h_p}, \frac{1}{h_o}, \frac{1}{h_i}, \frac{1}{h_t}$ = Air film resistance, each equals 1/2

k = Conductivity of insulation = 0.45 Btu/sq ft, hr, in °F

The temperature, t_m, of the pipe which can be maintained by the heat tracer is:

$$t_m = \frac{t_s d_t (2.22\, d_o \operatorname{Log}_e \frac{d_o}{d_i} + 2) + d_o t_a}{d_o + d_t (2.22\, d_o \operatorname{Log}_e \frac{d_o}{d_i} + 2)}$$

To calculate the maximum distance between steam traps, where

Δ = Loss in pressure, psi

lg = Length of pipe in feet

d_{ti} = Inside diameter of pipe in inches

ρ = Weight of one cubic foot of steam

W = Pounds of steam per hour

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THEORY - HEAT TRACING

VII. HEAT TRACING - Continued

B. Steam Heating - Continued

2. Steam Tracing - Continued

a. Air Convection Method - Continued

The maximum length (lg) between traps is:

$$lg = \left[\frac{\Delta \rho (d_{ti})^6 \left(d_o \operatorname{Log}_e \frac{d_o}{d_i} \times 0.9\right)^2}{d_o^2 (d_{ti} + 3.6)(t_m - t_a)^2} \right]^{\frac{1}{3}} + 74500$$

This maximum length (L) is in equivalent feet, not actual footage. The proper number of equivalent feet for elbows, valves, and other fittings must be taken into consideration in determining trap spacing. Pressure drop in tracer (Δ) is usually assumed as 10% of steam pressure.

b. High-Conductive Cement Method

Where it is necessary to provide high temperature for the process pipe, it can be done by attaching the steam tracer to the process pipe with high-conductive cement as snown in Figure 2.

The assumptions made for the conductivity of the insulation and the film factors are the same in the formula for calculating high-conductive cement heat tracing as were used in the air convection method. If actual conditions differ too greatly from these assumptions, the constants in the equations must be altered to obtain correct results.

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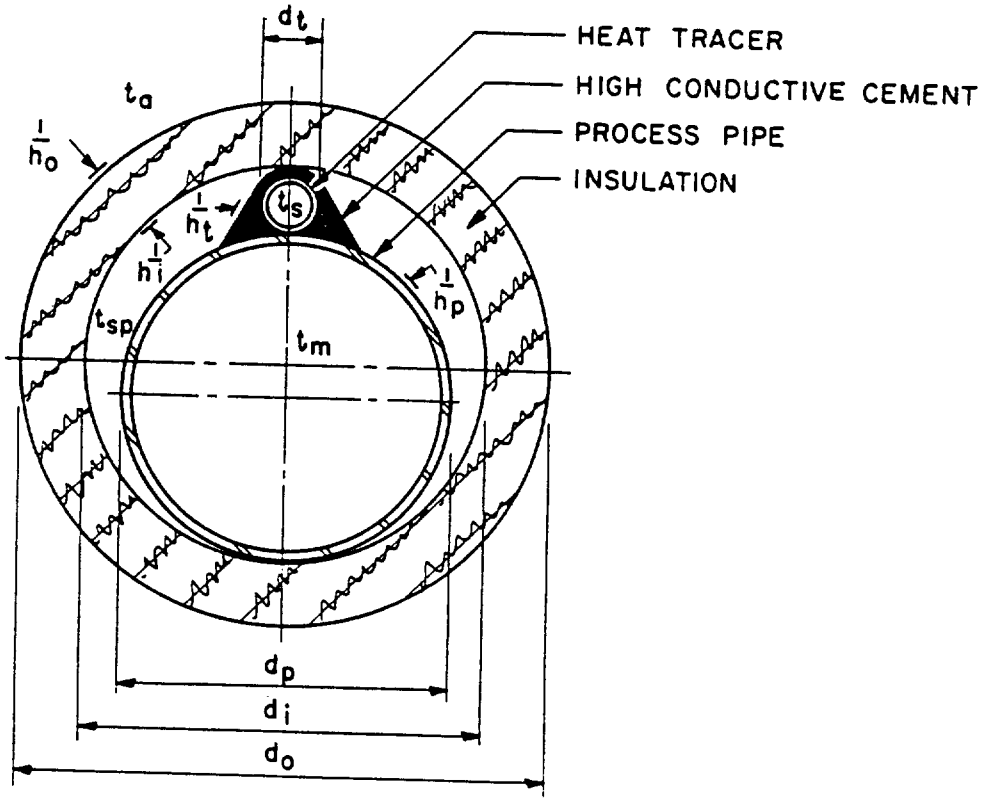
THEORY - HEAT TRACING

VII. HEAT TRACING - Continued

B. Steam Heating - Continued

2. Steam Tracing - Continued

b. High-Conductive Cement Method - Continued



With the same relationship as stated previously, and when overall transfer coefficient (U), between the tracer through the high-conductivity cement to the process pipe, is taken to equal 15 Btu/ sq ft/ hr °F, then

The temperature (t_m) of the pipe which can be maintained by the heat tracer is:

$$tm = \frac{(2.22\, d_o \operatorname{Log}_e \frac{d_o}{d_i} + 2)\, nd_t\, (8.5\, d_p - nd_t)\, t_s + d_o \left[nd_t \left(7.5\, t_s - t_a\right) + t_a\, d_p \right]}{(2.22\, d_o \operatorname{Log}_e \frac{d_o}{d_i} + 2)\, nd_t\, (8.5\, d_p - nd_t) + d_o\, (d_p + 6.5\, nd_t)}$$

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THEORY - HEAT TRANSFER

VII. HEAT TRACING - Continued

B. Steam Heating - Continued

2. Steam Tracing - Continued

b. High-Conductive Cement Method - Continued

The maximum distance between steam traps is:

The maximum distance between steam traps is:

$$lg = 74,500 \left[\frac{\Delta \rho n^2 (d_{ti})^6 (d_p - nd_t)\,2\, (d_o \operatorname{Log}_e \frac{d_o}{d_i} + 0.9)^2}{d_o^2 (d_{ti} + 3.6)\ t_m (d_p + 14\, nd_t) - nd_t\ 15\ (t_s - t_a) - d_p t_a} \right]^{\frac{1}{3}}$$

Again lg is in equivalent feet.

The steam tracing equations on the preceding pages have been electronically calculated for various conditions of steam pressure and ambient conditions. These tables are shown in the "Engineering Standards", P-142 through P-142E, which are included in Section III of this manual.

C. Electric Tracing

Electric heating of process lines and equipment can be accomplished by induction heating or resistance heating. Induction heating has seldom been used; however, for certain applications, it might be useful.

1. Induction Heating

Induction heating differs from other types of heating in that the current-carrying coils are located outside the insulation. The non-metallic type of insulation provides an air gap between the induction coil and pipe or vessel. Heat is generated in the pipe or vessel by induced currents and the induction coil, outside the insulation remains at low operating temperature. The desired temperature of the pipe or vessel can be maintained by manual or automatic controls.

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THEORY - HEAT TRANSFER

VII. HEAT TRACING - Continued

C. Electric Tracing - Continued

1. Induction Heating - Continued

a. Static Conditions

Under static conditions, the electric heat source must supply just sufficient heat to compensate for the losses through the insulation from the vessel or pipe. The electric power, in KWH, necessary to make up the losses can be determined as follows:

For flat surfaces

When: t_1 = Surface temperature of the insulation on hot side (vessel or pipe temperature)

t_3 = Ambient air temperature

L = Thickness of insulation

k = Conductivity of insulation

h = Conductivity of air film outside the insulation

Then:
$$KW = \frac{t_1 - t_3}{\frac{L}{k} + \frac{1}{h}} \times \frac{1}{3413} \text{ per sq ft of surface, per hr}$$

For cylindrical surfaces

When: r_1 = Inside radius of insulation in inches

r_2 = Outside radius of insulation in inches

$$KW = \frac{t_1 - t_3}{\frac{r_1 \text{Log}_e \frac{r_2}{r_1}}{\kappa} + \frac{1}{h}} \times \frac{1}{3413} \times \frac{\pi r_2}{6} \text{ per linear foot of pipe, per hr}$$

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THEORY - HEAT TRANSFER

VII. HEAT TRACING - Continued

C. Electric Tracing - Continued

1. Induction Heating - Continued

b. Operating Conditions

In many instances where inductive heating is used, it is necessary to raise the temperature of the material in the pipe as it passes through. The length of pipe then becomes a factor. Under these conditions,

When: L_{bm} = Weight of material per hour
S_{pm} = Specific heat of material
Δt = Degrees F material is to be raised
t_1 = Mean temperature of pipe or vessel
lg = Length of pipe in feet

$$KW = \frac{L_{bm} \times S_{pm} \times \Delta t}{3413} + \left[\left(\frac{t_1 - t_3}{\frac{r_1 \ \mathrm{Log}_e \frac{r_2}{r_1}}{k} + \frac{1}{h}} \times \frac{1}{3413} \right) \times \frac{lg\ r_2 \pi}{12} \right] \text{ per hour}$$

The above equation can be used for cylindrical vessels if the area of the heads is added to the area of the cylindrical section.

c. Heatup Conditions

In presenting the first two equations, it was assumed that the temperature of the pipe or vessel was for static conditions, thus requiring no heating. However, where it is necessary to heat up from one temperature to another, it is necessary to calculate the amount of heat necessary, not only to raise the temperature of the material but also the heat required to raise the temperature of pipe or vessel. Also it is necessary to consider time required under these conditions.

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THEORY - HEAT TRANSFER

VII. HEAT TRACING - Continued

C. Electric Tracing - Continued

1. Induction Heating - Continued

c. Heatup Conditions - Continued

When L_{be} = Weight of pipe or vessel

S_{pe} = Specific heat of metal, pipe or vessel

hr = Hours allowed for heating up

Then

$$KWH = \frac{L_{bm} \times S_{pm} \times \Delta t}{3413} + \frac{L_{be} \times S_{pe} \times \Delta t}{3413} + \left[\left(\frac{t_1 - t_3}{\frac{r_1 \log_e \frac{r_2}{r_1}}{k} + \frac{1}{h}} \times \frac{1}{6826} \right) \times \frac{\lg r^2}{\pi} \times hr \right]$$

The above equation can be used for cylindrical vessels if the area of the heads is added to the area of the cylindrical section. To determine KW

$$KW = \frac{KWH}{hr}$$

These equations indicate the electrical energy needed for the process material, pipe, and vessel. Such considerations as coil design, coil efficiency, power factors, controls, and power supply are covered in the electrical section of the Design Engineering Manual.

2. Resistance Heating

Resistance heating may be accomplished by two methods. One is by use of the pipe as a conductor. The other is by the use of a heater cable attached to the pipe. The first requires low voltage and high current, thus the power supply equipment must be heavy and large. In addition, if a break occurs in the pipe, sparking will be present at the break. These two factors make the system unsatisfactory for use in a chemical plant.

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THEORY - HEAT TRANSFER

VII. HEAT TRACING - Continued

C. Electric Tracing - Continued

2. Resistance Heating - Continued

Until the development of the use of mineral insulated cable, the system of electric cable heat tracing was limited to spots of little hazard. However, the mineral insulated, metal sheath cable now has Underwriter's approval for use in hazardous areas.

The application of this mineral insulated cable to the process pipe is similar to ordinary steam tracing which is thermally connected by high conductive cement. However, in this installation, the high conductive cement is essential to keep the sheath temperature below its maximum limits, thus all the calculations are based on this application method.

The calculations to determine watts input and heat loss through the insulation is by the finite difference or nodal method. Because these equations are complex and trial and error method must be used for solution, the answers must be obtained by electronic computation. For this reason, the formulas are not presented here. Tables for determination of electric heated cable size and insulation thickness for various requirements are given in "Electric Heat Tracing Manual" and also in Section III of this manual.

D. Importance of Insulation in Function of Electric Heated Systems

The selection of the correct insulation and its correct installation is essential for the proper function of electrically traced heated pipe and equipment. Electric tracing has a limit on heat input, whereas the heat input by steam can change considerably due to the fact the rate of its condensation can change considerably. This being true, the heat loss through the insulation must be regulated more closely than is necessary for steam heated lines and equipment. This means that insulation efficiency must be maintained.

The most detrimental element to mass insulation efficiency is moisture. For this reason electric traced lines should always be insulated with insulation which resists water absorption. In addition, the following

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THEORY - HEAT TRANSFER

VII. HEAT TRACING - Continued

D. Importance of Insulation in Function of Electric Heated Systems - Contd

is suggested: (1) Electric heated lines should be insulated from all beam crossings, (2) Where possible, the heated lines should be supported by cradles under the insulation rather than "T" supports, (3) Insulation should be full thickness and notching out the insulation to fit over tracer should not be allowed (4) Pipe area under tracer should be cleaned to obtain excellent bond with heat transfer cement, (5) Sufficiently more tracer must be applied at flanges, elbows, and valves to compensate for additional metal area, (6) It is essential that all tracers -- without gaps -- be correctly bonded to pipe, fittings and equipment with heat transfer cement. Any unbonded length may excessively heat up then burn out. Properly installed electric tracing will operate with very little maintenance.

E. Basis of Selection Tracing Medium

Steam always being some temperature over 212F makes it unsuitable for tracing of chemicals which may degrade or otherwise change in nature at temperatures lower than 212F. In these instances electric tracing provides a means to heat the lines to some lower temperature without overheating.

Where close control of temperature, at any level, electric tracing can be controlled to much closer limits than steam tracing.

Where overheating or close control of temperature of the chemical is of no importance, then steam tracing is most generally less costly than electric tracing if suitable steam supply is available. However, if the traced lines are considerable distance for steam supply, it is most frequently less expensive to run electric supply cables to the installation rather than steam piping.

Electric tracing eliminates the problem of condensate discharge to the atmosphere, or the complex problem of collecting steam condensate.

The selection must be determined by installation requirements.

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BASIC REQUIREMENTS FOR SELECTION OF INSULATING MATERIAL

Most thermal insulations possess relatively low heat transfer characteristics, thus will provide a good thermal barrier. For this reason, the choice of an insulation is seldom based only on the conductivity of the material. In most instances the material is selected which will most nearly satisfy the physical, chemical, and temperature requirements dictated by service, fabrication, and installation.

I. PROCESS INSULATION REQUIREMENTS

A. Physical Requirements most often determine the insulation or type of insulations which should be used for a certain installation. It is fundamental that an insulation must remain intact in its location if it is to fulfill its function as an insulant. The physical properties it must have to accomplish this depend upon the requirements of the installation. In addition, it must also fulfill the requirements imposed upon it by fabrication and application.

When rigid insulation is prefabricated into solid shapes it must have properties which allow it to be easily cut or formed. Surfaces should be smooth and suitable for bonding with cements or adhesives. Completed covers must have sufficient strength, both the material itself and its joints, to withstand abuse of transportation and application.

In service, rigid insulation must withstand the normal mechanical demands. In many instances the insulation must support the weight of the pipe and its contents. It must support the weight of a man walking on it. It must withstand the vibration and abrasion to which it is subjected. In all instances, it must be capable of being installed in such a manner that it will not be fractured or otherwise damaged by forces of expansion and contraction.

The above requirements are common to most chemical plant uses of insulation. A great percentage of the insulation is installed on the outer surfaces of pipes and vessels where it is subjected to mechanical abuse. Also, much insulation is preformed into the proper shapes before it is delivered to the field insulators for erection. Therefore, it must be sufficiently strong to withstand handling and shipping. This is true of both high and low temperature insulation.

Installations requiring internal insulation impose very exacting physical conditions upon the insulation. As the imposed conditions for this type of installation follow no general pattern, each must be solved and designed individually.

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BASIC REQUIREMENTS FOR SELECTION OF INSULATING MATERIAL

I. PROCESS INSULATION REQUIREMENTS

A. Continued

Contrary to the above, there are many installations which require the insulation to be flexible instead of rigid. Insulation on expansion joints must be able to move with the metal to which it is applied, so insulation blanket is used.

In some instances, flexible blanket must be used as a cushion between rigid insulation and expanding and contracting surfaces. This is common practice in both high and low temperature applications where a rigid shell of insulation is isolated from expansion and contraction of the vessel or pipe on which it is installed. In many instances the flexible blanket serves a dual function, not only to protect the outer insulation from excessive strain, but also protects the rigid insulation from thermal shock or vibration.

There are applications where insulation must be installed prior to the final shaping or assembling of the insulated object. Typical is application of insulation on tubing before the tubing is installed.

There are services which require the insulating material to have little or no mechanical strength. Such applications, as insulation powder poured in place between vessel and vessel jacket, or poured around a pipe in a trench which is to be backfilled are typical. However, in these applications it is essential that the insulation maintain its original volume without settling or decomposing.

Another consideration for a large number of installations is the physical ability of an insulation which allows it to be removed and then be replaced rapidly without breakage. In many instances the design must be such that operations personnel can remove and replace the insulation with the assistance of an insulator.

B. Chemical Requirements may be either or both of two different needs.

The first is that the insulation should be resistant to any chemicals to which it might be subjected by spillage, atmospheric contamination or, in the case of interior insulation, by direct contact.

The second is that the insulation should be of the correct chemical nature so as to not damage the vessels or pipe to which it is applied.

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BASIC REQUIREMENTS FOR SELECTION OF INSULATING MATERIAL

I. PROCESS INSULATION REQUIREMENTS - Continued

B. Continued

When applied on steel the insulation should be neutral or slightly alkaline, and when applied on aluminum it should be neutral or slightly acid. Where used on austenitic stainless steel, the insulation should be free of water-coluble chlorides so as to not contribute to or cause possible stress-corrosion cracking.

Thermal insulation on pipe or vessels never replaces the need for their being protected from corrosion. If it is necessary to protect metal from corrosion, such protection is needed under the insulation. As most insulations are absorbent, they provide the means of holding moisture in contact with the surface to which they are applied. In many instances insulation can accelerate corrosion rather than retard it.

C. Moisture Conditions to which insulation is to be subjected determine the properties the insulation should have, how it should be installed, and how it should be protected.

When dry, most insulations are quite effective. When insulation becomes wet, or damp, all or part of the small air spaces become filled with water. Heat transmission through the water filled spaces then approaches the rate of conductivity of the liquid instead of air.

Insulation must be protected from two forms of moisture: (1) that in the liquid state, and (2) in the vapor state. Thermal insulation, of any temperature range, located outdoors where it is subjected to rain, sleet or snow must be protected from liquid moisture by a weather barrier. Indoor applications in most chemical process plants must also be protected by weather barriers as it is common practice to wash down vessels and pipes with water streams when spillage occurs. Most high temperature insulations are highly absorbent and if they once become wet considerable heat is necessary to dry them out. Where absorbent insulations are used on vessels and lines which operate below 250°F, it is virtually impossible to dry them out if they once become wet. For this reason moisture-resistant insulation is recommended to be used where service temperatures are below 250°F.

Wherever insulation is used on services at temperatures below ambient, not only must it be protected from liquid moisture, but also from moisture in the vapor state. Moisture in the vapor state is a gas, and

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BASIC REQUIREMENTS FOR SELECTION OF INSULATING MATERIAL

I. PROCESS INSULATION REQUIREMENTS - Continued

C. Continued

in this state it will always seek to equalize any pressure difference by flowing from the high pressure area to the low pressure area. Whenever a barrier exists between a high and a low pressure area, the vapor will seek all means to reach the lower pressure by going through the insulation itself, through joints or cracks in the insulation, or around ends. When insulation is applied to equipment or piping which operates at temperatures less than ambient, this lower temperature on the inner surface of the insulation causes a lower vapor pressure area to exist at this point than exists in the ambient air. This vapor force is pressing inward on the entire outside area of the insulation, seeking any crack, hole, or weakness to penetrate. If the vapor does penetrate, as it encounters lower temperatures on its way toward the inner surface, the vapor will reach its dewpoint. At this point the vapor will condense to a liquid. This water will then replace some of the air in the air spaces. As the condensation continues, the air spaces in the insulation become filled with water or frost and the thermal conductivity is increased, with a resultant loss of insulating efficiency. Therefore, wherever insulation is used on low temperature application, provision must be made to prevent it being ruined by moisture vapor

One method of fulfilling this application requirement is to use vapor-resistant insulation. However, with vapor resistant insulation the weak point is in the joints. These joints have to be vapor sealed. This is also true of slip joints which are provided to take care of expansion and contraction.

Where it is necessary to use insulation which is limited in its vapor resistance, it is also necessary to provide a vapor barrier to protect the insulation. The barrier may be of mastic, tapes, jackets, or metal outer container, depending upon individual requirements.

Another method used for vapor control is to construct an inner and an outer vessel with insulated space between them. This space is kept dry by dry gas purge or by partial vacuum. This method can be the most efficient of all applications, but is also the most expensive and can only be warranted for the most critical of low temperature installations.

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BASIC REQUIREMENTS FOR SELECTION OF INSULATING MATERIAL

I. PROCESS INSULATION REQUIREMENTS - Continued

D. Electrical considerations are not often thought to be a function of thermal insulation. There are, however, some applications of electrically heated ovens and muffles where the insulation may also be required to be an electrical insulation.

Other than this, where dissimilar metals are separated by insulation, if the insulation becomes wet it can become an electrolyte, thus setting up galvanic currents. These galvanic currents soon damage the metal. In such applications, non-absorbent insulation must be used, or suitable corrosion precautions must be taken.

E. Hazards which might be caused by, or corrected by, a combination of previously given requirements are listed separately. Fire protection of pipe and vessels requires not only that an insulation have sufficient strength to withstand ordinary abuse, but should also withstand explosion shock of considerable force. It is required to withstand the high temperature of the fire, then the thermal shock and high physical force of a powerful stream of cold water. It is required to have a minimum of shrinkage at high temperatures to prevent gaps which in turn would allow the fire to reach the exposed metal. This service requires the retardation of the flow of heat for as long a time as possible.

Another application where time is a factor is where insulation is required on a vessel or pipe to prevent the vapor, or liquid, being heated above a certain temperature by solar radiation. Such a problem is one of insulating with the correct insulation of sufficient thickness to produce the needed time log.

Hot lines and vessels are insulated to protect personnel from burns by hot surfaces. Due to its conductivity, metal will cause burns at a temperature where a mastic or fibrous surface does not. Metal surfaces, for safety, should not exceed 135°F, whereas mastic and fibrous surfaces are safe up to 150°F.

Chemical leakage and atmospheric contamination may be absorbed by many insulations. Insulation saturated with chemicals can be a hazard in two ways. One, due to the large amount of liquid it can absorb, which can be over five times the original weight of the insulation, it can provide large quantities of fuel for a fire and be responsible for fire spread. Two, many chemicals react with insulation to cause fires, or their flash point and flame point temperature is so reduced that they are easily ignited.

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BASIC REQUIREMENTS FOR SELECTION OF INSULATING MATERIAL

I. PROCESS INSULATION REQUIREMENTS - Continued

E. Continued

In one year the Process Safety Department reported 35 fires in the South Charleston Plant caused by flammable chemicals in insulation. Results of testing self-ignition of chemicals in contact with insulation, although incomplete, are included as a guide for selection of materials. Chemicals in the following list have caused insulation fires; therefore, when these chemicals are present, selection of materials should be made with care.

Acetic Anhydride	Ethyl Butanol
Alcohol Ethanol	Ethyl Hexaldehyde
Anhydrous Amines	Ethyl Amines
Butanol	Hexanol
Butyraldehyde	Isopropanolamine
Carbowax	Merrill Oil
Carbowax Polyethylene Glycol 400	Methoxypolyglycol
Diethanolamine	Monocyclopentadiene
Dowtherm	Oil (Lube)
Ethylene Diamine	Plasticizer
Ethylene Oxide	Ucon Lubricant 75-H-90,000

Some insulations when heated to a certain point react within themselves. Temperatures produced by this self-internal heating can be above 2000°F. A critical mass sometimes causes this self-internal heating.

Saturable insulations may hold toxic chemicals, acids, or caustics. When once saturated, the insulation can hold these chemicals for years. When these chemicals are a personnel hazard, non-absorbent insulations should be used where possible. Should it be necessary to use absorbent insulation, special care must be used in the removal and handling of contaminated material.

Saturated insulations may also cause damage to equipment or piping by providing contact of corrosion causing chemicals with the metal. The breathing action, present through any insulation, can concentrate the corrosion producing chemical, or it can leach water-soluble chemicals from the insulation. This property is evident as one factor contributing to stress corrosion cracking of austenitic stainless steel.

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BASIC REQUIREMENTS FOR SELECTION OF INSULATING MATERIAL

II. COMMERCIAL INSULATION REQUIREMENTS

A. Physical Requirements as determined by its use in the building generally indicate the type of insulation to be used. The uses of insulation in a building are many. Depending upon its use, the insulation can range from fill type to structural type insulation materials.

The use of insulation in the walls, floor and roof of a building should be part of the architectural design. However, the engineer can assist the architect in the selection of the insulation which will best serve the thermal and structural needs of the building.

Depending upon the chosen construction, the insulation may be placed above, below, or it might be the roof deck. Mechanical abuse, method of application, and structural considerations determine the physical requirements of the insulation.

Wall and floor constructions are so varied that no general statement can be made as to the physical requirements of the insulation component. Like the insulation used in roofs, the insulation must withstand the mechanical abuse, installation requirements and structural demands which are imposed upon it. In addition, the insulation may serve a dual function as an acoustical material.

In addition to serving in the structural frame of the building, insulation is also used on piping, equipment,ductwork, and cold storage rooms. The physical requirements of the piping and equipment are similar to those mentioned in process insulation requirements. Ductwork may be insulated on its interior or exterior. When interior insulation is used, the insulation must be able to withstand the velocity of the air passing through the duct. Exterior duct insulation is exposed to mechanical abuse depending upon its use and location.

Cold storage and constant temperature and humidity rooms are generally structures consisting mainly of insulation. In many instances the insulation itself is the principal structural material. The physical requirements are severe, in that the doors are heavy, causing a securement problem. When such doors are slammed, heavy vibrations are transmitted to the walls and ceiling. Where materials are trucked into these rooms, severe bumping of walls can be expected.

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BASIC REQUIRE MENTS FOR SELECTION OF INSULATING MATERIAL

II. COMMERCIAL INSULATION REQUIREMENTS - Continued

B. Moisture Requirements of building insulation depend upon the building's location, its construction and its use.

Each location has a climate made up of many things: air temperature, sun, fog, rain, snow, hail, wind, and humidity. All of these, plus the use given the building, influence the moisture in liquid and vapor form to which the building will be subjected. Excessive moisture causes a great deal of harm to a building. It can blister outside paints, can cause transient salt stains or efflorescence on brick masonry, can cause wood to rot, can cause steel and iron to rust and ruin insulation. Most building moisture problems arise from vapor within the building and insulations with proper vapor barriers are necessary to solve this problem.

In cold climates, the warm air inside a building holds more water vapor than the cold air outside. This causes a vapor pressure difference and, since water vapor is a gas, it seeks its way out. Water vapor readily penetrates materials such as stone, brick, concrete, wood, and plaster.

While air does not move in the same way as the water vapor, there is air within these building materials and in the hollow spaces of the structure. The vapor seeking its way out increases the moisture content of the air at each place until, due to the colder temperature, the air cannot absorb any more moisture. Theoretically, the vapor will begin to condense into water at that point. However, if the vapor can keep on moving it will disperse itself in still colder air, but should there be any surface to resist this flow, and that surface is lower than dew point temperature, the vapor will condense to a liquid on this surface. This is the reason that vapor barriers must be located in the walls and roofs in a location where they remain at a temperature above dew point.

In the case of buildings located in cold climates where vapor pressure, for the greater part of the year, is outward, then the vapor barrier must be on the inner side of the wall or roof. Buildings located in warm climates which are air conditioned, thus causing the vapor pressure to be inward, require the vapor barrier on the outer side of the wall or roof. This last is also true of cold storage rooms.

Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation D... Published by AsbestosClaims.Law
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BASIC REQUIREMENTS FOR SELECTION OF INSULATING MATERIAL

II. COMMERCIAL INSULATION REQUIREMENTS - Continued

B. Continued

Again, these same principles are true wnen insulation is applied to ductwork. If the duct is cold, a vapor seal is required on the outer surface. If the ductwork is hot, a vapor barrier should not be installed on the outer surface.

As previously stated, insulation to be efficient must be dry, and there are installations in buildings where insulation may be subjected to liquid water. Such applications are exterior installations on walls and below grade, and beneath concrete slab floors. These require water-resistant cellular insulations.

C. Hazards - Besides the ordinary insulating function, insulating materials are used as fireproofing of building members. The time that the protected member must withstand a fire is the criterion. This time depends on importance of the member in the building, the use of the building, and governmental and insurance codes.

Unfortunately, some insulations can increase fire hazards. Many will burn. Where such insulations are used within a building they should be used with care and should be fire protected. Other insulations, when melted or burned, release toxic gases. Little has been published on this aspect, but until definite information is available, caution must be used in the selection of insulation for buildings.

Another consideration is smoke. Some materials release large quantities of smoke when heated or burned. The smoke can cause considerable damage to the interior of a building even though fire damage is slight. Even more important, in buildings of high occupancy, smoke can cause disastrous panic.

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BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS

For any particular temperature, there is no single correct thickness of insulation. The proper thickness depends on many factors. Some of these factors are location indoors or outdoors, ambient temperature, solar exposure, cost of heat, cost of insulation, process requirements, hours of operation, rate of amortization, safety, dew point, freezing point of materials, flash point of material, condensation point of material. Any one single factor may be paramount for a given problem. However, in most instances a combination of many of the factors decides the proper insulation thickness.

A. Elevated Temperature - External Insulation

1. Economic Consideration is based on savings of energy, as heat energy has a monetary value. However, there is no direct conversion from BTU's into dollars, as the cost of heat depends upon many factors, such as its form, location, and use. Insulation also has monetary value and, like heat, its cost varies. However, at some thickness of insulation the total cost of heat loss per year, plus the cost of insulation per year, adds up to the lowest possible cost per year. The thickness which provides this lowest possible cost per year is the economic thickness of insulation.

   Many factors enter into the cost of heat on an annual basis. These are:

   (a) Cost of fuel.

   (b) Capital investment in heat producing equipment and heat distribution system to point of use.

   (c) Cost of money for capital investment.

   (d) Interest on investment.

   (e) Depreciation.

   (f) Maintenance.

   (g) Number of hours of operation per year.

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BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS - Continued

A. Elevated Temperature - External Insulation - Continued

1. Economic Consideration - Continued

Most of the cost factors of heat also apply to insulation. These are:

(a) Capital investment of installed insulation.

(b) Cost of money for capital investment.

(c) Interest on investment.

(d) Depreciation.

(e) Maintenance.

In addition to the cost factors, the following physical and thermal factors enter into the determination of economic thickness:

(a) Temperature difference.

(b) Shape.

(c) Conductivity of the insulation.

The basic McMillan formula for determining economic thickness is presented in the section on theory. For special conditions, it may be necessary to calculate economic thickness using this formula, but for most conditions in process design the economic thickness can be determined from tables in manual on "Economic Thickness of Insulation for Flat Surfaces and Pipes".

To illustrate the influence of economical insulation on the capital investment and operating cost of a typical actual installation of insulation, consider an 8-inch steam line operation at 425°F. The insulation is calcium silicate. Its conductivity at this mean temperature is 0.45 Btu/hr/sq ft/in/°F. The average ambient temperature was 50°F. The cost factors were:

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BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS - Continued

A. Elevated Temperature - External Insulation - Continued

1. Economic Consideration - Continued

Capital Investment in Steam Production - $12.00/lb steam/hr

Capital Investment in Insulation - Installed Prices -

1-1/2" thickness	$3.30/linear foot
2" thickness	$4.10/linear foot
2-1/2" thickness	$4.84/linear foot
3" thickness	$5.90/linear foot

Depreciation Period - 15 years

Production Cost of Steam - $0.877/1000 lb

With no insulation at all, the heat loss would have been 2,841 Btu per hour, per linear foot of pipe. (The heat contained in 2.36 pounds of steam per hour, per linear foot of pipe.) To produce this lost heat, a capital investment for steam production of $28.32 per linear foot of pipe was required. The yearly cost of this lost heat would have been $18.13 per linear foot of pipe. It is apparent that insulation was necessary. The question is, what thickness would provide the best return on investment.

The following table presents comparative costs:

Insulation Thickness	Capital Investment to Provide Steam for Heat Loss	Capital Investment in Insulation	Total Capital Investment	Yearly Cost of Heat	Additional Cost for Each Added 1/2-in of Insulation	Fuel Savings For Each Added 1/2-in of Insulation
In.	$	$/L.F.	$	$	$	$
Bare	28.32	None	28.32	18.13	-	-
1-1/2	2.57	3.30	5.87	1.64	1.10	6.04
2	2.10	4.10	6.20	1.34	0.33	0.30
2-1/2	1.74	4.84	6.58	1.14	0.38	0.20
3	1.52	5.90	7.42	0.98	0.84	0.16

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BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS - Continued

A. Elevated Temperature - External Insulation - Continued

1. Economic Consideration - Continued

These figures give direct cost, not including maintenance, cost of money, interest on investment, all of which must be considered. By including these and using the "Economic Thickness Manual", it can be rapidly shown that 2-1/2 inch is the proper insulation thickness.

In the absence of compelling reasons otherwise, the economic thickness should determine insulation thickness. It should be remembered that even within a single chemical unit the economic thickness may differ from one pipe to another, even if all operate at the same temperature. The difference is caused by difference in cost of the heat to be conserved. For example: Heat caused by chemical reaction may have little value and might even be required to be dissipated. The cost of high pressure steam might be different from that of low pressure steam. Heat from a Dowtherm boiler is more expensive than steam. Electric heat or electrically heated Dowtherm is very costly energy. Good economy demands that each be insulated with the correct thickness.

2. Process Control is sometimes the paramount consideration to determine insulation thickness. The particular function which the insulation is to fulfill may be one of the following:

(a) It may have to prevent a critical Btu loss above which the vessel or system is unable to operate satisfactorily.

(b) It may have to maintain a critical temperature below which the vessel or system will not operate.

(c) It may have to maintain a critical temperature below which materials would solidify.

(d) It may have to maintain vessels, pipes or ducts above a given temperature to prevent condensation of contained gases.

(e) It may have to maintain vessels or pipes within limits to prevent thermal stresses or thermal shock.

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BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS - Continued

A. Elevated Temperature - External Insulation - Continued

2. Process Control - Continued

(f) It may have to contain heat within vessels or pipes which must be heated up within given time limits.

(g) It may have to control heat loss and act as heat container in vessels and pipe where external heat (tracers) must be added.

(h) Where surface temperatures are critical for the function of the weather barrier.

3. Safety Requirements frequently determine the thickness of insulation. The outer surface temperature of the insulation should be sufficiently low that it will protect personnel from burns if they accidentally come into contact with its surface. This safe surface temperature is dependent upon the nature of the external surface. If the surface is mastic of fibrous nature, the safe temperature is 150°F. If the surface is metal, the temperature should not exceed 135°F. This is due to the high conductivity of metal which, when touched, will transfer large quantities of heat to the skin in a short time.

A number of tables have been published giving surface temperatures of insulation in relation to temperature difference, ambient temperature and insulation thickness. All such tables are based on high emissive jacket surfaces. A low emissive jacket surface, such as aluminum, will raise the surface temperature as much as 100°F. For this reason, low emissive metal jacket surfaces may require two to three times the thickness of insulation as mastic jacket surfaced insulations to be within the safe surface temperature range. In many instances the thickness is in excess of that which can be economically justified.

Insulations may provide fire protection. Where they are designed to retard fire, they may act as "fireproofing" of vessels and pipe. Accurate calculation of temperature time lag is difficult. Approximate protection obtained by some insulations are as follows: One-inch cellular glass with fire resistant weather barrier will retard the temperature rise of steel in a gasoline fire to approximately 1.000°F for one hour. One-inch high-temperature insulation such

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BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS - Continued

A. Elevated Temperature - External Insulation - Continued

3. Safety Requirements - Continued

as calcium silicate, under the same conditions, the temperature rise of steel to 1000F will be approximately two hours. Vessels completely protected by insulation of sufficient thickness in moderately hazardous location may not require water spray protection.

Insulation is required in hazardous locations for the protection of skirts, vessels, instrument conduits, tank legs, pipe, and structural steel from fire. The length of time protection from fire exposure is required and the possible fire temperature determines the type and thickness of the insulation.

Another application of insulation, which is primarily for protection, is its use on a vessel to prevent the vapor, or liquid, from being heated beyond its safe temperature limits by solar radiation. This again is a problem of time log and the thickness of the insulation must be calculated as a special problem.

B. Elevated Temperature - Internal Insulation

1. Economic Consideration for insulation used internally in vessels, pipe, flues, and ducts is the same as for that of insulation used externally. Of course, proper cost factors must be used in the calculations.

2. Process Control most frequently determines the thickness of internal insulation. Some of the determining factors are similar to those listed for external insulation, and are:

(a) A critical heat loss which should not be exceeded.

(b) A critical temperature which must be obtained.

(c) A temperature which must be maintained above a condensation level.

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BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS - Continued

B. Elevated Temperature - Internal Insulation - Continued

2. Process Control - Continued

(d) A temperature drop which must be obtained through the insulation so that temperature is sufficiently low as to not damage outer shell or lining.

(1) Prevention of excessive thermal expansion on inside of shell.

(2) Prevention of temperature in excess of limits of lining -- such as lead lined vessels.

(3) Prevention of thermal shock.

Another function of internal insulation is to reduce the amount of heat absorbed by the heavy metal shell in heating and returned to interior of vessel when cooling. In cyclic operation the lower the mass which must be heated and cooled, the shorter the time required for the operation. The amount of heat available and allowable time of cycle will determine thickness of insulation required. Except in the case of extremely short time cycles where carry-over might be helpful, a low mass and high rate of diffusivity are desirable characteristics of the insulation.

C. Elevated Temperature Insulation - Underground

1. Economics of underground lines are influenced by several factors not present in the consideration on lines above grade. One is the extremely high cost of repair or replacement. In most instances if extensive insulation repair is needed, it is cheaper to install a new insulated line than it is to dig up the old one and repair it.

Another factor is that on conduit protected underground lines the conduit must be considered as part of the insulation cost. Likewise, with fill type insulation, extra width of trench, forming, pouring, tamping, insulation top protection, and curing must all be considered as insulation costs. However, as many of the costs are relatively fixed in underground installations, clear-cut economic thicknesses as determined by the "Economic Thickness Manual" are not always possible for this type of installation.

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BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS - Continued

C. Elevated Temperature Insulation - Underground - Continued

2. Process Requirements influence the thickness of underground insulation. Most common is that on long underground lines must be sufficiently thick to ensure that sufficient steam is available at the outlet to supply the demand. Heat losses of underground pipes can be excessive and many a long, small, underground steam line has ended up having only the ability to supply condensate at its outlet.

The proximity of other lines also influences the thickness of insulation on lines. Due to the fact that soil, expecially when dry, becomes a fair insulant, the temperature gradient spreads over a large area. For this reason process lines, or water lines which should not be heated, should be spaced a minimum of 6 ft 0 in from any insulated steam lines. If this is not possible, then the insulation of the hot line must be increased. In addition to lines running parallel, care must be taken with lines which cross under or over heated insulated lines. At cross-over spots the insulation may be required to be considerably thicker for a distance on either side to prevent a hot spot in the lower temperature pipes.

Location in the ground and type of soil affects the heat loss of underground lines, and insulation thickness should be designed accordingly. If the line is located where soil is water saturated, heat will be wasted both by heating and the vaporization of the water which comes in contact with the outer surface of the insulation, or its protective conduit.

The deeper an insulated hot line is buried in dry soil, the more effective it is. However, the deeper it is buried in wet soil, the greater the heat loss. These conditions should be considered in the determination of insulation thickness.

Underground heated lines always tend to dry out the soil above, and for this reason it is difficult to grow grass above these lines unless they are buried deeply and well insulated. This might be a factor if a line runs under a lawn where good appearance is desired.

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THEORY - SOLAR RADIATION

IV. RADIATION PROBLEMS

A. Solar Radiation to Insulated Vessels

1. In many instances, vessels are insulated to retard solar heat flow inward. The basic formula to determine net heat flow to outer projected surface area with no insulation is:

$$q = A_1 \left(0.174 \times 10^{-8}\right) \epsilon \left(T_2^{\,5} - T_a^{\,4}\right) = A_1 \alpha H_s$$

When A_1 = Projected area of body

ϵ = Emittance of surface

T_2 = Absolute temperature of body surface ($t_2 + 460$)

T_a = Absolute temperature of space for prevailing conditions ($t_a + 460$)

α = Absorptivity of body surface

H_s = Net radiation, Btu/hr, sq ft at given latitude

2. Of the Btu's radiated to surface from solar radiation, some of the heat continues to flow inward to heat the body and some are transferred from the surface to the ambient air by convection. The amount of heat which is transferred to the air and to the body is dependent upon the temperature differences existing divided by the thermal resistance. As the entire amount of solar heat to the surface must equal the total of the two heat transfers from the surface, the surface temperature t_2 will adjust itself

or q = Solar heat Btu/sq ft/hr of surface normal to the sun

q_{sc} = Solar heat convected to the air, Btu/sq ft/hr

q_{sb} = Solar heat conducted through the insulation to the body, Btu/sq ft/hr

$$q = w_{sc} + q_{sb}$$

The following graph gives values of q_s in Btu/sq ft/hr

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BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS - Continued

D. Low Temperature - External Insulation

1. Economic Consideration of low temperature insulation, like high, is based on the savings of energy. All the factors which apply to calculation of economic thickness of insulation for high temperature insulation also apply to low. The difference is in the values. For example, the cost of removing a Btu by refrigeration generally costs eight to ten times more than supplying a Btu for heating.

   Using the proper values, the McMillan formula will determine the economic thickness for low temperature insulation. These thicknesses are tabulated in the Manual for "Economic Thickness for Low Temperature Insulation for Flat Surfaces and Pipes". However, the thickness required to prevent condensation on the external surface of the insulation is often the determining factor. These thicknesses are also listed in the "Manual".

2. Process Control is often the controlling factor in low temperature insulation thickness design. Many of the factors are similar to those of high temperature except that the insulation is to prevent heat gain instead of heat loss. Some process requirements might be:

   (a) A heat gain above which the vessel or system cannot operate satisfactorily.

   (b) A temperature above which the vessel or piping will not operate.

   (c) The amount of refrigeration available to the system.

   (d) The amount of solar heat allowable.

   (e) The allowable time for cooling to a given temperature.

   (f) The surface temperature should be above frost point.

   (g) The surface temperature should be above condensation point.

   Wherever other factors determine a thickness which will be less than that necessary to keep the surface above condensation temperature,

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BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

I. INDUSTRIAL INSULATION THICKNESS REQUIREMENTS - Continued

D. Low Temperature - External Insulation - Continued

2. Process Control - Continued

the thickness to ensure a temperature above this point is generally used. This is due three important facts: (1) insulation surfaces operating at less than condensation temperature provide a continual water drip which rusts steel and causes slime, (2) vapor migration from a wetted surface is four to six times greater than from an unwetted surface. This reduces the life of the insulation to one-fourth that which could otherwise be obtained, (3) the weather vapor barrier life is similarly reduced.

3. Safety Requirements are sometimes the determining factor of low temperature insulation thickness. Wherever an insulation is to protect the piping or vessel from fire for a stipulated length of time, the insulation must be of sufficient thickness to retard heat for that period. In some very hazardous installations it is required that the low temperature insulation be of thickness decided by low temperature factors and then a high temperature insulation be used on the outside to protect the inner insulation from fire.

E. Low Temperatures - Cryogenic

This type of insulation, although externally separated from the space it insulates, is different in that it is contained by an outer shell and that the space between the inner and outer shell is evacuated. This system is more costly than non-vacuum insulation, so that basis of calculation is resistance to heat flow. These "super-insulations" are justified only when:

(a) Heat leak is very costly, such as losses of liquefied gases due to vaporization.

(b) Space is at a premium and highly efficient insulation is required, as in shipping containers for liquefied gases.

(c) Insulation must be covered by impervious casing to avoid the migration of air or water.

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BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

II. COMMERCIAL INSULATION

Commercial insulation falls into several different categories. These are: (1) piping and vessel insulation; (2) duct insulation; (3) cold storage insulation; and (4) the actual building insulation. Each of these have particular factors influencing thickness.

A. Piping and Vessel Insulation

1. Economic Considerations for both high and low temperature insulation have the same factors for their determination as previously mentioned, with one exception. This exception is that when hot lines are in air-conditioned space, not only is the loss of heat involved, but also the lost heat must be removed by refrigeration. In this case the removal of the heat costs approximately eight times more than the value of the heat itself. This warrants considerable insulation to keep heat from escaping from vessels and pipes into cooled areas.

2. Functional Considerations for both high and low temperature insulations must also enter into thickness design, such as whether a building is for process, storage, laboratory or office. Hot piping which makes an area completely unusable voids the function for which the building was erected. Where excessive heat loads are present, the insulation must be increased accordingly. Low temperature lines also can ruin the function of a building. Typical is the case of cold water lines which are not insulated to keep the water cold, but to prevent condensate drip.

B. Ductwork Insulation

1. Economic Consideration is based not on the insulation alone, but on use of insulation to obtain an economic heating and cooling system which provides the required air-conditioning in all the areas where it is needed. These requirements determine thickness.

2. Functional Considerations may be of acoustical control as well as heat control. Many ducts are lined with insulation to control sound as well as heat. In many instances the thickness of insulation required to control sound is greater than that required to control heat. In such cases sound control becomes the deciding factor. Fire control may also dictate minimum thicknesses of insulation used in or on ducts, especially if the ducts are of aluminum or plastic.

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BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

II. COMMERCIAL INSULATION - Continued

C. Cold Storage Rooms

1. Economic Consideration is based on savings of refrigeration. The economic thickness can be calculated from the McMillan formula. However, cold storage rooms are a structure composed mostly of insulation. Therefore, methods of construction and materials used can change the cost with no direct relationship to thickness. For this reason it is necessary to compare the cost of various methods of construction with resistance to heat flow.

2. Functional Consideration may be used on amount of refrigeration available, or time allowed to reduce temperature of contents in room. Also, the thickness might be determined by condensation temperature of outer surface.

D. Building Insulation

1. Economic Considerations in buildings must include the determination of heating and cooling costs related to the thermal performance of its roofs, walls, and floors. Analysis and evaluation of thermal performance of building constructions and their mechanical systems prove the need for thermal insulation to provide a return on investment by reducing operating costs and capital cost of air-conditioning equipment. Insulation is part of the design in building. Thus, to obtain maximum economic benefits it is essential that the engineers and architects work together.

   In buildings the insulation is not just added to a wall, floor, or ceiling, but is one of the building components. For this reason, it is impossible to use McMillan's formula for economic thickness. In the design of buildings it is necessary to compare design and methods of construction. A method for such comparison has been developed by Owens-Corning Fiberglas and is named "Dividend Engineering for Buildings".

2. Functions of the building may in some cases require more insulation than shown necessary by economics. The building must be thermally tight enough to maintain the desired environment. In addition, its walls and roofs must be so designed that its vapor barrier is located

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BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

II. COMMERCIAL INSULATION - Continued

D. Building Insulation

2. Functions - Continued

to be above condensation temperature. Floors on soil should also have their exposed surfaces at a temperature above dew point.

Even additional functions such as fire protection, sound absorption, or sound transmission using the insulation in dual function may be the factor which controls the thickness.

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PROPERTIES OF INSULATION MATERIALS

I. BASIC TYPES OF THERMAL INSULATIONS

Basically, there are four types of thermal insulation materials: fibrous, granular, cellular, and reflective. These differ widely in properties.

Some of the more common fibrous materials are rock wool, slag wool, glass wool, asbestos, hair felt, and quartz fibers.

Granular materials consist of small nodules which contain voids or hollow spaces. They are not considered as true cells since gas can be transferred between the individual spaces. Materials such as magnesia, calcium silicate, diatomaceous earth, expanded silica, and vegetable cork are in this classification.

Cellular materials consist of small individual cells sealed from each other. Cellular materials are produced of glass, rubber, and plastics. Their major difference from granular materials is that each cell is hermetically sealed from all others.

Reflective insulation is composed of parallel thin sheets, or foil, of high thermal reflectance, spaced to direct radiant heat back toward its source. The spacing also is designed to provide restricted air (or gas) spaces. It reduces heat transfer by convection and conduction. In most instances, the thin sheets or foil are made of aluminum or stainless steel. Reflective insulation may be installed by the construction of air spaces separated by the reflective metal, as is practiced in building insulation or cold storage installations; or it may be obtained as preformed pipe and vessel insulation for industrial purposes.

Of course, there are many instances of intermixing of the various types. For example, fibers are added to some granular materials to add to the tensile strength of the insulation. Also, reflective sheets are used with light-density fiber materials to obtain increased efficiencies. Some cryogenic insulations are produced with reflective sheets separated by lightweight fibers in high vacuum space. Thus, a single finished produce may use more than one basic type of insulation material.

II. FORMS OF INSULATION MATERIALS

Depending upon the material and its intended use, insulation is produced in many forms. Some of these are as follows:

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PROPERTIES OF INSULATION MATERIALS

II. FORMS OF INSULATION MATERIALS - Continued

A. Rigid board, block, and preformed pipe covering
B. Semi-rigid board, block, and preformed pipe covering
C. Flexible board and preformed pipe covering
D. Blanket
E. Felts
F. Tape
G. Rope
H. Cement
I. Loose
J. Fill
K. Reflective

1. Preformed
2. Sheets
3. Foil

L. Combination blanket and reflective
M. Preformed cryogenic - vacuum space
N. Insulation mastics

III. PROPERTIES OF INSULATION MATERIALS

The type of material and the form in which it is produced influences the properties of the finished product. Some of the properties are of a nature which can be tested and numerically evaluated. Others, although of no less importance, cannot be so evaluated. Some of the latter are:

A. Availability
B. Price
C. Shape and sizes available
D. Straightness of sides and ends
E. Smoothness of surfaces
F. Cutting characteristics
G. Dusting characteristics
H. Dust hazard - health
I. Compatibility with adhesive or cement
J. Speed and cost of fabrication
K. Speed and cost of installation
L. Shelf life

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PROPERTIES OF INSULATION MATERIALS

III. PROPERTIES OF INSULATION MATERIALS - Continued

M. Cost of shipping, handling, and storage
N. Dimensional stability
O. Packaging

The physical, chemical, moisture, and thermal properties of insulation are:

A. Abrasion resistance
B. Alkalinity, pH
C. Capillarity
D. Combustibility -

1. Flash point
2. Fire point
3. Self-ignition point
4. Melting point

E. Coefficient of expansion
F. Corrosion - rusting of carbon steel
G. Corrosion - stress corrosion of stainless steel
H. Cracking - hot surface
I. Density
J. Drop resistance
K. Hardness
L. Hygroscopicity
M. Resistance to acids
N. Resistance to caustics
O. Resistance to solvents
P. Shrinkage, heat

1. Linear
2. Volumetric

Q. Specific gravity

1. Real
2. Apparent

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PROPERTIES OF INSULATION MATERIALS

III. PROPERTIES OF INSULATION MATERIALS - Continued

R. Strength

1. Breaking
2. Compressive
3. Flexural
4. Shear
5. Tensile

S. Temperature limits, minimum and maximum

1. Continuous
2. Short periods
3. Cyclic

T. Temperature rise - self-internal heating
U. Thermal diffusivity
V. Thermal shock resistance
W. Vibration resistance
X. Warpage - in service
Y. Water absorption
Z. Water vapor transmission

Materials which are installed in a wet state, such as cements or mastics, have all the above listed properties as dry materials, but in addition have the following:

A. Adhesion

1. Wet
2. Dry

B. Shrinkage - wet to dry

1. Linear
2. Volumetric

These properties, their significance, and available or suggested method of test, are presented in the Design and Construction Manual "Properties of Thermal Insulation Materials and Their Significance". A tabulation of the general properties and characteristics of insulation are presented in the manual "Thermal Insulations and Accessories".

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PROPERTIES OF INSULATION MATERIALS

III. PROPERTIES OF INSULATION MATERIALS - Continued

FIRE TESTS OF INSULATION MATERIALS

The fire resistance properties of insulation systems have been studied by the Fire Research Group of Research and Development. The results of these studies were published in the manual "Fire Tests on Thermal Insulation and Weather Barriers". However, these tests were run in 1957 so that materials developed since that time are not included in the report. Also, this report was not condensed to provide information on generic materials. For this reason, this condensation of results is included.

Temperature of Pipe After 60 Minues - °F
Insulation on 3" Pipe

Insulation Material	1" Thick	2-1/2" Thick	Remarks
Aluminum Reflective - Aluminum Jacket		(1000F-12 min)	Melted after 11-1/2 min
Aluminum Reflective - S. S. Jacket		910	
Asbestos Fibers	710	200	
Asbestos Fibers and Perlite	515	200	
Calcium Silicate	710	218	
Calcium Silicate - High Temp	700	180	
Cellular Glass	1250	770	
Cellular Silica	760	400	
Diatomaceous Earth - Standard	615	190	
Diatomaceous Earth - High Temp	710	210	
Urethane Foam With 15 Mils of intumescent paint		(1000F-31 min)	
With stainless steel outer jacket		(1000F-10.5 min)	

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PROPERTIES OF INSULATION MATERIALS

III. PROPERTIES OF INSULATION MATERIALS - Continued

FIRE TESTS OF INSULATION MATERIALS - Continued

Temperature of Pipe After 60 Minutes - °F
Insulation on 3" Pipe
Continued

Insulation Material	1" Thick	2-1/2" Thick	Remarks
Glass Fiber		(1000F - 32 min)	Melted and dripped in 4-1/2 min
Magnesia, 85%	750	180	
Polystyrene, expanded		(1000F - 13 min)	Melted, burned and dripped - first min
Silica, expanded and binders	710	210	
Vegetable Cork		680	Supported combustion & continued burning after test

The Fire Research Group set up the criterion that if insulation could provide a one-hour time duration before the pipe or equipment would reach 1000F, this time delay would be of considerable assistance in fire protection. This does not apply to "fireproofing" where insurance regulations or codes require two to four hours protection.

Of the materials listed above, the following did not prove satisfactory:

Aluminum reflective with aluminum jacket melted after 11-1/2 minutes in the fire area, leaving the pipe exposed to direct flame impingement. Glass fibers melted in 4-1/2 minutes, leaving the pipe exposed to direct fire. 85% magnesia, although it protected the pipe for the required time, was reduced to almost a powder and washed away when hit by the water stream from a fire hose. Expanded polystyrene melted, burned, and provided burning drip, and was completely gone within the fire area in one minute. It also continued to burn outside the fire area. Vegetable cork supported combustion and continued to punk for hours after the fire test. Water from the fire hose could not stop this punking.

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PROPERTIES OF INSULATION MATERIALS

III. PROPERTIES OF INSULATION MATERIALS - Continued

FIRE TESTS OF INSULATION MATERIALS - Continued

Of the materials which did pass the fire test, the following was observed:

The reflective insulation depended completely upon the outer stainless steel jacket for protection of the inner aluminum reflective sheets. After one hour of exposure, several of the outermost aluminum reflective sheets had melted. Cellular glass failed by thermal shock and was broken into pieces and would have fallen from the pipe if it has not been contained by fire resistant type weather barrier.

Asbestos fibers, asbestos fibers and perlite, calcium silicate, diatomaceous earth, expanded silica and binders all had shrinkage from 1/8" to 1-1/2" for each 3'-0" section. For this reason, when used as "fireproofing", double layer, staggered joint construction, or stainless steel jacket is required to prevent hot spots.

The fire hazard which might be caused by chemical contamination of chemicals has been investigated at times when fires were known to have started from this cause. Because of the complex nature of the problem, no complete investigation was ever attempted, nor any comprehensive report written. For this reason, available information is presented in this design manual. The flash points of insulations, by themselves and in contact with contaminated chemicals, are presented in the following tables. Table A provides information obtained by ASTM Open Cup Flash Point and Electric Furnace Rising Temperature Test Method. Table B provides information obtained by the Fire Research Group's Ignition Test and Spontaneous Heat Test.

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PROPERTIES OF INSULATION MATERIALS

III. PROPERTIES OF INSULATION MATERIALS - Contd

TABLE A - FLASH POINT TEST

MATERIAL	OPEN CUP METHOD Temperature °F				RISING TEMPERATURE METHOD Temperature °F			
	Insula. Only	With Carbowax	With DEA	With Dowtherm	Insula. Only	With Carbowax	With DEA	With Dowtherm
Chemical only	(a)	470	270	240		470	270	320
Asbestocel	(a)	455	410		(b)	(c)	(c)	
Bunroc	(a)	430	460		(b)	437	718	
Glass Wool - White	(a)	300	425		(b)	450	430	
Hairfelt	480	415	280		555	602	523	
Calcium Silicate	(a)	420	383	210	(b)	455	415	389
85% Magnesia	(a)	375	310	175	(b)	410	455	277
Rock Cork	(a)	500	288		(b)	400	720	
Diatomaceous Earth	(a)	325	380	238	(b)	510	(d)	235
Asbestos Fiber	(a)	390	385	190	(b)	472	480	359
Vegetable Cork		220	360		650	640	665	
Mineral Wool Cem.	(a)	400	360		(b)	500	710	
Mineral Wool Blk.	(a)	305	280		(b)	431	320	
Mineral Wool Cem. Hydraulic Setting					(b)	565	525	

Symbols: (a) No flash or burning up to limit of open cup test
(b) No flash or burning up to limit or rising temperature heat
(c) Liquid completely vaporized without flashing
(d) Dense smoke - Pilot light would not burn

TABLE B

FIRE RESEARCH GROUP

IGNITION TEST AND SPONTANEOUS HEAT TEST

Insulation	Ignition Temperature °F	Spontaneously Heats When in Contact With			
	Ethylene Oxide/Air Contact	Ucon Lubricant 75-H - 90,000	Carbowax PCG 400	Tergitol Nonionic NPX	Dowtherm
Careytemp	752	Yes	Yes	No	
Fiberglas - Phenolic	779	No Data			
Fiberglas - White	779	No Data			
Foamglas	833	No Data			
Foamglas	890	No	No	No	No
Glass - Pyrex (Standard Auto-ignition temperature)	824	No Data			
Kaylo, Standard	617	Yes	Yes	No	Yes
Kaylo, No. 20		Yes	Yes	No	Yes
Magnesia, 85%	482	Yes	Yes	No	Yes
Magnesia, 85% (damp)	428				
Stainless - Reflective		No	No	No	
Superex	545	No Data			
Superex, (damp)	444	No Data			
Unibestos	572	No Data			

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WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

I. GENERAL

Thermal insulation, with the exception of reflective types, depends upon finely divided spaces containing air or gas to retard the flow of heat. When insulation becomes wet, or partly so, all or part of the small spaces become filled with water. The conductivity (in Btu/sq ft, 0°F, inch thickness) of water at 70F is 4.1 as compared with 0.17 for air. Therefore, from a completely dry to a completely wet state, the transmission of heat through insulation will increase 16 to 20 times. The function of water, weather, and vapor barriers is to keep insulation dry.

Insulation must be protected from liquid water if it is installed below ground. It must be protected from rain, sleet, snow, and liquid spillage when installed above ground. It must protect for moisture vapor if the temperature of the surface to which it is applied is below ambient. The protection against these conditions can be classified as water barrier, weather barrier, and vapor barrier. Depending upon conditions, the protection of the insulation may require any one, combination of two, or all three to maintain its initial efficiency.

II. WATER BARRIERS

Water barriers are required to protect insulation where it is submerged in water, or is located underground where ground moisture and water level present severe water resisting problems.

When submerged in any liquid, the only positive way to keep insulation dry is to encase it in a liquid-tight metal pipe, conduit, or container. In most instances, this requires special design to determine suitable metal closures, sealing, expansion and contraction, and corrosion resistance.

Underground lines must also be provided with water barriers. Soil is generally moist and sometimes becomes saturated due to rain and snow. Underground high temperature lines are generally insulated and water protected in one of three ways. One is by use of a granular bituminous fill insulation. Another is by use of conduit-encased insulation, and still another by use of reinforced mastic-sealed insulation.

A. Granular Bituminous Fill Insulation and Water Barrier

Granular bituminous fill materials are a combination water barrier and insulation. The material is installed by pouring and tamping around on

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WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

II. WATER BARRIERS - Continued

A. Granular Bituminous Fill Insulation and Water Barrier - Continued

underground pipe. It is cured by heat from the pipe at recommended temperatures and time durations before the line is placed in service. The curing process forms a consolidated core around the pipe, a sintered core around this first core, then unchanged material, all enclosed by the fill. Material is furnished in various grades for different service temperatures.

The unchanged portion of the fill material, which provides most of the insulating value, is outside the consolidated core which protects the pipe from water. For this reason its efficiency as an insulation is limited to locations where it is located above the ground water table and where it will not be subjected to drainage water. Also, as the consolidated core and sintered core are formed by heat, when heat is removed from the line, the contraction causes cracks in the protective core sections. For this reason they do not protect the line from corrosion when it is unheated, nor do they protect a line which cycles in temperature.

During periods of little rainfall, soil and sand can dry out and become relatively good insulation. This will cause a temperature rise of the fill insulation and the soil around it. To illustrate: if a pipe is operating at above 500F, the soil near the fill insulation may be well above 200°F. For this reason gas lines, water pipes, or any lines which should not be heated must be placed a minimum of 6'-0" from the hot insulated line. Likewise, lines which cross the hot insulated line, which should not be subjected to heating, should be a minimum of 2'-0" above or below the insulation of the heated pipe.

Fill insulation is not suitable for installation on hills or steep slopes.

B. Conduit Water Barriers

This system is basically an insulated line encased in another pipe or conduit. The outer pipe or conduit is made of galvanized steel or cast iron, and is so designed that the insulated encased pipe can slide so that its expansion and contraction is not transmitted to the outer enclosure. The system, including expansion loops, anchors, and fittings, must be

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WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

II. WATER BARRIERS - Continued

B. Conduit Water Barriers - Continued

designed to fulfill the operating and location conditions. The outer enclosure conduit may be metal, cement-asbestos conduit or plastic conduit. The conduits can be designed to contain one, two, or more pipes at the same or different temperatures. The temperature of each pipe would determine its insulation thickness. This system is also suitable for heat traced piping.

Properly installed, these systems are completely watertight, so they are suitable where the water table is high and soil is saturated. It is also suitable for installation on hills and steep slopes.

Although the ground temperature around a conduit will rise, due to the low conductivity of insulation inside the conduit, this increase will be less than the soil temperature increase around the granulated fill system. Unless the temperature of the hot pipe is very high, water and gas lines can be located within 2" of the side of the conduit. In some instances, this eliminates digging of separate trenches.

C. Reinforced Mastic-Sealed Insulation

The third method of water sealing insulation is to use weather-barrier jackets or mastics to seal the insulation from water entry. The materials used are also used as weather-barrier above grade and will be discussed in the following section. The only major difference in the application is that where these materials are used below grade, all joints and laps must be sealed sufficiently to withstand water pressure.

III. WEATHER AND VAPOR BARRIERS

A. General

As previously stated, insulation must be kept dry to retain its efficiency. Thus, it must be protected against moisture in liquid and vapor state. Insulation operating above ambient temperature needs only to be protected against liquid water, as the vapor pressure is outward. Such protection is called a weather barrier. Insulation operating at less than ambient temperature must be protected from moisture vapor which

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WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

III. WEATHER AND VAPOR BARRIERS

A. General - Continued

attempts to reach the cold surface of the pipe or vessel. The barrier to this vapor migration is called a vapor barrier. All lines and equipment operating at lower than ambient conditions, either indoors or outdoors, must be provided with a vapor barrier because the vapor pressure is inward.

Some coatings, jackets, or films are both weather and vapor barriers, whereas others are not. In many instances, a material such as a metal jacket, which is used more often as a weather barrier, may also be used as a vapor barrier if all its joints are vapor sealed.

Insulation on warm or hot applications indoors, where not subjected to water, may require only a surface finish to protect it from mechanical abuse, or to provide a decorative appearance. In a few instances, warm or hot applications of insulation which are located in building pipe chases, not subject to any abuse nor having any need for decorative appearance, are installed with no outer barrier or finish.

Overcoatings are sometimes required over weather or vapor barriers on either hot or low temperature insulations. In instances where it is necessary to match existing colors, or to color code the surface, the barrier is painted as desired. Paints which are compatible with the weather or weather-vapor barrier must be selected for this application. Another instance where overcoating is required is when the location is such that contamination or spillage of chemicals will attack the barrier. A third use of overcoatings is the use of intumescent paint on the barrier to provide fire protection.

Depending upon conditions, insulation may require: (1) no outer protection, (2) weather barrier, (3) vapor barrier, (4) weather and vapor barrier, (5) surface finish, or (6) overcoating over one of the barriers.

B. Weather Barriers

The fundamental purpose of a weather barrier on insulation is to prevent the insulation from getting wet. Wherever pipe or equipment insulation is subjected to rain, sleet, snow, liquid spillage, or hose washing, it

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WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

III. WEATHER AND VAPOR BARRIERS - Continued

B. Weather Barriers - Continued

must be protected. In addition to this primary function, weather barriers must also protect insulation from physical damage and abuse.

For successful protection of thermal insulation, the weather barrier must stay in place on the insulation and withstand movement caused by expansion and contraction without cracking or breaking. To accomplish this, the weather barrier must possess mechanical strength. It is also exposed to mechanical abuse from external forces. As most insulation materials are relatively soft, any load placed on the outside of the insulation surface must be transmitted by the weather barrier to the insulation without damage to the weather barrier. Mechanical abuse, such as walking on a weather barrier, involves impact, shear, compression, and abrasion. The barrier must be able to withstand all four.

Of course, a weather barrier's primary function is to resist the weather to which it is subjected. The ambient temperature may reach -40F or up to 110F. Over high temperature insulation, in summer under solar radiation, the temperature of weather barrier can exceed 180F. Therefore, the weather barrier must retain its characteristics over a wide range of temperatures.

In addition to weather, acid, caustics, and chemical, fumes can damage the weather barrier. It is of paramount importance that it be resistant to fumes and spillages to which it may be subjected.

Weather barriers used in chemical plants must not increase the fire hazard within the plant. Fire hazard can be increased in several ways. One is that the weather barrier could contribute to a fire or assist it to spread. Another is that it could react with chemical spillage or fumes to cause an accidental fire. A good weather barrier should resist fire and help protect the insulation so as to provide a thermal shield between the fire and piping and equipment.

Many materials have been used as weather barriers for thermal insulation. In general, they fall within two classifications -- jackets or mastics.

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WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

III. WEATHER AND VAPOR BARRIERS - Continued

B. Weather Barriers - Continued

1. Jackets

Various types of jackets are used as weather barriers for insulation. They can be applied around straight piping with relative ease. As barriers over fittings such as elbows, valves, and irregular surfaces, jackets are difficult and costly to apply. However, factory fabricated fitting jackets may partly solve this difficulty. Unless considerable care is exercised, the joints between jackets are not watertight. Some of the materials used for insulation weather barrier jackets are:

- Roofing rag felts
- Asbestos-asphalt felts
- Asbestos and asbestos-asphalt felts
- Mylar film
- Polyvinyl chloride film
- Asbestos sheets and asbestos-asphalt felts
- Foil faced rag felts
- Aluminum
- Aluminum-clad steel
- Painted steel
- Galvanized steel
- Prepainted galvanized steel
- Stainless steel
- Fiberglass reinforced plastic

2. Mastics

Similar to the jackets, there are many materials used as mastics for weather barriers. In most instances, it is recommended that the mastics be reinforced with a membrane to provide higher tensile strength. For this reason, the reinforcing membrane will be given with the mastic for which it is recommended.

Mastic	Reinforcing Membrane
Cutback asphalt and fiber	20 x 20 asphaltic binder glass cloth
Emulsion asphalt and fiber	1" hexagonal mesh monel wire netting
Chemically dispersed asphalt	1" hexagonal mesh monel wire netting

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WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

III. WEATHER AND VAPOR BARRIERS - Continued

B. Weather Barriers - Continued

2. Mastics - Continued

Mastic	Reinforcing Membrane
Polyvinyl acetate and fiber	8 x 8 Dynel cloth
PVA - Acrylic	8 x 8 Dynel cloth
Acrylic	8 x 8 Dynel cloth
Neoprene or Elastomers	

Where color is desired, the polyvinyl acetate and acrylic can be obtained in many standard colors. The asphaltic materials are black and may be overcoated with suitable paint for final color.

3. Recommendations on Selection of Weather Barrier

Metal jackets are most useful where they are installed on uninterrupted cylindrical surfaces -- such as long straight pipe runs. All metal pipe jackets should be installed with "Z" joints on longitudinal lap and with a double sealed closure band sround circumferential butt joints. This installation, as specified in General Specifications GS XV, will allow the jacket to expand and contract with the changes of dimension of the pipe. Metal jackets used on vessels should be installed as called for in General Specifications GS XV and Figure GA-7.

Aluminum jacketing should only be used where fire hazard is of no concern and where its high reflectance does not cause excessively high surface temperature.

Galvanized and prepainted steel is the most useful general purpose jacketing as it is much stronger than aluminum, does not cause excessive surface temperatures and will resist direct fire impingement for a considerable length of time.

Stainless steel jacketing is the most chemical resistant and fire resistant of all metal jackets. It is recommended where fire resistance is of upmost importance and where chemical contamination would damage the precoated galvanized steel jacketing.

Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation D... Published by AsbestosClaims.Law
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WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

III. WEATHER AND VAPOR BARRIERS - Continued

B. Weather Barriers - Continued

3. Recommendations on Selection of Weather Barrier - Continued

Mastics are most useful to provide weather barrier protection on complex piping, equipment having many nozzles, flanges or projections, heads and other irregular surfaces, where fitting of metal and water sealing of metal joints are difficult. On flat surfaces where the barrier depends on bond to the insulation for its support, mastics are easier to apply than metal.

Asphaltic mastics stiffen with age and have poor low temperature flexibility characteristics, thus have poor service life. They also are combustible and will spread fire. For these reasons they are not recommended.

The polyvinyl acetate, PVA-acrylic, and acrylic mastics have proven to be better weather barriers than the asphalts. Properly formulated, they prov.de long service life and they are fire resistant.

The ability of a mastic reinforced system to elongate without breaking or rupture, as the pipe or vessel expands, is essential for maintaining its function as a water barrier. Past practice of using glass fabric as the reinforcing membrane prevents elongation and should not be used as mastic reinforcement. The reinforcement should be Dynel cloth which can elongate 50% of its length.

The water emulsion PVA, PVA-acrylic, and acrylic mastics do have high vapor transmission; thus, when used on hot service insulation, any entrapped moisture vapor can escape without causing water blisters on the surface.

C. Vapor Barriers

Moisture in the vapor state is a gas, and in this state will always seek to equalize any pressure difference by flowing from the high pressure area to the low pressure area. When thermal insulation is on a surface which operates as a temperature less than the ambient temperature, this lower temperature on the inner surface of the insulation causes a lower vapor

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WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

III. WEATHER AND VAPOR BARRIERS - Continued

C. Vapor Barriers - Continued

pressure at this point than exists in the ambient air. To show the force of this vapor pressure, the following is presented:

> Assuming the temperature of the insulated surface as 30F and the air film on this surface at 100% relative humidity, the vapor pressure is 11.6 lbs/sq ft. If the ambient air is 90F with a relative humidity of 80%, the vapor pressure is 77.8 lbs/sq ft. The force is the difference, which is 66.2 lbs/sq ft. This force is pressing inward, seeking any hole or weakness in the outer surface. If the vapor does get through the barrier and enters the insulation, as it encounters lower temperatures on its way toward the inner surface, it will reach its dew point. At this point it will condense to a liquid. As this process continues, the insulation becomes saturated and its efficiency is lowered. Although the moisture migration cannot be entirely stopped, the vapor barrier must retard this vapor sufficiently to obtain a maximum economic life for the low temperature insulation.

The selection and installation of vapor barriers depend upon the characteristics of the thermal insulation to which it is to be applied. If the insulation is not highly vapor-resistant, a completely sealed vapor barrier must be provided. If the insulation is vapor-resistant, it can be sealed at its joints to form its own vapor barrier.

1. Vapor Barriers on Semi-Vapor Resistant Insulations

Semi-vapor resistant insulations depend upon a vapor barrier to maintain their thermal efficiency. Because of this, a superior vapor barrier is imperative. If the vapor barrier is broken or punctured, the moisture migrates into the insulation and condensate will form. Any outer surface vapor barrier, no matter how strong, may be subjected to fracture. Whenever multiple layers of insulation are warranted, an inner vapor barrier is good insurance to prevent excessive damage by moisture if the outer barrier is punctured. It is also advisable to install the barrier in sectional type construction. This can be accomplished by providing barriers in the butt joints at intervals to form sealed sections. By this method, only moisture entering a break in the outer vapor barrier will be restricted to that section. This is illustrated as follows:

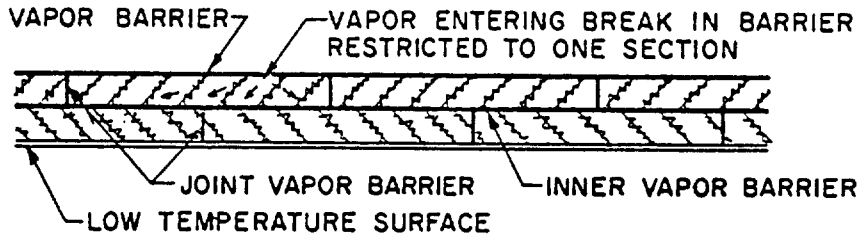
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WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

III. WEATHER AND VAPOR BARRIERS - Continued

C. Vapor Barriers - Continued

1. Vapor Barriers on Semi-Vapor Resistant Insulations - Continued



PROPER METHOD FOR SEALING SEMI-VAPOR RESISTANT INSULATION

In like manner, whenever straignt pipe insulation on lines is to be jointed with fitting insulation, the straight insulation should be stepped back from the fitting and the vapor barrier carried down over the butt ends and sealed to metal. This also applies to equipment insulation.

Low temperature insulations which fall into the semi-vapor resistant class are glass fibers, mineral wools, hair felt, cork organic foams. In most instances, these materials are less expensive than hermetically sealed cellular insulations. However, the expense of installing proper vapor barriers causes installed cost of this class of low temperature insulation to be quite high.

Selection of material and method of installation depend upon the insulation to be vapor protected, the temperatures to which the insulation and barrier are to be subjected, the mechanical and chemical exposure, and fire hazard. Vapor barriers are formed from many types of materials such as jackets, foils, tapes, and mastics, and various combinations of them.

Application where severe vibration is present, or extreme conditions of expansion and contraction exist, or where the insulation is also used as a sound absorber, require the use of semi-vapor resistant and flexible insulation. However, the vapor barrier must be carefully selected and designed.

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WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

III. WEATHER AND VAPOR BARRIERS - Continued

C. Vapor Barriers - Continued

1. Vapor Barriers on Semi-Vapor Resistant Insulations - Continued

(a) Jackets, Foils, Tapes

Metal Jackets of aluminum or stainless steel have been used as vapor barriers. Although these are the most vapor resistant materials that can be obtained, the forming and fitting to the shapes required of vapor barriers is difficult. In addition, all joints and laps must be vapor sealed. Sealers used to bond metal to metal into a vaporproof mechanically strong joint have been found to be only partially successful.

Composition Jackets made of laminations of asbestos paper and aluminum foil or other materials, although more flexible than the metal jackets, still present the same difficulty of forming and sealing.

Foils of aluminum are used as vapor barriers. However, very lightweight foils have pinholes and have little mechanical strength. For this reason, foils have been produced which are reinforced with glass fiber and plastic coating. These reinforced foils are efficient and easier to apply. However, the major difficulty of lap sealing still remains.

Tapes with pressure sensitive adhesive have been produced of many materials, such as rubber, fabric, aluminum, polyethylene, polyvinyl chloride, glass fibers, or combinations of these materials. These tapes are applied on vapor barriers in themselves, as joint sealers with the jackets, or as a base over which mastic is applied.

The number of materials and combinations possible is too large to present in this manual. A listing of available material is presented in the "Thermal Insulation and Accessories Manual".

(b) Mastics

Mastic weather barriers are made of asphaltic compounds, rubber or resins. These are of solvent type and are most

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WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

III. WEATHER AND VAPOR BARRIERS - Continued

C. Vapor Barriers - Continued

1. Vapor Barriers on Semi-Vapor Resistant Insulations - Continued

(b) Mastics - Continued

often applied over fabric tape, or are reinforced with a membrane such as glass fiber cloth.

Most of these mastics are quite flammable in the wet state, so they must be applied with caution. Even in the dried state, most will support combustion.

Frequently, an application will be made using jackets or reinforced foils on straight piping and cylindrical sides of vessels, with mastics completing the barriers over butt ends, valves and fittings, vessel heads, and irregular surfaces. No matter which system is used, it is essential that the vapor barrier is sectionalized in cell type enclosures.

After the vapor barriers are completed, unless the vapor barrier is also a weather barrier, it is necessary to install the outer finish or weather barrier on the outside surface.

D. Characteristics of Weather and Vapor Barriers

In selection of weather and vapor barriers, their properties must be considered in view of the requirements of the installation. The requirements as related to properties of materials are listed below to assist in such evaluation.

WEATHER AND VAPOR BARRIERS
REQUIREMENTS AS RELATED TO PROPERTIES OF MATERIALS

Function	Requirement	Properties
Transportation and storage	Economic handling	Can stability Freezing point Shell life Toxicity

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WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

III. WEATHER AND VAPOR BARRIERS - Continued

D. Characteristics of Weather and Vapor Barriers - Continued

Function	Requirement	Properties
Field installation	Application - coatings	Adhesion - wet Build Coverage Curing time Drying time Flash point Fire point Freezing point Shrinkage Sag - thickness Temperature limits - application Toxicity
	Jackets, foils, tapes	Adhesion to surface Flammability Flexibility Tear strength Tensile strength
In service	To withstand impact, mechanical wear, forces of expansion and contraction	Abrasion resistance Adhesion - dry Flexibility Hardness Impact strength Peelback Tensile strength
Chemical	Compability with metal with which it may be on contact	Alkalinity Corrosiveness Soluble chlorides
	Resistance to spillage or atmospheric contamination	Resistance to acids Resistance to caustics Resistance to solvents

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WATER, WEATHER, VAPOR BARRIERS, FINISHES AND OVERCOATINGS

V. OVERCOATINGS

C. Overcoating for Appearance - Continued

Another instance where overcoating is required is where piping is color coded. Providing all colors to be applied as insulation mastics would be quite difficult, and on Union contracts this amount of color finishing would be claimed by the painters. For these reasons, color coding painting is done after insulation finishing has been completed.

D. Overcoating for Fire Protection

When fire protection becomes important, overcoating of the weather or vapor barrier with an intumescent coating system will provide additional protection.

An intumescent system cannot be used on surfaces which melt, soften, or release solvents at relatively low temperatures, due to the fact that its intumescence starts at approximately 350F. At this temperature puffing action occurs and forms a lightweight carbonized insulation which will resist flame temperatures.

To illustrate the heat resistant action of intumescent overcoating systems, the following results obtained by fire test are presented:

Aluminum jacket unprotected melted in 1 minute, 30 seconds.

Aluminum jacket protected with intumescent paint system melted in 11 minutes, 30 seconds.

1-1/2" thick Foamglas with PVA weather barrier on 3" pipe -- pipe temperature 1000F after 41 minutes fire exposure.

1-1/2" thick Foamglas with PVA weather barrier overcoated with intumescent system on 3" pipe -- pipe temperature 1000F after 56 minutes fire exposure.

In very hazardous locations, low temperature insulation application can obtain additional time before failure by use of intumescent paint systems.

It is also possible to use this system directly on steel pipe or other members which are not insulated. Time of failure of unprotected steel is approximately five minutes, whereas if protected by the intumescent system, the failure time is approximately 25 minutes.

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FIRE TESTS ON WEATHER BARRIERS

I. GENERAL

Several properties of the weather barrier materials as related to fire are important. One is flame spread, another is fire-time resistance, another is flammability, and still another is reaction with chemicals which could cause fire.

The following fire exposure test data are results of fire tests by the Fire Research Group conducted in 1957. The test is described in the report "Fire Tests on Thermal Insulations and Weather Barriers?, March 1962. Many materials called "fire retardant" or "fire resistant" do not perform in accordance with their names. Thus these terms in manufacturers' literature should be ignored.

II. FIRE EXPOSURE TEST ON WEATHER BARRIERS

Weather Barrier	Time to Start Burning	Fire Spread	Condition After Exposure
Aluminum jacket .036" thick	Melted - 1 min 50 sec	None	Completely destroyed over fire area, 18 min
Aluminum jacket .016" thick	Melted - 53 sec	None	Completely destroyed over fire area, 18 min
Asbestos fire retardant felt	Started to burn after 1 min, 30 sec	Fire spread to end of test section	Completely destroyed over fire area, 18 min
Asphalt cutback mastic	Started to burn after 30 sec	Fire spread to end of test section	Completely destroyed full length of test section in 18 min
Asphalt emultion mastic	Started to burn after 35 sec	Fire spread to end of test section	Completely destroyed full length of test section in 18 min
Asphalt-Gilsonite cutback mastic	Started to burn after 35 sec	Fire spread to end of test section	Completely destroyed full length of test section in 18 min
Asphalt-Gilsonite fire-resistant cutback mastic	Started to burn after 35 sec	Fire spread to end of test section	Completely destroyed full length of test section in 18 min

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FIRE TESTS ON WEATHER BARRIERS - Continued

II. FIRE EXPOSURE TEST ON WEATHER BARRIERS - Continued

Weather Barrier	Time to Start Burning	Fire Spread	Condition After Exposure
Polyvinyl acetate emulsion mastic	Slight burning after 5 sec	Fire spread approximately 2'-0"	Carbonized over fire area but intact after 60 min
Polyvinyl chloride zip-on film jacket	Melted - 20 sec	None	Completely destroyed over fire area in 18 min
Roofing felt - 55 lb	Started to burn after 1 min, 30 sec	Fire spread to end of test section	Completely destroyed full length of test section in 18 min
Stainless steel	No burning or melting	None	Discolored over fire area. Undamaged after 60 min

FLASH POINT

Material	Flash Point °F	
	Wet	Dried
Asphalt, cutback weather barrier mastic	125	195
Asphalt, emulsion weather barrier mastic	*	510
Asphalt-Gilsonite cutback weather vapor barrier mastic	130	435
Asphalt-Gilsonite cutback insulating mastic	140	375
Asphalt vapor seal	165	-
Polyvinyl acetate weather barrier mastic	*	**

* No flash point, due to water boil-off.
** No flash at 525F (temperature limit of this open cup test).

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FIRE TESTS ON THERMAL INSULATIONS AND WEATHER BARRIERS

I. GENERAL

Prior to the fire tests conducted by the Research and Development Department Fire Research Group, the effect of fire on insulation and weather barrier materials was unknown.

The damage to insulated piping and equipment from plant fires indicated that action should be taken to determine and record data on insulation and weather barrier materials exposed to direct flame impingement. The Insulation Committee requested the Fire Research Group to develop a test procedure and to conduct tests which would duplicate plant fire exposures.

Test procedures and equipment, to determine the effect of fire exposure on various insulation and weather barrier materials, were developed. The test results, conclusions, and recommendations are included in this report.

II. SUMMARY

A. Requirements

Insulations which did not retard the temperature rise of the test pipe to less than 1000F after fire exposure for 60 minutes were considered as failures. The failing point of 1000F was selected because at or near this temperature many reactive chemicals decompose with explosive violence; also, steel rapidly loses its strength at temperatures above this level.

B. Materials Tested

Insulations and weather barriers of different compositions and various manufacturers were tested. These basic materials and their classification are as follows:

1. Insulations

   a. High Temperature

      (1) Calcium silicate
      (2) Diatomaceous earth
      (3) Asbestos fibers
      (4) Asbestos fibers and perlite
      (5) Magnesia
      (6) Aluminum and stainless steel reflective sheets with stainless steel jacket

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FIRE TESTS ON THERMAL INSULATIONS AND WEATHER BARRIERS

II. SUMMARY - Continued

B. Materials Tested - Continued

1. Insulations - Continued

b. Low Temperature

(1) Cellular glass
(2) Vegetable cork
(3) Cellular silica
(4) Foamed polystyrene
(5) Aluminum reflective sheets
(6) Glass fiber

2. Weather Barriers

a. Jackets

(1) Aluminum corrugated (0.016" thick)
(2) Aluminum corrugated (0.024" thick)
(3) Asbestos felt roofing
(4) Asphalt felt roofing
(5) Polyvinyl chloride
(6) Stainless steel

b. Mastics

(1) Asphalt emulsion
(2) Asphalt cutback
(3) Gilsonite
(4) Gilsonite (fire retardant)
(5) Polyvinyl acetate
(6) Polyvinyl acetate (overcoated with intumescent paint)

C. Conclusions

The test results indicate that many of the high-temperature and two of the low-temperature types of insulation adequately protected steel pipe from fire for one hour's duration and were considered satisfactory for use in plants of Union Carbide Corporation.

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FIRE TESTS ON THERMAL INSULATIONS AND WEATHER BARRIERS

II. SUMMARY - Continued

C. Conclusions - Continued

Most of the commonly used weather barriers were not satisfactory because of excessive flame propagation and rapid deterioration. However, stainless steel jacketing and the polyvinyl acetate and acrylic mastics were considered satisfactory.

III. DISCUSSION

A. Test Procedure

The Fire Research Group developed a test procedure which subjected the test materials to conditions similar to those experienced in plant fires. This test procedure was accepted by the Insulation Committee.

1. Equipment Required

   a. Pipe support rack and a 4' wide by 7'-6" long by 1'-6" deep fuel pan.

   b. Fuel supply and control equipment.

   c. Approximately 140 gallons of standard motor fuel was used for each test. This fuel was controlled at a rate of one gallon per minute for the first 5 minutes exposure, 1.8 gallons per minute for the next 10 minutes exposure, and 2.5 gallons per minute for the remainder of the exposure.

   d. Multipoint recording potentiometer (10 point minimum, two points for each pipe).

   e. Water supply and equipment for water stream and water spray application.

   f. Five 20-foot long, 3-inch IPS, Schedule 40 carbon steel pipes per test.

   g. Alumel-Chromel thermocouple wire, porcelain insulators, connections, etc.

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FIRE TESTS ON THERMAL INSULATIONS AND WEATHER BARRIERS

III. DISCUSSION - Continued

A. Test Procedure - Continued

2. Preparation

a. Thermocouples

Each 20-foot test pipe was cut at the center on a 30° angle to longitudinal centerline to form two sections. A thermocouple was installed on the inside wall of each section at points which located the thermocouples 180° apart and 10-feet from either end when pipe was reassembled. The two sections were welded together to reform the original 20-foot long test pipe.

b. Pipes (Test Materials Applied)

(1) Application of Insulation

Three methods of applying insulation were used.

(a) Single-layer, mass-type, 1-inch or 2 1/2-inch thick, 36-inch long sections of semi-cylindrical molded-type pipe insulation applied to the middle 12 linear feet of the test pipe, the insulation stopping 4 feet from each end of the pipe. The butt edges and ends of the sections of low-temperature insulations were "Buttered" (sealed) with joint sealer before applying. Both high-temperature and low-temperature insulations were applied with all joints tightly butted and fitted.

The insulation was secured to the pipe with 16 gage stainless steel wire. The wire was applied on 18-inch centers (9 inches from ends of sections).

(b) Double-layer, mass-type, 2 1/2-inch total thickness (the inner layer 1-inch thick, and the outer layer 1 1/2-inches thick), 36-inch long sections of semi-cylindrical molded-type pipe insulation. The sections of the inner layer were applied to the test pipe with the end joints staggered. The sections of the outer layer were applied with the longitudinal and the end butt-joints offset from the inner-layer joints a minimum of 2 inches. The butt edges and ends of the

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FIRE TESTS ON THERMAL INSULATIONS AND WEATHER BARRIERS

III. DISCUSSION - Continued

A. Test Procedure - Continued

2. Preparation - b. (1) (b) - Continued

sections of the outer layer of low-temperature insulations were "buttered" with joint sealer before applying.

Both high-temperature and low-temperature insulations were applied with all joints tightly butted and fitted. Insulation was applied to the middle 12 linear feet of the test pipe, the insulation stopping 4 feet from each end of the pipe.

The inner layer was secured to the pipe with 16 gage stainless steel wire. The outer layer was secured by 1/2-inch (0.020-inch thick) stainless steel bands. The wire and the bands were applied on 18-inch centers (9 inches from ends of sections).

(c) Reflective insulation, five semi-circular metal sheets spaced 1/2-inch apart. The insulation consisted of all-metal prefabricated units 24-inches long. Each unit was composed of five reflective sheets spaced and reinforced by flush separators arranged to form isolated air chambers. Each unit was fabricated in two semi-cylindrical sections. One circumferential edge of each unit and the longitudinal edges of one section were extended to provide overlap and watershed. Longitudinal edges of the inner sheets were flanged inward to provide strength and tight butt-joints between the two sections which form a unit.

The semi-circular sections were applied to a test pipe with the extended longitudinal edges of the one section overlapping the flush edges of the opposite semi-circular section which formed one complete unit. The flush end of each unit was telescoped into the circumferential extended end of the adjacent unit. These units of insulation were secured to the test pipe by 3/8-inch (0.020-inch thick) stainless steel bands applied on 12-inch centers starting 6 inches from ends of each unit.

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FIRE TESTS ON THERMAL INSULATIONS AND WEATHER BARRIERS

III. DISCUSSION - Continued

A. Test Procedure - Continued

2. Preparation - b. (1) (c) - Continued

Six units of insulation were applied, covering the middle 12 linear feet of the test pipe and stopping 4 feet from each end of the pipe.

(2) Application of Weather Barriers

(a) Metal sheets, 36-inches wide, were applied around the 1-inch thick insulation on the test pipe. The longitudinal lap joint was located on the lower part of the pipe at the 4 or 8 o'clock position to insure proper watershed. The longitudinal lap was 2 inches. One circumferential edge overlapped the adjoining sheet 3 inches. The jacket was secured by 1/2 inch (0.020-inch thick) stainless steel bands. One band was placed at each 3-inch lap and one band in between.

Felt roofing sheets were applied around the 1-inch insulation on the test pipe. The longitudinal lap joint was located on the lower part of the pipe at the 4 or 8 o'clock position to insure proper watershed. The circumferential and longitudinal joints were lapped 2 inches. All lap joints were sealed with a solvent asphalt sealer. The jacket was secured with 1/2-inch (0.020-inch thick) stainless steel bands. One band was placed at each circumferential lap and one band at each midpoint between joints.

Polyvinyl chloride, prefabricated jacket, enveloped the insulation of the test pipe. A longitudinal "zip-on" closure sealed the jacket in place.

(b) Mastics

Fibrated asphalt, asphalt emulsion, asphalt cutback, or Gilsonite cutback was applied by trowel over the insulation on the test pipe. Into this wet mastic coat a 20 x 20

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FIRE TESTS ON THERMAL INSULATIONS AND WEATHER BARRIERS

III. DISCUSSION - Continued

A. Test Procedure - Continued

2. Preparation - b. (1) (c) - Continued

mesh asphalt-saturated glass-fiber cloth was embedded. The wrinkles in the cloth were smoothed out and the seams were lapped 2 inches. After a drying period of 24 hours, a final coat of mastic was applied and troweled smooth. The combined thickness of these applications, after drying, was not less than 1/8". These applications were air dried in a minimum of 30 days before being tested.

Polyvinyl-acetate mastic was applied with a trowel over the insulation on the test pipe. A 10 x 10 mesh starch-sized glass-fiber cloth was embedded into this wet mastic. The mastic was pressed through the mesh of the glass cloth and troweled smooth. The combined thickness was not less than 1/16" after drying.

Polyvinyl acetate (overcoated with intumescent paint) was applied, as above, with an additional overcoat of intumescent paint. This paint was evenly brushed over the entire mastic-coated insulation. The paint was not less than 15-mil thickness after drying.

(c) Pre-Test Assembly

Five pipes were placed 16" on centers (two insulated pipes on each side of a bare unprotected pipe) on the support rack in the same horizontal plane. The thermocouples were centered over the fuel pan. See Figure 1 in Appendix.

The thermocouples were checked for continuity and the lead wires were connected to a potentiometer.

The open ends of each pipe were packed with white glass wool insulation to prevent air movement through the pipes.

The fuel pan was charged with water until the level was 1'-8" below the horizontal centerlines of the pipes.

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FIRE TESTS ON THERMAL INSULATIONS AND WEATHER BARRIERS

III. DISCUSSION - Continued

A. Test Procedure - Continued

3. Test Schedule - Insulation

a. Fuel (gasoline) was fed into the fuel pan until the water surface was covered. The fuel was ignited. The five pipes were fully exposed, simultaneously, to the fire.

b. The fuel flow into the pan was controlled so that the temperature in the bare pipe coincided with the ASTM Standard Fire Temperature Curve (1000F in 5 minutes, 1300F in 10 minutes, 1550F in 30 minutes, and 1700F in one hour).

c. The insulations were exposed to the fire for one hour. The weather barriers were exposed to fire for 10 minutes. Temperatures related to time of exposure were recorded.

d. The fuel was shut off. Each test pipe was inspected and observations recorded.

e. The fuel was reignited after 16 minutes and burned for 5 minutes to re-establish full exposure. The fuel was shut off.

f. Water at a rate of 75 gallons per minute was applied to the insulation in a straight stream through a 1-1/2" Elkhart Mystery Nozzle from a distance of 60' for 1-1/2 minutes.

g. The water application was changed from a straight stream to a spray. The water application was continued until the residual fuel burned out.

h. A second inspection of each test pipe was made and observations recorded.

i. The insulation was removed from each pipe, section by section. The effect of the heat and water on each section of insulation and the covered surface of the pipes was recorded.

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FIRE TESTS ON THERMAL INSULATIONS AND WEATHER BARRIERS

III. DISCUSSION - Continued

B. General Test Results

The data that were recorded and the observations that were made during and after the tests were analyzed by grouping the results under headings which included major components of an insulation and methods of application. This kind of grouping gave generalized conclusions on the resistance in fire exposure of generic materials. Detailed results of each insulation and weather barrier that was tested are presented in the following tables,

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FIRE TEST ON THERMAL INSULATIONS AND WEATHER BARRIERS

EFFECTS OF FIRE ON THERMAL INSULATION SYSTEMS

INSULATION SYSTEM	INTERNAL PIPE TEMPERATURE & EXPOSURE TIME	REACTION TO FIRE	THERMAL EFFECT	QUENCHING WATER EFFECT	REMARKS
2½" Thick Asbestos Fibers 1" inner 1½" outer layers PVA mastic weather barrier	130 F at 30 min 200 F at 60 min	Did not burn	Shrinkage (OL)1/8" per 3 ft (IL) none visible	No physical damage	Pipe not exposed to flame impingement. No physical damage to insulation.
1" Thick Asbestos Fibers PVA mastic weather barrier	360 F at 30 min 710 F at 60 min	Did not burn, discolored	Shrinkage 1/2" per 3 ft	No physical damage	Pipe was exposed to flame impingement. Insulation became structurally weak.
2½" Thick Calcium Silicate 1" inner, 1½" outer layers PVA mastic weather barrier	170 F at 30 min 210 at 60 min	Did not burn	Shrinkage (OL) 1" per 3 ft (IL) ½" per 3 ft	No physical damage - Saturated	Broken joints prevent pipe from flame impingement. Structural strength of outer layer impaired.
1" Thick calcium silicate PVA mastic weather barrier	390 F at 30 min 710 at 60 min	Did not burn	Shrinkage 3/4" per 3 ft	Saturated	Pipe was exposed to flame impingement through shrinkage cracks. Structural strength of insulation impaired.
2½" Thick diatomaceous earth 1" inner, 1½ outer layer PVA mastic weather barrier	130 F at 30 min 210 at 60 min	Did not burn	Shrinkage (OL) ½" per 3 ft (IL)1/16" per 3 ft	No physical damage - Saturated	Pipe not exposed to flame impingement. Structural strength of insulation impaired.
1" Thick diatomaceous earth PVA mastic weather barrier	370 F at 30 min 615 F at 60 mi	Did not burn	Shrinkage 1/2" per 3 ft	No physical damage - Saturated	Pipe was exposed to flame impingement through shrinkage cracks. Insulation had some surface spalling.
2½" Thick expanded silica PVA mastic weather barrier	165 F at 30 min 335 F at 60 min	Did not burn	Shrinkage (OL) ½" per 3 ft (IL)none usable	No physical damage - Saturated	Pipe not exposed to flame impingement. Structural strength of insulation impaired.
1" Thick expanded silica PVA mastic weather barrier	410 F at 30 min 850 F at 60 min	Did not burn	1/2" per 3 ft	No physical damage - Saturated	Pipe was exposed to flame through shrinkage cracks. Structural strength of insulation impaired.
2½" Thick reflective Stainless steel outer jacket 3 intermediate sheets of aluminum; 1 inner sheet of stainless steel	420 F at 30 min 910 F at 60 min	Did not burn	Some inner aluminum sheets melted during test	No additional damage	Pipe not exposed to flame impingement. Melted aluminum did not leak through outer stainless steel jacket.
2½" thick reflective Aluminum outer jacket 4 spaced sheets of aluminum	1000 F at 12 min 1500 F at 30 min 1600 F at 60 min	Melted	Partly melted after 1½ min exposure		Pipe was exposed to flame impingement after 1½ min. Deflection of pipe after 10 min.
2½" Thick cellular glass 1" inner, 1½ outer layer PVA mastic weather barrier	620 F at 30 min 770 F at 60 min	Did not burn	Broken into pieces. 3" crack at bottom	Part washed off of pipe	Pipe was exposed to flame impingement through crack at bottom. Insulation was broken into pieces.
1" Thick cellular glass PVA mastic weather barrier	810 F at 30 min 1000 F at 42 min 1250 F at 60 min	Did not burn	Complete. Broken into small pieces	Washed off of pipe	Weather barrier retained insulation around pipe prior to quenching water application. Pipe sagged.
1" thick outer calcium silicate 1½" thick inner cellular glass PVA mastic weather barrier	117 F at 30 min 400 F at 60 min	Did not burn	Shrinkage (OL)6" per 3 ft (IL) Broken into small pieces	OL Saturated	Pipe was exposed to flame impingement through cracks. Oute layer retained the inner layer.
2½" Glass fiber insulation PVA mastic weather barrier	1000 F at 32 min 1360 F at 60 min	Did not burn	Melted and dripped		Insulation melted completely exposing bare pipe to flame impingement.

FIRE TEST ON THERMAL INSULATIONS AND WEATHER BARRIERS

Insulation System	Internal Temp and Exposure Time	Reaction to Fire	Thermal Effect	Quenching Water Effect	Remarks
1" Foamed Styrene (self extinguishing) PVA mastic weather barrier	1000 F at 13 min 1150 F at 30 min 1180 F at 60 min	Combustible volatiles	Melted and dripped		Insulation failed completely exposing bare pipe to flame impingement.
1½" Outer layer cellular glass 1" Inner layer foamed styrene PVA Mastic weather barrier	640 F at 30 min 1000 F at 52 min 1160 F at 60 min	IL contributed combustible volatiles; OL did not burn	IL melted and dripped; OL broke into pieces	OL insulation dislodged	Insulation failed completely. IL burned between OL and pipe.
2½" Thick vegetable cork PVA mastic weather barrier	220 F at 30 min 680 F at 60 min	Supports and harbors hidden combustion	Completely charred. Shrinkage cracks	Did not extinguish hidden combustion	Effective as an insulation. In spite of attempts to extinguish with fire hose material continued to burn after test.
2½" Thick urethane foam PVA mastic weather barrier cover with 12 mils of intumescent paint	1000 F at 31 min	Considerable smoke. Intumescent paint foamed for good protection. All completely charred	Did not melt; completely charred	Washed away	Charred. Began to fall off after 26 min exposing pipe to flame impingement. Insulation completely disintegrated.
2½" Thick urethane foam 0.010" thick stainless steel jacket	1000 F at 10.5 min	Considerable smoke	Insulation completely charred	Stainless jacket remained around pipe	Pipe not exposed to direct flame impingement due to jacket remaining in place. Jacket rested on pipe in middle of fire.
1½" Outer layer calcium silicate 1" Inner layer urethane foam PVA mastic weather barrier	1000 F at 59.5 min	Considerable smoke	OL shrinkage ½" per 3 ft; IL completely charred	OL remained around pipe	Pipe exposed to direct flame impingement due to shrinkage of OL and complete charring of IL
Weather Barrier Systems All installed on 1" calcium silicate					
Asphalt cutback	15 min exposure	Propagated flame	Spalled and cracked	Disintegrated	Mastic started to burn after 35 sec, exposing insulation.
Asphalt emulsion	15 min exposure	Propagated flame	Spalled	Disintegrated	Mastic started to burn after 35 sec, exposing insulation.
Gilsonite cutback	15 min exposure	Propagated flame	Spalled and cracked	Disintegrated	Mastic started to burn after 35 sec, exposing insulation.
Polyvinyl acetate mastic (emulsion)	15 min exposure	Flame propagation limited to 2'-0" beyond fire	Cracked; brittle	Part washed away	Mastic in direct fire started burning in 53 sec. Was self-extinguishing 2'-0" from fire pan. Material directly in fire exposure still on insulation until water quenched.
Polyvinyl acetate mastic coated with intumescent paint	15 min exposure	Intumescent paint puffed	Paint 3/4 to 1" puff PVA - brittle	Part washed away	Same as above except PVA was in a little better condition.
Aluminum jacket 0.016" thick	15 min exposure	Did not burn	Melted	(Had melted off prior to quenching)	Aluminum melted and dripped exposing insulation after 2 min of fire exposure.
Asbestos felt jacket Asbestos outer surface Asphalt inner surface	15 min exposure	Propagated fire	Asphalt melted and flow out thru the asbestos	(Had dropped off prior to quenching)	Jacket completely destroyed, exposing insulation after 10 min exposure.
Asphalt 55 lb felt jacket	15 min exposure	Propagated fire	Asphalt melted and dripped	(Had been burned away prior to quenching)	Jacket completely destroyed, exposing insulation after 10 min fire exposure.
Polyvinyl chloride jacket	15 min exposure	Burned	Melted	(Had melted off prior to quenching)	Jacket completely destroyed in fire area in 20 sec. Did not spread fire outside of fire area.
Stainless steel jacket	15 min exposure	Did not burn	Discolored	Undamaged except for color	Jacket was undamaged. Protected insulation during entire exposure.

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ACCESSORIES

I. GENERAL

Accessories are the materials used for an insulation installation other than the basic insulation and weather or vapor barriers. Many materials are used in the fabrication, support, securement, and reinforcement of insulation. Each must be selected to fulfill its function and be compatible with the other parts of the system. A listing of accessories is included in the "Insulation and Accessories Manual".

II. FABRICATION ACCESSORIES

A. The basic insulation materials are shaped by cutting, grinding, or molding on suitable machines to sizes to fit equipment and piping. These sizes are dimensioned in the "Fabrication Manual for Insulation".

The cut shapes of insulation have to be assembled and cemented together to form the finished insulation fitting cover. The cements or adhesives used must provide a strong bond and also be suitable for the temperatures to which they will be subjected. In addition, the fabrication cements or adhesives used for low temperatures should be vapor resistant. Many of the properties listed for weather-vapor barriers apply to these materials used for bonding insulation together.

As a cement or adhesive must be suitable for bonding a particular insulation, it is well to list cements presently available for use on various insulations. There are new cements and adhesives being developed and some of these may prove to be better for certain services than those now being used. Also, as new insulation materials are introduced, it is likely that they may require different cements or adhesives.

FABRICATION CEMENTS AND ADHESIVES

Insulation	Spec. No.	Cement	Temp. Limits of Cement °F	Remarks
Cellular Glass	108	Carey, Fire Chex No. 400		For bonding cellular glass to roof
Cellular Glass	108	3M, CTA-H		Soft rubber based adhesive for bonding cellular glass to ceiling
Cellular Glass	10H, J & OX	Keene's Cement	Up to 850	Slow bonding and setting
Cellular Glass	10-J	Mimcle, RT-1000P	-40 to 400	Chemical setting, vapor resistant
Cellular Glass	10-L	Steep Asphalt	-250 to 180	Fast setting
Cellular Glass	10-OX	Vimasco J Seal "S"	-250 to 200	Slow setting, suitable for oxygen service

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ACCESSORIES

II. FABRICATION ACCESSORIES - Continued

A. Continued

FABRICATION CEMENTS AND ADHESIVES - Continued

Rigid Urethane	12-H	Armstrong S20 Armstrong 620	Up to 180 Up to 200	Contact adhesive Contact adhesive
Fibrous Glass (Preformed)	15-H	Foster No. 81-27		Fibrous adhesive
Fibrous Glass	15-L	Foster No. 81-33		Fire resistant adhesive
Asbestos Fibers or Calcium Silicate	21-H 23-H, 25-H	A. P. Green Insulation Adhesive	Up to 1100	Fibrous, cuts well after drying
		Refractory & Insulating Block Stick	Up to 1500	Smooth, relatively hard after drying
Expanded Silica	22-H, 32-H	Philip Carey Careytemp Adhesive	Up to 1500	Will adhere to moisture resistant Careytemp

B. In addition to the cements and adhesives used in fabrication, materials subject to wear from abrasion must be coated with an anti-abrasion coating. Although this can be applied in the field, it is most easily applied by spray or trowel (depending upon material) in the shop. Anti-abrasion coatings must be compatible with the material to which they are applied, the metal which they might contact, the chemicals to which they might be subjected, and the temperature to which they are subjected. The following anti-abrasive coatings are all suitable for fiber and cellular glass insulations. Their other properties are as follows:

Anti-Abrasive Coating	Temperature Limits °F	Remarks
Keene's Cement	32 to 850	Slow setting. Not recommended on stainless steel. Suitable for oxygen service.
Vimasco Vicarlon 500	-400 to 200	Relatively low maximum temperature limits. Will burn. Fast setting. Not recommended on stainless steel. Can be sprayed or brushed.
Dampney No. 70 Black	-400 to 850	Can be sprayed or brushed. Suitable for use on stainless Steel.

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ACCESSORIES

III. SUPPORTS

A. Pipe Supports and Cradles

1. High temperature piping, which is insulated, requires the use of pipe supports arranged to prevent the pipe from resting upon the insulation. Standards for pipe supports are presented in "Engineering Standards".

2. Low temperature insulated piping is supported on cradles as shown in Standard P-82 in "Engineering Standards". However, it should be noted that, as stated in this Standard, it applies only to horizontal piping and short vertical runs. Unless the pipe or cradle is spring supported on long vertical runs, such as to the top of a tall column, the expansion and contraction of the line or column will either cause compression forces which crush the insulation in the cradle, or lift all the weight off the cradle so that the weight of line and insulation is on the vessel nozzle.

B. Insulation Supports

1. Cylindrical vessels, either vertical or horizontal and operating at high or low temperatures, require insulation supports. Due to expansion and contraction, insulation cannot be banded sufficiently tight to hold it in place by friction. For this reason, supports must be provided to carry the insulation load. Insulation support details for cylindrical vessels up to 12'0" diameter are shown in Engineering Standards IS-31, IS-36, and IS-42. For vessels over 12'0" and 36'0" diameter, requiring insulation supports, details are shown on supplement to Standard IS-31. These are for use when vessels do not come equipped with supports from the vendor. Wherever possible supports should be obtained on the vessel from the vendor. In some instances, it is desirable on vessels above 12'0" to secure the insulation directly to the surface with blank nuts and wire, or studs and clips, similar to that used for flat surfaces.

2. Insulation supports must be provided above all vessel flanges so that insulation does not rest on the studs, and so that the insulation on body of the vessel will not slip down out of position should it be necessary to open the vessel at the flanges.

3. It is also necessary to provide insulation supports at the bottom of long vertical piping and above each pair of flanges in vertical piping to prevent insulation from slipping. These details are shown in "Specifications for Insulation".

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ACCESSORIES

IV. INSULATION SECUREMENTS

A. Insulation is secured in place by bands, wire, tape, studs and clips, adhesives, or a combination of them.

1. Bands are used for the securement of insulation on pipes where the diameter of the insulation exceeds 6" and for the securement to the surface of vertical vessels up to approximately 12'0" by single loop application. Vessels above 12'0" become difficult to bond in single loop applications, so the bands are attached to supports which divide the vessel into sections as shown in Supplement to Standard IS-31. Horizontal vessels of large diameter must also be divided into sections by supports to provide sufficient band lift to pull insulation into tight contact with the bottom of the vessel. Location of bottom supports is shown in Standard IS-36.

   Insulation on heads of vessels is secured by either bands or wire, depending upon conditions. These conditions are, in general, stated in the "Thermal Insulation Specifications".

   Bands can be obtained in various thicknesses and widths. Where necessary, due to heavy weights or large spans, 3/4" or 1" wide bands may be used. However, for most vessel applications, 1/2 x 0.020 stainless steel bands are sufficiently strong to secure insulation. Bands for pipe insulation shall be 3/8 x 0.015 stainless steel.

   Clips for bands must fit the bands. For ease of application, the double pronged clip has been found to be the most suitable.

2. Wire is used for securement of high temperature insulation up to 12" outside diameter, on inner lay insulation, insulation on irregular shapes, and on flat surfaces. Where wire is used to secure pipe insulation, it is looped around the insulation and drawn tight as the ends are twisted together. The twisted ends are bent down and embedded in the insulation.

   Wires used to secure insulation of flat or irregular surfaces must be fastened to blank nuts or pierced pins which are welded to the metal surface. Wires are brought out through the insulation then laced, criss-crossed, and drawn tight as ends are twisted together. Where insulation cements on outside of block insulation require wire netting reinforcement, the netting is drawn tight and secured with these same wires. Soft annealed, 18 gage, stainless steel wire is used except in special installations.

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ACCESSORIES

IV. INSULATION SECUREMENTS - Continued

A. Continued

3. Bands and wire can be obtained in most metals. In the past, galvanized steel was used for insulation strap and wire, but its life proved to be only 3 to 7 years before it rusted to failure.

   Stainless steel has proved the least expensive of metals for most insulation applications. In certain instances of highly corrosive atmosphere, such as in acid atmospheres, monel is better than stainless. Neither of these will cause galvanic attack on steel piping or equipment.

   Aluminum bands and wire may be used with lightweight glass fiber insulation and aluminum jackets. If much weight is to be held in place, or if diameters are large, the width and thickness of aluminum bands must be increased. Likewise, aluminum wire must be of heavier gage than stainless steel wire.

   As a general rule, copper bands or wire should be avoided, as contamination by acetone or acetates can form explosive copper acetylide.

4. Tape, vinyl backed, with glass filaments is used to install Foamglas up to 4" IPS outside diameter and for inner layers of Foamglas. Its use is restricted to relatively small diameters because insulation must be held tightly in place while the tape securement is installed. It cannot slip and draw tight as does wire and strap. Tape is also used on glass fiber and rigid urethane insulation up to large sizes as this type insulation will compress then spring back to shape as tape is wrapped around it.

5. Pins and clips are used to secure insulation to flat, large diameter, cylindrical surfaces and spherical surfaces. Because of direct passage through the insulation, their use is restricted to moderate and high temperature installations. Pins are welded to the surface to be insulated and the welding will damage the surface coating of vessel. For this reason, the vessel should be coated with "Dimetcote", as these weld spots will not destroy the effectiveness of the surrounding "Dimetcote" protection.

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ACCESSORIES

IV. INSULATION SECUREMENTS - Continued

A. Continued

5. Continued

Pins can be pressed through glass fiber and Careytemp insulation, then welded to the metal surface. When pressed through calcium-silicate, diatomaceous earth, or magnesia material, a satisfactory weld cannot be obtained, as the dust from these materials, when heated, causes a gas which ruins the weld.

Insulation for vessels, with factory installed metal jackets, is attached to the sides by welded studs and nuts.

Lightweight pins and studs up to 1/4" diameter can be welded to metal surfaces by capacitor discharge welders. Larger than 1/4" diameter requires direct current power welding. Fasteners must be suitable for installation (metal, strength, and corrosion requirements) and for welding equipment and gun available.

6. Adhesives for temporary and permanent securement. Pamrod Code 550 is used to hold Foamglas in place on dished heads or irregular surfaces until outer bands or wires can be placed on its outer surface.

This hydraulic setting or catalytic type adhesive is used to bond insulation to metal. Due to temperature limitations, this is presently recommended only for attaching of Foamglas to moderate temperature spheres. Use of this type of application will probably grow as new and better adhesives are developed.

V. REINFORCEMENTS

A. Reinforcements are used to add strength to insulations and to the weather barriers or finishes.

B. Insulation reinforcement and reinforcement for mastics are most often 1" hexagonal 20-gage wire mesh. It is used over rigid insulation as a base for application of insulating cements. The insulating cement is troweled over the wire mesh. The pressure of this troweling forces the cement

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ACCESSORIES

V. REINFORCEMENTS - Continued

B. Continued

under the wire and the mesh is effectively embedded in the cement. In the past, ordinary galvanized 1" mesh (chicken wire) was used; however, its life before rusting out was only 2 to 3 years. Presently, either Type 304 stainless steel or monel mesh is used. In installations of insulating mastic, the reinforcement is used only when the dried thickness of mastic is to exceed 1/4". In these applications, one coat of mastic is installed and allowed to dry. The mesh is then installed and stretched taut. The final coat of mastic follows. This provides a 3/16" to 1/2" thickness of reinforced mastic insulation.

C. Weather barrier reinforcement is provided by high-strength glass cloth. The heavy mastics require an open weave cloth, approximately 10 threads per inch. The binder used to hold the weave in place must be compatible with the mastic. Starch binder is suitable for PVA mastics, whereas asphalt cloth binder should be used with asphaltic mastic. Other types of mastics must be checked with the cloth binders for suitability.

D. Finish reinforcement may either be canvas or close weave cloth (20 threads per inch). Canvas should be used only where fire hazard is considered to be minimum.

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INSTALLATION REQUIREMENTS

I. An installation must be studied to determine its requirements. These requirements are the total of the requirements through all the phases of construction and service.

II. TRANSPORTATION AND STORAGE REQUIREMENTS

After an insulation is manufactured it must be able to withstand the handling, stacking and abuses during shipping and storage. During this period it may be subjected to outdoor weather, and very damp atmosphere. In most instances the ability of a material to withstand these forces will be apparent when it is to the point where it is to be fabricated or installed.

III. FABRICATION REQUIREMENTS

When rigid insulation is preformed into shapes it should have the properties which allow it to be easily cut or formed with cut surfaces, and uncut surfaces, suitable for bonding with adhesives or cements. Completed covers must have sufficient strength, both the material itself and its joints, to withstand abuse of transportation and application. Material should be able to be cut without the causing of excessive or hazardous dust.

IV. FIELD ERECTION REQUIREMENTS

During application rigid materials must have sufficient strength to resist breakage, sufficient abrasion resistance that edges and corners are not worn round and have dimensional trueness and stability that they can be installed with precision.

Blanket insulations must be of sufficient tensil strength that when it is handled in application it does not pull apart. The compressive strength required depends upon its function in the insulation system.

Cements should be easily mixed and should have good wet adhesion to the surface.

As much insulation dust can be a health hazard if dust counts are of hazardous amounts, protective masks should be used.

If insulation is absorbant it must be kept dry during application until weather barrier is installed.

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INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS

Service Temperature is most frequently one of the most deciding factors in the choice of insulation materials. As would be expected, the insulation must be suitable for the maximum temperature to which it is subject.

Another factor of service temperature is the manner in which it affects the vapor migration into or out from the insulation. Because vapor migration is a form of moisture, this effect will be presented under moisture requirements.

Physical Requirements of the installation should be investigated to determine if the insulation might be subjected to mechanical abuses such as being bumped or walked upon. Where insulation is supported by rings, it must have sufficient strength to be self support to the height to which is installed above each ring. If it applied on traced lines or between edge supports, then it must have sufficient tensile and shear strength to bridge these gaps.

Other physical forces such as abrasion and vibration imposed on it should be determined. Where movement occurs, the degree of flexibility necessary in the insulation necessary to accommodate that movement is essential.

One type of movement which must be considered in design is expansion and contraction of pipe and equipment and its relationship to the shrinkage or coefficient of expansion of the insulations.

As this is a basic problem of design, this subject is presented in more detail below.

Expansion, Contraction and Shrinkage

Expansion and contraction of vessels and pipe can cause serious damage to the thermal insulation and weather barrier covering. Other than the growth of high temperature vessels and pipes, the problem is further amplified because of the shrinkage of most high temperature insulations. The fact that the metal vessels and pipe expand with temperature increase and the insulation shrinks means that some method must be provided to allow for these dimensional changes. If not, the insulation and weather barrier will be fractured.

From an area standpoint, the size of the crack is insignificant. The amount of additional heat loss from heated vessels and pipes due to cracks would be quite small if all other factors remained the same. The big change is due to

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INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS - Continued

Expansion, Contraction and Shrinkage - Continued

water which can enter the cracks. Wet insulation has a conductivity of approximately fifteen times that of dry insulation. Thus, besides the heat loss due to the crack, all the wet insulation becomes inefficient. In addition, each pound of water which enters a crack will absorb approximately 960 Btu's as it is vaporized by the heat of the vessel or pipe. These losses are significant.

Cracks in low temperature insulation and its weather-vapor barrier can cause even greater losses than in high temperature insulation. Entry of water causes ice formation which completely ruins low temperature insulation rapidly. Iced-up low temperature insulation will transmit approximately forty-five times more heat than dry conventional mass insulation. Thus it is important that either hot or low temperature insulation be kept free of cracks for efficient operation.

Expansion and Contraction Coefficients of Various Materials

The amount of growth of a vessel or pipe depends upon its coefficient of expansion and its temperature rise from ambient to service temperature. Of course, low temperature operation would be in reverse.

Most coefficients of expansion are given as coefficients at given mean temperatures, such as steel at 70F mean is 6.5×10^{-6}. These figures have little meaning from a field applicator's point of view. For this reason the following table is presented:

Thermal Expansion of Metals
Inches Per 100 Feet - Based on 70F Ambient

	Operating Temperature °F						
Material	200	300	400	600	800	1000	1400
Steel	0.99	1.82	2.70	4.60	6.70	8.89	13.34
Stainless steel	1.46	2.61	3.80	6.24	8.80	11.48	16.92
Aluminum	2.00	3.66	5.39	9.02			
Copper	1.51	2.69	3.89	6.40			

Unfortunately, most high temperature insulations shrink as they are heated. Only after this shrinkage occurs do they have a coefficient of expansion. The following table gives the shrinkage of some commonly used insulations:

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INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS - Continued

Expansion and Contraction Coefficients of Various Materials - Continued

Heat Shrinkage of Insulations
Inches Per 100 Feet - Based on 70F Ambient

Insulation	700	1000	1200	1500	1900
Calcium Silicate	5.70	10.80	18.00		
*Cellular Glass	0				
Asbestos Fibers (Unibestos)	0.12	0.30	0.60		
Mineral Wool Block	7.00	9.80	12.00	15.50	24.00
Expanded Silica (Careytemp)	3.00	4.50	5.00	15.00	
Diatomaceous Silica	*	*	*	*	20.00

*Cellular glass has no high temperature shrinkage. Its coefficient of expansion is 0.0000046°F

From these tables, the magnitude of the problem can be determined. For example, if a steel column operating at 750F was 100 feet high, at ambient temperature it would increase approximately 6.2" in height when in operation. If calcium silicate insulation were the insulation, it would shrink 5.7". Thus the total difference in height between column and its insulation would be 11.9". This shows the need for expansion joints in the insulation to allow for the differential movement between the vessel and the insulation.

If the vessel were 10'-0" in diameter the change in diameter would be 0.62" (or 1.95" in circumference) and the circumferential change of insulation would be 1.8". Therefore, these differences demand a solution to prevent excessive cracks or insulation fracture. It must be further considered that any dimensional change affecting the insulation also affects the weather barrier.

Installation of Insulation on High Temperature Vessels

From the preceding, it can be understood that it becomes impractical to attempt to attach each piece of insulation directly to the shell of a vessel. Therefore, it is necessary to provide insulation supports on which the insulation will rest. Insulation supports for vertical vessels are shown in UCC Standard EG-64 and IS-31A. Insulation supports for horizontal vessels are shown in UCC Standard IS-36.

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INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS - Continued

Installation of Insulation on High Temperature Vessels - Continued

It has been noticed that rigid block insulation installed on vessels, less than 6'-0" in diameter and less than 500F operating temperature, did not show cracks which could have been caused by circumferential expansion, even though the rigid curved sectorial insulation was strapped directly around the vessel. The probability was that the slight irregularities of the curved insulat on and the insulation's relatively low compressive strength at low percentage of deformation combined to allow for growth of the vessel without outside insulation dimensional change.

Above these limits, cracks in the insulation and weather-barrier have occurred when the insulation was strapped to the vessel without provision for circumferential expansion. To provide an expansion space between the vessel wall, the vessel is first covered with a white glass wool blanket, installed with as little compression as possible. The curved sectorial insulation is cut to a 2" greater diameter than the vessel. The curved rigid insulation is placed over the wool blanket, then strapped in place. In effect, the rigid insulation is a cylinder of insulation, resting on the supports separated from the vessel by a compressible blanket. This system is satisfactory for vessels up to 12'-0" diameter and not over 1000F operating temperature. Should these limits be exceeded, other design methods must be considered.

Linear expansion joints must also be provided for vessels. The placement of insulation supports is a function of both the dimensional change of linear expansion and weight of insulation resting on support.

The remaining expansion problem concerning high temperature vessels is the movement of vessel nozzles, and lines connected to the vessel, in relation to the vessel insulation. The nozzle insulation covers should remain stationary with respect to the vessel insulation.

For this reason the nozzle covers are made oversize to allow movement of the nozzle and pipe within the insulation cover. Figures Nos. 3 and 4 show the application of insulation on blind nozzles and line nozzles.

Installation of Insulation on Hot Piping

The effect of expansion of hot piping will cause breaks in the insulation and its weather barriers. Due to size, and the fact that insulation manufacturers

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INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS - Continued

Installation of Insulation on Hot Piping - Continued

produce insulation with clearance between outer pipe diameter and inner insulation diameter, circumferential expansion of the pipe causes no problem. Linear expansion does cause a problem.

Large vertical pipes (over 4" NPS), like vessels, require insulation supports. With the exception of the bottom support, an insulation expansion joint should be provided at each support and at the top elbow.

Horizontal pipe, although requiring no support, does require insulation expansion joints if the line has long straight runs between fittings. Again, it has been noticed that expansion cracks do not occur as frequently in horizontal piping as they do in vertical pipes and vessels. It is assumed that due to friction of the pipe covering resting on the line that the expansion movement is taken up slightly by movement of each section of covering, this causing a slight opening at each butt joint. However, when the movement is greater than the dimensional change which can be absorbed in the butt joints, then a fracture will occur. For this reason the expansion joints are placed further apart than for vertical piping. On single layer insulation an expansion joint is installed every 42 feet and on multiple layer insulation every 21 feet. The difference between single and multiple layer is, of course, because of the difference in temperature level. This expansion joint is shown in Figure 7.

Installation of Insulation on Cold Vessels

As the temperature of low temperature vessels goes down, the vessel shrinks in size. The vessel tends to pull away from the insulation. Similar to the application of high temperature rigid insulation, rigid low temperature insulation is installed as an isolated cylinder (and heads) tested on hung on insulation supports. In this application the space is also filled with glass fiber blanket. However, under these conditions the one-inch blanket which is installed on the vessel should be compressed to 1/2-inch by the rigid insulation as it is installed. By this method, as the vessel pulls away from the rigid insulation the fiber glass blanket is decompressed and holds the outer shell of cellular-glass firmly in its original position.

Actual installation of the low temperature cellular glass is quite similar to the installation of rigid high temperature insulation. The system of insulation supports is identical. Glass wool blanket is installed over the vessel.

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INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS - Continued

Installation of Insulation on Cold Vessels - Continued

The cellular glass insulation is cut and fitted to be one inch greater in diameter than the vessel. When the rigid cellular glass is secured in position it compresses the glass wool 1/2-inch. Of course, on low temperature the outer layer of cellular glass joints are all vapor sealed to retard infiltration of moisture vapor.

The construction of compression joints at insulation supports, vessel flanges, are shown in Thermal Insulation Manual - Volume I, Specification 10-L, Figures 10-L-3 and 10-L-4. Vapor sealing of these joints is most important to obtain satisfactory service life.

Installation of Insulation on Cold Piping

The effect of contraction of cold piping will cause crushing or fracturing of rigid cellular glass insulation. This is due to the fact that the pipe becomes shorter as the operating temperature goes lower, and even though the insulation also becomes shorter, its reduction in length is not as great as the pipe. For this reason, insulation contraction joints must be placed in any long run of low temperature piping. Vertical contraction joints are shown in Specification 10-L, Figure 10-L-22, and horizontal contraction shown in Figure 10-L-19. Like the contraction joints of low temperature vessels, one of the most serious problems is to install and maintain an effective vapor barrier to retard the entry of moisture vapor.

Effect of Expansion and Contraction Motion on Weather-Vapor Barrier

From the previous discussion it is evident that the insulation is installed in such a manner as to try to eliminate as much movement as possible. However, even the best of applications cannot completely eliminate all motion of the rigid insulation. For this reason elasticity must be provided in the vapor-barrier and weather barriers.

Where motion is expected in low temperature insulation, the vapor barrier is specified to be a non-setting type sealer.

Motions affecting the weather barriers are handled in a number of ways. If the weather barrier is a stainless steel jacket, the metal is so installed as to have slip joints so constructed as to shed water, or joints which are sealed with non-setting sealer. All inside corners are caulked with a heavy fillet of caulking compound.

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INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS - Continued

Effect of Expansion and Contraction Motion on Weather-Vapor Barrier Continued

Investigation of failures of heavy-built PVA and acrylic mastic reveal that although the mastic itself was quite elastic, breaks were caused by the inability of the reinforcing membrane to elongate. Considerable research has taken place in trying to find a suitable reinforcing membrane. With the assistance of the Fibers Department, Dynel fabric having high elongation before tearing and suitable application properties was developed.

Tests proved that glass fabric reinforced membranes had a maximum elongation of 4-1/2% to 5% before the system would tear. Using Dynel reinforcing would provide elongation of 15% to 80% before the system would rupture. The wide spread of elongation, at which rupture occurs, is due to the difference of properties of the mastics tested and the temperature at which they were tested. Application of four years' duration show no joint tearing as was common with glass fabric reinforced mastic.

The use of Dynel fabric in the weather barrier does not eliminate the need for insulation expansion joints. These still are required for efficient operation of the insulation.

Chemical Requirements may be one of the necessities of insulation to resist product spillage or atmospheric contamination. Or, another chemical requirement may be that the insulation should be of such chemical nature that it does not damage the vessel or pipe to which it is applied.

Chemical Resistance of Insulations and Accessories

Where spillages occur or the atmosphere surrounding is contaminated, if at all possible the insulation selected should resist and not react with the chemicals involved.

In addition, under these conditions the insulation should resist saturation of these chemicals, for a number of reasons. If the chemical saturates the insulation the very presence of the chemical taking up air spaces reduces the thermal efficiency of the insulation. If the chemical is combustible, the saturated insulation can provide a large source of combustible fuel for a fire. If the chemical is toxic, the saturated insulation is toxic and almost no suitable means exists for its safe handling and disposal.

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INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS - Continued

Chemical Resistance of Insulations and Accessories - Continued

The considerations for insulations are true of the weather barriers as well as the basic insulation.

Pipe and Vessel Surface Corrosion

Because insulation covers metal vessels or pipes, many think it will prevent rust or corrosion. This is not so. As a matter of fact, in many instances, the insulation may cause or accelerate rusting of the metal to which it is applied. Corrosion under insulation can be divided into three categories: (1) corrosion of steel, (2) stress corrosion of austenitic stainless steel, (3) attack by galvanic currents, and (4) direct chemical attack. The causes of such corrosion will be discussed and recommendations for proper use of insulation to minimize them will be made in this manual. However, specific recommendations for coatings or paints to retard rusting are part of the Painting Manual.

1. Corrosion

Rusting of steel is caused by the presence of air and water. The presence of acid accelerates the process of rusting. Insulation installed over a metal does not exclude air or moisture. Air is 90% of most mass insulations. Even the surfaces of sealed cell insulations are composed of broken cells containing air. Thus, air is always present to cause rusting.

Moisture gets to the metal surface in a number of ways. One is liquid water from rain or snow, which finds passage through cracks or holes in the weather barrier. Due to expansion and contraction of the pipe or vessel and the effects of weather, even the best of weather barriers will develop some leaks after a period of time. Another source of moisture is the insulation itself. Most high temperature insulations are hygroscopic and absorb moisture from the atmosphere. Unless the temperature of the steel surface is above 212F, and preferably above 250F, moisture from slight leakage and from absorbent insulation is sufficient to cause corrosion. Still another source of moisture is condensed water vapor from the ambient air. When the surface temperature of the steel is lower than ambient air, a low vapor pressure is set up at this surface. This causes the higher temperature moisture-laden vapor to be drawn to the pipe surface where it condenses to a liquid.

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INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS - Continued

Pipe and Vessel Surface Corrosion - Continued

1. Corrosion - Continued

For these reasons, any steel operating at temperatures below 212F must be protected from corrosion regardless of the fact that it is insulated. One exception does exist. On piping or equipment which has continuous operating temperatures below 0 F, the tight frost film which forms on the surface excludes the air as a protective coating.

The choice of insulation materials and the tightness of the weather barrier do affect the rate of corrosion.

It is fundamental that the weather barrier be as water resistant as possible, and be properly maintained within practical economic limits, so as to preserve the insulation efficiency and limit the amount of moisture which causes rust. However, whenever a water leak does occur, the more absorbent the insulation, the greater the amount of water it will soak up and spread over a large area. In addition to this problem in service, hygroscopic, absorbent insulation picks up moisture in storage and during application. For these reasons it is advisable to use non-absorbent, non-hygroscopic insulations on services below 250F, or in cyclic or intermittent service, such as steam tracing on a bi-yearly cycle, where the lower temperature of the cycle is less than 212F.

When service temperatures are less than ambient temperature, vapor resistance of the insulation becomes a factor influencing the amount of moisture which can get to the steel surface. In these installations, the lower the vapor transmission rate of the insulation, the less moisture it will allow to reach the metal surface.

From the previous statements, it might be construed that if the operating temperature is above 250F, the problem of corrosion is eliminated. Unfortunately, this is not so. The previous statements are based upon relatively small amounts of moisture entering the insulation. In such cases, temperatures above 250F can provide sufficiently high vapor pressure that the steel surface remains dry. Where water can get directly to a steel surface and is then vaporized, rusting is greatly accelerated at elevated temperature. This occurs on uninsulated steel at high temperature, or poorly waterproofed, insulated piping underground. To prevent fast rusting of underground insulated piping, a water-tight jacket, casing, or protective system must be provided to prevent a head of water getting to the pipe surface.

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INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS - Continued

Pipe and Vessel Surface Corrosion - Continued

1. Corrosion - Continued

For the above mentioned reasons the temperature of vessels and pipes are very important in regard to surface corrosion and where corrosion protection is required they should be painted or coated in accordance with Painting Manual. On some vessels which have temperature gradients the problem is even more difficult, especially those which have high temperature at bottom and low temperature at top. With these it is essential that the various temperature zones be isolated from each other and each properly protected.

The chemical composition of insulation also affects the corrosion of steel. As previously stated, acid causes steel to rust, therefore the insulation should be neutral or slightly alkaline. The pH should be between 7 and 11.

The chemical composition of soils affects the corrosion of underground conduits protecting insulation of buried pipes. Where insulated conduit pipe is in corrosive oxidizing or reducing soils or cinders, the conduit itself must be protected by galvanizing or other suitable corrosion-resistant coating, and where soil conditions warrant it should be cathodic protected. Otherwise, the conduit will rust out and cease to waterproof the insulated line. Aluminum should never be used underground for conduit due to the difficulty of successfully applying cathodic protection.

Corrosion of Substrate Metal

Other than ordinary rusting, the insulation used should not contain chemicals that attack the metal to which they are applied. As high temperature insulations are more often applied to steel than other metals, most are slightly alkaline. Where aluminum is the metal to be insulated, the insulation should be neutral or slightly acid, where possible. This means that the pH should be less than 8. Where this is not possible, a corrosion-resistant coating must be installed between the aluminum and the insulation.

In contaminated atmospheres, any absorbent insulation can gather the chemicals from the air and condense and concentrate them. In many instances these concentrations will not be equal over the entire surface and will result in pitting of the metal by single surface cell galvanic action, termed concentrated in cell attack.

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INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS - Continued

Corrosion, Stress Cracking of Austenitic Stainless Steel

When insulations which contain water-soluble chlorides become moist, they can cause stress-corrosion of stressed austenitic stainless steel to which they are applied. Most high temperature insulations such as diatomaceous earth, calcium silicate, 85% magensia, phenolic bonded glass fibers, and water-mixed cements contain these water soluble chlorides. Absorbent insulations which contain no chlorides may pick up chlorides from the atmosphere, or chlorides can get behind one insulation from leaks, etc., especially in coastal areas.

The stress corrosion cracking of austenitic stainless steel takes place in the presence of concentrated chlorides and when the stainless is under tensile stress, residual or applied. The corrosive environment may be very mild; however, under the influence of stress, the corrosion concentrates along few paths and the penetration of the steel can be rapid.

Moisture absorbed by the insulation from the atmosphere, or from rain, leaches out the water soluble chlorides. At the hot surface of the pipe or equipment, these are concentrated by the evaporation of the water. In this way the environmental conditions necessary for stress corrosion of austenitic stainless steel are established under insulation. Although temperature limits at which stress cracking occurs have not been established, the most rapid failure seems to occur when the pipe or equipment is operating between 122F and 572F.

Tests have revealed that some insulations do contain sufficient water soluble chlorides to cause stress corrosion of austenitic stainless. Such insulations should not be used, however; in most instances the major source of difficulty is from pickup of chlorides from the atmosphere.

The Thermal Insulation Specifications for Materials and application suitable for use on austenitic stainless steel are designated by SS on their number. The insulation and accessories called for in such specifications have been tested and found free of chlorides which would contribute to causing stress corrosion. Care should be exercised that no substitute of an accessory is used without checking its suitability for the service. However, the use of proper insulation materials will not prevent stress corrosion if the chlorides can be absorbed from the atmosphere, spillage, or water.

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INSTALLATION REQUIREMENTS

V. SERVICE REQUIREMENTS - Continued

Corrosion, Stress Cracking of Austenitic Stainless Steel - Continued

For these reasons it is recommended that:

1. Thermal insulations and accessories which do not contribute to stress corrosion (designated SS in the Thermal Insulation Specifications) be used on stainless steel.

2. Austenitic stainless steel equipment and stress areas on stainless steel piping such as the surface beneath backup flanges and all critical piping be coated with protective coating in accordance with UCC Painting Specifications prior to installation of insulation.

VI. MOISTURE REQUIREMENTS

Moisture Conditions to which insulation is to be subjected determine the properties the insulation should have, how it should be installed and how it should be protected.

When dry, most insulations are quite effective. When insulation becomes wet, or damp, all or part of the small air spaces become filled with water. Heat transmission through the water filled spaces then approaches the rate of conductivity of liquid instead of air.

Insulation must be protected from two forms of moisture, (1) that in the liquid state and (2) that in the vapor state. Thermal insulation, of any temperature range, located outdoors where it is subjected to rain, sleet, or snow, must be protected from liquid moisture by a weather barrier. Indoor applications, in most chemical process plants, must also be protected by weather barriers as it is common practice to wash down vessels and pipe with a water stream when spillage occurs. Most high temperature insulations are highly absorbent and if they once become wet considerable heat is necessary to dry them out. Where absorbent insulations are used on vessels and lines which operate below 250F, it is virtually impossible to dry them out if they once become wet. For this reason, moisture resistant insulation is recommended to be used where service temperatures are below 250F.

Wherever insulation is used on services at temperatures below ambient, not only must it be protected from liquid moisture, but also from moisture in the vapor state. Moisture in the vapor state is a gas, and in this state it will

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INSTALLATION REQUIREMENTS

VI. MOISTURE REQUIREMENTS - Continued

always seek to equalize any pressure difference by flowing from the high pressure area to the low pressure area. Whenever a barrier exists between a high and low pressure area, the vapor will seek all means to reach the lower pressure by going through the insulation itself, through joints and cracks in the insulation or around ends. When insulation is applied to equipment or piping which operates at temperatures less than ambient, this lower temperature causes a lower vapor pressure to exist at this point than exists in the ambient air. This vapor force is pressing inward on the entire outside area of the insulation, seeking any crack, hole or weakness to penetrate. If the vapor does penetrate, as it encounters lower temperatures on its way to the inner surface, the vapor will reach its dew point. At this point the vapor will condense to a liquid. This water will then replace some of the air in the air spaces. As condensation continues, the air spaces in the insulation become filled with water or frost, and the thermal conductivity is increased, with resultant loss of insulation efficiency. Therefore, wherever insulation is used on low temperature applications, provision must be taken to prevent it being ruined by moisture vapor.

One method of fulfilling this application requirement is to use vapor resistant insulation. However, with vapor resistant insulation the weak point is in the joints. These joints have to be vapor sealed. This is also true of slip joints which are provided to take care of expansion and contraction.

Where it is necessary to use insulation which is limited in its vapor resistance, it is necessary to provide a vapor barrier to protect the insulation. The barrier may be of mastic, tapes, jackets or metal outer container, depending upon individual requirements.

Another method used for vapor control is to construct an inner and an outer vessel with an insulated space between each. This space is kept dry by gas purge or partial vacuum. This method can be the most efficient of all insulating systems; however, in most instances, because of its expense, it can be warranted only for the most critical of low temperature installations.

VII. BASIC CONSIDERATIONS FOR SELECTION OF THICKNESS OF INSULATION

Thermal Requirements on an installation determines the resistance to heat flow which the insulation must provide, the control of temperature required, or the retarding of temperature rise. The need for insulation may be any one or several different requirements.

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INSTALLATION REQUIREMENTS

VII. BASIC CONSIDERATIONS FOR SELECTION OF THICKNESSES OF INSULATION Continued

Process Insulation Thickness Requirements

For any particular temperature there is no single correct thickness of insulation. The proper thickness depends on many factors. Some of these factors are location indoors or outdoors, ambient temperature, solar exposure, cost of heat, cost of insulation, process requirements, hours of operation, rate of amortization, safety, dew point, freezing point of material, flash point of material, condensation point of material. Any one single factor may be the paramount one for a given problem. However, in most instances, a combination of many of the factors decides the proper insulation thickness.

Elevated Temperature - External Insulation

Economic Consideration is based on savings of energy, as heat energy has a monetary value. However, there is no direct conversion from btu's into dollars, as the cost of heat depends upon many factors, such as its form, location and use. Insulation also has monetary value, and like heat its cost varies. However, at some thickness of insulation the total cost of heat loss per year, plus the cost of insulation per year, adds up to the lowest possible cost per year. The thickness which provides this lowest possible cost per year is the economic thickness of insulation.

Solar Radiation Requirements

Control of solar radiation is another application where time is a factor. Where it is necessary to prevent the vapor or liquid in a pipe or vessel being heated above a certain temperature by solar radiation, the correct insulation and correct thickness of this insulation must be installed to produce the needed time lag. In many instances a combination of reflective and mass insulation becomes necessary to accomplish the desired results.

Safety Requirements

Fire protection of pipe and vessels require not only that an insulation have sufficient strength to withstand ordinary abuse, but should also withstand explosion shock of considerable force. It is required to withstand the high temperature of the fire, then the thermal shock and high physical force of a powerful stream of water. It is required to have a minimum of shrinkage at high temperature to prevent gaps which in turn would allow the fire to reach the exposed metal. This service requires the retardation of the flow of heat for as long a time as possible.

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INSTALLATION REQUIREMENTS

VII. BASIC CONSIDERATIONS FOR SELECTION OF THICKNESSES OF INSULATION Continued

Safety Requirements - Continued

Protection of personnel from burns from hot surfaces is a major function of thermal insulation. Due to its conductivity, metal will cause burns at a temperature where a mastic or fibrous surface does not. Metal surfaces, for safety should not exceed 140F, whereas mastic and fibrous surfaces are safe up to 150F. The emissivity of the surface material has a direct effect on the surface temperature. On insulated hot services the lower the emissivity of the outer weather barrier the higher the surface temperature will be. For this reason care must be exercised in the use of highly reflective metals on hot service where they are within possible personal contact.

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RELATION OF REQUIREMENTS TO PROPERTIES OF MATERIALS

The properties of an insulation are what makes it suitable to fulfill the requirements imposed on it by any specific installation. The first duty of an engineer is to determine all that he can about the facts of an installation. All functions, including installation, service, economics, safety, and their requirements should be considered. A table listing the basic functions and their requirements as related to the insulation properties follows:

Basic Function	Requirement	Insulation Properties
Transportation and Storage	To withstand transportation and handling without excessive breakage	Compressive strength Flexural strength Shear strength Tensile strength Abrasion resistance Weather resistance
	Economic handling	Density
	Protection from moisture	Absorptivity Capillarity
Fabrication	Dimensional	Shape and size available
	Fitting	Straightness Smoothness Tolerances
	Cutting or forming	Compressive strength Flexural strength Shear strength Tensile strength Abrasion resistance Hardness Cutting characteristics Dusting Dust hazard
	Joining	Surface dusting Compatibility with adhesive or cement Resistance to surface shear Comparable joint strength
Field Erection	Application	Dimensional trueness Cutting characteristics Dusting Density Flexural strength Breaking strength

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RELATION OF REQUIREMENTS TO PROPERTIES OF MATERIALS

Basic Function	Requirement	Insulation Properties
	Securement	Shear strength Compressive strength Abrasion resistance
	Resistance to weather during application	Absorptivity Capillarity Effect of moisture on other properties
	Finishing	Compatibility with cements, sealers, adhesives, or weather-barrier mastics
In Service		
Physical	To withstand deadloads, live loads, impact and mechanical wear. To withstand forces of expansion and contraction	Compressive strength Flexural strength Shear strength Tensile strength
	Vibration	Abrasion resistance Vibration resistance
Chemical	To be compatible with metal to which it is applied.	Alkalinity, ph Soluble chlorides
	Resistance to contamination by spillage, or atmosphere	Resistance to acids Resistance to caustics Resistance to solvents
Moisture	Resistance to moisture in liquid or vapor forms, or both.	Absorptivity Capillarity Hygroscopicity Vapor permeability
Electrical	Resistance to flow of galvanic current set up by dissimilar metals	Dielectric constant (when dry, when wet)
Thermal	Maximum temperature Minimum temperature Cyclic temperature	Continuous temperature- High and low temperature lim Cyclic temperature-high & lo temperature limit

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RELATION OF REQUIREMENTS TO PROPERTIES OF MATERIALS

Basic Function	Requirement	Insulation Properties
In Service - Contd		
Thermal - Contd	Dimensional change	% linear shrinkage Coefficient of expansion
	Resistance to heat flow	Conductivity
	Heat buildup	Diffusivity
	Heat storage	Specific heat density
Economic		
Investment Cost	Material	Price of pipe covering Price of block Price of accessories
	Shipping and handling	Weather resistance of insulation Weather resistance of packages Ability to be mechanically handled
	Fabrication	Speed of cutting and fitting Time required for cementing
	Application	Speed and ease of installing Weather resistance Suitability for weather and vapor barrier
Maintenance Cost	Continuing	Ability of insulation to function under service replacement
	Changes or repair of equipment and piping	Reuseability Speed of removal and replacement
Operational Savings	Savings in energy	Conductivity Resistance to moisture
Insurance Cost	Overhead cost	Potential increase or decrease of hazard Fire resistance Fire retardance

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RELATION OF REQUIREMENTS TO PROPERTIES OF MATERIALS

Basic Function	Requirement	Insulation Properties
Hazards		
Fire - Contribution to	Flammability	Flash point Fire point Self-ignition point Fuel contribution
	Contaminates, in contact with insulation	Absorptivity Hygroscopicity Lowering by contaminates of flash, fire and self-ignition points
Fire - Protection from	To protect pipe, equipment or steel	Diffusivity Specific heat Density Conductivity Resistance to thermal shock Resistance to water under pressure
Personnel Protection	Surface temperature	Conductivity of insulation Conductivity of weather-barrier Emissivity of weather-barrier
	Storage of toxic contaminants	Absorptivity Hygroscopicity Capillarity

After the installation requirements are determined, it is necessary to review the properties of obtainable materials to select the one which most nearly satisfied all the requirements.

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DEFINITIONS

Exact thermal definitions are not presented in standard dictionaries. To prevent misunderstanding of terms used in insulation engineering, the following terms are defined as to their thermal meaning.

Absolute pressure (psia) - Atmospheric pressure plus gauge pressure. The common units of measure are pounds per square inch.

Absolute temperature (T) - Temperature measured on one of the absolute scales (Kelvin or Rankine)

Absorptivity (α) - The radio of the radiant flux absorbed by a body to that incident upon it. This term is restricted to materials having opaque, optically flat surfaces. (highly polished)

Absorptance(α) - The ratio of the radiant flux absorbed by a body to that incident upon it.

Ambient air - Generally, the atmospheric air surrounding an object or a surface.

Black body - An ideal, perfect emitter and absorber of thermal radiation. It emits radiant energy at each wave length of the maximum rate possible as a consequence of its temperature, and absorbs all incident radiant flux while reflecting none.

Blanket Insulation - A flexible material which will retard heat flow and can be readily conformed to curved or irregular surfaces, suitably bound together to provide units of substantial area for handling and application, and which may be faced or reinforced with confining media.

British Thermal Unit (BTU) - The quantity of heat required to raise one pound of water one °F from and at 32°F and 29.92 inches mercury pressure.

British Thermal Unit, mean (Btu) - The mean Btu is 1/180 of the quantity of heat required to raise the temperature of one pound of water from 32F to 212F at 29.92 inches mercury pressure. (Does not include latent heat.)

British Thermal Unit, I.T. (Btu) - Heat unit established by definition. One I.T. Btu equals 251.996 I.T. calories or 778.26 ft lbs. It is close in value to the other types of Btu's and is now commonly used for heat transfer work.

Calorie - The quantity of heat required to raise one gram of water one °C from and at 0°C and 760 millimeters mercury pressure. Sometimes called gram calorie or small calorie.

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DEFINITIONS

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DEFINITIONS

Dew point - The temperature at which the condensation of water vapor begins for a given condition of humidity and pressure, as the temperature of the water vapor is reduced. The dew point temperature corresponds to 100 per cent relative humidity for a given absolute humidity at constant pressure.

Diffusivity, thermal (d) - An important factor in problems that involve unsteady conditions of heat flow. Its value is obtained by dividing thermal conductivity by heat capacity. ($d = k/\rho c$). For materials of the same thickness, heating or cooling time is inversely proportional to the thermal diffusivity of the materials. For materials having the same diffusivity, heating time is directly proportional to the square of the thickness.

Dry bulb temperature - The air temperature as shown by an ordinary thermometer.

Efficiency, insulation (e) - The ratio of heat saved by the insulation to the best dissipated by the bare surface when insulation is not used.

Emissivity (ϵ) - The ability of an opaque material having a highly polished surface (optically flat) to emit radiant energy as a result of its temperature. It is measured by the ratio of the rate of radiant emission of the material to the corresponding emission of a perfect emitter, or black body at the same temperature. The emissivity value of a material is the same as its absorptivity value.

Emittance (ϵ) - The ability of an opaque material to emit radiant energy as a result of its temperature. This is the same as emissivity except that the surface is not necessarily polished for the material.

Emittance, directional (or directional emissivity)(ϵ_θ) - Takes into account the rate of radiant emission per unit of solid angle and per unit of projected area of a source in a stated angular direction from the surface (usually normal). May be total or spectral emittance.

Emittance, hemispherical (or hemispherical emissivity) (ϵ_h) - Takes into account the rate of radiant emission from a unit area of a source in all the radial directions of the overspreading hemisphere. May be total or special emittance.

Emittance, spectral (or spectral emissivity)(ϵ_λ) - Takes into account only the radiant emission from a unit area of a source per unit of wavelength interval. See Emittance.

Emittance, total (or total emissivity) (ϵ_t) - Takes into account the radiant emission from a unit area of a source in all wavelengths. See Emittance.

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DEFINITIONS

Flame point - The temperature at which the vapors from a combustible material will ignite from an external spark.

Flash point - The temperature at which the vapors from a combustible material will ignite from an external spark and continue to burn.

Foot-pound - A unit of work. It is the work done in lifting a mass of one pound a distance of one foot.

Gauge pressure (psig) - Pressure measured from atmospheric pressure as a base.

Gray body - A body having the same spectral emittance at all wavelengths (less than unity).

Finishing cement - A prepared composition, in dry form, comprising fibrous or powdery materials, or both, which when mixed with a suitable proportion of water to develop a plastic consistency, readily adheres to thermal insulation over which it is applied, and dries to form a smooth, hard, protective surface for application of paint, fabric, or waterproofing.

Heat - A transient form of energy. It is the energy in transition from one body to another as a result of a temperature difference existing between the bodies.

Heat capacity - Ability of a substance to store and retain heat. Value is equal to the specific heat multiplied by its density.

Horsepower - A unit of the time rate of doing work. Equivalent to 550 foot-pounds per second or 2545 Btu per hour.

Insulation, thermal - A material having a relatively high resistance to the flow of heat per unit of thickness and used principally to retard the loss or gain of heat in pipes, vessels, equipment, appliances, and buildings.

Joule's equivalent (J) - A conversion factor between heat units and mechanical units. J = 778.2 foot-pounds/Btu.

Latent heat - The heat absorbed or rejected by a substance in changing from solid to liquid, liquid to vapor, or vice versa, without any change in temperature. The values for water at atmospheric pressure are: Water to steam - 970.3 Btu per lb; water to ice - 143.4 Btu per lb.

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DEFINITIONS

Length of path of heat flow (L) - The distance heat flows through a solid from a surface at one temperature to a surface at a lower temperature.

Mean temperature - The arithmetic mean of inner and outer surface temperatures of insulation. Mean temperature is used to select a value for conductivity in heat loss calculations.

Mechanical equivalent - Same as Joule's equivalent.

Micron - One one-thousandth of a millimeter.

Perm - A measure of vapor-transmission rate. Defined as one grain of water vapor per square ft/hour/inch of mercury-pressure difference.

Permeability - A rating of a material giving the amount of water vapor that will pass through one square foot of one inch thickness of the material. An accepted unit of permeability is a perm-inch, or 1 grain/inch/sq ft, hr, inch of mercury.

Permeance - Same as permeability except that it is a rating of the material of the thickness tested. An accepted unit of permeance is a perm, or 1 grain per square ft/hr/inch of mercury. Also stated as water vapor transmission divided by vapor pressure differential.

Radiance - The rate of radiant emission per unit of solid angle, and per unit of protected area of a source, in a stated angular direction from the surface (usually normal).

Radiation, thermal - The transmission of heat energy through space from one object to another by means of electromagnetic waves of very long wavelengths. Radiant energy may be absorbed, becoming thermal energy, and cause an increase in temperature of the absorbing body.

Radiant flux density (W) - The rate of radiant energy emission from a unit area of a source in all the radial directions of the overspreading hemisphere.

Reflectance - The ratio of the radiant flux reflected by a body to that incident upon it. For an opaque body, the sum of the reflectance and absorptance for the incident radiation is unity.

Reflective insulation - Thermal insulation depending for its efficiency in large part on reduction of radiant heat transfer across spaces by use of one or more surfaces of high reflectance and low emittance.

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DEFINITIONS

Reflectivity - The same as reflectance except it is restricted to apply to materials having opaque, optically flat surfaces.

Refrigeration, ton of - The removal of heat at the rate of 12,000 Btu per hour. This figure is obtained from the commercial unit of refrigeration capacity which is the heat required to melt 2000 pounds of pure ice at 32F to water at 32F in 24 hours.

Relative humidity - The ratio of the actual water vapor in the air to the amount which could be in the air of saturation.

Resistance, unit thermal (R_a) - The reciprocal of unit thermal conductance.

Resistance, thermal (R) - The reciprocal of thermal conductance.

Resistivity, thermal - The reciprocal of thermal conductivity. A specific property of a material.

Resistance, surface (R_s) - The reciprocal of surface conductance.

Specific gravity - The ratio of the mass of any volume of a material to the mass of an equal volume of water at 60F. The specific gravity of a gas may also be expressed as the ratio of the mass of any volume of gas to the mass of an equal volume of oxygen, hydrogen, or air at the same temperature and pressure as the gas.

Specific heat (c) - The number of heat units required to raise the temperature of one unit mass of the substance one degree under specified conditions, such as constant pressure, constant volume, etc.

Temperature - The thermal state of matter regarding its tendency to communicate heat to matter in contact with it. If there is no temperature difference, no heat will flow on contact.

Temperature difference - A potential force causing the actual transfer of heat energy.

Thermal conductances (C) - See Conductance, thermal.

Thermal conductance, unit (C_a) - See Conductance, unit thermal.

Thermal conductivity (k) - See Conductivity, thermal.

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DEFINITIONS

Thermal diffusivity (d) - See Diffusivity, thermal.

Thermal resistance (R) - See Resistance, thermal.

Thermal resistance, unit (R_a) - See Resistance, unit thermal.

Thermal resistivity - See Resistivity, thermal.

Thermal surface coefficient of heat transfer (h) - The heat flow rate per unit of area per degree temperature difference across a boundary surface. Also called surface conductance.

Transmission, heat - Heat transferred per unit of time. A general term for heat travel.

Transmittance, thermal (U) - Also called overall coefficient of heat transfer or U factor. The time rate of heat flow per unit area under steady conditions from the fluid on the warm side to the fluid on the cold side for a unit temperature difference of the fluids. The common unit is Btu per square foot, hour, °F.

U Factor - See Transmittance, thermal.

Vapor barrier - A material having a high resistance to the passage of water vapor. It is applied to surfaces to prevent vapor migration to regions of low temperatures where undesirable condensation may occur.

Vapor resistance - Reciprocal of Permeance.

Vapor resistivity - Reciprocal of Permeability. Resistance per inch thickness to the passage of water vapor.

Volume fluid flow rate (Q) - Rate of flow in units of volume per unit of time, such as cubic feet per hour.

Water vapor permeability - See Permeability.

Water vapor transmission, rate of (WVT) - The rate of water vapor transmission of a body between two specified parallel surfaces in the time rate of water vapor flow normal to the surfaces, under steady conditions, through unit area, under conditions of test. An accepted unit of WVT is 1 grain per square foot, hour (with test conditions stated).

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DEFINITIONS

Wet bulb temperature (t_w) - The temperature given by a thermometer when the bulb is covered with an absorbent material wet with water and exposed to the atmosphere. The standard speed of air movement past the wet wick is 10 feet per second, or mor

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SYMBOLS AND ABBREVIATIONS

A	Area
A_1	Projected area of a body
A_i	Inside area
A_m	Mean area
A_o	Outside area
B	Cost of insulation per square foot per inch thickness per year
B_p	Cost of insulation per linear foot per inch thickness per year
Btu	British thermal unit
Btuh	British thermal unit per hour
C	Conductance (area), Btu/(hr)(°F)
C_a	Unit conductance (area), (Btu/(hr)(°F)
C_e	Unit conductance (area), (Btu/(hr)(°F)
C_s	A constant depending on shape of surface
°C	Temperature in degrees Celsius (Centigrade)
c	Specific heat, Btu/(lb)(°F)
cu ft	Cubic foot or cubic ft
D	Diameter
d	Diameter
d_1	Inside diameter of insulation, inches
d_2	Outside diameter of insulation, inches
d_p	Outside diameter of pipe, inches
e	Insulation efficiency
°F	Temperature in degrees (Fahrenheit)
ft	Foot or feet
G	Flow rate (mass velocity), lb/(sq ft)(hr)
g	Acceleration of gravity
H	Height, ft
H_s	Net radiation, Btu/hr, sq ft, at given latitude (Solar)
h	Conductance of air film
hr	Hour
h_1	Conductance of inner or first air film
h_2	Conductance of second air film
IPS	Iron pipe size
ID	Inside diameter
J	Joule's constant
k	Thermal conductivity, Btu/(sq ft)(°F)(hr/inch thickness)
k_1	Conductivity of inner or first insulation material
k_2	Conductivity of second insulation material
k_3	Conductivity of third insulation material
L	Length of heat transfer path (thickness of insulation)
L_1	Thickness of inner or first layer of insulation
L_2	Thickness of second layer of insulation
L_3	Thickness of third layer of insulation
lb	Pound or pounds
lin	Linear

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SYMBOLS AND ABBREVIATIONS

M	Cost of heat, in dollars per million Btu
NPS	Nominal pipe size
OD	Outside diameter
psi	Pounds per square inch
psia	Pounds per square inch absolute pressure
psig	Pounds per square inch gauge pressure
Q	Total quantity of heat transferred
Q_f	Volume rate, fluid rate of flow by volume
q	Heat flow rate for a particular setup. Btu/hr (total per unit area)
q_a	Heat flow rate per unit area. Btu/hr, sq ft; or heat flow rate by convection and radiation per unit area
q_c	Heat flow rate across air film by convection under still air conditions
q_{ca}	Heat flow rate by convection for Δt
q_{cv}	Heat flow rate across air film by convection of a given velocity (V)
q_d	Heat flow rate for a unit of pipe length, Btu/(lin ft)(hr)
q_r	Heat flow rate across air film by radiation
q_{ra}	Heat flow rate by radiation from ambient air at a temperature t_a to insulation surface at temperature t_2
R	Reynolds number
R	Thermal resistance
R_a	Thermal resistance of a unit area
R_s	Thermal resistance of air film to the flow of heat
1/R	Thermal conductance, same as C
$1/R_a$	Thermal conductance per unit of area
°R	Temperature in degrees Rankine
r	Radius of pipe insulation, inches
r_1	Inside radius of inner pipe insulation, inches
r_2	Outside radius of inner insulation and inside radius of outer insulation, inches
r_3	Outside radius of outer insulation
sq	Square
T	Absolute temperature, °R or °K or = °F + 459.6
T_1	Absolute temperature of first surface
T_2	Absolute temperature of second surface
T_A	Absolute temperature of ambient air
t	Temperature, °F
t_a	Ambient air temperature or outside air temperature
t_{av}	Average ambient air temperature
t_i	Air temperature inside of insulation
t_m	Mean temperature

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SYMBOLS AND ABBREVIATIONS

t_1	Temperature of inner surface of inner insulation; or operating temperature of equipment of pipe (°F)
t_2	Temperature of outer surface of inner insulation and inner surface of outer insulation. Temperature of outer surface of insulation if only one material. (°F)
t_3	Temperature of outer surface of outer insulation when two materials are used (°F)
t_o	Operating temperature
t_s	Temperature of steam
t_w	Temperature of water
t_{wl}	Temperature of wall
U	Overall coefficient of heat transfer for a system, per unit of area, expressed as Btu/(hr)(sq ft)(°F)
U_1	Overall coefficient of transmittance based on area of pipe surface
U_2	Overall coefficient of transmittance based on outside surface area of one layer of insulation
U_3	Overall coefficient of transmittance based on outside surface area of two or more layers of insulation
V	Velocity of air over surface, ft/min
V	Volume, cu ft
VPD	Vapor pressure difference
W	Weight, lbs
W	Radiant flux density, $\frac{\Delta \Phi}{\Delta A}$
WVT	Water vapor transmission
w	Flow rate, lbs/unit of time
Y	Number of hours of operation per year
α	Absorptivity of absorptance
α^d	Thermal diffusivity
Δ	Difference or change in values
Δt_1	Temperature difference °F from air t_a to outer insulation surface t_2
Δt_2	Temperature difference °F from outer insulation surface t_2 to inner surface t_1
ϵ	Absorptance (same values as emittance) ratio to black body
μ	Viscosity of fluid, lb/ft hr
ρ	Density
Φ	Radiant flux

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DATA

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This section contains data which is most frequently used by an engineer designing insulation installations or in calculation of heat gains or losses.

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DATA

I. GENERAL

1. Conversion Tables

ENERGY, WORK AND HEAT EQUIVALENTS

BRITISH THERMAL UNITS	CENTIMETER-GRAMS	ERGS OR CENTIMETER-DYNES	FOOT-POUNDS	HORSEPOWER-HOURS	JOULES OR WATT-SECONDS	KILOCALORIES	KILOWATT-HOURS	METER-KILOGRAMS	WATT-HOURS
1	1.076×10^{3}	1.055×10^{10}	778.2	3.929×10^{-4}	1054.8	0.2520	2.930×10^{-4}	107.6	0.2930
9.297×10^{-4}	1	980.7	7.233×10^{-5}	3.654×10^{-11}	9.807×10^{-5}	2.343×10^{-8}	2.724×10^{-11}	1×10^{-5}	2.724×10^{-8}
9.480×10^{-11}	1.020×10^{-3}	1	7.367×10^{-8}	3.722×10^{-14}	1×10^{-7}	2.389×10^{-11}	2.778×10^{-14}	1.020×10^{-8}	2.778×10^{-11}
1.285×10^{-3}	1.383×10^{4}	1.356×10^{7}	1	5.050×10^{-7}	1.356	3.239×10^{-4}	3.766×10^{-7}	0.1383	3.766×10^{-4}
2.545	2.737×10^{10}	2.684×10^{13}	1.98×10^{6}	1	2.684×10^{6}	641.3	0.7457	2.737×10^{5}	745.7
9.480×10^{-4}	1.020×10^{4}	1×10^{7}	0.7376	3.722×10^{-7}	1	2.389×10^{-4}	2.778×10^{-7}	0.1020	2.778×10^{-4}
3.968	4.269×10^{7}	4.186×10^{10}	3.088	1.559×10^{-3}	4.186	1	1.163×10^{-3}	426.9	1.163
3.413	3.671×10^{10}	3.6×10^{13}	2.655×10^{6}	1.341	3.6×10^{6}	860.0	1	3.671×10^{5}	1.000
9.297×10^{-3}	1×10^{5}	9.807×10^{7}	7.233	3.653×10^{-6}	9.807	2.343×10^{-3}	2.724×10^{-6}	1	2.724×10^{-3}
3.413	3.671×10^{7}	3.6×10^{10}	2.655	1.341×10^{-3}	3.600	0.8600	0.001	367.1	1

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DATA

I. GENERAL

1. Conversion Tables

POWER EQUIVALENTS

Btu per sec	Btu per minute	Kilo-calories per sec or Large calories per sec	Calories (small) per sec	Foot pounds per sec	Kilo-gram meters per sec	Watts	Kilo-watts	Horse-power
1	60	0.2520	252.0	778.2	107.6	1055	1.055	1.415
0.01667	1	0.0042	4.2	12.07	1.793	17.57	0.01757	0.02356
3.968	238.1	1	1000	3088	426.9	418.7	4.187	5.615
0.003968	0.2381	0.001	1	3.088	0.4269	4.187	0.004187	0.005615
0.001285	0.0771	0.0003238	0.3238	1	0.1383	1.356	0.001356	0.00182
0.009295	0.5577	0.002342	2.342	7.233	1	9.807	0.009807	0.01315
0.0009478	0.05687	0.0002388	0.2388	0.7376	0.102	1	0.001	0.00134
0.9478	56.87	0.2388	238.8	737.6	102.0	1000	1	1.341
0.7068	42.408	0.1781	178.1	550	76.04	745.7	0.7457	1

Example: 1 Btu per sec equals 778.2 Ft lbs per sec

TEMPERATURE CONVERSION FORMULAS

To Get	CONVERSION FORMULAS			
	From ° Fahrenheit	From ° Kelvin	From ° Celsius (Centigrade)	From ° Rankine
° F =		9/5 (° K-273.16)+ 32	(9/5) ° C + 32	° R - 459.69
° K =	(5/9 (° F-32) + 273.16		° C+ 273.16	(5/9) ° R
° C =	5/9) (° F-32)	° K-273.16		5/9 (R) 273.16
° R =	° F + 459.69	(9/5) ° K	(9/5) ° C + 491.69	

Example: To get ° F from ° K, use the formula of 9/5 (° K - 273.16) + 32

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DATA

I. GENERAL

1. Conversion Tables

THERMAL CONDUCTIVITY CONVERSION FACTORS

TO GET k IN UNITS OF:					WITH k GIVEN IN UNITS OF $\frac{\text{Btu inches}}{\text{hr, sq ft, }^\circ\text{F}}$
HEAT UNITS	TIME UNITS	AREA UNITS	TEMP UNITS	THICKNESS UNITS	DIVIDE k BY:
Btu	Hour	Square feet	°F	Inch	1
Btu	Hour	Square feet	°F	Foot	12
Gram-Calorie	Second	Square centimeter	°C	Centimeter	2903
Watt-seconds	Second	Square centimeter	°C	Centimeter	694
Kilowatt hour	Hour	Square feet	°F	Inch	3415

Example: Given k = 0.40 $\frac{\text{Btu, inches}}{\text{hr, sq. ft., }^\circ\text{F.}}$ Find k in $\frac{\text{Btu, ft}}{\text{hr, sq ft, }^\circ\text{F.}}$ Read the extreme right column opposite these units and find that we must divide by 12. Then k = 0.40/12 = 0.033 $\frac{\text{Btu ft}}{\text{hr, sq ft, }^\circ\text{F}}$

Note: When converting to $\frac{\text{Btu, inches}}{\text{hr, sq ft, }^\circ\text{F}}$ from other units, multiply by the constant opposite these other units.

WATER VAPOR TRANSMISSION CONVERSION FACTORS

To Obtain	A.S.T.M. Procedure	Multiply			
		$\frac{\text{g}}{\text{24 Hr, Sq M}}$ By	$\frac{\text{g}}{\text{24 Hr, 100 Sq In}}$ By	$\frac{\text{grains}}{\text{Hr, Sq Ft}}$ By	Perms± By
$\frac{\text{g}}{\text{24 Hr, Sq M}}$	A &B, 73.4F	1	15.5	16.7	6.94
	C &D, 90F	1	15.5	16.7	11.9
	E 100F	1	15.5	16.7	29.1
$\frac{\text{g}}{\text{24 Hr, 100 Sq In}}$	A &B 73.4F	0.0645	1	1.08	0.448
	C &D, 90F	0.0645	1	1.08	0.767
	E 100F	0.0645	1	1.08	1.88
$\frac{\text{grains}}{\text{Hr, Sq Ft}}$	A &B 73.4F	0.0597	0.926	1	0.415
	C &D 90F	0.0597	0.926	1	0.710
	E 100F	0.0597	0.926	1	1.740
Perms±	A &B 73.4F	0.144	2.23	2.41	1
	C &D 90F	0.0841	1.30	1.41	1
	E 100F	0.034	0.532	0.575	1

± The conversion to Perms is based on the following vapor pressure differentials.

Procedure (A.S.T.M. E-96-53T)	In Hg
A and B	0.415
C and D	0.710
E	1.740

Note: Data obtained by one procedure cannot be reliably converted to data obtained by another procedure.

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DATA

I. GENERAL

1. Conversion Tables

TEMPERATURE CONVERSION TABLE
(Centigrade Scale Listed in Even Numbers)

0	273 16	459.69	0																				
1/16	272	457.6	1.1																				
2/16	271	455.8	1.9																				
3/16	270	454.0	2.7																				
4/16	269	452.2	3.5	88 16	-185	-301.0	158.7	173 16	-100	-148.0	311.7	258 16	-15	5.0	464.7	343 16	70	158.0	617.7	923	650	1202	1661
5/16	268	450.4	4.3	89 16	-184	-299.2	160.5	174 16	-99	-146.2	313.5	259 16	-14	6.8	466.5	344 16	71	159.8	619.5	933	660	1220	1679
6/16	267	448.6	5.1	90 16	-182	-297.4	162.3	175 16	-98	-144.4	315.3	260 16	-13	8.6	468.3	345 16	72	161.6	621.3	943	670	1238	1697
7/16	266	446.8	5.9	91 16	-181	-295.6	164.1	176 16	-97	-142.6	317.1	261 16	-12	10.4	470.1	346 16	73	163.4	623.1	953	680	1256	1715
8/16	265	445.0	6.7	92 16	-180	-293.8	165.9	177 16	-96	-140.8	318.9	262 16	-11	12.2	471.9	347 16	74	165.2	624.9	963	690	1274	1733
9/16	264	443.2	7.5	93 16	-179	-292.0	167.7	178 16	-95	-139.0	320.7	263 16	-10	14.0	473.7	348 16	75	167.0	626.7	973	700	1292	1751
10/16	263	441.4	8.3	94 16	-178	-290.2	169.5	179 16	-94	-137.2	322.5	264 16	-9	15.8	475.5	349 16	76	168.8	628.5	983	710	1310	1769
11/16	262	439.6	9.1	95 16	-177	-288.4	171.3	180 16	-93	-135.4	324.3	265 16	-8	17.6	477.3	350 16	77	170.6	630.3	993	720	1328	1787
12/16	261	437.8	9.9	96 16	-176	-286.6	173.1	181 16	-92	-133.6	326.1	266 16	-7	19.4	479.1	351 16	78	172.4	632.1	1003	730	1346	1805
13/16	260	436.0	10.7	97 16	-175	-284.8	174.9	182 16	-91	-131.8	327.9	267 16	-6	21.2	480.9	352 16	79	174.2	633.9	1013	740	1364	1823
14/16	259	434.2	11.5	98 16	-174	-283.0	176.7	183 16	-90	-130.0	329.7	268 16	-5	23.0	482.7	353 16	80	176.0	635.7	1023	750	1382	1841
15/16	258	432.4	12.3	99 16	-173	-281.2	178.5	184 16	-89	-128.2	331.5	269 16	-4	24.8	484.5	354 16	81	177.8	637.5	1033	760	1400	1859
16/16	257	430.6	13.1	100 16	-172	-279.4	180.3	185 16	-88	-126.4	333.3	270 16	-3	26.6	486.3	355 16	82	179.6	639.3	1043	770	1418	1877
17/16	256	428.8	13.9	101 16	-171	-277.6	182.1	186 16	-87	-124.6	335.1	271 16	-2	28.4	488.1	356 16	83	181.4	641.1	1053	780	1436	1895
18/16	255	427.0	14.7	102 16	-170	-275.8	183.9	187 16	-86	-122.8	336.9	272 16	-1	30.2	489.9	357 16	84	183.2	642.9	1063	790	1454	1913
19/16	254	425.2	15.5	103 16	-169	-274.0	185.7	188 16	-85	-121.0	338.7	273 16	0	32.0	491.7	358 16	85	185.0	644.7	1073	800	1472	1931
20/16	253	423.4	16.3	104 16	-168	-272.2	187.5	189 16	-84	-119.2	340.5	274 16	1	33.8	493.5	359 16	86	186.8	646.5	1083	810	1490	1949
21/16	252	421.6	17.1	105 16	-167	-270.4	189.3	190 16	-83	-117.4	342.3	275 16	2	35.6	495.3	360 16	87	188.6	648.3	1093	820	1508	1967
22/16	251	419.8	17.9	106 16	-166	-268.6	191.1	191 16	-82	-115.6	344.1	276 16	3	37.4	497.1	361 16	88	190.4	650.1	1103	830	1526	1985
23/16	250	418.0	18.7	107 16	-165	-266.8	192.9	192 16	-81	-113.8	345.9	277 16	4	39.2	498.9	362 16	89	192.2	651.9	1113	840	1544	2003
24/16	249	416.2	19.5	108 16	-164	-265.0	194.7	193 16	-80	-112.0	347.7	278 16	5	41.0	500.7	363 16	90	194.0	653.7	1123	850	1562	2021
25/16	248	414.4	20.3	109 16	-163	-263.2	196.5	194 16	-79	-110.2	349.5	279 16	6	42.8	502.5	364 16	91	195.8	655.5	1133	860	1580	2039
26/16	247	412.6	21.1	110 16	-162	-261.4	198.3	195 16	-78	-108.4	351.3	280 16	7	44.6	504.3	365 16	92	197.6	657.3	1143	870	1598	2057
27/16	246	410.8	21.9	111 16	-161	-259.6	200.1	196 16	-77	-106.6	353.1	281 16	8	46.4	506.1	366 16	93	199.4	659.1	1153	880	1616	2075
28/16	245	409.0	22.7	112 16	-160	-257.8	201.9	197 16	-76	-104.8	354.9	282 16	9	48.2	507.9	367 16	94	201.2	660.9	1163	890	1634	2093
29/16	244	407.2	23.5	113 16	-159	-256.0	203.7	198 16	-75	-103.0	356.7	283 16	10	50.0	509.7	368 16	95	203.0	662.7	1173	900	1652	2111
30/16	243	405.4	24.3	114 16	-158	-254.2	205.5	199 16	-74	-101.2	358.5	284 16	11	51.8	511.5	369 16	96	204.8	664.5	1183	910	1670	2129
31/16	242	403.6	25.1	115 16	-157	-252.4	207.3	200 16	-73	-99.4	360.3	285 16	12	53.6	513.3	370 16	97	206.6	666.3	1193	920	1688	2147
32/16	241	401.8	25.9	116 16	-156	-250.6	209.1	201 16	-72	-97.6	362.1	286 16	13	55.4	515.1	371 16	98	208.4	668.1	1203	930	1706	2165
33/16	240	400.0	26.7	117 16	-155	-248.8	210.9	202 16	-71	-95.8	363.9	287 16	14	57.2	516.9	372 16	99	210.2	669.9	1213	940	1724	2183
34/16	239	398.2	27.5	118 16	-154	-247.0	212.7	203 16	-70	-94.0	365.7	288 16	15	59.0	518.7	373 16	100	212.0	671.7	1223	950	1742	2201
35/16	238	396.4	28.3	119 16	-153	-245.2	214.5	204 16	-69	-92.2	367.5	289 16	16	60.8	520.5	383	110	230	689	1233	960	1760	2219
36/16	237	394.6	29.1	120 16	-152	-243.4	216.3	205 16	-68	-90.4	369.3	290 16	17	62.6	522.3	393	120	248	707	1243	970	1778	2237
37/16	236	392.8	29.9	121 16	-151	-241.6	218.1	206 16	-67	-88.6	371.1	291 16	18	64.4	524.1	403	130	266	725	1253	980	1796	2255
38/16	235	391.0	30.7	122 16	-150	-239.8	219.9	207 16	-66	-86.8	372.9	292 16	19	66.2	525.9	413	140	284	743	1263	990	1814	2273
39/16	234	389.2	31.5	123 16	-149	-238.0	221.7	208 16	-65	-85.0	374.7	293 16	20	68.0	527.7	423	150	302	761	1273	1000	1832	2291
40/16	233	387.4	32.3	124 16	-148	-236.2	223.5	209 16	-64	-83.2	376.5	294 16	21	69.8	529.5	433	160	320	779	1283	1010	1850	2309
41/16	232	385.6	33.1	125 16	-147	-234.4	225.3	210 16	-63	-81.4	378.3	295 16	22	71.6	531.3	443	170	338	797	1293	1020	1868	2327
42/16	231	383.8	33.9	126 16	-146	-232.6	227.1	211 16	-62	-79.6	380.1	296 16	23	73.4	533.1	453	180	356	815	1303	1030	1886	2345
43/16	230	382.0	34.7	127 16	-145	-230.8	228.9	212 16	-61	-77.8	381.9	297 16	24	75.2	534.9	463	190	374	833	1313	1040	1904	2363
44/16	229	380.2	35.5	128 16	-144	-229.0	230.7	213 16	-60	-76.0	383.7	298 16	25	77.0	536.7	473	200	392	851	1323	1050	1922	2381
45/16	228	378.4	36.3	129 16	-143	-227.2	232.5	214 16	-59	-74.2	385.5	299 16	26	78.8	538.5	483	210	410	869	1333	1060	1940	2399
46/16	227	376.6	37.1	130 16	-142	-225.4	234.3	215 16	-58	-72.4	387.3	300 16	27	80.6	540.3	493	220	428	887	1343	1070	1958	2417
47/16	226	374.8	37.9	131 16	-141	-223.6	236.1	216 16	-57	-70.6	389.1	301 16	28	82.4	542.1	503	230	446	905	1353	1080	1976	2435
48/16	225	373.0	38.7	132 16	-140	-221.8	237.9	217 16	-56	-68.8	390.9	302 16	29	84.2	543.9	513	240	464	923	1363	1090	1994	2453
49/16	224	371.2	39.5	133 16	-139	-218.2	241.5	218 16	-54	-65.2	394.5	304 16	31	87.8	547.5	533	260	500	959	1383	1110	2030	2489
50/16	223	369.4	40.3	134 16	-138	-216.4	243.3	219 16	-53	-63.4	396.3	305 16	32	89.6	549.3	543	270	518	977	1393	1120	2048	2507
51/16	222	367.6	41.1	135 16	-137	-214.6	245.1	220 16	-52	-61.6	398.1	306 16	33	91.4	551.1	553	280	536	995	1403	1130	2066	2525
52/16	221	365.8	41.9	136 16	-136	-212.8	246.9	221 16	-51	-59.8	399.9	307 16	34	93.2	552.9	563	290	554	1013	1413	1140	2084	2543
53/16	220	364.0	42.7	137 16	-135	-211.0	248.7	222 16	-50	-58.0	401.7	308 16	35	95.0	554.7	573	300	572	1031	1423	1150	2102	2561
54/16	219	362.2	43.5	138 16	-134	-209.2	250.5	223 16	-49	-56.2	403.5	309 16	36	96.8	556.5	583	310	590	1049	1433	1160	2120	2579
55/16	218	360.4	44.3	139 16	-133	-207.4	252.3	224 16	-48	-54.4	405.3	310 16	37	98.6	558.3	593	320	608	1067	1443	1170	2138	2597
56/16	217	358.6	45.1	140 16	-132	-205.6	254.1	225 16	-47	-52.6	407.1	311 16	38	100.4	560.1	603	330	626	1085	1453	1180	2156	2615
57/16	216	356.8	45.9	141 16	-131	-203.8	255.9	226 16	-46	-50.8	408.9	312 16	39	102.2	561.9	613	340	644	1103	1463	1190	2174	2633
58/16	215	355.0	46.7	142 16	-130	-202.0	257.7	227 16	-45	-49.0	410.7	313 16	40	104.0	563.7	623	350	662	1121	1473	1200	2192	2651
59/16	214	353.2	47.5	143 16	-129	-200.2	259.5	228 16	-44	-47.2	412.5	314 16	41	105.8	565.5	633	360	680	1139	1483	1210	2210	2669
60/16	213	351.4	48.3	144 16	-128	-198.4	261.3	229 16	-43	-45.4	414.3	315 16	42	107.6	567.3	643	370	698	1157	1493	1220	2228	2687
61/16	212	349.6	49.1	145 16	-127	-196.6	263.1	230 16	-42	-43.6	416.1	316 16	43	109.4	569.1	653	380	716	1175	1503	1230	2246	2705
62/16	211	347.8	49.9	146 16	-126	-194.8	264.9	231 16	-41	-41.8	417.9	317 16	44	111.2	570.9	663	390	734	1193	1513	1240	2264	2723
63/16	210	346.0	50.7	147 16	-125	-193.0	266.7	232 16	-40	-40.0	419.7	318 16	45	113.0	572.7	673	400	752	1211	1523	1250	2282	2741
64/16	209	344.2	51.5	148 16	-124	-191.2	268.5	233 16	-39	-38.2	421.5	319 16	46	114.8	574.5	683	410	770	1229	1533	1260	2300	2759
65/16	208	342.4	52.3	149 16	-123	-189.4	270.3	234 16	-38	-36.4	423.3	320 16	47	116.6	576.3	693	420	788	1247	1543	1270	2318	2777
66/16	207	340.6	53.1	150 16	-122	-187.6	272.1	235 16	-37	-34.6	425.1	321 16	48	118.4	578.1	703	430	806	1265	1553	1280	2336	2795
67/16	206	338.8	53.9	151 16	-121	-185.8	273.9	236 16	-36	-32.8	426.9	322 16	49	120.2	579.9	713	440	824	1283	1563	1290	2354	2813
68/16	205	337.0	54.7	152 16	-120	-184.0	275.7	237 16	-35	-31.0	428.7	323 16	50	122.0	581.7	723	450	842	1301	1573	1300	2372	2831
69/16	204	335.2	55.5	153 16	-119	-182.2	277.5	238 16	-34	-29.2	430.5	324 16	51	123.8	583.5	733	460	860	1319	1583	1310	2390	2849
70/16	203	333.4	56.3	154 16	-118	-180.4	279.3	239 16	-33	-27.4	432.3	325 16	52	125.6	585.3	743	470	878	1337	1593	1320	2408	2867
71/16	202	331.6	57.1	155 16	-117	-178.6	281.1	240 16	-32	-25.6	434.1	326 16	53	127.4	587.1	753	480	896	1355	1603	1330	2426	2885
72/16	201	329.8	57.9	156 16	-116	-176.8	282.9	241 16	-31	-23.8	435.9	327 16	54	129.2	588.9	763	490	914	1373	1613	1340	2444	2903
73/16	200	328.0	58.7	157 16	-115	-175.0	284.7	242 16	-30	-22.0	437.7	328 16	55	131.0	590.7	773	500	932	1391	1623	1350	2462	2921
74/16	199	326.2	59.5	158 16	-114	-173.2	286.5	243 16	-29	-20.2	439.5	329 16	56	132.8	592.5	783	510	950	1409	1633	1360	2480	2939
75/16	198	324.4	60.3	159 16	-113	-171.4	288.3	244 16	-28	-18.4	441.3	330 16	57	134.6	594.3	793	520	968	1427	1643	1370	2498	2957
76/16	197	322.6	61.1	160 16	-112	-169.6	290.1	245 16	-27	-16.6	443.1	331 16	58	136.4	596.1	803	530	986	1445	1653	1380	2516	2975
77/16	196	320.8	61.9	161 16	-111	-167.8	291.9	246 16	-26	-14.8	444.9	332 16	59	138.2	597.9	813	540	1004	1463	1663	1390	2534	2993
78/16	195	319.0	62.7	162 16	-110	-166.0	293.7	247 16	-25	-13.0	446.7	333 16	60	140.0	599.7	823	550	1022	1481	1673	1400	2552	3011
79/16	194	317.2	63.5	163 16	-109	-164.2	295.5	248 16	-24	-11.2	448.5	334 16	61	141.8	601.5	833	560	1040	1499	1683	1410	2570	3029
80/16	193	315.4	64.3	164 16	-108	-162.4	297.3	249 16	-23	-9.4	450.3	335 16	62	143.6	603.3	843	570	1058	1517	1693	1420	2588	3047
81/16	192	313.6	65.1	165 16	-107	-160.6	299.1	250 16	-22	-7.6	452.1	336 16	63	145.4	605.1	853	580	1076	1535	1703	1430	2606	3065
82/16	191	311.8	65.9	166 16	-106	-158.8	300.9	251 16	-21	-5.8	453.9	337 16	64	147.2	606.9	863	590	1094	1553	1713	1440	2624	3083
83/16	190	310.0	66.7	167 16	-105	-157.0	302.7	252 16	-20	-4.0	455.7	338 16	65	149.0	608.7	873	600	1112	1571	1723	1450	2642	3101
84/16	189	308.2	67.5	168 16	-104	-155.2	304.5	253 16	-19	-2.2	457.5	339 16	66	150.8	610.5	883	610	1130	1589	1733	1460	2660	3119
85/16	188	306.4	68.3	169 16	-103	-153.4	306.3	254 16	-18	-0.4	459.3	340 16	67	152.6	612.3	893	620	1148	1607	1743	1470	2678	3137
86/16	187	304.6	69.1	170 16	-102	-151.6	308.1	255 16	-17	1.4	461.1	341 16	68	154.4	614.1	903	630	1166	1625	1753	1480	2696	3155
87/16	186	302.8	69.9	171 16	-101	-149.8	309.9	256 16	-16	3.2	462.9	342 16	69	156.2	615.9	913	640	1184	1643	1763	1490	2714	3173
88/16	185	301.0	70.7	172 16	-100	148.0	311.7	257 16	-15	5.0	464.7	343 16	70	158.0	617.7	923	650	1202	1661	1773	1500	2732	3191

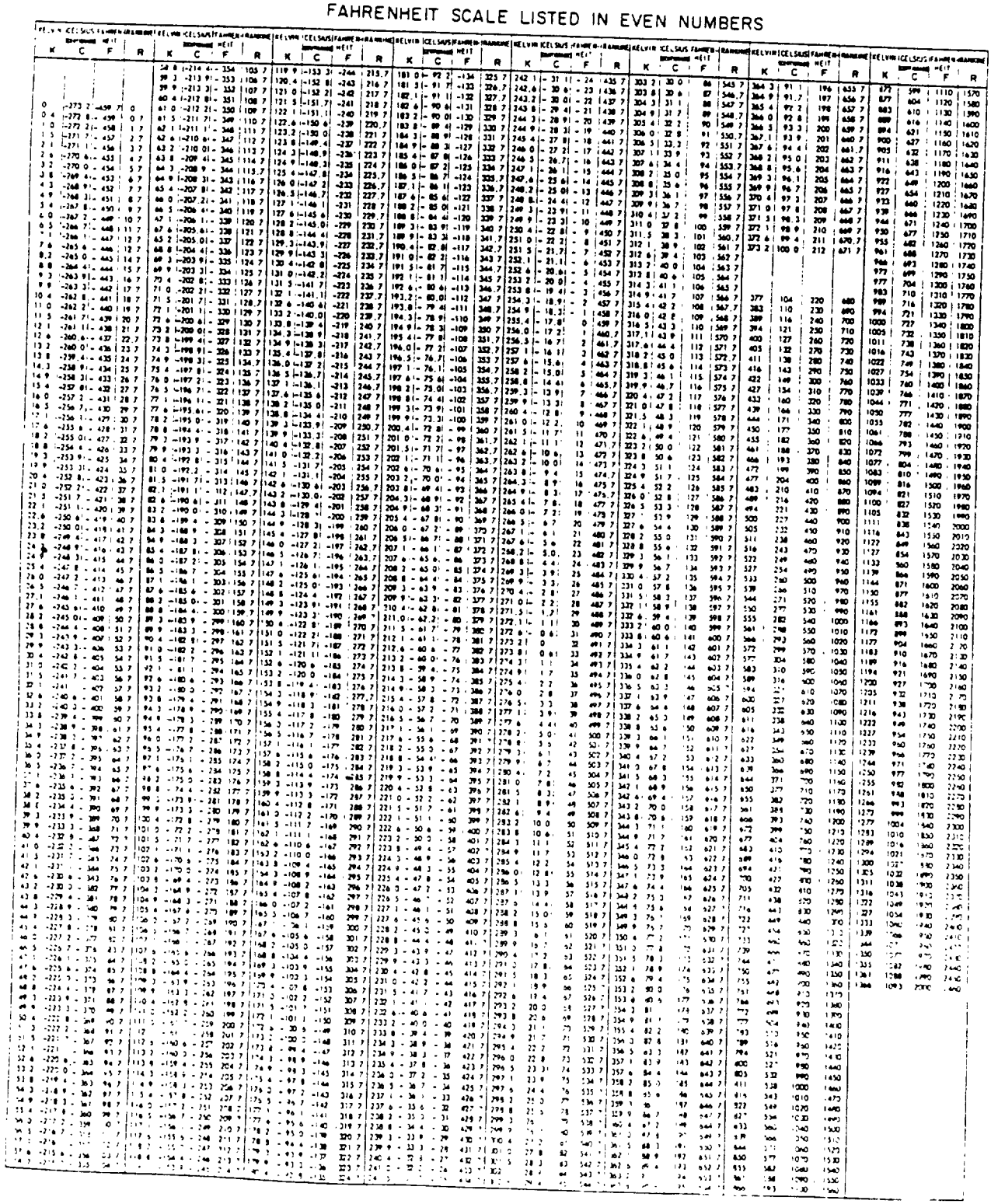
DATA

I. GENERAL

1. Conversion Tables

TEMPERATURE CONVERSION TABLE

FAHRENHEIT SCALE LISTED IN EVEN NUMBERS



DATA

I. GENERAL

2. Thermal Properties of Materials

INCHES OF LINEAR EXPANSION PER 100 FEET

Temperature, Degrees Fahrenheit	"A" Nickel	Monel	Carbon and Low-Alloy Steel	Cast Iron	Wrought Iron	18-8 Stainless Steel	Copper	Brass 70-30 to 85-15	2S and 3S Aluminum	"Hastelloy" Alloy B (Rolled)	"Hastelloy" Alloy C (Cast)	Silicon Bronze (Everdur-1010)	Lead	Temperature, Degrees Fahrenheit
-300	-2.04	-2.28												-300
-280	-1.89	-2.04												-280
-260	-1.78	-1.92												-260
-240	-1.67	-1.80												-240
-220	-1.56	-1.66												-220
-200	-1.44	-1.49	-1.28	-1.06	-1.29	-2.03	-1.96	-2.07	-2.69					-200
-180	-1.32	-1.39	-1.18	-0.98	-1.18	-1.85	-1.78	-1.89	-2.42					-180
-160	-1.19	-1.22	-1.07	-0.89	-1.07	-1.67	-1.61	-1.71	-2.18					-160
-140	-1.03	-1.08	-0.95	-0.79	-0.96	-1.48	-1.43	-1.51	-1.92					-140
-120	-0.89	-0.96	-0.83	-0.69	-0.83	-1.30	-1.24	-1.31	-1.66					-120
-100	-0.72	-0.82	-0.69	-0.59	-0.71	-1.09	-1.04	-1.09	-1.40					-100
- 80	-0.60	-0.66	-0.56	-0.48	-0.57	-0.88	-0.84	-0.89	-1.13					- 80
- 60	-0.46	-0.48	-0.43	-0.37	-0.44	-0.67	-0.63	-0.67	-0.86					- 60
- 40	-0.30	-0.34	-0.29	-0.25	-0.29	-0.45	-0.42	-0.45	-0.58					- 40
- 20	-0.12	-0.18	-0.15	-0.13	-0.15	-0.23	-0.21	-0.23	-0.30					- 20
0	0.	0.	0.	0.	0	0	0	0	0.	0.	0.	0	0	0
20	0.18	0.12	0.15	0.13	0.15	0.22	0.24	0.23	0.30	0.27	0.18	0.23	0.40	20
32	0.24	0.24	0.23	0.21	0.25	0.36	0.37	0.37	0.46	0.35	0.28	0.37	0.61	32
40	0.36	0.30	0.29	0.26	0.31	0.45	0.45	0.47	0.60	0.37	0.35	0.46	0.76	40
60	0.48	0.48	0.45	0.39	0.47	0.67	0.68	0.69	0.90	0.47	0.50	0.69	1.16	60
80	0.65	0.70	0.58	0.52	0.63	0.89	0.89	0.92	1.20	0.57	0.65	0.93	1.55	80
100	0.84	0.85	0.75	0.66	0.79	1.12	1.13	1.15	1.50	0.67	0.80	1.16	1.92	100
120	0.98	1.03	0.91	0.79	0.96	1.34	1.37	1.39	1.81	0.82	1.00	1.39	2.32	120
140	1.20	1.20	1.06	0.92	1.11	1.55	1.59	1.63	2.12	0.92	1.15	1.62	2.70	140
160	1.34	1.37	1.22	1.07	1.28	1.78	1.80	1.87	2.43	1.07	1.35	1.86	3.10	160
180	1.50	1.56	1.38	1.22	1.45	2.00	2.05	2.10	2.76	1.22	1.50	2.09	3.48	180
200	1.68	1.73	1.55	1.37	1.63	2.23	2.29	2.34	3.08	1.37	1.70	2.33	3.86	200
212	1.79	1.74	1.64	1.45	1.72	2.36	2.43	2.47	3.26	1.47	1.80	2.47	4.10	212
220	1.82	1.92	1.71	1.51	1.78	2.46	2.52	2.58	3.40	1.57	1.85	2.56		220
240	2.01	2.11	1.88	1.65	1.96	2.68	2.76	2.83	3.73	1.72	2.00	2.80		240
260	2.17	2.30	2.04	1.80	2.13	2.92	2.99	3.07	4.06	1.87	2.20	3.03		260
280	2.36	2.48	2.21	1.96	2.31	3.13	3.22	3.32	4.42	2.07	2.40	3.26		280
300	2.54	2.65	2.37	2.11	2.48	3.38	3.46	3.57	4.74	2.22	2.55	3.50		300
320	2.76	2.86	2.55	2.27	2.65	3.62	3.69	3.82	5.08	2.37	2.70	3.74		320
340	2.90	3.08	2.72	2.42	2.84	3.84	3.96	4.07	5.43	2.57	2.90	3.97		340
360	3.10	3.26	2.88	2.57	3.02	4.08	4.18	4.32	5.78	2.77	3.05			360
380	3.30	3.48	3.07	2.73	3.19	4.35	4.42	4.56	6.12	2.92	3.25			380
400	3.49	3.68	3.23	2.88	3.37	4.56	4.67	4.83	6.48	3.07	3.40			400
420	3.70	3.86	3.42	3.06	3.57	4.80	4.91	5.08	6.82	3.21	3.60			420
440	3.89	4.08	3.59	3.22	3.75	5.05	5.15	5.34	7.18	3.35	3.80			440
460	4.08	4.32	3.78	3.38	3.94	5.34	5.41	5.60	7.54	3.49	3.95			460
480	4.27	4.51	3.96	3.56	4.13	5.54	5.65	5.93	7.90	3.63	4.15			480
500	4.50	4.73	4.15	3.72	4.33	5.80	5.91	6.12	8.27	3.77	4.30			500
520	4.70	4.93	4.34	3.89	4.53	6.05	6.15	6.38	8.63	3.91	4.50			520
540	4.91	5.16	4.53	4.06	4.71	6.32	6.41	6.65	8.99	4.05	4.70			540
560	5.15	5.39	4.72	4.24	4.91	6.57	6.65	6.92	9.37	4.19	4.85			560
580	5.34	5.62	4.91	4.41	5.12	6.80	6.92	7.17	9.73	4.33	5.05			580
600	5.60	5.86	5.10	4.59	5.30	7.04	7.18	7.44	10.10	4.47	5.20			600
620	5.77	6.05	5.29	4.77	5.51	7.29	7.43	7.72	10.46	4.60	5.40			620
640	6.00	6.28	5.48	4.96	5.69	7.55	7.69	7.98	10.83	4.80	5.60			640
660	6.20	6.50	5.69	5.13	5.92	7.80	7.95	8.24	11.19	4.95	5.75			660
680	6.43	6.73	5.88	5.32	6.11	8.04	8.19	8.52	11.57	5.15	5.95			680
700	6.67	6.98	6.08	5.50	6.33	8.31	8.47	8.78	11.95	5.30	6.15			700
720	6.88	7.20	6.28	5.68	6.52	8.57	8.71	9.05	12.30	5.45	6.35			720
740	7.10	7.44	6.49	5.88	6.75	8.83	8.99	9.32	12.69	5.65	6.50			740
760	7.32	7.68	6.69	6.07	6.95	9.07	9.26	9.60	13.07	5.80	6.70			760
780	7.56	7.92	6.90	6.26	7.16	9.35	9.53	9.87	13.45	6.00	6.90			780
800	7.79	8.16	7.11	6.46	7.36	9.61	9.79	10.15	13.83	6.20	7.10			800
820	8.00	8.39	7.32	6.65	7.61	9.87	10.07	10.43		6.35	7.30			820
840	8.22	8.64	7.52	6.84	7.80	10.14	10.31	10.69		6.50	7.45			840
860	8.47	8.87	7.74	7.05	8.04	10.40	10.61	10.98		6.60	7.65			860
880	8.69	9.10	7.95	7.25	8.25	10.66	10.97	11.25		6.75	7.85			880
900	8.94	9.35	8.17	7.45	8.49	10.93	11.16	11.55		6.90	8.05			900
920	9.12	9.59	8.40	7.67	8.72	11.20	11.42	11.82		7.00	8.25			920
940	9.36	9.80	8.61	7.86	8.94	11.46	11.71	12.12		7.10	8.45			940
960	9.59	10.06	8.83	8.07	9.15	11.73	11.98	12.42		7.20	8.65			960
980	9.84	10.30	9.05	8.28	9.39	11.99	12.27	12.72		7.35	8.85			980
1000	10.10	10.54	9.28	8.49	9.62	12.26	12.54	13.08		7.45	9.05			1000
1050			9.81	9.06	10.25	12.88				7.80	9.55			1050
1100			10.41	9.56	10.85	13.58				8.25	10.05			1100
1150			11.01	10.06	11.45	14.28				8.80	10.60			1150
1200			11.61	10.66	12.05	14.98				9.50	11.10			1200
1250			12.21	11.26	12.65	15.58				10.10	11.65			1250
1300			12.81	11.86	13.25	16.28				10.80	12.20			1300
1350			13.41	12.46	13.95	16.98				11.45	12.75			1350
1400			14.11	13.06	14.55	17.58				12.10	13.35			1400
1450										12.75	13.95			1450
1500										13.40	14.50			1500
1550										14.05	15.15			1550
1600										14.70	15.75			1600
1650										15.40	16.40			1650
1700										16.00	17.00			1700
1750										16.70	17.70			1750
1800										17.30	18.35			1800

NOTE:

Tabulated data is intended primarily for calculating expansion and contraction in piping systems due to temperature changes.

For reference material used in developing this tabulation, refer to development file M-110, Standards Section, Department of Construction and Design.

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DATA

I. GENERAL

2. Thermal Properties of Materials - Continued

RADIATION EMITTANCE TABLE

Metals	Surface Temp °F	Total Normal Emittance
Aluminum		
Highly polished	440-1070	0.039-0.057
Polished	100-1000	0.04-0.06
Rough plate	78	0.055-0.070
Oxidized @ 1110F	390-1110	0.11-0.19
Roofing surface		0.216
Oxide	530-1520	0.63-0.26
Foil	212	0.087
Bismuth	175	0.34
Brass		
Highly polished	497-710	0.03-0.04
Polished	100	0.05
Rolled plate, natural	72	0.06
Rolled, coarse emeried	72	0.20
Oxidized @ 1110F	390-1110	0.61-0.59
Dull plate	120-660	0.22
Chromium		
Polished	100-1000	0.08-0.26
Polished	100-500	0.06-0.08
	Solar	0.50
Copper		
Electrolytic, polished	176	0.02
Commercial plate, polished	66	0.030
Heated @ 1110F	390-1110	0.57-0.57
Thick oxide coating	77	0.78
Cuprous oxide	1470-2010	0.66-0.54
Everdur, dull	200	0.11
Gold		
Highly polished	440-1160	0.02-0.40
Polished	100	0.06

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DATA

I. GENERAL

2. Thermal Properties of Materials - Continued

RADIATION EMITTANCE TABLE - Continued

Metals	Surface Temp °F	Total Normal Emittance
Iron and Steel		
Pure iron, polished	350-1800	0.05-0.37
Wrought iron, polished	100-480	0.28
Cast iron, polished		0.21
Smooth oxidized iron	260-980	0.78-0.82
Strongly oxidized iron	100-480	0.95
Steel polished	100-1000	0.07-0.14
Steel, polished	Solar	0.045
Steel, rolled sheet	70	0.657
Steel, rough plate	100-700	0.94-0.97
Smooth sheet iron	1650-1900	0.55-0.60
Plate steel, rusted	67	0.69
Steel, oxidized	100-1000	0.79-0.79
Lead		
Pure	260-440	0.06-0.08
Gray, oxidized	75	0.28
Oxidized @ 390F	390	0.63
Magnesium		
Polished	100-1000	0.07-0.22
Monel metal		
Washed, abrasive soap	75	0.17
Repeated heating	450-1610	0.46-0.65
Nickel and alloys		
Electrolytic, polished	74	0.05
Electroplated, not polished	68	0.11
Wire	368-1844	0.10-0.19
Oxidized @ 1110F	390-1110	0.37-0.48
Oxide	1200-2290	0.59-0.86
Nickel copper, polished	212	0.06
Nickel silver, polished	212	0.14
Nickelin, gray oxide	70	0.26
Nichrome wire, bright	120-1830	0.65-0.79
Nichrome wire, oxidized	120-930	0.95-0.98
Chrome - nickel		.36 - .97

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DATA

I. GENERAL

2. Thermal Properties of Materials - Continued

RADIATION EMITTANCE TABLE - Continued

Metals	Surface Temp °F	Total Normal Emittance
Platinum, polished	440-2960	0.05-0.17
Silver, pure, polished	440-1160	0.02-0.03
Stainless steels		
Type 316, cleaned	75	0.28
316, repeated heating	450-1600	0.57-0.66
304, 42 hrs @ 980F	420-980	0.62-0.73
310, furnace service	420-980	0.90-0.97
Tin, bright	76	0.04-0.06
Tungsten		
Filament	100-1000	0.03-0.08
Filament	2000-5000	0.19-0.34
Zinc		
Pure, polished	440-620	0.05
Galv. iron, bright	82	0.23
Galv. gray oxidized	75	0.28
Galv. iron, dirty	2500	0.90
Galv. iron, dirty	Solar	0.90
Galv. iron	Solar	0.54

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DATA

I. GENERAL

2. Thermal Properties of Materials - Continued

SURFACE EMITTANCES

Refractories	Surface Temp °F	Total Normal Emittance ε
Alumina Refractory	800	0.45
	1200	0.37
	1600	0.31
	2000	0.28
	2400	0.34
	2700	0.37
AL_2O_3 Bonded Refractory	1500	0.47
Carbon Refractory	1500	0.97
Chrome Refractory	1500	0.97
Fosterlite Refractory	1500	0.95
Fused Castable Refractory	1500	0.51
Graphite Refractory	1500	0.97
Gypsum	100	0.91
Kaolin Insulating Brick	800	0.80
	1200	0.61
	1600	0.49
	2000	0.48
	2400	0.50
	2550	0.59
Magnesium Oxide Refractory 98% MgO	800	0.56
	1200	0.38
	1600	0.33
	2000	0.32
	2400	0.35
Magnesite	1500	0.48

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DATA

I. GENERAL

2. Thermal Properties of Materials - Continued

SURFACE EMITTANCES - Continued

Refractories	Surface Temp °F	Total Normal Emittance ϵ
Mullite, Converted	1500	0.51
Mullite, Synthetic	1500	0.51
Silica Refractory	1500	0.76
Silica, Translucent, 3/16" thick over Kaolin	800	0.98
	1200	0.80
	1600	0.70
	2000	0.68
	2400	0.67
Silicon Carbide Refractory (Crystolon)	1000	0.95
	1200	0.93
	1600	0.92
	2000	0.90
	2400	0.88
Silicon - Nitride Refractory	1500	0.93
Superduty Fireclay Refractory	1500	0.54
Zircon Refractory	1500	0.53
Zirconia Refractory 98% Zirconia	800	0.74
	1200	0.44
	1600	0.33
	2000	0.31
	2400	0.25

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DATA

I. GENERAL

2. Thermal Properties of Materials - Continued

SURFACE EMITTANCES - Continued

Miscellaneous Materials	Surface Temperature °F	Total Normal Emittance ϵ
Aluminum paints	212	0.27-0.67
26% al, 27% lacquer	212	0.3
Asbestos board	100	0.96
Asbestos paper	100-700	0.93-0.95
Asbestos cloth	200	0.90
Asphalt pavement	Solar	0.93
Brick		
Glazed		0.75
Red, rough	Solar	0.70
Silica	2500	0.84
Refractory	200-1000	0.92-0.97
Carbon black	70-700	0.95
Concrete	2500	0.63
Concrete	Solar	0.65
Glass	72	0.937
Gypsum	70	0.903
Ice	32	0.96-0.99
Marble, polished	70	0.931
Mica	200	0.84
Oak, planed	70	0.895
Oil film	68	0.27-0.82
Paint, black	200-600	0.92-0.95
Black	1000	0.97
Black	Solar	0.90
Green	200-600	0.93-0.90
Green	1000	0.80
Green	Solar	0.50
White	200-600	0.92-0.84
White	1000	0.68
White	Solar	0.30
Aluminum	212	0.27-0.67
Oil paint		0.92-0.96
Paper, white	70	0.924-0.944
Paper, black roofing	100	0.95
Porcelain, glazed	70	0.924

DATA

I. GENERAL

2. Thermal Properties of Materials - Continued

SURFACE EMITTANCES - Continued

Miscellaneous Materials	Surface Temperature °F	Total Normal Emittance
Refractories		0.65-0.90
Roofing paper		0.91
Rubber		
Hard, glossy	70	0.945
Soft, rough	76	0.859
Water	70	0.95-0.96
Wood	100	0.83-0.92

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DATA

I. GENERAL

2. Thermal Properties of Materials - Continued

SURFACE EMITTANCES

Oxide Surfaces	Observed Range Of Emittances	Probable Value For Oxide Forms on Smooth Metal
Aluminum Oxide	0.22-0.40	0.30
Beryllium Oxide	0.07-0.37	0.35
Cerium Oxide	0.58-0.80	
Chromium Oxide	0.60-0.80	0.70
Cobalt Oxide		0.75
Columbium Oxide	0.55-0.71	0.70
Copper Oxide	0.60-0.80	0.70
Iron Oxide	0.63-0.98	0.70
Magnesium Oxide	0.10-0.43	0.20
Nickel Oxide	0.85-0.96	0.90
Thorium Oxide	0.20-0.57	0.59
Tin Oxide	0.32-0.60	
Titanium Oxide		0.50
Uranium Oxide		0.39
Vanadium Oxide		0.70
Yttrium Oxide		0.60
Zircunium Oxide	0.18-0.43	0.40
Alumel (Oxidized)		0.87
Cast iron (Oxidized)		0.70
80 Ni 20 Cr (Oxidized)		0.90
60 Ni 24 Fe 16 Cr (Oxidized)		0.83
55 Fe 37.5 Cr 7.5 Al (Oxidized)		0.78
70 Fe 23 Cr 5 Al 2 Co (Oxidized)		0.75
Constantan (SS Co. 45 Ni) Oxidized)		0.84
Carbon Steel (Oxidized)		0.80
Stainless Steel (18-8) (Oxidized)		0.85

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I. GENERAL

2. Thermal Properties of Materials - Continued

SURFACE EMITTANCES

Refractories	Surface Temp °F	Total Normal Emittance ϵ
Alumina Refractory	800	0.45
	1200	0.37
	1600	0.31
	2000	0.28
	2400	0.34
	2700	0.37
$AL_2 0_3$ Bonded Refractory	1500	0.47
Carbon Refractory	1500	0.97
Chrome Refractory	1500	0.97
Fosterlite Refractory	1500	0.95
Fused Castable Refractory	1500	0.51
Graphite Refractory	1500	0.97
Gypsum	100	0.91
Kaolin Insulating Brick	800	0.80
	1200	0.61
	1600	0.49
	2000	0.48
	2400	0.50
	2550	0.59
Magnesium Oxide Refractory 98% Mg 0	800	0.56
	1200	0.38
	1600	0.33
	2000	0.32
	2400	0.35
Magnesite	1500	0.48
Mullite, Converted	1500	0.51
Mullite, Synthetic	1500	0.51
Silica Refractory	1500	0.76
Silica, Translucent, 3/16" thick over Kaolin	800	0.98
	1200	0.80
	1600	0.70
	2000	0.68
	2400	0.67

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DATA

I. GENERAL

2. Thermal Properties of Materials - Continued

SURFACE EMITTANCES - Continued

Refractories	Surface Temp °F	Total Normal Emittance ε
Silicon Carbide Refractory (Crystolon)	1000	0.95
	1200	0.93
	1600	0.92
	2000	0.90
	2400	0.88
Silicon - Nitride Refractory	1500	0.93
Superduty Fireclay Refractory	1500	0.54
Zircon Refractory	1500	0.53
Zirconia Refractory	800	0.74
98% Zirconia	1200	0.44
	1600	0.33
	2000	0.31
	2400	0.25

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DATA

I. GENERAL

2. Thermal Properties of Materials - Continued

RADIATION EMITTANCE TABLE
WEATHER-BARRIERS AND FINISHES
USED ON THER MAL INSULATIONS

Weather-Barrier or Surface Finish	Condition	Emittance (At Surface Temp of Approx. 100F)
Aluminum	Polished	0.03 to 0.06
	Gray-Dull	0.06 to 0.09
	Oxidized	0.10 to 0.12
Aluminum Paint	New	0.20 to 0.30
	After Weathering	0.40 to 0.70
Asbestos Paper	Clean	0.90 to 0.94
Asphalt Asbestos Felts		0.93 to 0.96
Asphalt Mastics		0.90 to 0.95
Galvanized Steel	New - bright	0.06 to 0.10
	Dull	0.20 to 0.30
Paints	White - clean	0.55 to 0.70
	Green - clean	0.65 to 0.80
	Gray - clean	0.80 to 0.90
	Black - clean	0.90 to 0.95
Painted Canvas	Color as painted	Will be approx. the same as for color of paint used
PVA Mastics	White - clean	0.60 to 0.70
	Green - Clean	0.70 to 0.80
	Gray - medium - clean	0.85 to 0.90
	Black	0.85 to 0.95
Roofing Felts		0.90 to 0.95
Stainless Steel	Polished	0.22 to 0.26
	No. 4 mill finish	0.35 to 0.40
	Oxidized	0.80 to 0.85

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DATA

I. GENERAL

2. Thermal Properties of Materials - Continued

SPECIFIC HEATS AND WEIGHTS OF MATERIALS

Material	Temperature °F	Mean Specific Heat	Weight lbs/cu ft
Aluminum		0.215	168
Asbestos	32-212	0.20	150
Bakelite - Phenolic	32-212	0.3-0.4	
Brass, yellow	32-212	0.088	534
Brass, red	32-212	0.09	534
Bronze	32-212	0.014	509-554
Brick	32-212	0.20-0.22	125-143
Carbon	32-212	0.165	139
Chalk	32-212	0.215	143
Charcoal	32-212	0.20	25
Cinders	32-212	0.18	
Coal	32-212	0.24-0.3	81-94
Concrete	32-212	0.156	137
Cork	32-212	0.485	
Coke	32-212	0.203	75
Copper	32-212	0.094	556
Glass	32-212	0.12-0.19	162
Graphite	32-212	0.201	135
Gold		0.031	1205
Granite	32-212	0.195	168
Gypsum	32-212	0.259	155
Humus (soil)	32-212	0.44	76-100
Ice		0.465	56
Ice	32	0.487	64
Iron, cast		0.130	442
Iron, wrought	32-212	0.110	485
Iron, wrought	32-572	0.122	485
Iron, at high temperatures	1382-1832	0.213	485
Lead		0.031	710
Limestone		0.217	155-162

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DATA

I. GENERAL

2. Thermal Properties of Materials - Continued

SPECIFIC HEATS AND WEIGHTS OF MATERIALS - Continued

Material	Temperature °F	Mean Specific Heat	Weight lbs/cu ft
Marble	32-212	0.210	170
Mercury	32-212	0.033	850
Masonry, brick	32-212	0.20-0.22	
Nickel		0.109	537
Oil, machine	0.	0.400	
Porcelain	32-212	0.22	
Quartz	32-212	0.17-0.28	165
Sand	32-212	0.195	100-125
Sandstone	32-212	0.22	143
Silver		0.056	655
Silica		0.191	
Steel, mild		0.116	485
Steel, high carbon		0.117	485
Stone, average		0.200	150
Tin		0.056	459
Water		1.000	62.4
Wood, fir		0.650	25-32
Wood, oak		0.570	42-54
Wood, pine		0.67	27-42
Zinc		0.095	440

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DATA

I. GENERAL

2. Thermal Properties of Materials - Continued

THERMAL CONDUCTIVITY OF MATERIALS

k = Btu in/ hr, sq ft, in, °F

Miscellaneous Solid Materials	Mean Temp °F	k
Asbestos, 36 lb density	200	1.32
Asbestos, wool, 25 lb density	212	0.696
Asbestos paper, 61 lb density	212	1.089
Asbestos millboard, 60 lb density	86	0.84
Ashes, soft wood, 12 lb density	68	0.216
Ashes, volcanic, 51 lb density	300	1.476
Asphalt, 132 lb density	68	5.16
Bricks		
Building	70	5.0
Refractory, average	1000	9.0
Basalt	32-210	8.88-19.32
Carbon black, 12 lb density	133	0.144
Cardboard, corrugated		0.444
Celluloid, 87 lb density	86	1.44
Concrete, sand and gravel 142 lb density	75	12.6
Concrete, cinder 97 lb density	75	4.92
Charcoal, powder, 12 lb density	63	0.348
Cotton wool, 5 lb density	100	0.420
Earth plus 42% water, frozen, 108 lb density	0	7.44
Glass		3.6-7.32
Glass, pyrex, 139 lb density	200	7.08
Glass, soda lime	200	7.08
Gravel, 116 lb density	68	2.64

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DATA

I. GENERAL

2. Thermal Properties of Materials - Continued

THERMAL CONDUCTIVITY OF MATERIALS - Continued
k = Btu in/hr, sq ft, in, °F

Miscellaneous Solid Materials	Mean Temp °F	k
Gypsum plaster, sand aggregate		5.55
Gypsum plaster, light wt aggregate		1.56
Gypsum board, 51 lb density	99	0.744
Ice, 57.5 lb density		15.12
Leather, sole, 62.4 lb density		1.104
Mica, 122 lb density		3.0
Rubber, hard, 74.3 lb density	100	1.104
Rubber, soft, 68 lb density	86	0.96
Sand, dry, 94.8 lb density	68	2.26
Sawdust, dry, 13.4 lb density	68	0.504
Soil, dry	68	0.90
Soil, dry, including stones, 127 lb density	68	3.6
Soil, wet		to 12.0
Snow, 7 to 31 lb density	32	4.08-15.6
Titonium oxide, 52 lb density	1000	0.492
Wool, pure, 5.6 lb density	86	0.252
Wood, average		1.2

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DATA

I. GENERAL

Thermal Properties of Materials - Continued

THERMAL CONDUCTIVITY OF MATERIALS

k = Btu in/hr, sq ft, in, °F

Metals	Mean Temp °F	k
Aluminum	64	1404
	212	1428
	930	1855
Antimony	32	127
	212	116
Bismuth	64	56
	212	47
Brass (20% Cu, 30% Zn)	32	672
	212	720
Bronze		1308
Cadmium	64	644
	212	626
Copper, pure	64	2688
	212	2616
Gold	64	2028
	212	2040
Iron, pure	64	468
	212	439
Iron, wrought	64	419
	212	415
Iron, cast	129	332
	216	322
Lead	64	241
	212	238
Magnesium	32-212	1104
Mercury	32	58
Nickel	64	432

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DATA

I. GENERAL

2. Thermal Properties of Materials - Continued

THERMAL CONDUCTIVITY OF MATERIALS - Continued
k = Btu in/hr, sq ft, in, °F

Metals	Mean Temp °F	k
Platinum	64	482
	212	503
Silver	64	2904
		2856
Sodium	32	384
Steel, 1% carbon content	64	314
	212	311
Steel, mild	212	312
Steel, 13% Cr, 0.2% Ni	932	199
Steel, 18% Cr, 8% Ni	932	149
Steel, 23% Cr, 12% Ni	932	130
Steel Wool, density 6.3 lbs/cu ft	50-212	0.607
Tantalium	64	384
Tin	64	432
Zinc	212	308
	64	780
	212	768

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DATA

I. GENERAL

2. Thermal Properties of Materials - Continued

THERMAL CONDUCTIVITY OF MATERIALS

k = Btu in/hr, sq ft, in, °F

Gases	Mean Temp °F	k
Air	32	0.168
Ammonia	32	0.151
Argon	32	0.110
Carbon dioxide	32	0.101
	212	0.154
Carbon monoxide	32	0.162
Chlorine	32	0.052
Ethane	32	0.127
Ethylene	32	0.121
Helium	32	0.982
Hydrogen	32	1.159
	122	1.488
Methane	32	0.210
Neon	32	0.0307
Nitrogen	32	0.168
Oxygen	32	0.170
Steam	32	0.117

Liquids	Mean Temp °F	k
Acetone	68	1.236
Ammonia	45	3.480
Ethyl alcohol	68	1.260
Methyl alcohol	68	1.488
Petroleum oil (Average)	68	1.00
Sulphur dioxide	68	2.34
Water	68	4.10

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DATA

I. GENERAL

2. Thermal Properties of Materials - Continued

THERMAL CONDUCTIVITY OF MATERIALS

k = Btu in/hr, sq ft, in, °F

Woods, Oven Dried (heat flow across grain)	Density lb/cu ft	Mean Temp °F	k
Aspen	26	85	0.828
Bald cypress	24	85	0.756
Balsa	10	85	0.408
Balsam wool	2.2	90	0.27
Boxwood	56	68	10.45
Basswood	24	85	0.696
Douglas fir	29	85	0.756
Elm rock	48	85	1.164
Elm, soft	34	75	0.88
Fir, white	26	85	0.828
Hemlock	29	85	0.792
Larch, western	36	85	0.936
Maple, sugar	43	85	1.128
Maple, soft	36	75	0.089
Oak, red	42	85	1.188
Pine, southern yellow	35	85	0.936
Pine, white	25	85	0.72
Red cedar, western	21	85	0.636
Redwood	25	85	0.744
Redwood, California	22	75	0.66
Spruce	21	85	0.624

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DATA

I. GENERAL

2. Thermal Properties of Materials - Continued

THERMAL CONDUCTANCES OF AIR SPACES
Btu/hr, sq ft, ° F

MEAN TEMPERATURE ° F	Width of Air Space, Inches						
	0.128	0.250	0.364	0.493	0.713	1.00	1.50
20	2.300	1.370	1.180	1.100	1.040	1.030	1.022
30	2.385	1.425	1.234	1.148	1.080	1.070	1.065
40	2.470	1.480	1.288	1.193	1.125	1.112	1.105
50	2.560	1.535	1.340	1.242	1.168	1.152	1.149
60	2.650	1.590	1.390	1.295	1.210	1.195	1.188
70	2.730	1.648	1.440	1.340	1.250	1.240	1.228
80	2.819	1.702	1.492	1.390	1.295	1.280	1.270
90	2.908	1.757	1.547	1.433	1.340	1.320	1.310
100	2.990	1.813	1.600	1.486	1.380	1.362	1.350
110	3.078	1.870	1.650	1.534	1.425	1.402	1.392
120	3.167	1.928	1.700	1.580	1.467	1.445	1.435
130	3.250	1.980	1.750	1.630	1.510	1.485	1.475
140	3.340	2.035	1.800	1.680	1.550	1.530	1.519
150	3.425	2.090	1.852	1.728	1.592	1.569	1.559

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DATA

1. GENERAL

2. Thermal Properties of Materials - Continued

HEAT UNITS FOR WATER AT VARIOUS TEMPERATURES

Temp., deg.F	Lb. per cu. ft.	B.t.u. per lb.	Temp., deg.F	Lb. per cu. ft.	B.t.u. per lb.	Temp., deg.F	Lb. per cu. ft.	B.t.u. per lb.	Temp., deg.F	Lb. per cu. ft.	B.t.u. per lb.
32	62.41	0.	91	62.10	58.99	150	61.19	117.84	208	59.92	175.98
33	62.41	1.01	92	62.08	59.98	151	61.17	118.85	209	59.90	176.99
34	62.42	2.01	93	62.07	60.98	152	61.15	119.85	210	59.87	177.99
35	62.42	3.02	94	62.06	61.97	153	61.13	120.85	211	59.85	179.00
36	62.42	4.03	95	62.05	62.96	154	61.11	121.85	212	59.82	180.00
37	62.42	5.03	96	62.04	63.96	155	61.09	122.85	214	59.81	182.02
38	62.42	6.04	97	62.02	64.95	156	61.07	123.85	216	59.77	184.03
39	62.42	7.04	98	62.01	56.94	157	61.05	124.85	218	59.70	186.04
40	62.42	8.05	99	62.00	66.94	158	61.03	125.85	220	59.67	188.06
41	62.42	9.05	100	61.99	67.93	159	61.01	126.85	230	59.42	198.15
42	62.42	10.05	101	61.98	68.92	160	60.99	127.85	240	59.17	208.26
43	62.42	11.05	102	61.96	69.92	161	60.97	128.85	250	58.89	218.39
44	62.42	12.05	103	61.95	70.91	162	60.95	129.85	260	58.62	228.55
45	62.42	13.05	104	61.94	71.91	163	60.93	130.85	270	58.34	238.74
46	62.41	14.06	105	61.93	72.91	164	60.91	131.85	280	58.04	248.95
47	62.41	15.06	106	61.91	73.90	165	60.89	132.85	290	57.74	259.20
48	62.41	16.06	107	61.90	74.90	166	60.87	133.85	300	57.41	269.48
49	62.41	17.06	108	61.89	75.90	167	60.85	134.85	310	57.08	279.80
50	62.40	18.06	109	61.87	76.89	168	60.83	135.85	320	56.75	290.17
51	62.40	19.06	110	61.86	77.89	169	60.81	136.85	330	56.40	300.59
52	62.40	20.06	111	61.84	78.89	170	60.79	137.85	340	56.02	311.05
53	62.39	21.06	112	61.83	79.89	171	60.77	138.85	350	55.65	321.55
54	62.39	22.06	113	61.81	80.89	172	60.75	139.85	360	55.25	332.10
55	62.38	23.06	114	61.80	81.89	173	60.73	140.85	370	54.85	342.71
56	62.38	24.05	115	61.78	82.89	174	60.71	141.85	380	54.47	353.39
57	62.38	25.05	116	61.77	83.88	175	60.68	142.86	390	54.05	364.14
58	62.37	26.05	117	61.75	84.88	176	60.66	143.86	400	53.62	374.96
59	62.37	27.05	118	61.74	85.88	177	60.64	144.86	410	53.19	385.86
60	62.36	28.05	119	61.72	86.88	178	60.62	145.86	420	52.74	396.84
61	62.35	29.05	120	61.71	87.88	179	60.60	146.87	430	52.33	407.91
62	62.35	30.05	121	61.69	88.88	180	60.57	147.87	440	51.87	419.07
63	62.34	31.05	122	61.68	89.88	181	60.55	148.87	450	51.28	430.3
64	62.34	32.04	123	61.66	90.88	182	60.53	149.87	460	51.02	441.7
65	62.33	33.04	124	61.64	91.88	183	60.51	150.87	470	50.51	453.2
66	62.32	34.04	125	61.63	92.87	184	60.49	151.87	480	50.00	465.0
67	62.32	35.04	126	61.61	93.87	185	60.46	152.87	490	49.50	477.0
68	62.31	36.03	127	61.60	94.87	186	60.44	153.88	500	48.78	489.1
69	62.30	37.03	128	61.58	95.87	187	60.42	154.88	510	48.31	501.6
70	62.30	38.03	129	61.56	96.86	188	60.40	155.88	520	47.62	514.2
71	62.29	39.03	130	61.55	97.86	189	60.37	156.89	530	46.95	527.0
72	62.28	40.02	131	61.53	98.86	190	60.35	157.89	540	46.30	540.0
73	62.27	41.02	132	61.51	99.86	191	60.33	158.90	550	45.66	553.2
74	62.26	42.02	133	61.50	100.86	192	60.30	159.90	560	44.84	566.7
75	62.25	43.01	134	61.48	101.85	193	60.28	160.90	570	44.05	580.4
76	62.25	44.01	135	61.46	102.85	194	60.26	161.91	580	43.29	594.4
77	62.24	45.01	136	61.44	103.85	195	60.23	162.91	590	42.37	608.7
78	62.23	46.00	137	61.43	104.85	196	60.21	163.92	600	41.49	623.2
79	62.22	47.00	138	61.41	105.84	197	60.19	164.92	610	40.49	638.0
80	62.21	48.00	139	61.39	106.84	198	60.16	165.93	620	39.37	653.4
81	62.20	49.00	140	61.37	107.84	199	60.14	166.93	630	38.31	669.5
82	62.19	50.00	141	61.36	108.84	200	60.11	167.94	640	37.17	686.6
83	62.18	51.00	142	61.34	109.84	201	60.09	168.95	650	35.97	705.2
84	62.17	52.00	143	61.32	110.84	202	60.07	169.95	660	34.48	725.3
85	62.16	53.00	144	61.30	111.84	203	60.04	170.96	670	32.89	747.5
86	62.15	54.00	145	61.28	112.84	204	60.02	171.96	680	31.06	772.6

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DATA

I. GENERAL

3. Psychometric Information

TABLE II

DEW POINT TEMPERATURE °F

DRY BULB TEMP. °F	% RELATIVE HUMIDITY																				
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
5	-35	-30	-25	-21	-17	-14	-12	-10	-8	-6	-5	-4	-2	-1	1	2	3	4	5
10	-31	-25	-20	-16	-13	-10	-7	-5	-3	-2	0	2	3	4	5	7	8	9	10
15	-28	-21	-16	-12	-8	-5	-3	-1	1	3	5	6	8	9	10	12	13	14	15
20	-24	-16	-11	-8	-4	-2	2	4	6	8	10	11	13	14	15	16	18	19	20
25	-20	-15	-8	-4	0	3	6	8	10	12	15	16	18	19	20	21	23	24	25
30	-15	-4	-3	2	5	8	11	13	15	17	20	22	23	24	25	27	28	29	30
35	-12	-5	1	5	9	12	15	18	20	22	24	26	27	28	30	32	33	34	35
40	-7	0	5	9	14	16	19	22	24	26	28	29	31	33	35	36	38	39	40
45	-4	3	9	13	17	20	23	25	28	30	32	34	36	38	39	41	43	44	45
50	-1	7	13	17	21	24	27	30	32	34	37	39	41	42	44	45	47	49	50
55	3	11	16	21	25	28	32	34	37	39	41	43	45	47	49	50	52	53	55
60	6	14	20	25	29	32	35	39	42	44	46	48	50	52	54	55	57	59	60
65	10	18	24	28	33	38	40	43	46	49	51	53	55	57	59	60	62	63	65
70	13	21	28	33	37	41	45	48	50	53	55	57	60	62	64	65	67	68	70
75	17	25	32	37	42	46	49	52	55	57	60	62	64	66	69	70	72	74	75
80	20	29	35	41	46	50	54	57	60	62	65	67	69	72	74	75	77	78	80
85	23	32	40	45	50	54	58	61	64	67	69	72	74	76	78	80	82	83	85
90	27	36	44	49	54	58	62	66	69	72	74	77	79	81	83	85	87	89	90
95	30	40	48	54	59	63	67	70	73	76	79	82	84	86	88	90	91	93	95
100	34	44	52	58	63	68	71	75	78	81	84	86	88	91	92	94	96	98	100
105	38	48	56	62	67	72	76	79	82	85	88	90	93	95	97	99	101	103	105
110	41	52	60	66	71	77	80	84	87	90	92	95	98	100	102	104	106	108	110
115	45	56	64	70	75	80	84	88	91	94	97	100	102	105	107	109	111	113	115
120	48	60	68	74	79	85	88	92	96	99	102	105	107	109	112	114	116	118	120
125	52	63	72	78	84	89	93	97	100	104	107	109	111	114	117	119	121	123	125

Problem: Given a 'Dry-Bulb' temperature of 60F and a relative humidity of 25%. Find the Dew Point Temperature.

Solution: From a 'Dry-Bulb' temperature of 60F in the left column, read across the table to the right. Where this line intersects the column of 25% relative humidity, we read a Dew Point Temperature of 25 F.

DATA

I. GENERAL

3. Psychometric Information - Continued

VAPOR PRESSURES
at 100%Relative Humidity

TEMP.		VAPOR PRESSURE		TEMP.		VAPOR PRESSURE		TEMP.		VAPOR PRESSURE		TEMP.		VAPOR PRESSURE	
°F	°C	In. of Hg.	Lbs./Sq.Ft.	°F	°C	In. of Hg.	Lbs./Sq.Ft.	°F	°C	In. of Hg.	Lbs./Sq.Ft.	°F	°C	In. of Hg.	Lbs./Sq.Ft.
-40	-40	.0029	.2758	32	0.0	.1803	12.752	77	25.0	.9352	66.147	134	56.7	5.03	355.77
-35	-37.2	.0052	.3678	33	0.6	.1878	13.283	78	25.6	.9666	68.367	136	57.8	5.30	374.87
-30	-34.4	.0070	.4951	34	1.1	.1955	13.827	79	26.1	.9989	70.652	138	58.9	5.59	395.38
-25	-31.7	.0094	.6648	35	1.7	.2035	14.393	80	26.7	1.032	72.993	140	60.0	5.88	415.89
-20	-28.9	.0126	.8912	36	2.2	.2218	14.981	81	27.2	1.066	75.398	142	61.1	6.19	437.82
-15	-26.1	.0167	1.181	37	2.8	.2403	15.582	82	27.8	1.102	77.944	144	62.2	6.51	460.45
-10	-23.3	.0220	1.556	38	3.3	.2492	16.211	83	28.3	1.138	80.490	146	63.3	6.85	484.50
-5	-20.6	.0289	2.044	39	3.9	.2383	16.855	84	28.9	1.175	83.108	148	64.4	7.20	509.25
0	-17.8	.0377	2.667	40	4.4	.2478	17.527	86	29.4	1.213	85.795	150	65.6	7.57	535.42
1	-17.2	.0397	2.808	41	5.0	.2576	18.220	86	30.0	1.253	88.625	152	66.7	7.95	562.20
2	-16.7	.0419	2.964	42	5.6	.2677	18.934	87	30.6	1.293	91.454	154	67.8	8.35	590.59
3	-16.1	.0441	3.119	43	6.1	.2782	19.677	88	31.1	1.335	94.452	156	68.9	8.77	620.30
4	-15.6	.0464	3.282	44	6.7	.2891	20.448	89	31.7	1.378	97.466	158	70.0	9.20	650.71
5	-15	.0488	3.452	45	7.2	.3004	21.247	90	32.2	1.422	99.578	160	71.1	9.65	682.54
6	-14.4	.0514	3.636	46	7.8	.3120	22.068	91	32.8	1.467	103.76	162	72.2	10.12	715.78
7	-13.9	.0542	3.869	47	8.3	.3240	22.916	99	33.3	1.513	107.01	164	73.3	10.61	750.44
8	-13.3	.0570	4.032	48	8.9	.3364	23.794	93	33.9	1.561	110.41	166	74.4	11.12	786.52
9	-12.8	.0599	4.237	49	9.4	.3493	24.706	94	34.4	1.610	113.87	168	75.6	11.65	824.00
10	-12.2	.0629	4.449	50	10.0	.3626	25.64	95	35.0	1.660	117.41	170	76.7	12.20	862.90
11	-11.7	.0661	4.675	51	10.6	.3764	26.623	96	35.6	1.712	121.09	172	77.8	12.77	903.22
12	-11.1	.0695	4.916	52	11.1	.3906	27.627	97	36.1	1.765	124.84	174	78.9	13.37	945.66
13	-10.6	.0730	5.163	53	11.7	.4052	28.659	98	36.7	1.819	128.65	176	80.0	13.98	994.41
14	-10.0	.0767	5.425	54	12.2	.4203	29.728	99	37.2	1.875	132.62	178	81.1	14.63	1034.78
15	-9.4	.0806	5.701	55	12.8	.4359	30.831	100	37.8	1.933	136.72	180	82.2	15.29	1081.46
16	-8.9	.0847	5.990	56	13.3	.4520	31.970	101	38.3	1.992	140.89	182	83.3	15.98	1130.26
17	-8.3	.0889	6.288	57	13.9	.4686	33.144	102	38.9	2.052	145.14	184	84.4	16.70	1181.19
18	-7.6	.0933	6.599	58	14.4	.4858	34.360	103	39.4	2.114	149.52	186	85.6	17.44	1233.53
19	-7.2	.0979	6.924	59	15.0	.5035	35.612	104	40.0	2.178	154.05	188	86.7	18.21	1287.99
20	-6.7	.1028	7.271	60	15.6	.5218	36.906	105	40.6	2.24	158.43	190	87.8	19.01	1344.58
21	-6.1	.1078	7.625	61	16.1	.5407	38.244	106	41.1	2.31	163.39	192	88.9	19.84	1403.28
22	-5.6	.1131	7.999	62	16.7	.5601	39.616	1-7	41.7	2.38	168.34	194	90.0	20.70	1464.11
23	-5.0	.1186	8.388	63	17.2	.5802	41.037	108	42.2	2.45	173.29	196	91.1	21.59	1527.06
24	-4.4	.1243	8.792	64	17.8	.6009	42.501	109	42.8	2.52	178.23	198	92.2	22.52	1592.84
25	-3.9	.1303	9.216	65	18.3	.6222	44.008	110	43.3	2.60	183.89	200	93.3	23.47	1660.03
26	-3.3	.1366	9.662	66	18.9	.6422	45.564	112	44.4	2.75	194.51	202	94.4	24.46	1730.06
27	-2.8	.1432	10.128	67	19.4	.6669	47.169	114	45.6	2.91	205.82	204	95.6	25.48	1802.20
28	-2.2	.1500	10.609	68	20.0	.6903	48.825	116	46.7	3.08	217.85	206	96.7	26.53	1876.47
29	-1.7	.1571	11.112	69	20.6	.7144	50.529	1.8	47.8	3.26	230.58	208	97.8	27.63	1954.27
30	-1.1	.1645	11.635	70	21.1	.7392	52.283	120	48.9	3.45	244.02	210	98.9	28.76	2034.19
31	-0.6	.1723	12.186	71	21.7	.7648	54.044	122	50.0	3.64	257.45	212	100.0	29.92	2116.24
32	0.0	.1803	12.752	72	22.2	.7912	55.961	124	51.1	3.85	272.31	214	101.1	31.13	2201.82
				73	22.8	.8183	57.878	126	52.2	4.06	287.16	216	102.2	32.38	2290.24
				74	23.3	.8462	59.311	128	53.5	4.29	303.43	218	103.3	33.66	2380.77
				75	23.9	.8750	61.889	130	54.4	4.53	320.41	220	104.4	34.90	2414.48
				76	24.4	.9064	63.892	132	55.6	4.77	337.38				

DATA

I. GENERAL

3. Psychrometric Information

PERCENT RELATIVE HUMIDITY ABOVE WHICH CONDENSATION WILL OCCUR ON SURFACE OF EQUIPMENT OR PIPE NOT INSULATED

EQUIP. OR PIPE TEMP. F	AMBIENT AIR TEMPERATURE ° F												
	40	45	50	55	60	65	70	75	80	85	90	95	100
35	82	68	57	48	39	33	28	24	20	17	15	13	11
40		82	68	57	48	40	33	28	24	20	17	15	14
45			82	69	57	48	41	34	29	25	21	18	16
50				82	69	57	49	41	35	30	26	22	19
55					83	70	59	50	42	36	31	27	23
60						84	70	60	51	43	37	32	27
65							84	71	60	52	44	38	33
70								84	71	61	52	45	38
75									84	72	62	53	46
80										85	73	63	54
85											85	73	63
90												86	74
95													86

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DATA

I. GENERAL

4. Vapor Permeability of Materials

WATER VAPOR PERMEABILITY TABLE
MISCELLANEOUS MATERIALS

MATERIAL	PERMEABILITY, perms
Aluminum foil, 0.0025 inch thickness	0.005 to 0.01
Aluminum foil, 0.001 inch thickness	0.01 to 0.05
Aluminum foil, cloth backed	0.004
Aluminum tape, paper backed	0.006
Asphalt-saturated 15 lb felt, coated with 25 lb asphalt per 100 sq. ft.	0.05
Calcium-silicate insulation, one inch thickness	21 to 35
Cellular glass insulation, one-half inch thickness	0.00005
Cork, one inch thickness	3 to 7
Duplex laminated kraft paper (30-30-30)	0.20
Duplex laminated kraft paper, reinforced	0.70
Fiberboard, 3/4 inch thickness	12.5
Foil-faced kraft paper	0.01
Foil-faced reflective insulation, double faced	0.08 to 0.13
Friction tape, single layer	2.34
double layer	1.45
Gypsum lath, metallic aluminum backing	0.09 to 0.39
Laminated paper and foil	0.01
Mineral wool, unprotected, 4 inch thickness	29.07
Plaster, fiberboard or gypsum lath	19.7 to 20.6
Plywood, 2 coats aluminum paint	1.29
Plywood, 2 coats asphalt paint	0.43
Polyethylene, 0.004 inch thickness	0.10
Polyethylene, 0.03 inch thickness	0.002
Roll roofing, smooth 40-65 lb per 108 sq. ft.	0.13 to 0.17
Sheating paper, asphalt-impregnated, glossy	0.17 to 2.05
Vinyl membrane, 0.004 inch thickness	0.80 to 2.0

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DATA

I. GENERAL

4. Vapor Permeability of Materials

TABLE I -- PERMEANCE OF BUILDING MATERIALS

	Thick-ness Inches	Perme-ability Perm, in.	Permeance Perms
MEMBRANE TYPE MATERIALS			
Built-up roofing, tar and gravel	3/8	-	0.43
Roofing felt, 2 ply, 30 lb. asphalt saturated	-	-	0.14
Building paper, single thickness	-	-	49.0
Building felts			
Asphalt saturated asbestos			
15 lb.	-	-	13.1
20 lb., one surface asphalt coated	-	-	0.16
50 lb., saturated, not coated	-	-	0.38
Asphalt saturated rag			
10 lb.	-	-	0.9
15 lb.	-	-	3.0
20 lb.	-	-	0.5
25 lb.	-	-	30.0
30 lb.	-	-	0.6
Johns Manville, 30 lb.			
one sheet	-	-	1.79
two sheets	-	-	1.16
three sheets	-	-	0.92
Regal, one surface coated, 20 lb.	-	-	0.21
Super-Regal, coated one surface, 25 lb.	-	-	0.29
Superite sheathing coated both surfaces			
Light	-	-	0.14
Heavy	-	-	0.91
Light, coated both surfaces, 15 lb.	-	-	0.17
Super, coated both surfaces, 18 lb.	-	-	0.06
Base felt, coated both surfaces, 42 lb.	-	-	0.08
Coated one surface	-	-	0.15
Carpet felt, 17 oz.	-	-	167.0
Tar saturated asbestos, 15 lb.	-	-	1.68
Tar saturated rag, 12.5 lb. (7 oz.)	-	-	28
13 lb. (10 oz.)	-	-	38
25 lb. (16 oz.)	-	-	34
Paper			
Asbestos, 14 lb.	0.28	-	138.0
Asphalt Coated Kraft (not saturated)			
Heavy, 4.8 lb.	0.013	-	0.41-0.742
Asphalt Saturated and Coated Kraft, 9 lb.	0.013	-	0.19
	0.018		0.49
Asphalt Saturated Sheathing			
No. 2, 6.25 lb.	0.015	-	0.14-16.2
	0.017		
Renown, 6.25 lb.	0.017	-	4.18
Kraft, 6.25 lb.	0.015	-	1.54

	Thick-ness Inches	Perme-ability Perm, in.	Permeance Perms
COATING MATERIALS			
Bituplastic, no primer	1/16	-	0.32
1 coat of primer	1/16	-	0.26
2 coats of primer	1/16	-	0.63
Kopper's coating, "F-73," no primer	1/16	-	0.62
1 coat of primer	1/16	-	0.14
2 coats of primer	1/16	-	0.98
"Lumino," 3 coats and 2 coats of primer	*	-	7.10
I.P.C., no primer	1/16	-	12.50
Flinkote No. 20, no primer	1/16	-	0.69
1 coat of primer	1/16	-	0.29
2 coats of primer	1/16	-	0.69
Flinkote -- C-13-H.P.C., no primer	1/16	-	0.27
1 coat of primer	1/16	-	0.56
2 coats of primer	1/16	-	0.49
Robertson No. 460, 3 coats, no primer	*	-	7.30
Robertson No. 455, no primer	1/32	-	0.66
1 coat of primer	1/32	-	0.57
2 coats of primer	1/32	-	0.61
J. M. Asbestile, no primer	1/16	-	0.29
1 coat of primer	1/16	-	1.09
2 coats of primer	1/16	-	0.91
J. M. Airlite, no primer	1/16	-	0.14
1 coat of primer	1/16	-	0.30
2 coats of primer	1/16	-	0.39
Paraffine Aluminum No. 6507, 3 coats, no primer	*	-	0.75
3 coats, 1 coat of primer	*	-	1.15
Protek -- Coal, no primer	1/16	-	0.35
1 coat of primer	1/16	-	0.14
2 coats of primer	1/16	-	0.29
Ceraseal, 2 coats, no primer	*	-	2.90
1 coat of primer	*	-	1.73
Bituplastic No. 50, no primer	1/16	-	5.70
1 coat of primer	1/16	-	2.94
2 coats of primer	1/16	-	0.63
Wm. L. Crow pitch marked			
'before heating,' no primer	1/16	-	1.07
'after heating,' no primer	1/16	-	0.45
Uncoated discs of cinder blocks	-	-	22.30
Coatings on 1 in. Corkboard			
Two coats of plastic emulsion	1/4	-	0.73
ditto with two coats of Aluminum Cold Storage Paint	-	-	0.17

DATA

I. GENERAL

4. Vapor Permeability of Materials - Continued

ditto with one coat Asphalt Covering					
Paint	0.004	-	-	-	
ditto with one coat white Cold Storage Sealer Enamel	-	-	-	-	0.46
Two coats Weatherproof plastic	-	-	1/8	-	0.11
Two coats S. P. Emulsion	-	-	1/4	-	0.43
ditto with two coats Aluminum Cold Storage Paint	0.003-	0.106-	-	-	0.36
ditto with one coat White Cold Storage Sealer Enamel	0.004	1.19	-	-	0.13
	0.005-	0.15-			
	0.006	0.36			
* Brush application, soaked into cinder block disc, leaving thin coating.	0.007	0.545-4.9			
PAINT TYPE MATERIALS					
Aluminum 1 coat on pine	-	-	-	-	3.5
2 coats on pine	-	-	-	-	0.53
Enamel 1 coat on pine	-	-	-	-	4.5
2 coats on pine	-	-	-	-	13.0
Paint films only					
Aluminum Bronze (Bronzing liquid vehicle)	-	-	-	-	-
on plaster, two coats	-	-	-	-	3.52
on plaster, three coats	-	-	-	-	1.57
Aluminum paint (varnish vehicle)					
on Celotex, insulating lath, one coat	-	-	-	-	8.95
on Celotex insulating lath, two coats	-	-	-	-	0.359
on Homosote, one coat	-	-	-	-	32.8
on Homosote, two coats	-	-	-	-	
on Pine, one coat	-	-	-	-	3.52
on Pine, two coats	-	-	-	-	0.526
on Pine, three coats	-	-	-	-	0.394
on Plaster, two coats	-	-	-	-	1.76
on Plaster, three coats	-	-	-	-	0.910
Asphalt					
on Concrete, two coats	-	-	-	-	14.5
Enamel, white (Varnish vehicle)					
on Pine, one coat	-	-	-	-	4.47
on Pine, two coats	-	-	-	-	1.25
on Pine, three coats	-	-	-	-	0.910
on Plaster, two coats	-	-	-	-	1.36
on Plaster, three coats	-	-	-	-	1.06
Flat white					
on Cedar, three coats	-	-	-	-	2.29
on Plywood, two coats	-	-	-	-	4.17
Flat Interior, white (Linseed Rosin vehicle)					
on Plaster, two coats	-	-	-	-	2.56
on Plaster, three coats	-	-	-	-	1.79

Kraft					
1 sheet	0.004	-	78.50		
2 sheets	-	-	49.80		
3 sheets	-	-	37.4		
4 sheets	-	-	29.6		
5 sheets	-	-	25.0-30.4		
7 sheets	-	-	17.8-21.2		
8 sheets	-	-	15.4-17.8		
Kraft (Waxed)					
Light, 2 lb.	0.003-	-	0.106-		
	0.004		1.19		
Medium, 2.8 lb.	0.005-	-	0.15-		
	0.006		0.36		
Heavy, 4 lb.	0.007	-	0.545-4.9		
Kraft (Asphalt infused)					
Waxed, ribbed, one surface infused	0.006	-	0.516		
Waxed, ribbed, one surface infused	0.007	-	0.516		
Waxed, one surface infused	0.008	-	0.44		
Unwaxed, one surface infused	0.005	-	0.815		
Red Rosin Sheathing					
Plain	-	-	60.50		
Roofing					
Base Sheet, 39 lb.	0.076	-	0.35		
Cap Sheet, 39 lb.	0.080	-	0.074		
Janus, medium, 42 lb.	0.066	-	0.074		
Janus, light, 32 lb.	0.052	-	0.089		
Janus, heavy, 51 lb.	0.073	-	0.059		
Janus, extra heavy, 60 lb.	0.105	-	0.089		
Janus, super heavy, 69 lb.	0.115	-	0.03		
Talisman, medium, 42 lb.	0.073	-	0.059		
Talisman, heavy, 51 lb.	0.088	-	0.059		
Talisman, extra heavy, 60 lb.	0.109	-	0.14		
Talisman, super heavy, 69 lb.	0.126	-	0.11		
Tar Saturated Sheathing					
No. 2, 6.25 lb.	0.016-	-	9.93-		
	0.018	-	22.7		
11 lb.	0.032-	-	12.6-		
	0.040		18.6		
12.5 lb.	0.031	-	25.0		
Waxed					
Light, 4 lb.	0.004	-	0.13-1.12		
Medium, 4.8 lb.	0.005-	-	0.41-2.72		
	0.006				
Heavy, 4 lb.	0.007-	-	1.33-3.27		
	0.008				

DATA

I. GENERAL

4. Vapor Permeability of Materials - Continued

Flat Interior, white (Rosin Perrilla Oil vehicle)										
on Plaster, two coats	-	-	1.17							
on Plaster, three coats	-	-	1.22							
Interior-Exterior Paint (Linseed vehicle)										
on Plaster, two coats	-	-	3.44							
on Plaster,	-	-	1.15							
Seal Coat, white (Varnish vehicle)										
on Plaster, two coats	-	-	1.85							
on Plaster, three coats	-	-	1.13							
Semi-gloss Interior, white (Lins. Tung vehicle)										
on Plaster, two coats	-	-	2.47							
on Plaster, three coats	-	-	1.75							
MANUFACTURED BOARDS										
Fiberboard										
Plain	1.06	-	18.7							
Plain	0.83	-	21.3							
Plain	0.599	-	27.7							
Plain	0.492	-	29.8							
Plain	0.405	-	36.6							
Plain	0.201	-	65.50							
Dipped asphalt one surface	0.633	-	8.50							
Roller asphalt one surface	0.492									
Two ½ in. samples joined with asphalt	0.985	-	1.35							
Laminated, 6 layers fiberboard, 5 of asphalt	0.527	-	0.114							
Insulating Sheathing	25/32	-	16.7							
Celotex insulating lath	0.50	-	28.6							
with one coat aluminum paint	0.50	-	6.83							
with two coats aluminum paint	0.50	-	0.35							
Celotex vapor seal sheathing	0.78	-	1.96							
Homasote	0.50	-	1.91							
with one coat aluminum paint	0.50	-	1.21							
with two coats aluminum paint	0.50	-	0.0							
John-Manville rock cork	0.523	-	2.96							
	0.984	-	2.43							
	2.001	-	2.01							
John-Manville Flexboard	0.125	-	5.80							
Nu-wood	0.50	-	42.4							
Pressed cork board	0.905-0.985	-	2.33-2.66							
Masonite										
Presdwood (Tempered)	0.13	-	4.80							
Presdwood	1.13	-	10.7							
5 thicknesses	"	-	3.07							
7 thicknesses	"	-	2.36							
Plasterboard										
Plaster between paper	0.37	-	34.6							
Plywood										
Douglas Fir (G25)	0.25	-	3.68-4.46							
with two coats white lead paint	0.375	-	4.52							
	0.25	-	1.95							
INSULATION										
Bats, enclosed both sides	-	-	123							
Cane fibreboard	-	-	9.5							
Foamglas	-	-	0.0							
Sawdust, dry	-	-	62.0							
Rockwool	1.0	-	25.5-230.0							
MASONRY										
Clay tile, 4 in. Hollow	-	-	4.3							
Clay tile, 4 in. Hollow, glazed face	-	-	2.0							
Clay tile, 8 in. Hollow	-	-	2.9							
Tile and Terrazo for floors	-	2.0	-							
Metal lath and 3/4 in. plaster	-	-	14.0							
Brick, select hard common	-	4.5	-							
Concrete, light weight aggregate	-	4.9	-							
Concrete, sand and gravel aggregate	-	2.6	-							
Two coats Portland Cement Mortar	1/2	-	3.8							
MISCELLANEOUS										
Plaster										
1/2 in. on metal lath	-	-	16.5							
3/4 in. on metal lath	-	-	13.5							
1 in. on metal lath	-	-	11.1							
1/2 in. on wood lath	-	-	6.75							
1/2 in. on 3/8 in. gypsum board	-	-	11.3							
1/2 in. on 1/2 in. wood fiber board	-	-	16.4							
Solid plaster, 1.34 in.	-	1.78	13.3							
Wood, Pine, yellow, unpainted	-	0.80	-							
Maple, unpainted	-	0.62	-							
Wood, Spruce, unpainted	-	0.86	-							
Maple, unpainted	-	0.62	-							
Wood, Spruce, unpainted	-	0.86	-							
Cedar, siding, unpainted	-	-	1.82							
Cedar, with 3 coats white lead paint	-	-	1.01							
Still air	-	126.0	-							
Ground cornstalks	2.0	-	42.0							
Hole (1/16 in.) in sheet metal	-	-	0.42							
Metal, sheets	-	-	0.0							
Water surface, free standing	-	-	608.5							
Air film any position, any velocity	-	-	Infinite							
Glass block	-	0	0							
Window glass	-	0	0							

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DATA

I. GENERAL

4. Vapor Permeability of Materials - Continued

REGAIN OF HYGROSCOPIC MATERIALS

MOISTURE CONTENT EXPRESSED IN PER CENT OF DRY WEIGHT OF THE SUBSTANCE AT VARIOUS RELATIVE HUMIDITIES-TEMPERATURE, 75F

Classification	Material	Description	Relative Humidity - Per cent									Authority
			10	20	30	40	50	60	70	80	90	
Natural Textile Fibers	Cotton	Sea island-roving	2.5	3.7	4.6	5.5	6.6	7.9	9.5	11.5	14.1	Hartshorne
	Cotton	American-cloth	2.6	3.7	4.4	5.2	5.9	6.8	8.1	10.0	14.3	Schloesing
	Cotton	Absorbent	4.8	9.0	12.5	15.7	18.5	20.8	22.8	24.3	25.8	Fuwa
	Wool	Australian merino-skein	4.7	7.0	8.9	10.8	12.8	14.9	17.2	19.9	23.4	Hartshorne
	Silk	Raw chevennes-skein	3.2	5.5	6.9	8.0	8.9	10.2	11.9	14.3	18.8	Schloesing
	Linen	Table cloth	1.9	2.9	3.6	4.3	5.1	6.1	7.0	8.4	10.2	Atkinson
	Linen	Dry spun-yarn	3.6	5.4	6.5	7.3	8.1	8.9	9.8	11.2	13.8	Sommer
	Jute	Average of several grades	3.1	5.2	6.9	8.5	10.2	12.2	14.4	17.1	20.2	Storch
	Hemp	Manilla and sisal-rope	2.7	4.7	6.0	7.2	8.5	9.9	11.6	13.6	15.7	Fuwa
Rayons	Viscose Nitrocellulose Cuprammonium	Average skein	4.0	5.7	6.8	7.9	9.2	10.8	12.4	14.2	16.0	Robertson
	Cellulose Acetate	Fiber	0.8	1.1	1.4	1.9	2.4	3.0	3.6	4.3	5.3	Robertson
Paper	M. F. Newspring	Wood pump -- 24% ash	2.1	3.2	4.0	4.7	5.3	6.1	7.2	8.7	10.6	U.S.B. of S.
	H.M.F. Writing	Wood pump -- 3% ash	3.0	4.2	5.2	6.2	7.2	8.3	9.9	11.9	14.2	U.S.B. of S.
	White Bond	Rag -- 12 ash	2.4	3.7	4.7	5.5	6.5	7.5	8.8	10.8	13.2	U.S.B. of S.
	Com. Ledger	75% rag -- 1% ash	3.2	4.2	5.0	5.6	6.2	6.9	8.1	10.3	13.9	U.S.B. of S.
	Kraft Wrapping	Coniferous	3.2	4.6	5.7	6.6	7.6	8.9	10.5	12.6	14.9	U.S.B. of S.
Misc. Organic Materials	Leather	Sole oak -- tanned	5.0	8.5	11.2	13.6	16.0	18.3	20.6	24.0	29.2	Phelps
	Catgut	Racquet strings	4.6	7.2	8.6	10.2	12.0	14.3	17.3	19.8	21.7	Fuwa
	Glue	Hide	3.4	4.8	5.8	6.6	7.6	9.0	10.7	11.8	12.5	Fuwa
	Rubber	Solid tires	0.11	0.21	0.32	0.44	0.54	0.66	0.76	0.88	0.94	Fuwa
	Wood	Timber (average)	3.0	4.4	5.9	7.6	9.3	11.3	14.0	17.5	22.0	Forest P. Lab.
	Soap	White	1.9	3.8	5.7	7.6	10.0	12.9	16.1	19.8	23.8	Fuwa
	Tobacco	Cigarette	5.4	8.6	11.0	13.3	16.0	19.5	25.0	33.5	50.0	Ford
Food-stuffs	White Bread		0.5	1.7	3.1	4.5	6.2	8.5	11.1	14.5	19.0	Atkinson
	Crackers		2.1	2.8	3.3	3.9	5.0	6.5	8.3	10.9	14.9	Atkinson
	Macroni		5.1	7.4	8.8	10.2	11.7	13.7	16.2	19.0	22.1	Atkinson
	Flour		2.6	4.1	5.3	6.5	8.0	9.9	12.4	15.4	19.1	Bailey
	Starch		2.2	3.8	5.2	6.4	7.4	8.3	9.2	10.6	12.7	Atkinson
	Gelatin		0.7	1.6	2.8	3.8	4.9	6.1	7.6	9.3	11.4	Atkinson
Misc. Inorganic Materials	Asbestos Fiber	Finely Divided	0.16	0.24	0.26	0.32	0.41	0.51	0.62	0.73	0.84	Fuwa
	Silica Gel		5.7	9.8	12.7	15.2	17.2	18.8	20.2	21.5	22.6	Fuwa
	Domestic Coke		0.20	0.40	0.61	0.81	1.03	1.24	1.46	1.67	1.89	Selvig
	Activated Charcoal	Steam activated	7.1	14.3	22.8	26.2	28.3	29.2	30.0	31.1	32.7	Fuwa
	Sulfuric Acid	H_2SO_4	33.0	41.0	47.5	52.5	57.0	61.5	67.0	73.5	82.5	Mason

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DATA

I. GENERAL

5. Pipe and Tube Insulation Dimensions

OUTSIDE DIAMETERS AND AVERAGE THICKNESSES FOR PIPE INSULATION
ASTM Recommended Practice

NPS Pipe		Insulation Thickness							
		1/2 Nominal		1" Nominal		1½" Nominal		2" Nominal	
NOM SIZE	O.D. Inches	Avg. Thk. Inches	O.D. Inches	Avg. Thk. Inches	O.D. Inches	Avg. Thk. Inches	O.D. Inches	Avg. Thk. Inches	O.D. Inches
1/8	0.405	0.45	1.315	0.98	2.375	1.54	3.500	2.05	4.500
1/4	0.540	0.55	1.660	1.16	2.875	1.72	4.000	2.22	5.000
3/8	0.675	0.49	1.660	1.09	2.875	1.66	4.000	2.16	5.000
1/2	0.840	0.52	1.900	1.00	2.875	1.57	4.000	2.07	5.000
3/4	1.050	0.42	1.900	0.91	2.875	1.47	4.000	1.97	5.000
1	1.315	0.52	2.375	1.09	3.500	1.59	4.500	2.12	5.563
1¼	1.660	0.60	2.875	0.91	3.500	1.66	5.000	1.94	5.563
1½	1.900	0.48	2.875	1.04	4.000	1.54	5.000	2.36	6.625
2	2.375	0.55	3.500	1.05	4.500	1.58	5.563	2.11	6.625
2½	2.875	0.55	4.00	1.05	5.000	1.86	6.625	2.36	7.625
3	3.500	0.49	4.500	1.02	5.563	1.55	6.625	2.05	7.625
3½	4.000	0.49	5.000	1.30	6.625	1.80	7.625	2.30	8.625
4	4.500	0.54	5.563	1.05	6.625	1.55	7.625	2.05	8.625
4½	5.000	0.80	6.625	1.30	7.625	1.80	8.625	2.30	9.625
5	5.563	0.49	6.625	0.99	7.625	1.49	8.625	1.99	9.625
6	6.625	0.46	7.625	0.96	8.625	1.46	9.625	2.02	10.750
7	7.625					1.52	10.750	2.02	11.750
8	8.625					1.52	11.750	2.02	12.750
9	9.625					1.52	12.750	2.15	14.000
10	10.750					1.59	14.00	2.09	15.000
11	11.750					1.59	15.000	2.09	16.000
12	12.750					1.58	16.000	2.08	17.000
14	14.000					1.45	17.00	1.95	18.000
15	15.000					1.45	18.00	1.95	19.000
16	16.000					1.45	19.000	1.95	20.000
17	17.000					1.45	20.000	1.95	21.000
18	18.000					1.45	21.000	1.95	22.000
19	19.000					1.45	22.000	1.95	23.000
20	20.000					1.45	23.000	1.95	24.000
21	21.000					1.45	24.000	1.95	25.000
22	22.000					1.45	25.000	1.95	26.000
23	23.000					1.45	26.000	1.95	27.000
24	24.000					1.45	27.000	1.95	28.000
25	25.000					1.45	28.000	1.95	29.000
26	26.000					1.45	29.000	1.95	30.000
27	27.000					1.45	30.000	1.95	31.000
28	28.000					1.45	31.000	1.95	32.000
29	29.000					1.45	32.000	1.95	33.000
30	30.000					1.45	33.000	1.95	34.000
31	31.000					1.45	34.000	1.95	35.000
32	32.000					1.45	35.000	1.95	36.000
33	33.000					1.45	36.000	1.95	37.000
34	34.000					1.45	37.000	1.95	38.000
35	35.000					1.45	38.000	1.95	39.000
36	36.000					1.45	39.000	1.95	40.000

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DATA

I. GENERAL

5. Pipe and Tube Insulation Dimensions - Continued

OUTSIDE DIAMETERS AND AVERAGE THICKNESSES FOR PIPE INSULATION
ASTM Recommended Practice

NPS Pipe		Insulation Thickness							
		2½" Nominal		3" Nominal		3½" Nominal		4" Nominal	
NOM SIZE	O.D. Inches	Avg. Thk. Inches	O.D. Inches	Avg. Thk. Inches	O.D. Inches	Avg. Thk. Inches	O.D. Inches	Avg. Thk. Inches	O.D. Inches
1/8	0.405	2.57	5.563	3.10	6.625	3.60	7.625	4.10	8.625
1/4	0.540	2.50	5.563	3.04	6.625	3.54	7.625	4.04	8.625
3/8	0.675	2.44	5.563	2.97	6.625	3.47	7.625	3.97	8.625
1/2	0.840	2.89	6.625	3.39	7.625	3.89	8.625	4.39	9.625
3/4	1.050	2.78	6.625	3.28	7.625	3.78	8.625	4.28	9.625
1	1.315	2.64	6.625	3.15	7.625	3.65	8.625	4.15	9.625
1¼	1.660	2.48	6.625	2.98	7.625	3.48	8.625	3.98	9.625
1½	1.900	2.86	7.625	3.36	8.625	3.86	9.625	4.42	10.750
2	2.375	2.61	7.625	3.11	8.625	3.61	9.625	4.17	10.750
2½	2.875	2.86	8.625	3.36	9.625	3.92	10.750	4.42	11.750
3	3.500	2.55	8.625	3.05	9.625	3.61	10.750	4.11	11.750
3½	4.000	2.80	9.625	3.36	10.750	3.86	11.750	4.36	12.750
4	4.500	2.55	9.625	3.11	10.750	3.61	11.750	4.11	12.750
4½	5.000	2.86	10.750	3.36	11.750	3.86	12.750	4.49	14.000
5	5.563	2.56	10.750	3.06	11.750	3.56	12.750	4.18	14.000
6	6.625	2.52	11.750	3.02	12.750	3.65	14.000	4.15	15.000
7	7.625	2.52	12.750	3.15	14.000	3.65	15.000	4.15	16.000
8	8.625	2.65	14.000	3.15	15.000	3.65	16.000	4.15	17.000
9	9.625	2.65	15.000	3.15	16.000	3.65	17.000	4.15	18.000
10	10.750	2.59	16.000	3.09	17.000	3.59	18.000	4.09	19.000
11	11.750	2.59	17.000	3.09	18.000	3.59	19.000	4.09	20.000
12	12.750	2.58	18.000	3.08	19.000	3.58	20.000	4.08	21.000
14	14.000	2.45	19.000	2.95	20.000	3.45	21.000	3.95	22.000
15	15.000	2.45	20.000	2.95	21.000	3.45	22.000	3.95	23.000
16	16.000	2.45	21.000	2.95	22.000	3.45	23.000	3.95	24.000
17	17.000	2.45	22.000	2.95	23.000	3.45	24.000	3.95	25.000
18	18.000	2.45	23.000	2.95	24.000	3.45	25.000	3.95	26.000
19	19.000	2.45	24.000	2.95	25.000	3.45	26.000	3.95	27.000
20	20.000	2.45	25.000	2.95	26.000	3.45	27.000	3.95	28.000
21	21.000	2.45	26.000	2.95	27.000	3.45	28.000	3.95	29.000
22	22.000	2.45	27.000	2.95	28.000	3.45	29.000	3.95	30.000
23	23.000	2.45	28.000	2.95	29.000	3.45	30.000	3.95	31.000
24	24.000	2.45	29.000	2.95	30.000	3.45	31.000	3.95	32.000
25	25.000	2.45	30.000	2.95	31.000	3.45	32.000	3.95	33.000
26	26.000	2.45	31.000	2.95	32.000	3.45	33.000	3.95	34.000
27	27.000	2.45	32.000	2.95	33.000	3.45	34.000	3.95	35.000
28	28.000	2.45	33.000	2.95	34.000	3.45	35.000	3.95	36.000
29	29.000	2.45	34.000	2.95	35.000	3.45	36.000	3.95	37.000
30	30.000	2.45	35.000	2.95	36.000	3.45	37.000	3.95	38.000
31	31.000	2.45	36.000	2.95	37.000	3.45	38.000	3.95	39.000
32	32.000	2.45	37.000	2.95	38.000	3.45	39.000	3.95	40.000
33	33.000	2.45	38.000	2.95	39.000	3.45	40.000	3.95	41.000
34	34.000	2.45	39.000	2.95	40.000	3.45	41,000	3.95	42.000
35	35.000	2.45	40,000	2.95	41.000	3.45	42.000	3.95	43.000
36	36.000	2.45	41.000	2.95	42.000	3.45	43.000	3.95	44.000

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DATA

I. GENERAL

5. Pipe and Tube Insulation Dimensions - Continued

INSIDE DIAMETERS FOR PIPE INSULATION
ASTM Recommended Practice

IRON PIPE NOM SIZE	IRON PIPE O.D. Inches	Nominal Insulation I.D. Inches	Insulation I.D. Tolerance, Inches Minus	Insulation I.D. Tolerance, Inches Plus	Minimum Insulation I.D. Inches	Maximum Insulation I.D. Inches
1/8	0.405	0.421	0	1/16	0.421	0.483
1/4	0.540	0.556	0	1/16	0.556	0.618
3/8	0.675	0.691	0	1/16	0.691	0.753
1/2	0.840	0.856	0	1/16	0.856	0.918
3/4	1.050	0.066	0	1/16	1.066	1.128
1	1.315	1.331	0	1/16	1.331	1.393
1¼	1.660	1.676	0	1/16	1.676	1.738
1½	1.900	1.916	0	1/16	1.916	1.978
2	2.375	2.406	1/64	3/32	2.391	2.499
2½	2.875	2.906	1/64	3/32	2.891	2.999
3	3.500	3.531	1/64	3/32	3.516	3.624
3½	4.000	4.031	1/64	3/32	4.016	4.124
4	4.500	4.531	1/64	3/32	4.516	4.624
4½	5.000	5.031	1/64	3/32	5.016	5.124
5	5.563	5.641	1/32	3/32	5.610	5.734
6	6.625	6.703	1/32	3/32	6.672	6.796
7	7.625	7.703	1/32	3/32	7.672	7.796
8	8.625	8.703	1/32	3/32	8.672	8.796
9	9.625	9.703	1/32	3/32	9.672	9.796
10	10.750	10.828	1/32	3/32	10.797	10.921
11	11.750	11.828	1/32	3/32	11.797	11.921
12	12.750	12.844	3/64	5/32	12.797	13.000
14	14.000	14.094	3/64	5/32	14.047	14.250
15	15.000	15.094	3/64	5/32	15.047	15.250
16	16.000	16.094	3/64	5/32	16.047	16.250
17	17.000	17.094	3/64	5/32	17.047	17.250
18	18.000	18.094	3/64	5/32	18.047	18.250
19 thru 32	.000	.094	3/64	5/32	.047	.250
33	33.000	33.094	3/64	5/32	33.047	33.250

OUTER SIZE FOR PIPE INSULATION
ASTM Recommended Practice
Expressed in Nominal Iron Pipe Size

IRON PIPE SIZE	PIPE O.D. Inches	Nominal Thickness 1	1½	2	2½	3	3½	4
1/2	0.84	2½	3½	4½	6	7	8	9
3/4	1.05	2½	3½	4½	6	7	8	9
1	1.32	3	4	5	6	7	8	9
1¼	1.66	3	4½	5	6	7	8	9
1½	1.90	3½	4½	6	7	8	9	10
2	2.38	4	5	6	7	8	9	10
2½	2.88	4½	6	7	8	9	10	11
3	3.50	5	6	7	8	9	10	11
3½	4.00	6	7	8	9	10	11	12
4	4.50	6	7	8	9	10	11	12
4½	5.00	7	8	9	10	11	12	14
5	5.56	7	8	9	10	11	12	14
6	6.63	8	9	10	11	12	14	15
7	7.63	9	10	11	12	14	15	16
8	8.63	10	11	12	14	15	16	17
9	9.63	11	12	14	15	16	17	18
10	10.75	12	14	15	16	17	18	19
11	11.75	14	15	16	17	18	19	20
12	12.75	15	16	17	18	19	20	21
14	14.00	16	17	18	19	20	21	22
15	15.00	17	18	19	20	21	22	23
16	16.00	18	19	20	21	22	23	24
17	17.00	19	20	21	22	23	24	25
18	18.00	20	21	22	23	24	25	26
19	19.00	21	22	23	24	25	26	27
20	20.00	22	23	24	25	26	27	28
21	21.00	23	24	25	26	27	28	29
22	22.00	24	25	26	27	28	29	30
23	23.00	25	26	27	28	29	30	31
24	24.00	26	27	28	29	30	31	32
25	25.00	27	28	29	30	31	32	33
26	26.00	28	29	30	31	32	33	34
27	27.00	29	30	31	32	33	34	35
28	28.00	30	31	32	33	34	35	36
29	29.00	31	32	33	34	35	36	37
30	30.00	32	33	34	35	36	37	38
31	31.00	33	34	35	36	37	38	39
32	32.00	34	35	36	37	38	39	40
33	33.00	35	36	37	38	39	40	41
34	34.00	36	37	38	39	40	41	42
35	35.00	37	38	39	40	41	42	43

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DATA

I. GENERAL

5. Pipe and Tube Insulation Dimensions - Continued

BASIC OUTSIDE DIAMETERS FOR TUBE INSULATION
ASTM Recommended Practice

Tube Size	O.D.	Nominal Thickness of Insulation							
		1/2	1	1½	2	2½	3	3½	4
1/4	0.250	1.315	2.875	3.500	4.500	5.625	6.625	7.625	8.625
3/8	0.375	1.660	2.875	3.500	4.500	5.625	6.625	7.625	8.625
1/2	0.500	1.660	2.875	3.500	4.500	5.625	6.625	7.625	8.625
1/2	0.625	1.660	2.875	3.500	4.500	5.625	6.625	7.625	8.625
3/4	0.750	1.900	2.875	4.000	5.000	5.625	7.625	8.625	9.625
3/4	0.875	1.900	3.500	4.000	5.000	6.625	7.625	8.625	9.625
1	1.000	2.375	3.500	4.000	5.000	6.625	7.625	8.625	9.625
1	1.125	2.375	3.500	4.000	5.000	6.625	7.625	8.625	9.625
1¼	1.250	2.375	3.500	4.500	5.563	6.625	7.625	8.625	9.625
1½	1.500	2.875	4.000	4.500	5.563	6.625	7.625	8.625	9.625
1½	1.625	2.875	4.000	4.500	5.563	6.625	7.625	8.625	9.625
2	2.000	3.500	4.000	5.000	6.625	7.625	8.625	9.625	10.750
2	2.125	3.500	4.500	5.563	6.625	7.625	8.625	9.625	10.750
2½	2.500	3.500	4.500	5.563	6.625	7.625	8.625	9.625	10.750
2½	2.625	4.000	5.000	5.563	6.625	7.625	8.625	9.625	10.750
3	3.000	4.000	5.000	6.625	7.625	8.625	9.625	10.750	11.750
3	3.125	4.500	5.563	6.625	7.625	8.625	9.625	10.750	11.750
3 5/8	3.625	5.000	6.625	7.625	8.625	9.625	10.750	11.750	12.750
4	4.000	5.000	6.625	7.625	8.625	9.625	10.750	11.750	12.750
4	4.125	5.563	6.625	7.625	8.625	9.625	10.750	11.750	12.750
5	5.000	6.625	7.625	8.625	9.625	10.750	11.750	12.750	14.000
5	5.125	6.625	7.625	8.625	9.625	10.750	11.750	12.750	14.000
6	6.000	7.625	8.625	9.625	10.750	11.750	12.750	14.000	15.000
6	6.125	7.625	8.625	9.625	10.750	11.750	12.750	14.000	15.000
8	8.000			11.750	12.750	14.000	15.000	16.000	17.000
8	8.125			11.750	12.750	14.000	15.000	16.000	17.000
10	10.000			12.750	14.000	15.000	16.000	17.000	18.000
10	10.125			14.000	14.000	15.000	16.000	17.000	18.000
12	12.000			15.000	16.000	17.000	18.000	19.000	20.000
14	14.333			18.000	19.000	20.000	21.000	33.000	23.000
16	16.333			20.000	21.000	22.000	23.000	24.000	25.000
18	18.333			22.000	23.000	24.000	25.000	26.000	27.000
20	20.333			24.000	25.000	26.000	27.000	28.000	29.000
24	24.333			28.000	29.000	30.000	31.000	32.000	33.000

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DATA

I. GENERAL

5. Pipe and Tube Insulation Dimensions - Continued

SURFACE AREAS OF PIPE INSULATION
Based on NPS Pipe and ASTM Dimensional Standard
Pipe Insulation - Square Feet per linear foot

NOM. PIPE SIZE	Nominal Insulation Thicknesses											
	BARE	1	1½	2	2½	3	3½	4	4½	5	5½	6
1/8	0.106	0.62	0.92	1.18	1.46	1.73	2.00	2.26				
1/4	0.141	0.75	1.05	1.30	1.46	1.73	2.00	2.26				
3/8	0.177	0.75	1.05	1.30	1.46	1.73	2.00	2.26				
1/2	0.220	0.75	1.05	1.30	1.73	2.00	2.25	2.52				
3/4	0.275	0.75	1.05	1.30	1.73	2.00	2.25	2.52				
1	0.344	0.92	1.18	1.46	1.74	2.00	2.26	2.52				
1 1/4	0.435	0.92	1.31	1.46	1.74	2.00	2.26	2.52				
1 1/2	0.498	1.05	1.31	1.74	2.00	2.26	2.52	2.81				
2	0.622	1.18	1.46	1.73	2.00	2.26	2.52	2.81				
2 1/2	0.753	1.31	1.73	2.00	2.26	2.52	2.81	3.08				
3	0.917	1.46	1.73	2.00	2.26	2.52	2.81	3.08	3.34			
3 1/2	1.047	1.73	2.00	2.26	2.52	2.81	3.08	3.34	3.67			
4	1.178	1.73	2.00	2.26	2.52	2.81	3.08	3.34	3.67			
4 1/2	1.309	2.00	2.26	2.52	2.81	3.08	3.34	3.67	3.67			
5	1.456	2.00	2.26	2.52	2.81	3.08	3.34	3.67	3.93	4.19		
6	1.734	2.26	2.52	2.81	3.08	3.34	3.67	3.93	4.18	4.45		
7	1.996		2.81	3.08	3.34	3.67	3.93	4.19	4.45	4.71	4.97	
8	2.258		3.08	3.34	3.67	3.93	4.19	4.45	4.71	4.97	5.24	
9	2.520		3.34	3.67	3.93	4.19	4.45	4.71	4.97	5.24	5.50	
10	2.814		3.67	3.93	4.19	4.45	4.71	4.97	5.24	5.50	5.76	
11	3.076		3.93	4.19	4.45	4.71	4.97	5.24	5.50	5.76	6.02	
12	3.338		4.19	4.45	4.71	4.97	5.24	5.50	5.76	6.02	6.28	6.54
14	2.665		4.45	4.71	4.97	5.24	5.50	5.76	6.02	6.28	6.54	6.81
16	4.189		4.97	5.24	5.50	5.76	6.02	6.28	6.54	6.81	7.07	7.33
18	4.712		5.50	5.76	6.02	6.28	6.54	6.81	7.07	7.33	7.59	7.85
20	5.236		6.02	6.28	6.54	6.81	7.07	7.33	7.59	7.85	8.12	8.38
22	5.759		6.54	6.81	7.07	7.33	7.59	7.85	8.12	8.38	8.64	8.90
24	6.283		7.07	7.33	7.59	7.85	8.12	8.38	8.64	8.90	9.16	9.42
26	6.807		7.59	7.85	8.12	8.38	8.64	8.90	9.16	9.42	9.69	9.95
28	7.331		8.12	8.38	8.64	8.90	9.16	9.42	9.69	9.95	10.21	10.47
30	7.854		8.64	8.90	9.16	9.42	9.69	9.95	10.21	10.47	10.73	11.00

DATA

I. GENERAL

5. Pipe and Tube Insulation Dimensions - Continued

VOLUMES OF PIPE INSULATION

Cubic Feet Per Linear Foot

IPS Pipe Size	Nominal Insulation Thickness																		
	½	1	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9
¼	0.013	0.040	0.083	0.133	0.231	0.313	0.400	0.498										
⅜	0.010	0.038	0.082	0.130	0.228	0.310	0.398	0.496										
½	0.018	0.056	0.100	0.154	0.225	0.307	0.394	0.493										
¾	0.029	0.051	0.122	0.148	0.219	0.302	0.388	0.487										
1	0.027	0.071	0.120	0.218	0.300	0.388	0.486	0.611										
1¼	0.038	0.082	0.137	0.208	0.289	0.377	0.474	0.600										
1½	0.044	0.093	0.191	0.273	0.360	0.458	0.583	0.709										
2	0.044	0.068	0.169	0.251	0.338	0.437	0.562	0.688	0.818	1.003	1.162	1.331						
2½	0.049	0.148	0.229	0.317	0.414	0.540	0.665	0.796	0.892	0.982	1.140	1.309						
3	0.055	0.126	0.208	0.294	0.393	0.518	0.643	0.774	0.960	1.118	1.288	1.468						
4	0.082	0.169	0.268	0.393	0.518	0.649	0.834	0.993	1.162	1.342	1.533	1.734	1.948	2.171	2.405	2.651	2.908	3.174
6		0.223	0.349	0.480	0.666	0.823	0.993	1.173	1.363	1.565	1.778	2.002	2.237	2.482	2.738	3.005	3.283	3.573
8			0.257	0.442	0.600	0.769	0.949	1.140	1.342	1.554	1.778	2.013	2.258	2.514	2.782	3.060	3.349	3.649	3.960
10			0.343	0.513	0.693	0.883	1.086	1.298	1.522	1.757	2.003	2.258	2.525	2.803	3.093	3.393	3.703	4.025	4.356
12			0.328	0.508	0.658	0.900	1.113	1.337	1.571	1.817	2.073	2.340	2.618	2.908	3.207	3.518	3.840	4.173	4.516
14			0.363	0.573	0.786	1.009	1.243	1.489	1.745	2.013	2.291	2.580	2.88	3.191	3.513	3.845	4.189	4.543	4.909
16				0.414	0.638	0.873	1.118	1.374	1.642	1.920	2.209	2.509	2.820	3.142	3.474	3.818	4.173	4.538	4.914	5.302
18				0.458	0.703	0.960	1.228	1.505	1.794	2.094	2.405	2.728	3.060	3.403	3.758	4.123	4.500	4.887	5.285	5.694
20				0.546	0.834	1.134	1.445	1.768	2.100	2.443	2.798	3.163	3.540	3.927	4.325	4.734	5.154	5.585	6.027	6.480
24				0.677	1.031	1.397	1.773	2.160	2.558	2.968	3.388	3.818	4.259	4.713	5.176	5.651	6.136	6.633	7.139	7.658
30				0.808	1.222	1.658	2.100	2.553	3.016	3.491	3.976	4.473	4.980	5.498	6.027	6.567	7.118	7.679	8.253	8.836
36																			

Note: Density of insulation in lbs/cu ft times the cu ft per linear ft = lbs per linear ft

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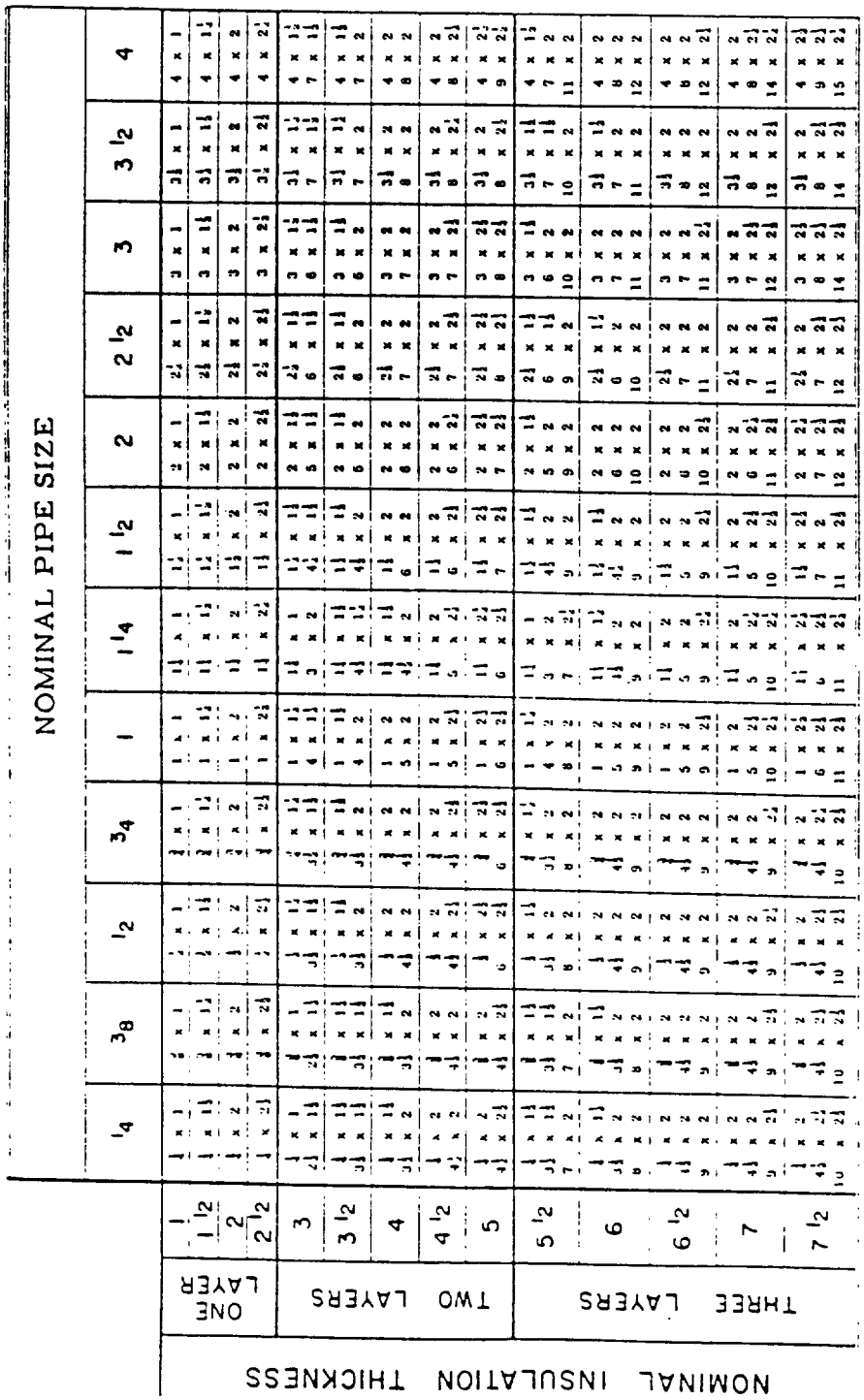
DATA

I. GENERAL

5. Pipe and Tube Insulation Dimensions - Continued

RECOMMENDED SIZES OF INSULATION LAYERS TO OBTAIN TOTAL NOMINAL THICKNESS

NPS X NOMINAL LAYER THICKNESS



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DATA

I. GENERAL

5. Pipe and Tube Insulation Dimensions - Continued

RECOMMENDED SIZES OF INSULATION LAYERS TO OBTAIN TOTAL NOMINAL THICKNESS

NPS X NOMINAL LAYER THICKNESS

NOMINAL INSULATION THICKNESS		NOMINAL PIPE SIZE																					
		4½	5	6	8	10	12	14	16	18	20	22	24
ONE LAYER	1	4½ x 1	5 x 1	6 x 1	8 x 1	10 x 1	12 x 1	14 x 1	16 x 1	18 x 1	20 x 1	22 x 1	24 x 1
	1½	4½ x 1½	5 x 1½	6 x 1½	8 x 1½	10 x 1½	12 x 1½	14 x 1½	16 x 1½	18 x 1½	20 x 1½	22 x 1½	24 x 1½
	2	4½ x 2	5 x 2	6 x 2	8 x 2	10 x 2	12 x 2	14 x 2	16 x 2	18 x 2	20 x 2	22 x 2	24 x 2
	2½	4½ x 2½	5 x 2½	6 x 2½	8 x 2½	10 x 2½	12 x 2½	14 x 2½	16 x 2½	18 x 2½	20 x 2½	22 x 2½	24 x 2½
TWO LAYERS	3	4½ x 1½ 4½ x 2	5 x 1½ 5 x 2	6 x 1½ 6 x 2	8 x 1½ 8 x 2	10 x 1½ 10 x 2	12 x 1½ 12 x 2	14 x 1½ 14 x 2	16 x 1½ 16 x 2	18 x 1½ 18 x 2	20 x 1½ 20 x 2	22 x 1½ 22 x 2	24 x 1½ 24 x 2
	3½	4½ x 2½ 4½ x 3	5 x 2½ 5 x 3	6 x 2½ 6 x 3	8 x 2½ 8 x 3	10 x 2½ 10 x 3	12 x 2½ 12 x 3	14 x 2½ 14 x 3	16 x 2½ 16 x 3	18 x 2½ 18 x 3	20 x 2½ 20 x 3	22 x 2½ 22 x 3	24 x 2½ 24 x 3
	4	4½ x 3 4½ x 3½	5 x 3 5 x 3½	6 x 3 6 x 3½	8 x 3 8 x 3½	10 x 3 10 x 3½	12 x 3 12 x 3½	14 x 3 14 x 3½	16 x 3 16 x 3½	18 x 3 18 x 3½	20 x 3 20 x 3½	22 x 3 22 x 3½	24 x 3 24 x 3½
	4½	4½ x 3½ 4½ x 4	5 x 3½ 5 x 4	6 x 3½ 6 x 4	8 x 3½ 8 x 4	10 x 3½ 10 x 4	12 x 3½ 12 x 4	14 x 3½ 14 x 4	16 x 3½ 16 x 4	18 x 3½ 18 x 4	20 x 3½ 20 x 4	22 x 3½ 22 x 4	24 x 3½ 24 x 4
	5	4½ x 4 4½ x 4½	5 x 4 5 x 4½	6 x 4 6 x 4½	8 x 4 8 x 4½	10 x 4 10 x 4½	12 x 4 12 x 4½	14 x 4 14 x 4½	16 x 4 16 x 4½	18 x 4 18 x 4½	20 x 4 20 x 4½	22 x 4 22 x 4½	24 x 4 24 x 4½
THREE LAYERS	5½	4½ x 4½ 4½ x 5 4½ x 5½	5 x 4½ 5 x 5 5 x 5½	6 x 4½ 6 x 5 6 x 5½	8 x 4½ 8 x 5 8 x 5½	10 x 4½ 10 x 5 10 x 5½	12 x 4½ 12 x 5 12 x 5½	14 x 4½ 14 x 5 14 x 5½	16 x 4½ 16 x 5 16 x 5½	18 x 4½ 18 x 5 18 x 5½	20 x 4½ 20 x 5 20 x 5½	22 x 4½ 22 x 5 22 x 5½	24 x 4½ 24 x 5 24 x 5½
	6	4½ x 5½ 4½ x 6 4½ x 6½	5 x 5½ 5 x 6 5 x 6½	6 x 5½ 6 x 6 6 x 6½	8 x 5½ 8 x 6 8 x 6½	10 x 5½ 10 x 6 10 x 6½	12 x 5½ 12 x 6 12 x 6½	14 x 5½ 14 x 6 14 x 6½	16 x 5½ 16 x 6 16 x 6½	18 x 5½ 18 x 6 18 x 6½	20 x 5½ 20 x 6 20 x 6½	22 x 5½ 22 x 6 22 x 6½	24 x 5½ 24 x 6 24 x 6½
	6½	4½ x 6½ 4½ x 7 4½ x 7½	5 x 6½ 5 x 7 5 x 7½	6 x 6½ 6 x 7 6 x 7½	8 x 6½ 8 x 7 8 x 7½	10 x 6½ 10 x 7 10 x 7½	12 x 6½ 12 x 7 12 x 7½	14 x 6½ 14 x 7 14 x 7½	16 x 6½ 16 x 7 16 x 7½	18 x 6½ 18 x 7 18 x 7½	20 x 6½ 20 x 7 20 x 7½	22 x 6½ 22 x 7 22 x 7½	24 x 6½ 24 x 7 24 x 7½
	7	4½ x 7½ 4½ x 8 4½ x 8½	5 x 7½ 5 x 8 5 x 8½	6 x 7½ 6 x 8 6 x 8½	8 x 7½ 8 x 8 8 x 8½	10 x 7½ 10 x 8 10 x 8½	12 x 7½ 12 x 8 12 x 8½	14 x 7½ 14 x 8 14 x 8½	16 x 7½ 16 x 8 16 x 8½	18 x 7½ 18 x 8 18 x 8½	20 x 7½ 20 x 8 20 x 8½	22 x 7½ 22 x 8 22 x 8½	24 x 7½ 24 x 8 24 x 8½
	7½	4½ x 8½ 4½ x 9 4½ x 9½	5 x 8½ 5 x 9 5 x 9½	6 x 8½ 6 x 9 6 x 9½	8 x 8½ 8 x 9 8 x 9½	10 x 8½ 10 x 9 10 x 9½	12 x 8½ 12 x 9 12 x 9½	14 x 8½ 14 x 9 14 x 9½	16 x 8½ 16 x 9 16 x 9½	18 x 8½ 18 x 9 18 x 9½	20 x 8½ 20 x 9 20 x 9½	22 x 8½ 22 x 9 22 x 9½	24 x 8½ 24 x 9 24 x 9½

DATA

1. GENERAL

6. Pipe

RADIATING AREA OF FLANGED FITTINGS

(Including accompanying flanges in square feet and in equivalent length of same size pipe standard weight fittings)

Pipe size, in.	Flanged couplings		90° ells		Long radius ells		Tees		Crosses	
	Area, sq.ft.	Pipe length, ft.	Area, sq.ft.	Pipe length ft.	Area sq.ft.	Pipe length, ft.	Area, sq. ft.	Pipe length ft.	Area, sq. ft.	Pipe length ft.
1	.32	.93	.79	2.31	.89	2.59	1.24	3.59	1.62	4.72
1 1/4	.38	.88	.96	2.20	1.08	2.49	1.48	3.40	1.94	4.47
1 1/2	.48	.95	1.19	2.35	1.34	2.68	1.82	3.64	2.38	4.78
2	.67	1.08	1.65	2.65	1.84	2.96	2.54	4.08	3.32	5.34
2 1/2	.84	1.12	2.09	2.78	2.32	3.08	3.21	4.26	4.19	5.56
3	.95	1.03	2.38	2.60	2.68	2.93	3.66	3.99	4.77	5.70
3 1/2	1.12	1.07	2.98	2.85	3.28	3.13	4.48	4.28	5.83	5.56
4	1.34	1.14	3.53	2.90	3.96	3.36	5.41	4.59	7.03	5.97
4 1/2	1.47	1.13	3.95	3.01	4.43	3.38	6.07	4.63	7.87	6.01
5	1.62	1.11	4.44	3.05	5.00	3.43	6.81	4.67	8.82	6.06
6	1.82	1.05	5.13	2.95	5.99	3.45	7.84	4.53	10.08	5.81
7	2.17	1.05	6.17	3.09	7.38	3.70	9.37	4.69	12.00	6.01
8	2.41	1.07	6.98	3.09	8.56	3.79	10.55	4.67	13.44	5.96
9	3.00	1.19	8.71	3.46	10.57	4.20	13.18	5.23	16.78	6.66
10	3.43	1.22	10.18	3.61	12.35	4.38	15.41	5.47	19.58	6.95
12	4.41	1.32	13.08	3.92	16.35	4.90	19.67	5.89	24.87	7.45
14	5.39	1.47	16.38	4.47	20.17	5.47	24.81	6.78	31.48	8.60
16	6.69	1.60	20.17	4.82	25.41	6.07	30.32	7.23	38.34	9.15

AREAS, SIZES AND CAPACITIES OF STANDARD PIPE

(All dimensions and weights are nominal)

Size, in.	Diameter, in.		Thickness, in.	Circumference, in.		Transverse areas, sq. in.		External surface area, sq.ft.lin ft. of pipe	Length of pipe containing cu.ft.	Wt of water per foot, lb.
	External	Internal		External	Internal	External	Internal			
1/8	0.405	0.269	0.068	1.272	0.845	0.129	0.057	0.1060	2533.775	0.025
1/4	0.540	0.364	0.088	1.696	1.144	0.229	0.104	0.1414	1383.789	0.045
3/8	0.675	0.493	0.091	2.121	1.549	0.358	0.191	0.1767	754.360	0.083
1/2	0.840	0.622	0.109	2.639	1.954	0.554	0.304	0.220	473.906	0.132
3/4	1.050	0.824	0.113	3.299	2.589	0.866	0.533	0.275	270.034	0.231
1	1.315	1.049	0.133	4.131	3.296	1.358	0.861	0.344	166.618	0.375
1 1/4	1.660	1.380	0.140	5.215	4.335	2.164	1.495	0.435	96.275	0.65
1 1/2	1.900	1.610	0.145	5.969	5.058	2.835	2.036	0.498	70.733	0.88
2	2.375	2.067	0.154	7.461	6.494	4.430	3.355	0.622	42.913	1.45
2 1/2	2.875	2.469	0.203	9.032	7.757	6.492	4.788	0.753	30.077	2.07
3	3.500	3.068	0.216	10.996	9.638	9.621	7.393	0.917	19.479	3.20
3 1/2	4.000	3.548	0.226	12.566	11.146	12.566	9.886	1.047	14.565	4.29
4	4.500	4.026	0.237	14.137	12.648	15.904	12.730	1.178	11.312	5.50
4 1/2	5.000	4.506	0.247	15.708	14.156	19.635	15.947	1.3009	9.030	6.91
5	5.563	5.047	0.258	17.477	15.856	24.306	20.006	1.4586	7.198	8.67
6	6.625	6.065	0.280	20.813	19.054	34.472	28.891	1.7384	4.984	12.51
7	7.625	7.023	0.301	23.955	22.063	45.664	38.738	1.996	3.717	16.80
8	8.625	8.071	0.277	27.096	25.356	58.426	51.161	2.2350	2.815	22.18
8	8.625	7.981	0.322	27.096	25.073	58.426	50.027	2.2053	2.878	21.70
9	9.625	8.941	0.342	30.238	28.089	72.760	62.786	2.5220	2.294	27.20
10	10.750	10.192	0.279	33.772	32.019	90.763	81.585	2.8174	1.765	35.37
10	10.750	10.136	0.307	33.772	31.843	90.763	80.691	2.8104	1.826	34.20
10	10.750	10.020	0.365	33.772	31.479	90.763	78.855	2.8104	1.826	34.20
11	11.750	11.000	0.375	36,914	34.558	108.434	95.033	3.076	1.515	41.20
12	12.750	12.090	0.330	40.055	37.892	127.676	114.800	3.338	1.254	49.70
12	12.750	12.000	0.375	40.055	37.699	127.676	113.097	3.338	1.273	49.00

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DATA

I. GENERAL

7. Surface Areas

Area of dished head equals $\frac{2\pi DH}{12}$

Area of flat head equals $0.7854\ D^2$

Area per lin. ft. equals πD

D equals diameter in feet
R equals head radius in feet
H equals 1.608 R equals 1.608D

Tank with dished heads where R equals D

AREAS OF TANKS FOR INSULATION COVERAGE

Tank Diameter Ft.	Dished Head Area Sq. Ft.	Flat Head Area Sq. Ft.	Area Per L.F. of Cyl. Sq. Ft.	"H" Dimension Inches
1'-0"	.84	.79	3.14	1.61
1'-1"	.99	.92	3.40	1.75
1'-2"	1.14	1.07	3.66	1.88
1'-3"	1.32	1.23	3.93	2.01
1'-4"	1.50	1.40	4.19	2.15
1'-5"	1.69	1.58	4.45	2.28
1'-6"	1.89	1.77	4.71	2.41
1'-7"	2.11	1.97	4.97	2.54
1'-8"	2.34	2.18	5.23	2.68
1'-9"	2.58	2.41	5.50	2.81
1'-10"	2.87	2.64	5.76	2.95
1'-11"	3.09	2.89	6.02	3.08
2'-0"	3.37	3.14	6.28	3.22
2'-1"	3.65	3.41	6.54	3.35
2'-2"	3.95	3.69	6.81	3.48
2'-3"	4.25	3.98	7.07	3.61
2'-4"	4.57	4.28	7.33	3.75
2'-5"	4.91	4.51	7.59	3.88
2'-6"	5.21	4.91	7.85	4.02
2'-7"	5.61	5.24	8.11	4.15
2'-8"	5.98	5.58	8.37	4.28
2'-9"	6.36	5.94	8.64	4.42
2'-10"	6.74	6.31	8.90	4.55
2'-11"	7.15	6.68	9.17	4.68

Tank Diameter Ft.	Dished Head Area Sq. Ft.	Flat Head Area Sq. Ft.	Area Per L.F. of Cyl. Sq. Ft.	"H" Dimension Inches
3'-0"	7.56	7.07	9.43	4.82
3'-1"	8.00	7.47	9.69	4.96
3'-2"	8.43	7.88	9.95	5.09
3'-3"	8.87	8.30	10.21	5.22
3'-4"	9.32	8.73	10.47	5.35
3'-5"	9.81	9.17	10.73	5.49
3'-6"	10.30	9.62	11.00	5.62
3'-7"	10.77	10.01	11.26	5.75
3'-8"	11.32	10.56	11.52	5.89
3'-9"	11.82	11.05	11.73	6.02
3'-10"	12.34	11.54	12.04	6.16
3'-11"	12.92	12.05	12.30	6.30
4'-0"	13.45	12.57	12.57	6.44
4'-1"	14.03	13.09	12.83	6.57
4'-2"	14.60	13.47	13.09	6.70
4'-3"	15.19	14.18	13.35	6.83
4'-4"	15.78	14.73	13.61	6.96
4'-5"	16.39	15.32	13.88	7.09
4'-6"	17.05	15.90	14.14	7.22
4'-7"	17.64	16.50	14.40	7.36
4'-8"	18.32	17.11	14.66	7.50
4'-9"	18.95	17.72	14.92	7.63
4'-10"	19.63	18.35	15.18	7.77
4'-11"	20.35	18.99	15.44	7.91

Tank Diameter Ft.	Dished Head Area Sq. Ft.	Flat Head Area Sq. Ft.	Area Per L.F. of Cyl. Sq. Ft.	"H" Dimension Inches
5'-0"	21.10	19.64	15.71	8.04
5'-1"	21.74	20.30	15.97	8.17
5'-2"	22.48	20.97	16.23	8.30
5'-3"	23.17	21.65	16.49	8.44
5'-4"	23.93	22.34	16.76	8.57
5'-5"	24.68	23.05	17.02	8.70
5'-6"	25.50	23.76	17.28	8.84
5'-7"	26.18	24.48	17.54	8.98
5'-8"	27.00	25.22	17.80	9.11
5'-9"	27.82	25.97	18.06	9.25
5'-10"	28.64	26.73	18.33	9.38
5'-11"	29.49	27.49	18.59	9.52
6'-0"	30.20	28.27	18.85	9.64
6'-1"	31.13	29.07	19.11	9.78
6'-2"	32.03	29.87	19.37	9.92
6'-3"	32.98	30.68	19.64	10.06
6'-4"	33.79	31.49	19.90	10.20
6'-5"	34.69	32.29	20.16	10.33
6'-6"	35.60	33.17	20.42	10.47
6'-7"	36.49	34.04	20.68	10.60
6'-8"	37.43	34.91	20.95	10.73
6'-9"	38.37	35.79	21.21	10.86
6'-10"	39.28	36.67	21.47	10.99
6'-11"	40.29	37.50	21.73	11.12

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DATA

I. GENERAL

7. Surface Areas - Continued

Tank Diameter Ft.	Dished Head Area Sq.Ft.	Flat Head Area Sq.Ft.	Area Per L.F. of Cyl. Sq.Ft.	"H" Dimension Inches
10'-0"	84.15	78.54	31.42	16.08
10'-1"	85.54	79.85	31.63	16.21
10'-2"	86.96	81.18	31.94	16.34
10'-3"	88.37	82.52	32.20	16.48
10'-4	89.78	83.86	32.46	16.61
10'-5"	91.26	85.22	32.73	16.74
10'-6"	92.71	86.59	32.99	16.87
10'-7"	94.15	87.97	33.25	17.00
10'-8"	95.68	89.35	33.51	17.14
10'-9"	97.22	90.76	33.77	17.27
10'-10"	98.69	92.11	34.03	17.40
10'-11"	100.26	93.60	34.30	17.53
11'-0"	101.89	95.03	30.56	17.68
11'-1"		96.48	34.82	
11'-2"		97.93	35.08	
11'-3"		99.40	35.34	
11'-4"		100.88	35.60	
11'-5"		102.37	35.87	
11'-6"	111.22	103.87	36.13	18.47
11'-7"		105.38	36.39	
11'-8"		106.90	36.65	
11'-9"		108.43	36.91	
11'-10"		109.98	37.18	
11'-11"		111.53	37.44	
12'-0"	121.18	113.10	37.70	19.31
12'-1"		114.67	37.96	
12'-2"		116.26	38.22	
12'-3"		117.86	38.48	
12'-4"		119.47	38.75	
12'-5"		121.09	39.01	
12'-6"	131.49	122.72	39.27	20.09
12'-7"		124.36	39.53	
12'-8"		126.01	39.79	
12'-9"		127.67	40.06	
12'-10"		129.35	40.32	
12'-11"		131.04	40.58	

Tank Diameter Ft.	Dished Head Area Sq.Ft.	Flat Head Area Sq.Ft.	Area Per L.F. of Cyl. Sq.Ft.	"H" Dimension Inches
13'-0"	142.22	132.73	40.84	20.91
13'-1"		134.44	41.10	
13'-2"		136.16	41.36	
13'-3'		137.89	41.63	
13'-4"		139.63	41.89	
13'-5"		141.38	42.15	
13'-6"	153.36	143.14	42.41	21.72
13'-7"		144.91	42.67	
13'-8"		146.69	42.94	
13'-9"		148.36	43.20	
13'-10"		150.30	43.46	
13'-11"		152.11	43.72	
14'-0	164.94	153.94	43.98	22.53
14'-6"	176.93	165.13	45.55	23.31
15'-0"	189.34	176.31	47.12	24.13
15'-6	202.18	188.69	48.70	24.94
16'-0'	215.43	201.06	50.27	25.75
16'-6"		213.83	51.84	
17'-0"		226.98	53.41	
17'-6"		240.53	54.98	
18'-0'		254.47	56.55	
18'-6"		268.80	58.12	
19'-0"		283.53	59.69	
19'-6"		298.65	61.26	
20'-0"		314.16	62.83	
21'-0"		346.36	65.97	
22'-0'		380.13	69.11	
23'-0"		415.58	72.26	
24'-0"		450.79	75.40	
25'-0"		490.86	78.54	

Tank Diameter Ft.	Dished Head Area Sq.Ft.	Flat Head Area Sq.Ft.	Area Per L.F. of Cyl. Sq.Ft.	"H" Dimension Inches
'-0"	41.30	38.49	21.99	11.25
'-1"	42.20	39.41	22.25	11.39
'-2	43.21	40.34	22.51	11.52
'-3"	44.25	41.28	22.78	11.66
7'-4'	45.26	42.24	23.04	11.80
'-5"	46.33	43.20	23.30	11.93
'-6"	47.50	44.16	23.56	12.06
'-7	48.37	45.16	23.82	12.19
'-8"	49.46	46.16	24.09	12.32
'-9'	50.56	47.17	24.35	12.46
'-10"	51.63	48.19	24.61	12.60
'-11"	52.76	49.22	24.87	12.73
'-0'	53.85	50.27	25.13	12.86
'-1"	54.96	51.32	25.39	13.00
'-2"	56.15	52.38	25.66	13.13
'-3"	57.31	53.46	25.92	13.27
'-4"	58.45	54.54	26.18	13.40
'-5"	59.64	56.64	26.64	13.53
'-6"	60.65	56.75	26.70	13.66
'-7"	61.96	57.89	26.97	13.80
'-8"	63.24	58.99	27.23	13.93
'-9"	64.34	60.13	27.49	14.06
3'-10"	65.60	61.28	27.75	14.20
3'-11"	66.88	62.45	28.01	14.33
'0"	68.10	63.62	28.27	14.46
'-1"	69.33	64.80	28.54	14.59
'-2"	70.65	66.00	28.80	14.72
'-3'	71.97	67.20	29.06	14.86
'-4"	73.22	68.42	29.32	15.00
'-5"	74.61	69.64	29.58	15.13
'-6"	76.00	70.88	29.85	15.26
'-7"	77.14	72.13	30.11	15.40
'-8'	78.64	73.39	30.37	25.54
'-9"	79.96	74.66	30.63	25.67
'-10	81.37	75.94	30.89	15.80
'-11"	82.81	77.93	31.15	15.95

DATA

I. GENERAL

7. Surface Area and Volume - Continued

AREAS AND VOLUMES - CYLINDERS

Diameter	Surface Area Sq. Ft. Per Linear Ft.	Volume Cu. Ft. Per Linear Ft.	Capacity Gals. Per Linear Ft.	Diameter	Surface Area Sq. Ft. Per Linear Ft.	Volume Cu. Ft. Per Linear Ft.	Capacity Gals. Per Linear Ft.
0'-6"	1.5708	0.1963	1.4688	29'-0"	91.1064	660.52	4941.0
1'-0"	3.1416	0.7854	5.8752	29'-6"	92.6772	683.49	5112.9
1'-6"	4.7124	1.7671	13.219	30'-0"	94.2480	706.86	5287.7
2'-0"	6.2832	3.1416	23.501	30'-6"	95.8188	730.62	5465.4
2'-6"	7.8540	4.9087	36.720	31'-0"	97.3896	744.77	5646.1
3'-0"	9.4248	7.0686	52.877	31'-6"	98.9604	779.31	5829.7
3'-6"	10.9956	9.6211	71.971	32'-0"	100.5312	804.25	6016.2
4'-0"	12.5664	12.566	94.003	32'-6"	102.1020	829.58	6205.7
4'-6"	14.1372	15.904	118.97	33'-0"	103.6728	855.30	6398.1
5'-0"	15.7080	19.635	146.88	33'-6"	105.2436	881.41	6593.4
5'-6"	17.2788	23.758	177.72	34'-0"	106.8144	907.92	6791.7
6'-0"	18.8496	28.274	211.51	34'-6"	108.3852	934.82	6992.9
6'-6"	20.4204	33.183	248.23	35'-0"	109.9560	962.11	7197.1
7'-0"	21.9912	38.485	287.88	35'-6"	111.5268	989.80	7404.2
7'-6"	23.5620	44.179	330.48	36'-0"	113.0976	1017.9	7614.2
8'-0"	25.1328	50.265	376.01	36'-6"	114.6684	1046.3	7827.2
8'-6"	26.7036	56.745	424.48	37'-0"	116.2392	1075.2	8043.1
9'-0"	28.2744	63.617	475.89	37'-6"	117.8100	1104.5	8262.0
9'-6"	29.8452	70.882	530.24	38'-0"	119.3808	1134.1	8483.8
10'-0"	31.4160	78.540	587.52	38'-6"	120.9516	1164.2	8708.5
10'-6"	32.9868	86.590	747.74	39'-0"	122.5224	1194.6	8936.2
11'-0"	34.5576	95.033	710.90	39'-6"	124.0932	1225.4	9166.8
11'-6"	36.1284	103.87	776.99	40'-0"	125.6640	1256.6	9400.3
12'-0"	37.6992	113.10	846.03	40'-6"	127.2348	1288.2	9636.8
12'-6"	39.2700	122.72	918.00	41'-0"	128.8056	1320.3	9876.2
13'-0"	40.8408	132.73	992.91	41'-6"	130.3764	1352.7	10119
13'-6"	42.4116	143.14	1070.8	42'-0"	131.9472	1385.4	10364
14'-0"	43.9824	153.94	1151.3	42'-6"	133.5180	1418.6	10612
14'-6"	45.5532	165.13	1235.3	43'-0"	135.0888	1452.2	10863
15'-0"	47.1240	176.71	1321.9	43'-6"	136.6586	1486.2	11117
15'-6"	48.6948	188.69	1411.5	44'-0"	138.2364	1520.5	11374
16'-0"	50.2656	201.06	1504.0	44'-6"	139.8012	1555.3	11634
16'-6"	51.8364	213.82	1599.5	45'-0"	141.3720	1590.4	11897
17'-0"	53.4072	226.98	1697.9	45'-6"	142.9428	1626.0	12163
17'-6"	54.9780	240.53	1799.3	46'-0"	144.5136	1661.9	12432
18'-0"	56.5488	254.47	1903.6	46'-6"	146.0844	1698.2	12704
18'-6"	58.1196	268.80	2010.8	47'-0"	147.6552	1734.9	12978
19'-0"	59.6904	283.53	2120.9	47'-6"	149.2260	1772.1	13256
19'-6"	61.2612	298.65	2234.0	48'-0"	150.7968	1809.6	13536
20'-0"	62.8320	314.16	2350.1	48'-6"	152.3676	1847.5	13820
20'-6"	64.4028	330.06	2469.0	49'-0"	153.9384	1885.7	14106
21'-0"	65.9736	346.36	2591.0	49'-6"	155.5092	1924.4	14396
21'-6"	67.5444	363.05	2715.8	50'-0"	157.0800	1963.5	14683
22'-0"	69.1152	380.13	2843.6	60'-0"	188.50	2827.4	21150
22'-6"	70.6860	397.61	2974.3	70'-0"	219.91	3848.5	28789
23'-0"	72.2568	415.48	3108.0	80'-0"	251.33	5026.5	37601
23'-6"	73.8276	433.74	3244.6	90'-0"	282.74	6361.7	47589
24'-0"	75.3984	452.39	3384.1	100'-0"	314.16	7854.0	58752
24'-6"	76.9692	471.44	3526.6	110'-0"	345.58	9503.3	71090
25'-0"	78.5400	490.87	3672.0	120'-0"	377.00	11,309.7	84602
25'-6"	80.1108	510.71	3820.3	130'-0"	408.41	13,273.2	99290
26'-0"	81.6816	530.93	3971.6	140'-0"	439.82	15,393.8	115154
26'-6"	83.2524	551.55	4125.8	150'-0"	471.24	17,671.5	132192
27'-0"	84.8232	572.56	4283.0	175'-0"	549.78	24,052.8	179927
27'-6"	86.3940	593.96	4443.1	200'-0"	628.32	31,415.9	235007
28'-0"	87.9648	615.75	4606.1				
28'-6"	89.5356	637.94	4772.1				

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DATA

I. GENERAL

7. Surface Area and Volume - Continued

AREAS AND VOLUMES - SPHERES

Diameter	Surface Area in Sq. Ft.	Volume in Cu. Ft.	Total Capacity in Gallons
0'-6"	.7854	.0654	.4892
1'-0"	3.1416	.5236	3.917
1'-6"	7.0686	1.7671	13.22
2'-0"	12.566	4.1888	31.33
2'-6"	19.635	8.1812	61.20
3'-0"	28.274	14.137	105.8
3'-6"	38.485	22.449	167.9
4'-0"	50.265	33.510	250.7
4'-6"	63.617	47.713	356.9
5'-0"	78.540	65.450	489.6
5'-6"	95.033	87.114	651.7
6'-0"	113.10	113.10	846.1
6'-6"	132.73	143.79	1076
7'-0"	153.94	179.59	1343
7'-6"	176.71	220.89	1652
8'-0"	201.06	268.08	2005
8'-6"	226.98	321.56	2405
9'-0"	254.47	381.70	2855
9'-6"	283.53	448.92	3358
10'-0"	314.16	523.60	3917
10'-6"	346.36	606.13	4534
11'-0"	380.13	696.91	5213
11'-6"	415.48	796.33	5957
12'-0"	452.39	904.78	6768
12'-6"	490.87	1022.7	7650
13'-0"	530.93	1150.3	8605
13'-6"	572.56	1288.2	9637
14'-0"	615.75	1436.8	10748
14'-6"	660.52	1596.3	11941
15'-0"	706.86	1767.1	13219
15'-6"	754.77	1949.8	14586
16'-0"	804.25	2144.7	16044
16'-6"	855.30	2352.1	17595
17'-0"	907.92	2572.4	19243
17'-6"	962.11	2806.2	20992
18'-0"	1017.9	3053.6	22843
18'-6"	1075.2	3315.2	24799
19'-0"	1134.1	3591.4	26866
19'-6"	1194.6	3882.4	29042
20'-0"	1256.6	4188.8	31334
20'-6"	1320.3	4510.9	33744
21'-0"	1385.4	4849.0	36273
21'-6"	1452.2	5203.7	38926
22'-0"	1520.5	5575.3	41706
22'-6"	1590.4	5964.1	44615
23'-0"	1661.9	6370.6	47655
23'-6"	1734.9	6795.2	50832
24'-0"	1809.6	7238.2	54146
24'-6"	1885.7	7700.1	57601
25'-0"	1963.5	8181.2	61200
25'-6"	2042.8	8682.0	64946
26'-0"	2123.7	9202.8	68842
26'-6"	2206.2	9744.0	72890
27'-0"	2290.2	10306.0	77094
27'-6"	2375.8	10889.0	81455
28'-0"	2463.0	11494.0	85981
28'-6"	2551.8	12121.0	90671

Diameter	Surface Area in Sq. Ft.	Volume in Cu. Ft.	Total Capacity in Gallons
29'-0"	2642.1	12770.0	95526
29'-6"	2734.0	13442.0	100553
30'-0"	2827.4	14137.0	105752
30'-6"	2922.5	14856.0	111131
31'-0"	3019.1	15599.0	116689
31'-6"	3117.2	16366.0	122426
32'-0"	3217.0	17157.0	128343
32'-6"	3318.3	17974.0	134463
33'-0"	3421.2	18818.0	140760
33'-6"	3525.7	19685.0	147254
34'-0"	3631.7	20580.0	153949
34'-6"	3739.3	21501.0	160839
35'-0"	3848.5	22449.0	167930
35'-6"	3959.2	23425.0	175231
36'-0"	4071.5	24429.0	182741
36'-6"	4185.4	25461.0	190462
37'-0"	4300.8	26522.0	198398
37'-6"	4417.9	27612.0	206552
38'-0"	4536.5	28731.0	214923
38'-6"	4656.6	29880.0	223518
39'-0"	4778.4	31059.0	232338
39'-6"	4901.7	32269.0	241389
40'-0"	5026.5	33510.0	250672
40'-6"	5153.0	34783.0	260195
41'-0"	5281.0	36087.0	269950
41'-6"	5410.6	37423.0	279944
42'-0"	5541.8	38792.0	290184
42'-6"	5674.5	40194.0	300672
43'-0"	5808.8	41630.0	311414
43'-6"	5944.7	43099.0	322403
44'-0"	6082.1	44602.0	333646
44'-6"	6221.1	46140.0	345151
45'-0"	6361.7	47713.0	356918
45'-6"	6503.9	49321.0	368847
46'-0"	6647.6	50965.0	381245
46'-6"	6792.9	52645.0	393312
47'-0"	6939.8	54362.0	406656
47'-6"	7083.2	56115.0	419759
48'-0"	7228.2	57906.0	433167
48'-6"	7389.8	59734.0	446841
49'-0"	7543.0	61601.0	460808
49'-6"	7697.7	63506.0	475058
50'-0"	7854.0	65450.0	489,600
55'-0"	9,503	87,116	651,673
60'-0"	11,310	113,097	846,024
65'-0"	13,273	143,788	1,075,609
70'-0"	15,394	179,595	1,343,464
75'-0"	17,672	220,894	1,652,402
80'-0"	20,106	268,083	2,005,400
85'-0"	22,698	321,556	2,405,406
90'-0"	25,447	381,704	2,855,344
95'-0"	28,353	448,920	3,358,155
100'-0"	31,416	523,598	3,916,785

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DATA

I. GENERAL

7. Surface Area and Volume - Continued

BARE AREA OF PIPE FITTINGS

(Including accompanying flanges in square feet and in equivalent length of same size pipe standard weight fittings)

Pipe size In.	Flanged couplings		90° ells		Long radius ells		Tees		Crosses	
	Area Sq. Ft.	Pipe length Ft.	Area Sq. Ft.	Pipe length Ft	Area Sq. Ft.	Pipe length Ft	Area Sq. Ft.	Pipe length Ft.	Area Sq. Ft.	Pipe length Ft.
1	.32	.93	.79	2.31	.89	2.59	1.24	3.59	1.62	4.72
1¼	.38	.88	.96	2.20	1.08	2.47	1.48	3.40	1.94	4.47
1½	.48	.95	1.17	2.35	1.34	2.68	1.82	3.64	2.38	4.78
2	.67	1.08	1.65	2.65	1.84	2.96	2.54	4.08	3.32	5.34
2½	.84	1.12	2.09	2.78	2.32	3.08	3.21	4.26	4.19	5.56
3	.95	1.03	2.38	2.60	2.68	2.93	3.66	3.99	4.77	5.70
3½	1.12	1.07	2.98	2.85	3.28	3.13	4.48	4.28	5.83	5.56
4	1.34	1.14	3.53	2.90	3.96	3.36	5.41	4.59	7.03	5.97
4½	1.47	1.13	3.95	3.01	4.43	3.38	6.07	4.63	7.87	6.01
5	1.62	1.11	4.44	3.05	5.00	3.43	6.81	4.67	8.82	6.06
6	1.82	1.05	5.13	2.95	5.99	3.45	7.84	4.53	10.08	5.81
7	2.17	1.05	6.17	3.09	7.38	3.70	9.37	4.69	12.00	6.01
8	2.41	1.07	6.98	3.09	8.56	3.79	10.55	4.67	13.44	5.96
9	3.00	1.19	8.71	3.46	10.57	4.20	13.18	5.23	6.78	6.66
10	3.43	1.22	10.18	3.61	12.35	4.38	15.41	5.47	19.58	6.95
12	4.41	1.32	13.08	3.92	16.35	4.90	19.67	5.89	24.87	7.45
14	5.39	1.47	16.38	4.47	20.17	5.47	24.81	6.78	31.48	8.60
16	6.69	1.60	20.17	4.82	25.41	6.07	30.32	7.23	38.34	9.15

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SELECTION LIST OF INSULATION AND PROTECTIVE COVER FOR VARIOUS SE

An insulation, its covering, and method of application should be selected to fulf requirements of the service to which it is installed. The number of services an variations of requirements are many, thus no one insulation, nor one applicatio system best suits all the different requirements of these many services. Thus service requirements must be evaluated to determine their relative importance then on insulation selected whose properties will fulfill these requirements and further the method of application which should be used. As there are many ser and variations of requirements within Union Carbide, it is necessary to have ma material and application specifications from which to select the one (or more) w will fulfill a specific service and set of conditions.

Each particular service has primary requirements and secondary requirements. Thus for a particular service many insulations may fulfill the primary requirem (such as service temperature) but only one or two may fulfill some of the other quirements. Thus, proper selection of insulation materials becomes one of sel ing a material whose properties fulfill the essential requirements, which, at lea partly, fulfill most of the secondary requirements. Depending upon condition, a requirement which is critical for one service may not be critical in another ser Therefore, it is impossible to list which requirements are primary, or seconda or to arrive at any order of importance.

In some instances, due to the nature of the requirements, not a single material pletely fulfills all that is desired and selection is limited to the one that has the disadvantages. In other instances, two or more materials may be equally techn acceptable and final choice may be dictated by cost, availability or other non-technical factors.

To assist in the selection of proper insulation material and application specifica the following table has been prepared. Of course it is impossible to list each an every service and all variations of requirements existing within our plants in a single table, thus this table presents the services most common to Union Carbid operation. Nor is it possible to list all of the individual requirements connected with each of the services. Only the most significant are listed, yet a more sign cant requirement for a particular operation, and not considered in this listing, m be the most decisive for a particular use.

From a general standpoint the selection tables give the proper material and appl tion recommended for that service. Where more than one specification may be the one best suited, based on technical reasons, is present first. Where the wo or is used between recommendations, it indicates equal acceptability.

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INDIVIDUAL INSULATION SPECIFICATION IDENTIFICATION AND SYMBOLS

SPECIFICATION NUMBER	INSULATION	OPERATING TEMPERATURE RANGE
10-H, 10-HSS	Cellular Glass (with glass fiber inner cushion blanket).	70F (21C) to 600F (316C)
10-J, 10-JSS	Cellular Glass	50F (10C) to 400F (204C)
10-JU, 10-JUSS	Cellular Glass - Underground	50F (10C) to 350F (177C)
10-L, 10-LSS	Cellular Glass (with glass fiber inner cushion blanket on equipment only)	-300F (-184C) to 400F (204C)
10-LSP	Cellular Glass	-40F (-40C) to 150F (66C)
10-OX	Cellular Glass (with heat treated fiber inner cushion blanket)	-300F (-184C) to Atmos.
12-H, 12-HSS	Rigid Urethane Foam	50F (10C) to 220F (104C)
14-J	Flexible Plastic Foam	50F (10C) to 180F (82C)
15-H	Fibrous Glass, Bonded	70F (21C) to 400F (204C)
19-H	Fibrous Glass Panels, Faced with Corrugated Aluminum	70F (21C) to 400F (204C)
19-J	Fibrous Glass Panels, Faced with Smooth Aluminum	70F (21C) to 400F (204C)
21-H, 21-HSS	Asbestos Fibers, Bonded	212F (100C) to 1000F (538C)
22-H, 22-HSS	Bonded Expanded Silica	40F (4C) to 1400F (760C)
23-H, 23-HSS	Calcium Silicate	212F (100C) to 1000F (538C)
25-H	High Temperature Calcium Silicate (inner layer), Calcium Silicate (outer layer)	750F (399C) to 1600F (871C)
31-H, 31-HSS	Reflective, Stainless Steel Cased Reflective Shields	33F (1C) to 1000F (538C)
32-HFP, 32-HFPSS	Bonded Expanded Silica (double layer-broken joint construction)	40F (4C) to 1400F (760C)
32-LFP, 32-L	Cellular Glass (inner layer), Bonded Expanded Silica (outer layer)	-300F (-184C) to 400F (204C)
37-H	Steel Underground Conduit - Insulation as Selected - Underground	40F (4C) to 750F (399C)
38-H	Molded Urethane Foam on Pipe in PVC Conduit - Underground	50F (10C) to 220F (4C)
39-H	Bituminous Fill - Underground	220F (104C) to 520F (271C)
40-J	Cork Filled PVA Mastic	34F (1C) to 180F (82C)
41-H	Sprayed Amosite Asbestos	70F (21C) to 700F (371C)
42-H	Sprayed Crocitolite Asbestos	700F (371C) to 1350F (732C)
43-H, 43-HSS	Sprayed Urethane Foam	50F (10C) to 250F (121C)

Letters In Specifications:

H indicates Ambient to high temperature service.
J indicates Ambient or cyclic temperature service.
L indicates Low temperature service.
SS indicates suitable for application to stainless steel surface.
SP indicates for application to sphere.
OX indicates for oxygen service.
FP indicates suitable for Fire Protection.
U inaicates for underground service.

Metal Jackets

When metal jackets are specified add M to Spec. No. for stainless steel or MT for treated steel.

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SELECTION OF INSULATION AND ITS PROTECTIVE COVER FOR VARIOUS SERVICES AND OPERATING CONDITIONS

TABLE I EQUIPMENT

FOR APPLICATION WHERE OPERATING TEMPERATURES ARE BELOW AMBIENT

SERVICE	OPERATING TEMP. RANGE	LOCATION	SPECIFICATION NUMBER	INSULATION	PROTECTIVE COVER	LIMITATIONS	SPECIAL PROPERTIES	COMMENTS
Process equipment except oxygen, oxide and acetylene	50F (10C) down to -300F (-185C)	Indoors or outdoors	10-L, 10-LSS	Cellular glass (glass blanket inner layer cushion blanket)	Dynel reinforced Mastic	Good fire resistance for limited time. For extended time, fire protection use Spec. 32-LFP.	Excellent resistance to vapor migration. Good resistance to solar radiation.	Easy to shop fabricate.
Oxygen equipment	50F (10C) down to -300F (-185C)	Indoors or outdoors	10-LOX, 10-LOXSS	Cellular glass (heat treated glass blanket inner layer cushion blanket)	Dynel reinforced Mastic	Good fire resistance for limited time. (For extended time fire protection use stainless steel jacket instead of Mastic)	Excellent resistance to vapor migration.	All materials and accessories have been tested to be safe for oxygen service.
Oxides, acetylene and other low temperature process equipment requiring extended time fire protection.	50F (10C) down to -300F (-185C)	Indoors or outdoors	32-LFP M or MT 32-LFP SS M or MT	Cellular glass and Expanded Silica, outer layer (glass blanket inner layer cushion blanket)	Metal jacket on cylindrical section. Dynel reinforced Mastic on heads and fittings.	Care must be taken that insulation is installed broken joint construction.	Excellent resistance to vapor migration. Two hour fire protection.	Metal on cylindrical sections selected suitable to resist surrounding contamination.
Process equipment, low temperature with thawout up to 400F	400F (205C) Thawout down to -300F (-185C)	Indoors or outdoors	Use appropriate system above					Exercise special care in design and construction of expansion-contraction joints.
Water and process equipment, to prevent condensate drip.	Slightly below ambient	Indoors	40-J	PVA cork filled Mastic (color as specified)	None	Not suitable for conservation of refrigeration. Thickness $\frac{1}{8}$" to $\frac{1}{4}$".	An insulating Mastic which retards condensate drip on vessels slightly below ambient temp.	Applied by palm, trowel or spray to required thick. Surface must be dry at time of application and until mastic sets.

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TABLE I EQUIPMENT

FOR APPLICATIONS WHERE OPERATING TEMPERATURES ARE ABOVE AMBIENT

SERVICE	OPERATING TEMP. RANGE	LOCATION	SPECIFICATION NUMBER	INSULATION	PROTECTIVE COVER	LIMITATIONS	SPECIAL PROPERTIES	COMMENTS
Process and storage vessels except those containing reative chemicals.	50F (10C) to 250F (121C)	Outdoors	43-H, 43-HSS	Sprayed urethane foam	Mastic	Short time resistance to external fire. Must be used in accordance with Fire Protection recommendations.	Light weight. Water resistant.	Spray application of insulation and mastic. Use proper safety precautions during spraying.
Process and utility equipment except those containing reative chemicals.	50F (10C) to 400F (205C)	Indoors or outdoors	15-H, 15-HM, 15-HMT	Glass fiber	Glass cloth and PVA Coating indoors. Metal or Dynel reinforced mastic outdoors.	Relatively soft. Will not withstand heavy mechanical abuse. Short time fire resistance.	Good flexibility. Will meet building code requirements on flame spread and smoke density.	Not easily shop fabricated. Limited sizes of molded glass fiber fittings are marketed.
Process and storage vessels, except those containing reative chemicals.	50F (10C) to 400F (205C)	Outdoors	19-H, 19-J	Glass fiber panel with factory attached facing on side walls. 19-H expanded silica roof and heads. 19-H glass fiber roof insulation on roof.	Aluminum weather-barrier facing. 19-H is ribbed facing. 19-J is smooth facing.	Not suitable for vessels less than 12'0" OD in diameter. Short time fire resistance.	Light weight. Fast installation. Panels cover	19-H can be installed by strap or studs. 19-J requires studs be welded to vessel wall.
Process and storage vessels or equipment. (Especially if highly toxic chemicals are involved)	50F (10C) to 350F (178C)	Indoors and outdoors	10-J, 10-JSS	Cellular glass	Dynel reinforced Mastic.	Will crack if subjected to rapid change of operating temperature.	Excellent resistance to vapors and liquids. Will not become saturated by hazardous or toxic fumes or liquids. Good resistance to solar radiation.	Proper expansion and contraction joints are essential.
Process and storage vessels or equipment (where operating temperature is subject to rapid change).	50F (10C) to 600F (315C)	Indoors or outdoors	10-H, 10-HSS	Cellular glass and high temperature mineral fiber cushion blanket inner layer.	Dynel reinforced Mastic.	Inner mineral fiber inner layer is absorbent.	Most vapor and liquid resistant insulation system for rapid operating temperature change and temperature above 350F.	Proper expansion and contraction joints are essential.

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TABLE I EQUIPMENT

FOR APPLICATIONS WHERE OPERATING TEMPERATURES ARE ABOVE AMBIENT

SERVICE	OPERATING TEMP. RANGE	LOCATION	SPECIFICATION NUMBER	INSULATION	PROTECTIVE COVER	LIMITATIONS	SPECIAL PROPERTIES	COMMENTS
Steam, and process including acetylene oxide and other reative chemical equipment. Also electric and steam traced vessels.	50F (10C) to 1400F (760C)	Indoors or outdoors	22-H, 22-HM, or MT 22-HSS, 22-HSS M or MT	Expanded silica	Metal and/or Dynel reinforced Mastic depending upon size, shape and conditions.	Although it is silicone treated to obtain repellency, it can be saturated by some chemicals.	Water repellent. Max. resistance to external fire. This, and Spec. 32-H, are only spec's suitable for Ethylene Oxide.	Is more difficult to fabricate than calcium-silicate.
Steam, and process equipment.	212F (100C) to 1000F (529C)	Indoors or outdoors	23-H, 23-HM, or MT 23-HSS, 23-HSM, or MT	Calcium silicate	Metal and/or Dynel reinforced Mastic depending upon size, shape and conditions.	Very absorbent. Subject to saturation by leaked or spilled liquids. Weather-barrier must be tight to prevent water damage.	Strong, can be cut and fabricated with ease. Max. resistance to external fire.	Must be protected from rain during installation.
Process equipment except stainless steel.	1000F (529C) to 1800F (982C)	Indoors or outdoors	25-H, 25-HM or MT	High temperature calcium silicate inner layer, calcium silicate outer layer.	Metal and/or Dynel reinforced Mastic depending upon size, shape and conditions.	Very absorbent. Subject to saturation by leaked or spilled liquids. Weather-barrier must be tight to prevent water damage.	Strong, can be cut and fabricated with ease. Max. resistance to external fire.	Must be protected from rain during installation.
Process equipment, where absorbence cannot be tolerated or where quick removal and replacement is necessary.	35F (2C) to 1000F (529C)	Indoors or outdoors	31-H, 31-HSS	Prefabricated units consisting of stainless steel jacket enclosing aluminum or stainless steel reflective sheets.	Factory fabricated units to fit side walls, heads and trim.	Prefabricated as a system, thus must be ordered from the manufacturer to fit the particular equipment. Detail information must be provided.	Advantageous for frequent removal and replacement. Desirable where absorption of hazardous liquids or vapor cannot be tolerated.	For temperatures above 1000F. Units made of special alloys are obtainable.

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TABLE I EQUIPMENT

FOR APPLICATION WHERE OPERATING TEMPERATURES ARE ABOVE AMBIENT

SERVICE	OPERATING TEMP. RANGE	LOCATION	SPECIFICATION NUMBER	INSULATION	PROTECTIVE COVER	LIMITATIONS	SPECIAL PROPERTIES	COMMENTS
Process equipment, for extended time fire protection.	Ambient to 1400F (760C)	Indoors or outdoors	32-HM or MT 32-HSS M or MT	Expanded silica	Metal jacket on cylindrical sections. Dynel reinforced mastic on values and fittings.	Same as specifications 22-H, 22-HSS	Installed in double layer--broken joint construction.	Suitable for application on reactive chemicals equipment, including oxide and acetylene.
Process equipment of irregular shape such as turbines.	70F (21C) to 700F (370C)	Indoors or outdoors	41-H	Sprayed Amosite asbestos fibers	Dynel reinforced Mastic	Effective for insulation of large areas only. Do not use on small equipment.	Can be applied to any contour. Has sufficient extensionability to move with metal expansion.	Depends upon surface adhesion Surface must be properly cleaned or prepared before application.
Large flat areas such as flue gas ducts.	700F (370C) to 1350F (732C)	Indoors or outdoors	41-H	Sprayed Crocidolite asbestos fibers				

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SELECTION OF INSULATION AND ITS PROTECTIVE COVER
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TABLE II PIPE AND PIPE FITTINGS

FOR APPLICATION WHERE OPERATING TEMPERATURES ARE BELOW AMBIENT

SERVICE	OPERATING TEMP. RANGE	LOCATION	SPECIFICATION NUMBER	INSULATION	PROTECTIVE COVER	LIMITATIONS	SPECIAL PROPERTIES	COMMENTS
Process lines except oxygen, oxide, and acetylene.	50F (10C) Down to -300F (-185C)	Indoors or outdoors	10-L, 10-LSS	Cellular glass	Dynel reinforced Mastic	Good fire resistance for limited time. For extended time fire protection use Spec. 32-LFP.	Excellent resistance to vapor migration.	Easy to shop fabricate.
Oxygen lines.	50F (10C) Down to -300F (-185C)	Indoors or outdoors	10-L OX, 10-L OXSS	Cellular glass	Dynel reinforced Mastic	Good fire resistance for limited time. For extended time fire protection use stainless steel jacket instead of mastic.	Excellent resistance to vapor migration.	All material and accessories must be safe for oxygen service.
Oxides, acetylene and other low temp. process lines requiring extended time fire protection.	50F (10C) Down to -300F (-185C)	Indoors or outdoors	32-LFP M or MT 32-LFPSS M or MT	Cellular glass and expanded silica (outer layer).	Metal jacket on straight pipe, Dynel reinforced Mastic on valves and fittings.	Care must be taken that insulation is installed broken joint construction.	Excellent resistance to vapor migration. Two hour fire resistance.	Metal on straight pipe selected to be suitable to resist surrounding contamination.
Process lines, low temperature with thaw-out up to 400F.	400F (205C) Thaw-out down to -300F (-185C)	Indoors or outdoors	Use appropriate system above.					Exercise special care in design and construction of expansion-contraction joints.
Water and process lines, to prevent condensate drip.	Slightly below ambient.	Indoors	40-J	PVA cork filled mastic.	None	Not suitable for conservation of refrigeration. Thickness $\frac{1}{8}$" to $\frac{1}{4}$". Should be used only on pipes 3" NPS and larger.	An insulating mastic which retards condensate drip from lines operating slightly below ambient.	Applied by palm, trowel or spray, surface must be dry at time of application and until mastic sets.

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SELECTION OF INSULATION AND ITS PROTECTIVE COVER FOR VARIOUS SERVICES AND OPERATING CONDITIONS

TABLE II PIPE AND PIPE FITTINGS

FOR APPLICATION WHERE OPERATING TEMPERATURES ARE ABOVE AMBIENT

SERVICE	OPERATING TEMP. RANGE	LOCATION	SPECIFICATION NUMBER	INSULATION	PROTECTIVE COVER	LIMITATIONS	SPECIAL PROPERTIES	COMMENTS
Water lines and instrument tubing to conserve heat or prevent condensate drip.	50F (10C) to 160F (71C)	Indoors or outdoors	14-J, 14-JSS	Flexible plastic foam	Vinyl paint	Poor fire resistance. Limited usage under building codes.	For semi-flexible instrument tubing and air cond. unit run outs.	Can be installed on tubing before tubing is bent and installed.
Process lines, for extended time fire protection.	Ambient to 1400F (760C)	Indoors or outdoors	32-HM or MT 32-HSS M or MT	Expanded silica	Metal jacket on straight pipe. Dynel reinforced mastic on valves and fittings.	Same as specification 22-H and 22-HSS	Suitable for application on reactive chemical lines, including oxide and acetylene.	Installed in double layer-broken joint construction.
Underground process, hot water and low pressure steam.	50F (10C) to 230F (110C)	Underground	38-H	PVC conduit encased urethane foam insulated pipe. Factory made.	Rigid PVC high impact plastic conduit.	Not available for pipe sizes over 10" N.P.S.	Fittings are factory insulated. Obtained as complete pipe and insulation system.	Field installed by welding pipe together and sealing PVC conduit with special couplings.
Underground process, and steam lines.	Special glass fiber up to 400F (205C). Calcium silicate up to 1000F (529C)	Underground	37-H	Pipe and insulation (as specified).	Factory formed and coated steel conduit.	System designed by the manufacturer.	Suitable for locations below ground water level.	Field installed by welding pipe together and sealing conduit with special couplings.
Underground process and traced lines	50F (10C) to 350F (173C)	Underground	10-JU	Cellular glass	Bituminous mastic with two layers of glass fabric.	Must be above height of water table and be provided with drainage for surface water.	Only system suitable for easy installation of tracing systems.	Where temperatures exceed 350F special system is required.
Underground process and steam lines	220F (104C) to 520F (271C) depending on grade.	Underground	39-H	Granulated bitumen fill type.	None	Must be in soil of excellent drainage. Not recommended on slopes or pipes with down time or cycle temp.	Heat causes material to form water barrier around pipe.	Galvanic protection of importance.

NOTES (1) Where run of pipe is short between fittings, use Dynel reinforced mastic.

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TABLE II PIPE AND PIPE FITTINGS

FOR APPLICATION WHERE OPERATING TEMPERATURES ARE ABOVE AMBIENT

SERVICE	OPERATING TEMP. RANGE	LOCATION	SPECIFICATION NUMBER	INSULATION	PROTECTIVE COVER	LIMITATIONS	SPECIAL PROPERTIES	COMMENTS
Process lines	1000F (529C) to 1800 (982C)	Indoors or outdoors	25-HM, 25-HMT	High temp. calcium-silicate inner layer. Calcium-silicate outer layer.	Metal jacket on straight pipe. Dynel reinforced Mastic on valves and fittings.(1)	Very absorbent. Subject to saturation by leaked or spilled liquids. Weather-barrier must be tight to prevent water damage.	Strong, can be cut or fabricated with ease. Max. resistance to external fires.	Metal on straight pipe selected to be suitable to resist surrounding contamination.
Process lines, where absorbence cannot be tolerated or where quick removal and replacement is necessary.	35F (2C) to 1000F (529C)	Indoors or outdoors	31-H, 31-HSS	Prefabricated units consisting of stainless steel jacket enclosing aluminum or stainless steel reflective sheets.	Factory jacketed pipe and fittings.	Prefabricated as a system, thus must ordered from manufacturer to fit the pipe system.	Advantageous for frequent removal and replacement. Desirable where absorption of hazardous liquids or vapor cannot be tolerated.	For temperatures above 1000F units are obtainable.
Process lines, high pressure steam traced process lines.	212F (100C) to 1000F (529C)	Indoors or outdoors	21-HM, 21-HMT 21-HSSM, 21-HSSMT	Asbestos fibers.	Metal jacket on straight pipe, Dynel reinforced Mastic on valves and fittings.(1)	Very absorbent. Subject to saturation by leaked or spilled. liquids. Weather-barrier must be tight.	Excellent bridging properties. Resists fracturing.	Fitting covers requiring block must be prefabricated with calcium-silicate.
Water and process lines to retard freezing.	Atmospheric	Outdoors	10-L, 10-LSS	Cellular glass	Dynel reinforced Mastic	Insulation, without heat source, will only retard freezing.	Excellent resistance to vapor and water migration.	Easy to shop fabricate.
Water, steam, process lines and utilities in buildings.	50F (10C) to 400F (205C)	Indoors	15-H	Glass fiber	Factory applied jacket on straight pipe. Fabric reinforced water emulsion coatings on fittings (where exposed).	Relatively soft. Will not withstand heavy mechanical abuse. Short time fire resistance.	Good flexibility, easy handling. Will meet building code requirements on flame spread and smoke density.	In pipe chases, over suspended ceiling, etc., jacket required. Where exposed, selected required jacket must be specified.

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TABLE II PIPE AND PIPE FITTINGS

FOR APPLICATIONS WHERE OPERATING TEMPERATURES ARE ABOVE AMBIENT

SERVICE	OPERATING TEMP. RANGE	LOCATION	SPECIFICATION NUMBER	INSULATION	PROTECTIVE COVER	LIMITATIONS	SPECIAL PROPERTIES	COMMENTS
Water and process lines except reactive chemicals.	50F (10C) to 220F (115C)	Outdoors	12-HM, 12-HSS M	Rigid Urethane Foam	Metal jacket on straight pipe Dynel reinforced Mastic on valves and fittings.(1)	Short time resistance to external fire. Must be used in accordance fire protection recommendations.	Light weight, water resistant.	Shop molded, PVC jacketed fitting covers may be used where available.
Steam and process, including acetylene, amine, and other reactive chemical piping. Electric and steam traced lines.	50F (10C) to 1400F (760C)	Indoors or outdoors	22-HM, or 22-HMT 22-HSSM or 22-HSSMT	Expanded silica	Metal jacket on straight pipe. Dynel reinforced Mastic on valves and fittings. (1)	Although it is silicone treated to obtain repellency it can be saturated by some chemicals.	Water repellent. Max. resistance to external fire. This, and Spec. 32-H, are only spec's. suitable for Ethylene Oxide service.	Metal on straight pipe selected to be suitable to resist surrounding contamination.
Steam, process, electric traced lines (especially if highly toxic chemicals are involved).	50F (10C) to 400F (205C)	Indoors or outdoors	10-J, 10-JSS	Cellular glass	Dynel reinforced Mastic.	Will crack if subjected to rapid change of operating temperature.	Excellent resistance to vapors and liquids. Will not become saturated by hazardous fumes or liquids.	Proper expansion and contraction joints are essential.
Steam, process, electric traced lines (where operating temperature is subject to rapid change).	50F (10C) to 600F (315C)	Indoors or outdoors	10-H, 10-HSS	Cellular glass and high temperature mineral fiber cushion inner layer.	Dynel reinforced Mastic.	Inner mineral fiber cushion insulation is absorbent.	Specially useful for electric or steam traced aluminum lines.	Proper expansion and contraction joints are essential.
Steam, process, and steam traced lines.	212F (100C) to 1000F (529C)	Indoors or outdoors	23-HM or 23-HMT 23-HSSM or 23-HSSMT	Calcium silicate.	Metal jacket on straight pipe. Dynel reinforced Mastic on valves and fittings.(1)	Very absorbent. Subject to saturation by leaked or spilled liquids. Weather-barrier must be tight to prevent water damage.	Strong, can be cut and fabricated with ease. Max. resistance to external fires.	Metal on straight pipe selected to be suitable to resist surrounding contamination.

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INSULATION THICKNESS REQUIREMENTS

For any particular operating temperature there is no single correct thickness of insulation. The proper thickness depends upon many factors. The first of these factors of utmost importance is the function the insulation is to serve. Some of these functions are: (1) to conserve energy, (2) to maintain process temperature (3) to protect equipment or piping from fire, (4) to maintain a safe surface temperature, (5) to maintain a surface temperature above dew point, (6) to limit heat transfer as required by process requirements, (7) to maintain stored or transit materials within given temperature range for a given temperature range for a give period of time.

Additional factors, other than function, which influence the correct thickness of insulation are: (1) ambient temperature and humidity, (2) investment cost of energy production equipment, (3) energy production cost, (4) insulation investme cost, (5) insulation maintenance cost, (6) amortization, (7) hours of operation, (8) desired life, (9) hazard of area, (10) location (indoors or outdoors), (11) condensation or freeze point of product, (12) conductivity of insulation, (13) emittanc of surface coating or jacket over insulation, (14) size of pipe or equipment.

The possible combinations of only the most common services with the variables of climate and fuel and insulation costs of all the Group I plants require a considerable number of insulation thickness tables to fulfill the needs of engineering design and plant maintenance. The thickness of insulation must be determined by the function that it is to accomplish. The major functions of our use of insulation are:

1. Conservation of Energy
2. Control of Temperature - both internal and external
3. Control of Heat Loss or Gain
4. Protection of Personnel from Burns
5. Protection of Pipe and Equipment from Fire

In many applications the insulation serves more than one of these functions.

To assist in design, a series of tables has been developed to select the proper thickness of insulation. A service designation has been assigned to the various use or service function. In some instances, although a service designation has been provided for a particular service, tables have not been included, at present, because it is doubtful that use would warrant their calculation or because the need is special and requires individual consideration.

The service designation and a summary discussion of the use of each follows:

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INSULATION THICKNESS REQUIREMENTS

Service Designation A - Air Condition Duct Insulation is for insulation of ducts outdoors or indoors. Tables are not included on the insulation thickness depends upon location - indoors or outdoors, temperature of air or gas in ducts, ambient temperatures, relative humidity, and emittance of exterior surface. The possible combinations of these many variables would require considerable number of tables and for the amount of ducts insulated it does not appear to warrant calculation of a set of tables. Material and Application Specification for Ducts are 17 RX, RY, and 18 FX, FY.

Service Designation B - Building Insulation is reserved for tables for recommended insulation thicknesses for floors, walls, and roofs of buildings. Tables have not been calculated as the number of possible combinations of building materials would make such tabulations unwarranted for the expected usage. Material and Application Specifications for Cellular Glass in Buildings is 10-B.

Service Designation C - Cold Pipe and Equipment Insulation Thicknesses are the bases for design of insulation of low temperature equipment and pipe. It is based on the fact that low temperature insulation will deteriorate approximately three times faster when its surface is wet than when the temperature of its surface is above the ambient dew point. Although surface temperature will be below dew point when ambient air is 100 percent relative humidity, the tables give the thickness of insulation which will be above most of the time so that mastics remain in good condition, maintenance can be performed, minimize fungus growth, and minimize rusting of steel. Differences in thicknesses for various plants are mainly due to differences in climatic conditions. Material and Application Specification is 10-L Cellular Glass. 10-J is also used where operation is cyclic. In this case the thicknesses are the greater as determined by comparison of Service Designations C and E.

Service Designation D - Insulation of Water Lines and Equipment to Prevent Drip is to be used when mastic is used on surfaces to prevent water drip from moisture condensation. In most instances it is used on overhead water lines, water storage tanks, and coal hoppers to prevent water drip. It should not be used for refrigerated pipe or equipment. Material and Application Specification is 40-J.

Service Designation E - Economic Insulation Thicknesses for Hot Pipe and Equipment is based on economics to obtain the optimum balance between cost of insulation and cost of heat. Thus cost of heat, cost of insulation, conductivity of insulation, temperature difference affect the thickness. The tables were calculated for the individual plant cost, installed insulation costs, and climatic conditions for most of the insulations commonly used. Of course selection of the insulation depends upon its properties as related to physical, chemical and thermal, and moisture conditions of the installation. Material and Application Specifications for the insulation selected are one of the following: 10-H, 10-J, 12-H, 15-H, 16-H, 19-H, 19-J, 21-H, 22-H, 25-H, or 41-H.

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INSULATION THICKNESS REQUIREMENTS

Service Designation F - Insulation of Water Pipe to Retard Freezing

Insulation cannot prevent freezing of outdoor water lines of no flow. For water lines which do have some flow, a table is presented as to the minimum flow per 100 feet of pipe with water entering at 40F for various thicknesses of insulation. Materi and Application Specification should be 10-L and 10-J.

Service Designation M - Insulation to Control Maximum Heat Loss

Process requirements may dictate that the equipment or piping system can tolerate only so much heat loss and still function properly. Although a service designation has been assigned to this insulation function, tables cannot be provided as the thicknesses to control heat losses within the limits must be calculated for the individual installation.

Service Designation N - Insulation to Control Maximum Heat Gain

Process requirements may dictate that the equipment or piping system can tolerate only so much heat gain and still function properly. Although a service designation has been assigned to this insulation function, tables cannot be provided as the thicknesses to control heat gains within the limits must be calculated for the individual installation.

Service Designation P - Fire Protection Insulation Thickness

Insulation thicknesses for fire protection of equipment and piping in hazardous locations are provided for low temperature, atmospheric, and high temperature installations. As the insulation may serve other functions other than for fire protection, tables are included not only for atmospheric operation temperature but low temperature and high temperature operation. Therefore, the tables will have a second service designation to serve as a guide to dual function the insulation is to serve.

Service Designation R - Reflective Insulation Thicknesses

The thermal resistance of reflective insulation is determined by the number of reflective shields. This insulation is supplied in completely finished units and the spacing of reflective sheets and its total thickness determine its total efficiency. For this reason, other than thickness, the shield spacing is provided in the tables. As number of shield or thicknesses in a unit is not a straight line cost factor, the tables provided have been taken into consideration the surface temperature, and economics, and may be used directly for Service Functions E, S, and T.

Service Designation S - Safe Surface Temperature Insulation Thicknesses

When insulation is used to provide safe surface temperature and when process heat is less valuable than heat provided by steam or Dowtherm, less thickness of insulation is required. However, safe surface temperatures are a function not only of

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INSULATION THICKNESS REQUIREMENTS

Service Designation S - Safe Surface Temperature Insulation Thicknesses - Continued the insulation thickness and operating temperatures, but also the emittance of the outer surface. For this reason, tables are provided for safe surface temperatures based on operating temperatures and outer surface emittances of weather barriers commonly used. On high temperature installations excessively thick insulation may be required if weather barrier has low emittance. Although the table for safe surface temperature of low emittance weather barrier is provided, where the thicknesses exceed the thicknesses required for economics, a weather barrier of higher emittance should be specified.

Service Designation T - Traced Pipe and Equipment Insulation Thicknesses
Heat traced pipe and equipment are generally heat traced using steam or electric as source of heat. The steam heated tracing may supply the heat to the pipe by heating the annulus air space around the pipe. Where higher temperatures are required than can be obtained by a single tracer by this method, the steam tracer is thermally bonded to the process pipe or equipment with heat transfer cement. Tables for the design of these and the insulation thicknesses required are provided. The insulation thickness selected should be cross-checked with the economic thickness tables to determine that the optimum thickness of insulation is provided. However, the savings of tracer tubing or elimination of trap stations may warrant additional insulation than the thickness based on steam savings only.

Tables for design, and insulation thicknesses for electric tracing are also provided. Tables are based on electric tracer being bonded to process pipe with high conductive cement.

Service Designation U - Underground Insulation Thicknesses
Piping located underground requires factory-made conduits, field-made conduits or fill insulation. Various insulation can be supplied with the factory-made conduits, Specification No. 37-H, so in that particular specification the insulation material to be used must be selected as determined by operation requirements. The insulation thickness required of underground fill insulation, Specification No. 39-H, is given in the specification so no thickness table is included. Specification No. 39-H is recommended only where ground conditions are relatively dry and good drainage is possible.

An index of the service designation thickness tables follows.

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INSULATION THICKNESS REQUIREMENTS

SERVICE AND USE INSULATION THICKNESS TABLES

Service Designation	Service or Use	Spec. No.	Table No.	Page
A	Air Conditioning Duct Insulation Thickness	10-B	Not included	
B	Building Insulation Thicknesses	17	" "	
C	Cold Pipe and Equipment Insulation Thicknesses	10-L	C-1 to C-3	
D	Control of Water Drip From Surfaces	40-J	D-1	
E	Economic Insulation Thicknesses Steam, and Steam-Heated Processes	10-H	E1 to E-10	
		10-J 10-JSS	E11 to E-20	
		12-H	E-21 to E-24	
		16-H	E-25 to E-31	
		19-H	E-32, E-33	
		15-H 21-H 21-HSS 22-H 22-HSS 23-H 23-HSS	E-34 to E-43	
		22-H 22-HSS 25-H	E-44 to E-52	
		41-H 42-H	E-53	
	Dowtherm, and Dowtherm-Heated Processes (Not Calculated at Present)			
F	Insulation Thicknesses to Retard Freezing of Water Pipes	10-J 10-L	F-1	
M	Maximum Heat Loss from Equipment or Piping System		Not included	

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INSULATION THICKNESS REQUIREMENTS

SERVICE AND USE INSULATION THICKNESS TABLES - Continued

N		Maximum Heat Gain to Equipment or Piping System		Not included
P		Fire Protection Insulation Thicknesses		
	PS	High Temperature Fire Protection and Safe Surface Temperature	32-H	PS-1, PS-2
	PE	High Temperature Fire Protection and Economic Thickness	32-H	PE-3 to PE-12
	PC	Low Temperature Fire Protection - Cold Service	32-L	PC-13 to PC-15
		Table of Thicknesses of Insulation Layers	32-L	P-16 to P-18
R		Reflective Insulation Thicknesses	13-H	R-1, R-2
S		Safety Insulation Thicknesses - Safe Surface Temperature	21-H 22-H 23-H 25-H	
		Emissivity of Surface 0.9 (Mastic Finishes)	21-H 22-H 23-H 25-H	S-1, S-2
		Emissivity of Surface 0.4 (Stainless Steel Jackets)	21-H 22-H 23-H 25-H	S-3, S-4
		Emissivity of Surface 0.05 (Aluminum Jacket)	21-H 22-H 23-H 25-H	S-5, S-6

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INSULATION THICKNESS REQUIREMENTS

SERVICE AND USE INSULATION THICKNESS TABLES - Continued

T	Heat Traced Piping and Equipment Steam Heated	*	
	Pipe Spaced Tracer System (Air Convection Annulus Space)	*	T-1 to T-7
	Pipe Cemented Tracer System (Bonded with Heat Trans. Cement)	*	T-8 to T-14
	Equipment Cemented Tracer System (Bonded with Heat Trans. Cement)	*	T-15 to T-30
	Electric Traced Electrically Heated	*	
	Pipe Cemented Tracer System (Bonded with Heat Trans. Cement)	*	T-31 to T-65
U	Underground Insulation Thicknesses		
	Urethane Conduit System	38-H	U-1, U-3
	Cellular Glass	10-U 10-USS	U-4 to U-8
	Steel Conduit	37-H	U-9 to U-13

* Specification selection may be based on other considerations other than the fact that pipe or equipment require heat tracing.

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INSULATION THICKNESS REQUIREMENTS

Service Designation C-1

CONDENSATION PREVENTION INSULATION THICKNESSES

PLANTS: ALL PLANTS
SPEC. NO'S: 10-L CELLULAR GLASS

SERVICE: INDOORS - AIR CONDITIONED BUILDINGS (75F-60%RH)

NOM PIPE SIZE	OPERATING TEMPERATURE °C																														
	19 to 10	9 to 5	4 to 0	-1 to -5	-6 to -10	-11 to -15	-16 to -20	-21 to -25	-26 to -30	-31 to -35	-36 to -40	-41 to -45	-46 to -50	-51 to -55	-56 to -60	-61 to -65	-66 to -70	-71 to -75	-76 to -80	-81 to -85	-86 to -90	-91 to -95	-96 to -100	-101 to -105	-106 to -110	-111 to -115	-116 to -120	-121 to -125
½	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
¾	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
1	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
1¼	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
1½	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
2	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
2½	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
3	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
3½	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
4	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
5	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
6	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
8	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
10	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
12	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
14	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
16	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
18	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
20	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
22	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
24	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
26	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
28	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
30	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
36	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
EQUIP FLAT	1½	1½	1½	2	2	2½	3	-5	-14	-23	-32	-41	-50	-59	-68	-77	-86	-95	-104	-113	-122	-131	-140	-149	-158	-167	-176	-185
	67 to 50	49 to 41	40 to 32	31 to 23	22 to 14	13 to 5	4 to -4	-5 to -13	-14 to -22	-23 to -31	-32 to -40	-41 to -49	-50 to -58	-59 to -67	-68 to -76	-77 to -85	-86 to -94	-95 to -103	-104 to -112	-113 to -121	-122 to -130	-131 to -139	+140 to +148	-149 to -157	-158 to -166	-167 to -175	-176 to -184	-185 to -198
	OPERATING TEMPERATURE °F																											

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INSULATION THICKNESS REQUIREMENTS

Service Designation C-2

CONDENSATION PREVENTION INSULATION THICKNESSES

PLANTS: MONTREAL 053, NIAGARA FALLS 516, OTTAWA
SPEC. NO'S: 1C-1 CELLULAR GLASS

SERVICE: LOW TEMPERATURE - OUTDOORS

NOM. PIPE SIZE	OPERATING TEMPERATURE °C																											
	19 to 10	9 to 5	4 to 0	-1 to -5	-6 to -10	-11 to -15	-16 to -20	-21 to -25	-26 to -30	-31 to -35	-36 to -40	-41 to -45	-46 to -50	-51 to -55	-56 to -60	-61 to -65	-66 to -70	-71 to -75	-76 to -80	-81 to -85	-86 to -90	-91 to -95	-96 to -100	-101 to -105	-106 to -110	-111 to -115	-116 to -120	-121 to -125
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3
¾	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3
1	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3	3	3½
1¼	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½
1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½
2	1½	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4
2½	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4	4½
3	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4	4½	4½
3½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4	4½	4½	4½	4½	4½	5	5
4	1½	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3	3½	3½	4	4	4	4	4½	4½	4½	5	5	5	5	5
6	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5	5	5	5	5½	5½
8	1½	1½	2	2	2	2	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5	5	5	5½	5½	5½	5½
10	1½	2	2	2	2	2	2½	2½	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5	5	5½	5½	5½	5½	5½	6
12	1½	2	2	2	2	2	2½	2½	3	3	3½	3½	4	4	4	4½	4½	5	5	5	5½	5½	6	6	6	6	6	6½
14	1½	2	2	2	2	2	2½	2½	3	3	3½	4	4	4	4	4½	4½	5	5	5	5½	6	6	6	6	6	6½	6½
16	1½	2	2	2	2	2	2½	2½	3	3	3½	4	4	4	4	4½	4½	5	5	5	5½	6	6	6	6	6½	6½	6½
18	1½	2	2	2	2	2	2½	2½	3	3	3½	4	4	4	4	4½	4½	5	5	5	5½	6	6	6	6½	6½	6½	7
20	1½	2	2	2	2	2	2½	2½	3	3	3½	4	4	4	4	4½	4½	5	5	5	5½	6	6	6	6½	6½	7	7
22	1½	2	2	2	2	2	2½	2½	3	3	3½	4	4	4	4	4½	4½	5	5	5	5½	6	6	6	6½	6½	7	7
24	1½	2	2	2	2	2	2½	2½	3	3	3½	4	4	4	4	4½	4½	5	5	5	5½	6	6	6	6½	6½	7	7
26	1½	2	2	2	2	2	2½	2½	3	3	3½	4	4	4	4	4½	4½	5	5	5	5½	6	6	6	6½	6½	7	7
28	1½	2	2	2	2	2	2½	2½	3	3	3½	4	4	4	4	4½	4½	5	5	5	5½	6	6	6	6½	6½	7	7
30	1½	2	2	2	2	2	2½	2½	3	3	3½	4	4	4	4	4½	4½	5	5	5	5½	6	6	6	6½	6½	7	7
36	1½	2	2	2	2	2	2½	2½	3	3	3½	4	4	4	4	4½	4½	5	5	5	5½	6	6	6	6	6	6½	7
ECONOMY FLAT	1½	2	2	2	2	2½	2½	3	3	3½	4	4	4	4½	4½	5	5	5	5	5½	6	6	6	6	6	6	6½	7
	67 to 50	49 to 41	40 to 32	31 to 23	22 to 14	13 to 5	4 to -4	-5 to -13	-14 to -22	-23 to -31	-32 to -40	-41 to -49	-50 to -58	-59 to -67	-68 to -76	-77 to -85	-86 to -94	-95 to -103	-104 to -112	-113 to -121	-122 to -130	-131 to -139	-140 to -148	-149 to -157	-158 to -166	-167 to -175	-176 to -184	-185 to -198
	OPERATING TEMPERATURE °F																											

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INSULATION THICKNESS REQUIREMENTS

Service Designation C-3

CONDENSATION PREVENTION INSULATION THICKNESSES

PLANTS: SEADRIFT-510, INSTITUTE-518, TORRANCE-512, S. CHARLESTON-514, TAFT-519, BROWNSVILLE-526, SISTERSVILLE-380, MARIETTA-314, PONCE-293, BOUND BROOK-312, CARTERSVILLE-325, WHITING-517

SPEC. NO'S: 10-L CELLULAR GLASS

SERVICE: LOW TEMPERATURE - OUTDOORS

NOM PIPE SIZE	OPERATING TEMPERATURE °C																														
	19 to 10	9 to 5	4 to 0	-1 to -5	-6 to -10	-11 to -15	-16 to -20	-21 to -25	-26 to -30	-31 to -35	-36 to -40	-41 to -45	-46 to -50	-51 to -55	-56 to -60	-61 to -65	-66 to -70	-71 to -75	-76 to -80	-81 to -85	-86 to -90	-91 to -95	-96 to -100	-101 to -105	-106 to -110	-111 to -115	-116 to -120	-121 to -125
½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	4
¾	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	3½	3½	4	4	4	4	4	4
1	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	4	4	4	4	4	4	4½
1¼	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4	4	4½	4½	4½	4½	4½
1½	1½	1½	2	2	2	2	2½	2½	3	3	3	3	3½	3½	4	4	4	4	4	4	4	4½	4½	4½	4½	4½	4½	5
2	1½	2	2	2	2	2½	2½	3	3	3	3	3½	3½	4	4	4	4	4	4	4½	4½	4½	5	5	5	5	5	5
2½	1½	2	2	2	2	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5	5	5	5	5½	5½	6	6
3	1½	2	2	2	2	2½	3	3	3	3	3½	4	4	4	4½	4½	5	5	5	5½	5½	6	6	6	6	6	6½	6½
3½	1½	2	2	2	2	2½	3	3	3	3½	4	4	4	4½	4½	5	5	5	5½	5½	6	6	6	6½	6½	6½	6½	7
4	1½	2	2	2	2	2½	3	3	3½	3½	4	4	4½	4½	5	5	5½	5½	6	6	6	6½	6½	6½	7	7	7	7
6	1½	2	2	2	2½	2½	3	3	3½	4	4	4½	5	5	5½	5½	6	6	6½	6½	6½	7	7	7	7	7	7½	7½
8	2	2	2	2½	2½	3	3½	3½	4	4	4½	5	5	5½	6	6	6½	6½	7	7	7	7½	7½	8	8	8	8	8
10	2	2	2	2½	3	3	3½	4	4	4½	5	5	5½	6	6	6½	7	7	7½	8	8	8½	8½	9	9	9	9	9
12	2	2	2	2½	3	3	3½	4	4	4½	5	5	5½	6	6	6½	7	7	7½	8	8	8½	9	9	9	9	9½	9½
14	2	2	2	2½	3	3	3½	4	4	4½	5	5	5½	6	6	6½	7	7	7½	8	8	8½	9	9	9½	9½	10	10
16	2	2	2	2½	3	3	3½	4	4	4½	5	5	5½	6	6	6½	7	7	7½	8	8	8½	9	9½	9½	10	10	10
18	2	2	2	2½	3	3	3½	4	4	4½	5	5	5½	6	6	6½	7	7	7½	8	8	8½	9	9½	10	10	10½	10½
20	2	2	2	2½	3	3	3½	4	4	4½	5	5	5½	6	6	6½	7	7	7½	8	8	8½	9	9½	10	10	10½	11
22	2	2	2	2½	3	3	3½	4	4	4½	5	5	5½	6	6	6½	7	7	7½	8	8	8½	9	9½	10	10	10½	11
24	2	2	2	2½	3	3	3½	4	4	4½	5	5	5½	6	6	6½	7	7	7½	8	8	8½	9	9½	10	10	10½	11
26	2	2	2	2½	3	3	3½	4	4	4½	5	5	5½	6	6	6½	7	7	7½	8	8	8½	9	9½	10	10	10½	11
28	2	2	2	2½	3	3	3½	4	4	4½	5	5	5½	6	6	6½	7	7	7½	8	8	8½	9	9½	10	10	10½	11
30	2	2	2	2½	3	3½	3½	4	4	4½	5	5	5½	6	6	6½	7	7	7½	8	8	8½	9	9½	10	10	10½	11
32	2	2	2	2½	3	3½	3½	4	4	4½	5	5½	6	6	6½	7	7	7½	8	8	8½	9	9	9½	10	10	10½	11
EQUIP FLAT	2	2½	3	3	3½	4	4	4½	5	5	5½	6	6	6½	7	7	7	7½	8	8	8½	8½	8½	9	9	9	9	9
	67 to 10	49 to 5	40 to 0	31 to -5	22 to -10	13 to -15	4 to -20	-5 to -25	-14 to -30	-23 to -35	-32 to -40	-41 to -45	-50 to -50	-59 to -55	-68 to -60	-77 to -65	-86 to -70	-95 to -75	-104 to -80	-113 to -85	-122 to -90	-131 to -95	-140 to -100	-149 to -105	-158 to -110	-167 to -115	-176 to -120	-185 to -125
	50	41	32	23	14	5	-4	-13	-22	-31	-40	-49	-58	-67	-76	-85	-94	-103	-112	-121	-130	-139	-148	-157	-166	-175	-184	-198

OPERATING TEMPERATURE °F

INSULATION THICKNESS REQUIREMENTS

Service Designation

INSULATION THICKNESSES FOR
CONTROL OF WATER DRIP FROM SURFACE OF PIPE AND EQUIPMENT

SERVICE: PREVENTION OF WATER DRIP

PLANTS: ALL PLANTS
SPEC. NO. 40-J PVA INSULATING MASTIC

PERCENT RELATIVE HUMIDITY, ABOVE WHICH CONDENSATION WILL OCCUR ON SURFACES

Pipe or Equipment Temperature		Insulated with 1" thickness of mastic Ambient Temperature °C												Insulated with 3/8" thickness of mastic Ambient Temperature °C											
C	F	7.2	10.0	12.8	15.6	18.3	21.1	23.9	26.7	29.4	32.2	35.0	37.8	7.2	10.0	12.8	15.6	18.3	21.1	23.9	26.7	29.4	32.2	35.0	37.8
4.4	40	86	81	74	68	63	59	55	52	49	47	43	41	92	84	79	76	69	66	63	59	57	55	53	50
7.2	45		91	82	75	69	64	60	57	54	50	48	45		92	85	80	74	70	67	64	61	58	56	53
10.0	50			91	82	75	69	65	61	58	55	51	48			92	85	80	76	71	68	64	62	59	57
12.8	55				91	83	77	71	66	62	59	54	52				92	86	80	76	72	69	66	63	60
15.6	60					91	83	78	72	67	63	59	56					92	86	81	77	73	69	67	63
18.3	65						92	84	78	73	68	64	60						92	87	82	78	73	70	68
21.1	70							92	84	79	73	68	64							93	88	82	78	74	71
23.9	75								92	86	79	74	69								93	90	82	79	74
26.7	80									92	86	79	77									93	88	83	79
29.4	85										92	86	80										93	88	84
32.2	90											92	87											93	88
35.0	95												92												93
		45	50	55	60	65	70	75	80	85	90	95	100	45	50	55	60	65	70	75	80	85	90	95	100
		Ambient Temperature °F												Ambient Temperature °F											

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ECONOMIC INSULATION THICKNESSES

PLANTS: SILICONES - SISTERSVILLE PLANT
SPEC. NO'S: 10-H CELLULAR GLASS (FIBER GLASS INNER LAYER)
SERVICE: STEAM AND STEAM HEATED PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C												
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
3	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
3½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2
4	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
6	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
8	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
10	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½
12	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3
14	1½	1½	1½	2	2	2	2	2	2½	2½	3	3	3
16	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3½
18	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3½
20	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3½
22	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3½
24	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½	4
26	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½	4
28	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½	4
30	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½	4
36	1½	1½	2	2	2½	2½	2½	3		3	3½	3½	4
EQUIP FLAT	1½	1½	2	2½	2½	2½	3	3	3	3½	4	4	4
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607
	OPERATING TEMPERATURE ° F												

NOTE: Inner cushion of fiber glass not considered as part of specified thickness.

ECONOMIC INSULATION THICKNESSES

PLANTS: WHITING PLANT 517
SPEC. NO'S: 10-H CELLULAR GLASS (FIBER GLASS INNER LAYER)
SERVICE: STEAM AND STEAM HEATED PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C												
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2
3	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½
3½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½
4	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½
6	1½	1½	1½	1½	1½	2	2	2	2	2	2	2½	2½
8	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½
10	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3	3
12	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3½	3½
14	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3½	3½
16	1½	1½	2	2	2½	2½	2½	3	3	3	3	3½	3½
18	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½	3½
20	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½	4
22	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½	4
24	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½	4
26	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½	4
28	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½	4
30	1½	1½	2	2½	2½	2½	3	3	3	3½	4	4	4
36	1½	1½	2	2½	2½	2½	3	3	3	3½	4	4	4
EQUIP FLAT	1½	2	2	2½	3	3	3½	3½	3½	4	4½	4½	4½
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607
	OPERATING TEMPERATURE ° F												

NOTE: Inner cushion of fiber glass not considered as part of specified thickness.

Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation D...
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asbestosclaims.law/library/19432/291

ECONOMIC INSULATION THICKNESSES

PLANTS: GULF COAST PLANTS - SEADRIFT-510, TEXAS CITY-515, TAFT-519, BROWNSVILLE-526
SPEC. NO'S: 10-H CELLULAR GLASS (FIBER GLASS INNER LAYER) SERVICE: STEAM AND STEAM HEATED PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE • C												
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2½
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2½
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½
3	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½
3½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½
4	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
6	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3
8	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3
10	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3½
12	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3½
14	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3½	3½
16	1½	1½	1½	2	2	2½	2½	2½	3	3	3½	3½	3½
18	1½	1½	1½	2	2	2½	2½	3	3	3	3½	3½	4
20	1½	1½	1½	2	2	2½	2½	3	3	3	3½	3½	4
22	1½	1½	1½	2	2	2½	2½	3	3	3	3½	3½	4
24	1½	1½	1½	2	2½	2½	2½	3	3	3	3½	4	4
26	1½	1½	1½	2	2½	2½	2½	3	3	3	3½	4	4
28	1½	1½	1½	2	2½	2½	2½	3	3	3	3½	4	4
30	1½	1½	2	2	2½	2½	3	3	3	3½	4	4	4
36	1½	1½	2	2½	2½	2½	3	3	3½	3½	4	4	4
EQUIP FLAT	1½	1½	2	2½	3	3	3½	3½	3½	4	4½	4½	5
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607
	OPERATING TEMPERATURE • F												

NOTE: Inner cushion layer of glass fiber not considered as part of specified thickness.

ECONOMIC INSULATION THICKNESSES

PLANTS: TORRANCE PLANT 513
SPEC. NO'S: 10-H CELLULAR GLASS (FIBER GLASS INNER LAYER) SERVICE: STEAM AND STEAM HEATED PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE • C												
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2½
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2½
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½
3	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½
3½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½
4	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
6	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3
8	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3
10	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3½
12	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3½
14	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3½	3½
16	1½	1½	1½	2	2	2½	2½	2½	3	3	3½	3½	3½
18	1½	1½	1½	2	2	2½	2½	3	3	3	3½	3½	4
20	1½	1½	1½	2	2	2½	2½	3	3	3	3½	3½	4
22	1½	1½	1½	2	2	2½	2½	3	3	3	3½	3½	4
24	1½	1½	1½	2	2½	2½	2½	3	3	3	3½	4	4
26	1½	1½	1½	2	2½	2½	2½	3	3	3	3½	4	4
28	1½	1½	1½	2	2½	2½	2½	3	3	3	3½	4	4
30	1½	1½	2	2	2½	2½	3	3	3	3½	4	4	4
36	1½	1½	2	2½	2½	2½	3	3	3½	3½	4	4	4
EQUIP FLAT	1½	1½	2	2½	3	3	3½	3½	3½	4	4½	4½	5
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607
	OPERATING TEMPERATURE • F												

NOTE: Inner cushion of fiber glass not considered as part of specified thickness.

Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation D...
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Published by AsbestosClaims.Law
asbestosclaims.law/library/19432/292

ECONOMIC INSULATION THICKNESSES

PLANTS: KANAWHA VALLEY PLANTS - INSTITUTE-512, SOUTH CHARLESTON-514
SPEC. NO'S: 10-H CELLULAR GLASS (FIBER GLASS INNER LAYER) SERVICE: STEAM AND STEAM HEATED PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE • C												
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
3	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
3½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½
4	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½
6	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
8	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	3
10	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3
12	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3
14	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3
16	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3½
18	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3½	3½
20	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3½	3½
22	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3½	3½
24	1½	1½	1½	2	2	2½	2½	2½	3	3	3½	3½	3½
26	1½	1½	1½	2	2	2½	2½	2½	3	3	3½	3½	3½
28	1½	1½	1½	2	2	2½	2½	2½	3	3	3½	3½	3½
30	1½	1½	2	2	2½	2½	2½	2½	3	3	3½	3½	3½
36	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½	3½
EQUIP FLAT	1½	1½	2	2	2½	2½	3	3	3	3	4	4	4
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607
	OPERATING TEMPERATURE • F												

NOTE: Inner cushion layer of fiber glass not considered as part of specified thickness.

ECONOMIC INSULATION THICKNESSES

PLANTS: MONTREAL PLANT 053
SPEC. NO'S: 10-H CELLULAR GLASS (FIBER GLASS INNER LAYER) SERVICE: STEAM AND STEAM HEATED PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE • C												
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
3	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
3½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
4	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
6	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
8	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
10	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3
12	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3
14	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3
16	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3
18	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3
20	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3½
22	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3½
24	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3½
26	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3½
28	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3½
30	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3½	3½
36	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3½	3½
EQUIP FLAT	1½	1½	2	2	2½	2½	3	3	3	3	3½	4	4
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607
	OPERATING TEMPERATURE • F												

NOTE: Inner cushion layer of fiber glass not considered as part of specified thickness.

Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation D...
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INSULATION THICKNESS REQUIEMENTS

Service Designation E-7

ECONOMIC INSULATION THICKNESSES

PLANTS: PONCE
SPEC. NO'S: 10-H CELLULAR GLASS (FIBER GLASS INNER LAYER)
SERVICE: STEAM AND STEAM HEATED EQUIPMENT AND PIPE

NOM PIPE SIZE	OPERATING TEMPERATURE °C												
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
3/4	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
3	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2
3½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
4	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2
6	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2
8	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
10	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½
12	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3
14	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3
16	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3
18	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3
20	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3
22	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3
24	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3½	3½
26	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3½	3½
28	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3½	3½
30	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3½	3½
36	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3½	3½
EQUIP FLAT	1½	1½	2	2	2½	2½	3	3	3	3½	3½	3½	4
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 417	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607
	OPERATING TEMPERATURE °F												

ECONOMIC INSULATION THICKNESSES

PLANTS: BOUND BROOK PLANT - PLASTIC DIVISION
SPEC. NO'S: 10-H CELLULAR GLASS SERVICE: STEAM AND STEAM HEATED
(FIBER GLASS INNER LAYER) PIPE AND EQUIPMENT

INSULATION THICKNESS REQUIREMENTS

Service Designation E-8
E-9

NOM PIPE SIZE	OPERATING TEMPERATURE °C														
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319		
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½		
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½		
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½		
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2		
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2		
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2		
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2		
3	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½		
3½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½		
4	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½		
6	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½		
8	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½		
10	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½		
12	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3		
14	1½	1½	1½	1½	2	2	2	2½	2½	3	3	3	3½		
16	1½	1½	1½	1½	2	2	2	2½	2½	3	3	3	3½		
18	1½	1½	1½	1½	2	2	2	2½	2½	3	3	3	3½		
20	1½	1½	1½	1½	2	2	2	2½	2½	3	3	3	3½		
22	1½	1½	1½	1½	2	2	2	2½	2½	3	3	3	3½		
24	1½	1½	1½	2	2	2	2	2½	2½	3	3	3	3½		
26	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3½		
28	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3½		
30	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3½		
36	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3½		
EQUIP FLAT	1½	1½	2	2	2½	2½	2½	3	3	3½	3½	3½	3½		
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607		
	OPERATING TEMPERATURE °F														

Note: Inner layer of fiber glass not considered as part of specified thickness.

ECONOMIC INSULATION THICKNESSES

PLANTS: CARTERSVILLE PLANT - OTTAWA PLANT, PLASTICS DIVISION
SPEC. NO'S: 10-H CELLULAR GLASS SERVICE: STEAM AND STEAM HEATED
(FIBER GLASS INNER LAYER) PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE °C														
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319		
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½		
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½		
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½		
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2		
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2		
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2		
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2		
3	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½		
3½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½		
4	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½		
6	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½		
8	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½		
10	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½		
12	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3		
14	1½	1½	1½	1½	2	2	2	2½	2½	3	3	3	3½		
16	1½	1½	1½	1½	2	2	2	2½	2½	3	3	3	3½		
18	1½	1½	1½	1½	2	2	2	2½	2½	3	3	3	3½		
20	1½	1½	1½	1½	2	2	2	2½	2½	3	3	3	3½		
22	1½	1½	1½	1½	2	2	2	2½	2½	3	3	3	3½		
24	1½	1½	1½	2	2	2	2	2½	2½	3	3	3	3½		
26	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3½		
28	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3½		
30	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3½		
36	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3½		
EQUIP FLAT	1½	1½	2	2	2½	2½	2½	3	3	3½	3½	3½	3½		
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607		
	OPERATING TEMPERATURE °F														

Note: Inner layer of fiber glass not considered as part of specified thickness

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INSULATION THICKNESS REQUIREMENTS

Service Designation E-10

ECONOMIC INSULATION THICKNESSES

PLANTS: MARIETTA PLANT - PLASTICS DIVISION
SPEC. NO'S: 10-H CELLULAR GLASS (FIBER GLASS INNER LAYER) SERVICE: STEAM AND STEAM HEATED PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C												
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
3	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
3½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
4	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
6	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2
8	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2
10	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
12	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½
14	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
16	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½
18	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½
20	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½
22	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½
24	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½
26	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½
28	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½
30	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½
36	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½
EQUIP FLAT	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3½
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607
	OPERATING TEMPERATURE ° F												

Note: Inner layer of fiber glass not considered as part of specified thickness.

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ECONOMIC INSULATION THICKNESSES

PLANTS: WHITING PLANT 517
SPEC. NO'S: 10-J, 10-J SS CELLULAR GLASS

SERVICE: STEAM AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C											
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
1¼	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
2	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
2½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
3	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½
3½	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3
4	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3
6	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3
8	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½
10	1½	1½	2	2	2½	2½	3	3	3	3½	3½	3½
12	1½	1½	2	2	2½	2½	3	3	3	3½	3½	3½
14	1½	1½	2	2½	2½	3	3	3	3½	3½	3½	3½
16	1½	1½	2	2½	2½	3	3	3	3½	3½	3½	3½
18	1½	2	2½	2½	2½	3	3	3½	3½	3½	3½	4
20	1½	2	2½	2½	3	3	3½	3½	3½	4	4	4
22	1½	2	2½	2½	3	3	3½	3½	3½	4	4	4
24	1½	2	2½	2½	3	3	3½	3½	3½	4	4	4
26	1½	2	2½	2½	3	3	3½	3½	3½	4	4	4
28	1½	2	2½	2½	3	3	3½	3½	3½	4	4	4
30	2	2	2½	3	3	3½	3½	3½	4	4	4½	4½
36	2	2	2½	3	3	3½	3½	3½	4	4	4½	4½
EQUIP FLAT	2	2½	3	3½	3½	4	4½	4½	5	5	5	5½
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571
	OPERATING TEMPERATURE ° F											

ECONOMIC INSULATION THICKNESSES

PLANTS: TORRANCE PLANT 513
SPEC. NO'S: 10-J, 10-JSS CELLULAR GLASS

SERVICE: STEAM AND STEAM HEATED PROCESS, PIPES AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C											
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
1¼	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
2	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
2½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
3	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½
3½	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3
4	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3
6	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3
8	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½
10	1½	1½	2	2	2½	2½	3	3	3	3½	3½	3½
12	1½	1½	2	2	2½	2½	3	3	3	3½	3½	3½
14	1½	1½	2	2½	2½	3	3	3	3½	3½	3½	3½
16	1½	1½	2	2½	2½	3	3	3	3½	3½	3½	3½
18	1½	2	2½	2½	2½	3	3	3½	3½	3½	3½	4
20	1½	2	2½	2½	3	3	3½	3½	3½	4	4	4
22	1½	2	2½	2½	3	3	3½	3½	3½	4	4	4
24	1½	2	2½	2½	3	3	3½	3½	3½	4	4	4
26	1½	2	2½	2½	3	3	3½	3½	3½	4	4	4
28	1½	2	2½	2½	3	3	3½	3½	3½	4	4	4
30	2	2	2½	3	3	3½	3½	3½	4	4	4½	4½
36	2	2	2½	3	3	3½	3½	3½	4	4	4½	4½
EQUIP FLAT	2	2½	3	3½	3½	4	4½	4½	5	5	5	5½
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571
	OPERATING TEMPERATURE ° F											

Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation D...
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ECONOMIC INSULATION THICKNESSES

PLANTS: KANAWHA VALLEY PLANTS – INSTITUTE-512, SOUTH CHARLESTON-514
SPEC. NO'S: 10-J and 10-JSS CELLULAR GLASS SERVICE: STEAM AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

INSULATION THICKNESS REQUIREMENTS

Service Designation E-1 E-1

NOM PIPE SIZE	OPERATING TEMPERATURE ° C														
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299			
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2			
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2			
3	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2			
3½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2			
4	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2			
6	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½			
8	1½	1½	1½	1½	2	2	2	2	2	2½	2½	3			
10	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3			
12	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3			
14	1½	1½	1½	2	2	2½	2½	2½	3	3	3	3			
16	1½	1½	1½	2	2	2½	2½	3	3	3	3	3			
18	1½	1½	2	2	2	2½	2½	3	3	3	3	3			
20	1½	1½	2	2	2	2½	2½	3	3	3	3	3			
22	1½	1½	2	2	2	2½	2½	3	3	3	3	3			
24	1½	1½	2	2	2	2½	2½	3	3	3	3	3			
26	1½	1½	2	2	2	2½	2½	3	3	3	3	3			
28	1½	1½	2	2	2	2½	2½	3	3	3	3	3			
30	1½	1½	2	2	2	2½	2½	3	3	3	3	3½			
36	1½	1½	2	2	2	2½	2½	3	3	3	3	3½			
EQUIP FLAT	2	2	2½	2½	2½	3	3	3	3½	3½	3½	4			
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571			
	OPERATING TEMPERATURE ° F														

ECONOMIC INSULATION THICKNESSES

PLANTS:
SPEC. NO'S: SILICONES – SISTERSVILLE PLANT
10-J and 10-JSS CELLULAR GLASS SERVICE: STEAM AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C														
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299			
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2			
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2			
3	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2			
3½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2			
4	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2			
6	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½			
8	1½	1½	1½	1½	2	2	2	2	2	2½	2½	3			
10	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3			
12	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3			
14	1½	1½	1½	2	2	2½	2½	2½	3	3	3	3			
16	1½	1½	1½	2	2	2½	2½	3	3	3	3	3			
18	1½	1½	2	2	2	2½	2½	3	3	3	3	3			
20	1½	1½	2	2	2	2½	2½	3	3	3	3	3			
22	1½	1½	2	2	2	2½	2½	3	3	3	3	3			
24	1½	1½	2	2	2	2½	2½	3	3	3	3	3			
26	1½	1½	2	2	2	2½	2½	3	3	3	3	3			
28	1½	1½	2	2	2	2½	2½	3	3	3	3	3			
30	1½	1½	2	2	2	2½	2½	3	3	3	3	3½			
36	1½	1½	2	2	2	2½	2½	3	3	3	3	3½			
EQUIP FLAT	2	2	2½	2½	3	3	3½	4	4	4½	4½	4½			
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571			
	OPERATING TEMPERATURE ° F														

INSULATION THICKNESS REQUIREMENTS

Service Designation E-15
E-16

ECONOMIC INSULATION THICKNESSES

PLANTS: MONTREAL-053
SPEC. NO'S: 10-J, 10-JSS CELLULAR GLASS SERVICE: STEAM AND STEAM HEATED PROCESS LINES AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C														
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299			
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
3	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
3½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
4	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2			
6	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2			
8	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2			
10	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2			
12	1½	1½	1½	1½	1½	2	2	2	2	2	2	2½			
14	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½			
16	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½			
18	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½			
20	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3			
22	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3			
24	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3			
26	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3			
28	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3			
30	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3			
36	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3			
EQUIP FLAT	1½	2	2½	3	3	3½	3½	4	4	4	4	4½			
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571			
	OPERATING TEMPERATURE ° F														

ECONOMIC INSULATION THICKNESSES

PLANTS: GULF COAST PLANTS - SEADRIFT-510, TEXAS CITY-515, TAFT-519, BROWNSVILLE-526
SPEC. NO'S: 10-J and 10-JSS CELLULAR GLASS SERVICE: STEAM AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C														
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299			
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
3	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
3½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½			
4	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2			
6	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2			
8	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2			
10	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2			
12	1½	1½	1½	1½	1½	2	2	2	2	2	2	2½			
14	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½			
16	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½			
18	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½			
20	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3			
22	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3			
24	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3			
26	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3			
28	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3			
30	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3			
36	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3			
EQUIP FLAT	1½	1½	2	2	2	2½	2½	3	3	3	3	3½			
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571			
	OPERATING TEMPERATURE ° F														

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INSULATION THICKNESS REQUIREMENTS

Service Designation
E-17

ECONOMIC INSULATION THICKNESSES

PLANTS: PONCE
SPEC. NO'S: 10-J and 10-JSS CELLULAR GLASS

SERVICE: STEAM & STEAM HEATED EQUIPMENT & PIPE

NOM PIPE SIZE	OPERATING TEMPERATURE °C											
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
3/4	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
3	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2
3½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
4	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
6	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
8	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½
10	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½
12	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3
14	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3
16	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3
18	1½	1½	1½	2	2	2½	2½	2½	3	3	3	3
20	1½	1½	1½	2	2	2½	2½	2½	3	3	3	3
22	1½	1½	1½	2	2	2½	2½	2½	3	3	3	3
24	1½	1½	1½	2	2	2½	2½	2½	3	3	3	3½
26	1½	1½	1½	2	2	2½	2½	2½	3	3	3	3½
28	1½	1½	1½	2	2	2½	2½	2½	3	3	3	3½
30	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½
36	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½
EQUIP FLAT	1½	1½	2	2½	2½	3	3	3	3½	3½	3½	4
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571
	OPERATING TEMPERATURE °F											

ECONOMIC INSULATION THICKNESSES

INSULATION THICKNESS REQUIREMENTS

Service Designation E-18
E-19

PLANT: CARTERSVILLE PLANT - OTTAWA PLANT, PLASTICS DIVISION
SPEC. NO'S: 10-J, 10-JSS SERVICE: STEAM AND STEAM HEATED
CELLULAR GLASS PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE • C												
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	
1¼	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	
1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	
2	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	
2½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	
3	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	
3½	1½	1½	1½	1½	2	2	2	2½	2½	3	3	3	
4	1½	1½	1½	2	2	2	2	2½	3	3	3	3½	
6	1½	1½	2	2	2	2½	2½	3	3	3½	3½	3½	
8	1½	1½	2	2	2½	2½	3	3	3½	3½	3½	4	
10	1½	2	2	2	2½	3	3	3½	3½	3½	4	4	
12	1½	2	2	2½	2½	3	3½	3½	4	4	4	4½	
14	1½	2	2	2½	3	3	3½	4	4	4	4½	4½	
16	1½	2	2½	2½	3	3½	3½	4	4	4½	4½	5	
18	1½	2	2½	3	3	3½	4	4	4½	4½	5	5	
20	1½	2	2½	3	3	3½	4	4½	4½	5	5	5	
22	1½	2	2½	3	3½	4	4	4½	5	5	5	5½	
24	1½	2	2½	3	3½	4	4½	5	5	5½	5½	6	
26	1½	2	2½	3	3½	4	4½	5	5½	5½	6	6	
28	1½	2	2½	3	3½	4	4½	5	5½	6	6	6	
30	1½	2	2½	3	3½	4	4½	5	5½	6	6	6½	
36	1½	2	2½	3	3½	4	4½	5	5½	6	6½	6½	
EQUIP FLAT	1½	2	2½	3	3½	4	4½	5	5½	6	6½	6½	

OPERATING TEMPERATURE • F													
140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571		

ECONOMIC INSULATION THICKNESSES

PLANTS: BOUND BROOK PLANT - PLASTICS DIVISION
SPEC. NO'S: 10-J, 10-J SS CELLULAR GLASS SERVICE: STEAM AND STEAM HEATED
PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE • C												
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	
2½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	
3	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	
3½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2½	
4	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	
6	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	
8	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	3	
10	1½	1½	2	2	2	2	2½	2½	2½	2½	3	3	
12	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	
14	1½	1½	2	2	2	2	2½	2½	3	3	3	3	
16	1½	1½	2	2	2	2½	2½	3	3	3	3	3½	
18	1½	1½	2	2	2	2½	2½	3	3	3	3½	3½	
20	1½	2	2	2	2	2½	2½	3	3	3	3½	3½	
22	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	
24	1½	2	2	2	2½	2½	3	3	3	3½	3½	3½	
26	1½	2	2	2	2½	2½	3	3	3	3	3½	3½	
28	1½	2	2	2	2½	2½	3	3	3	3½	3½	3½	
30	1½	2	2	2½	2½	3	3	3	3½	3½	3½	3½	
36	1½	2	2½	2½	2½	3	3	3	3½	3½	3½	3½	
EQUIP FLAT	1½	2	2½	2½	2½	3	3	3	3½	3½	3½	3½	

OPERATING TEMPERATURE • F													
140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571		

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INSULATION THICKNESS REQUIREMENTS

ECONOMIC INSULATION THICKNESSES

PLANTS: MARIETTA PLANT - PLASTICS DIVISION
SPEC. NO'S: 10-J, 10-J SS CELLULAR GLASS SERVICE: STEAM AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C											
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
3	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2
3½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2
4	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
6	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2
8	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2
10	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2
12	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½
14	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½
16	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½
18	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	2½
20	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	2½
22	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	2½
24	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	2½
26	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	2½
28	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	3
30	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3
36	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3
EQUIP FLAT	1½	1½	2	2	2½	2½	3	3	3	3	3	3½
	140 to 175	176 to 211	212 to 247	248 to 283	234 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571
	OPERATING TEMPERATURE ° F											

INSULATION THICKNESS REQUIREMENTS

Service Designation E-21
E-22

ECONOMIC INSULATION THICKNESSES

PLANTS: SILICONES-SISTERSVILLE, MONTREAL-053, TORRANCE-513, NIAGARA FALLS-516, OTTAWA

SPEC. NO'S: 12-H URETHANE SERVICE: TRACED, LOW PRESS STEAM, PROCESS-MODERATE SERVICE

NOM PIPE SIZE	OPERATING TEMPERATURE ° C 20 to 39	40 to 59	60 to 79	80 to 99	100 to 119
½	1	1	1	1	1
¾	1	1	1	1	1
1	1	1	1	1	1
1¼	1	1	1	1	1
1½	1	1	1	1	1
2	1	1	1	1	1
2½	1	1	1	1	1
3	1	1	1	1	1
3½	1	1	1	1	1
4	1	1	1	1½	1½
6	1	1	1	1½	1½
8	1	1	1	1½	1½
10	1	1	1½	1½	1½
12	1	1	1½	1½	1½
14	1	1	1½	1½	1½
16	1	1	1½	1½	1½
18	1	1	1½	1½	1½
20	1	1	1½	1½	1½
22	1	1	1½	1½	1½
24	1	1	1½	1½	1½
26	1	1	1½	1½	1½
28	1	1	1½	1½	1½
30	1	1	1½	1½	1½
36	1	1	1½	1½	1½
EQUIP FLAT	1	1½	2	2	
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247
	OPERATING TEMPERATURE ° F				

ECONOMIC INSULATION THICKNESSES

PLANTS: KANAWHA VALLEY PLANTS AND GULF COAST PLANTS, CARTERSVILLE, MARIETTA, BOUND BROOK

SPEC. NO'S: 12-H URETHANE SERVICE: TRACED, LOW PRESS, STEAM, PROCESS-MODERATE SERVICE

NOM PIPE SIZE	OPERATING TEMPERATURE ° C 20 to 39	40 to 59	60 to 79	80 to 99	100 to 119
½	1	1	1	1	1
¾	1	1	1	1	1
1	1	1	1	1	1
1¼	1	1	1	1	1
1½	1	1	1	1	1
2	1	1	1	1	1
2½	1	1	1	1	1
3	1	1	1	1	1
3½	1	1	1	1	1
4	1	1	1	1	1
6	1	1	1	1	1
8	1	1	1	1	1
10	1	1	1	1½	1½
12	1	1	1	1½	1½
14	1	1	1	1½	1½
16	1	1	1	1½	1½
18	1	1	1	1½	1½
20	1	1	1	1½	1½
22	1	1	1	1½	1½
24	1	1	1	1½	1½
26	1	1	1	1½	1½
28	1	1	1	1½	1½
30	1	1	1	1½	1½
36	1	1	1	1½	1½
EQUIP FLAT	1	1	1	1½	1½
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247
	OPERATING TEMPERATURE ° F				

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INSULATION THICKNESS REQUIREMENTS

Service Designation E-23
E-24

ECONOMIC INSULATION THICKNESSES

PLANTS: PONCE
SPEC. NO'S: 12-H URETHANE
SERVICE: TRACED, LOW PRESSURE STEAM PROCESS - MODERATE SERVICE

NOM PIPE SIZE	OPERATING TEMPERATURE °C 20 to 39	40 to 59	60 to 79	80 to 99	100 to 119
½	1	1½	1½	1½	1½
¾	1	1½	1½	1½	1½
1	1	1½	1½	1½	1½
1¼	1	1½	1½	1½	1½
1½	1	1½	1½	1½	1½
2	1	1½	1½	1½	1½
2½	1	1½	1½	1½	1½
3	1	1½	1½	1½	1½
3½	1	1½	1½	1½	1½
4	1	1½	1½	1½	1½
6	1	1½	1½	1½	1½
8	1	1½	1½	1½	1½
10	1	1½	1½	1½	1½
12	1	1½	1½	1½	1½
14	1	1½	1½	1½	1½
16	1	1½	1½	1½	1½
18	1	1½	1½	1½	1½
20	1	1½	1½	1½	1½
22	1	1½	1½	1½	1½
24	1	1½	1½	1½	1½
26	1	1½	1½	1½	1½
28	1	1½	1½	1½	1½
30	1	1½	1½	1½	1½
36	1	1½	1½	1½	1½
EQUIP FLAT	1	1½	1½	1½	2
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247
	OPERATING TEMPERATURE °F				

ECONOMIC INSULATION THICKNESSES

PLANTS: WHITING PLANT-517
SPEC. NO'S: 12-H URETHANE
SERVICE: TRACED, LOW PRESS STEAM, PROCESS-MODERATE SERVICE

NOM PIPE SIZE	OPERATING TEMPERATURE °C 20 to 39	40 to 59	60 to 79	80 to 99	100 to 119
½	1	1½	1½	1½	2
¾	1	1½	1½	1½	2
1	1	1½	1½	1½	2
1¼	1	1½	1½	1½	2
1½	1	1½	1½	1½	2
2	1	1½	1½	1½	2
2½	1	1½	1½	1½	2
3	1	1½	1½	1½	2
3½	1	1½	1½	1½	2
4	1	1½	1½	1½	2
6	1	1½	1½	1½	2
8	1	1½	1½	1½	2
10	1	1½	1½	1½	2
12	1	1½	1½	1½	2
14	1	1½	1½	1½	2
16	1	1½	1½	1½	2
18	1	1½	1½	1½	2
20	1	1½	1½	1½	2
22	1	1½	1½	1½	2
24	1	1½	1½	1½	2
26	1	1½	1½	1½	2
28	1	1½	1½	1½	2
30	1	1½	1½	1½	2
36	1	1½	1½	1½	2
EQUIP FLAT	1	1½	1½	1½	2
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247
	OPERATING TEMPERATURE °F				

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INSULATION THICKNESS REQUIREMENTS

Service Designation E-25
E-26

ECONOMIC INSULATION THICKNESSES

PLANTS: MONTREAL 053, OTTAWA
SPEC. NO'S: 16-H FIBEROUS GLASS (LOW DENSITY)
SERVICE: STEAM AND HEATED PROCESS PIPE, MILD SERVICE, INDOORS

NOM PIPE SIZE	OPERATING TEMPERATURE °C 60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199
½	½	½	1	1	1	1	1
¾	½	½	1	1	1	1	1
1	½	1	1	1	1	1	1
1¼	½	1	1	1	1	1	1
1½	1	1	1	1	1½	1½	1½
2	1	1	1	1	1½	1½	1½
2½	1	1	1	1½	1½	1½	1½
3	1	1	1	1½	1½	1½	1½
3½	1	1	1	1½	1½	1½	1½
4	1	1	1½	1½	1½	1½	1½
6	1	1	1½	1½	1½	2	2
8	1½	1½	1½	1½	2	2	2
10	1½	1½	1½	1½	2	2	2
12	1½	1½	1½	2	2	2	2
14	1½	1½	2	2	2	2	2½
16	1½	1½	2	2	2	2	2½
18	1½	1½	2	2	2	2½	2½
20	1½	1½	2	2	2	2½	2½
22	1½	1½	2	2	2	2½	2½
24	1½	1½	2	2	2	2½	2½
26	1½	1½	2	2	2	2½	2½
28	1½	1½	2	2	2	2½	2½
30	1½	1½	2	2	2½	2½	2½
36	1½	2	2	2	2½	2½	2½
EQUIP FLAT	1½	2	2	2½	2½	2½	3

OPERATING TEMPERATURE °F							
140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	

ECONOMIC INSULATION THICKNESSES

PLANTS: KANAWHA VALLEY PLANTS: INSTITUTE-512, SOUTH CHARLESTON-514, MARIETTA, BOUND BROOK
SPEC. NO'S: 16-H FIBROUS GLASS (LOW DENSITY)
SERVICE: STEAM AND STEAM HEATED PROCESS PIPE, MILD SERVICE

NOM PIPE SIZE	OPERATING TEMPERATURE °C 60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199
½	½	½	½	½	½	1	1
¾	½	½	½	½	½	1	1
1	½	½	½	½	½	1	1
1¼	½	½	½	½	½	1	1
1½	½	½	½	½	½	1	1
2	½	½	½	½	½	1	1
2½	½	½	½	½	½	1	1
3	½	½	½	½	½	1	1½
3½	½	½	½	½	½	1	1½
4	½	½	½	½	½	1	1½
6	½	½	½	½	½	1	1½
8	½	½	½	½	½	1	1½
10	½	½	½	½	½	1	1½
12	½	½	½	½	½	1½	2
14	½	½	½	½	½	1½	2
16	½	½	½	½	½	1½	2
18	½	½	½	½	1	1½	2
20	½	½	½	½	1	1½	2
22	½	½	½	½	1	1½	2
24	½	½	½	½	1	1½	2
26	½	½	½	½	1	1½	2
28	½	½	½	½	1	1½	2
30	½	½	½	½	1	1½	2
36	½	½	½	½	1	1½	2
EQUIP FLAT	1½	2	2	2	2½	2½	3

OPERATING TEMPERATURE °F							
140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	

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INSULATION THICKNESS REQUIREMENTS

Service Designation E-2
E-2

ECONOMIC INSULATION THICKNESSES

PLANTS: WHITING PLANT-517
SPEC. NO'S: 16-H FIBROUS GLASS (LOW DENSITY)

SERVICE: STEAM AND STEAM HEATED PROCESS LINES, MILD SERVICE, INDOORS

NOM PIPE SIZE	OPERATING TEMPERATURE °C 60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199
½	½	½	1	1	1	1	1
¾	½	½	1	1	1	1	1
1	½	1	1	1	1	1	1
1¼	½	1	1	1	1	1	1
1½	½	1	1	1	1	1	1
2	½	1	1	1	1	1	1
2½	½	1	1	1	1	1	1
3	1	1	1	1	1	1½	1½
3½	1	1	1	1	1	1½	1½
4	1	1	1	1	1½	1½	1½
6	1	1	1	1½	1½	1½	1½
8	1½	1½	1½	1½	1½	2	2
10	1½	1½	1½	1½	1½	2	2
12	1½	1½	1½	1½	2	2	2
14	1½	1½	1½	1½	2	2	2
16	1½	1½	1½	2	2	2	2
18	1½	1½	1½	2	2	2	2
20	1½	1½	1½	2	2	2	2
22	1½	1½	1½	2	2	2	2
24	1½	1½	1½	2	2	2	2½
26	1½	1½	1½	2	2	2	2½
28	1½	1½	1½	2	2	2	2½
30	1½	1½	2	2	2	2½	2½
36	1½	1½	2	2	2	2½	2½
EQUIP FLAT	1½	2	2	2½	2½	2½	3
OPERATING TEMPERATURE °F	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391

ECONOMIC INSULATION THICKNESSES

PLANTS: TORRANCE PLANT
SPEC. NO'S: 16-H FIBROUS GLASS (LOW DENSITY)

SERVICE: STEAM AND STEAM HEATED PROCESS LINES, MILD SERVICE INDOORS

NOM PIPE SIZE	OPERATING TEMPERATURE °C 60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199
½	½	½	1	1	1	1	1
¾	½	½	1	1	1	1	1
1	½	1	1	1	1	1	1
1¼	½	1	1	1	1	1	1
1½	½	1	1	1	1	1	1
2	½	1	1	1	1	1	1
2½	½	1	1	1	1	1	1
3	1	1	1	1	1	1½	1½
3½	1	1	1	1	1	1½	1½
4	1	1	1	1	1½	1½	1½
6	1	1	1	1½	1½	1½	1½
8	1½	1½	1½	1½	1½	2	2
10	1½	1½	1½	1½	1½	2	2
12	1½	1½	1½	1½	2	2	2
14	1½	1½	1½	1½	2	2	2
16	1½	1½	1½	2	2	2	2
18	1½	1½	1½	2	2	2	2½
20	1½	1½	1½	2	2	2	2½
22	1½	1½	1½	2	2	2	2½
24	1½	1½	1½	2	2	2	2½
26	1½	1½	1½	2	2	2	2½
28	1½	1½	1½	2	2	2	2½
30	1½	1½	2	2	2	2½	2½
36	1½	1½	2	2	2	2½	2½
EQUIP FLAT	1½	2	2½	3			3½
OPERATING TEMPERATURE °F	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391

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INSULATION THICKNESS REQUIREMENTS

Service Designation E-29
E-30

ECONOMIC INSULATION THICKNESSES

PLANTS: SILICONES - SISTERSVILLE PLANT, CARTERSVILLE
SPEC. NO'S: 16-H FIBROUS GLASS (LOW DENSITY) SERVICE: STEAM AND STEAM HEATED PROCESS LINES, MILD SERVICE, INDOORS

NOM PIPE SIZE	OPERATING TEMPERATURE ° C						
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199
½	1	1	1	1	1	1	1
¾	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1
1¼	1	1	1	1	1	1½	1½
1½	1	1	1	1	1	1½	1½
2	1	1	1	1	1½	1½	1½
2½	1	1	1	1	1½	1½	1½
3	1	1	1	1½	1½	1½	1½
3½	1	1	1	1½	1½	1½	1½
4	1	1	1½	1½	1½	1½	1½
6	1	1½	1½	1½	2	2	2
8	1½	1½	1½	1½	2	2	2
10	1½	1½	1½	1½	2	2	2
12	1½	1½	1½	1½	2	2	2
14	1½	1½	1½	2	2	2	2
16	1½	1½	2	2	2	2	2½
18	1½	1½	2	2	2	2½	2½
20	1½	1½	2	2	2½	2½	2½
22	1½	1½	2	2	2½	2½	2½
24	1½	2	2	2	2½	2½	2½
26	1½	2	2	2	2½	2½	2½
28	1½	2	2	2	2½	2½	2½
30	1½	2	2	2	2½	2½	2½
36	1½	2	2	2	2½	2½	2½
EQUIP FLAT	1½	2	2	2½	2½	3	3

OPERATING TEMPERATURE ° F						
140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 353	356 to 391

ECONOMIC INSULATION THICKNESSES

PLANTS: GULF COAST PLANTS - SEADRIFT-510, TEXAS CITY-515, TAFT-519, BROWNSVILLE-526
SPEC. NO'S: 16-H FIBROUS GLASS (LOW DENSITY) SERVICE: STEAM AND HEATED PROCESS PIPE, MILD SERVICE, INDOORS

NOM PIPE SIZE	OPERATING TEMPERATURE ° C						
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199
½	1	1	1	1	1	1	1
¾	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1
1¼	1	1	1	1	1	1	1
1½	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1
2½	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1
3½	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1½
6	1	1	1	1	1½	1½	1½
8	1½	1½	1½	1½	1½	1½	1½
10	1½	1½	1½	1½	1½	1½	1½
12	1½	1½	1½	1½	1½	1½	1½
14	1½	1½	1½	1½	1½	1½	1½
16	1½	1½	1½	1½	1½	1½	1½
18	1½	1½	1½	1½	2	2	2
20	1½	1½	1½	1½	2	2	2
22	1½	1½	1½	1½	2	2	2
24	1½	1½	1½	1½	2	2	2
26	1½	1½	1½	1½	2	2	2
28	1½	1½	1½	1½	2	2	2
30	1½	1½	1½	1½	2	2	2
36	1½	1½	1½	1½	2	2	2
EQUIP FLAT	1½	1½	1½	2	2	2	2

OPERATING TEMPERATURE ° F						
140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391

UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

INSULATION THICKNESS REQUIREMENTS

Service Designation E-31

ECONOMIC INSULATION THICKNESSES

PLANTS: PONCE
SPEC. NO'S: 16-H FIBROUS GLASS (LOW DENSITY)
SERVICE: STEAM & STEAM HEATED LINES, MILD SERVICE INDOORS

NOM PIPE SIZE	OPERATING TEMPERATURE °C						
	60 to 79	80 to 99	100 to 110	120 to 139	140 to 159	160 to 179	180 to 199
½	½	½	½	½	1	1	1
3/4	½	½	½	1	1	1	1
1	½	½	½	1	1	1	1
1½	½	1	1	1	1	1	1½
1½	½	1	1	1	1	1½	1½
2	½	1	1	1	1	1½	1½
2½	½	1	1	1	1	1½	1½
3	½	1	1	1	1	1½	1½
3½	1	1	1	1	1½	1½	1½
4	1	1	1	1½	1½	1½	1½
6	1	1	1	1½	1½	1½	1½
8	1	1	1½	1½	1½	1½	2
10	1	1	1½	1½	1½	1½	2
12	1	1	1½	1½	1½	2	2
14	1	1½	1½	1½	2	2	2
16	1	1½	1½	1½	2	2	2
18	1	1½	1½	1½	2	2	2
20	1	1½	1½	1½	2	2	2
22	1	1½	1½	1½	2	2	2
24	1	1½	1½	1½	2	2	2
26	1	1½	1½	1½	2	2	2
28	1	1½	1½	1½	2	2	2
30	1½	1½	1½	2	2	2	2½
36	1½	1½	1½	2	2	2	2½
EQUIP FLAT	1½	1½	2	2	2½	2½	2½
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391
	OPERATING TEMPERATURE °F						

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INSULATION THICKNESS REQUIREMENTS

Service Designation E-32
E-33

ECONOMIC INSULATION THICKNESSES

SPEC. NO'S: 19-J ALUMINUM JACKETED GLASS FIBER
SERVICE: STORAGE VESSELS (LOW FIRE HAZARD AREAS)

PLANT	OPERATING TEMPERATURE • C					
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179
INSTITUTE 512	1½	2	2	2½	2½	2½
S. Chas. 514	1½	2	2	2½	2½	2½
SEADRIFT 510	1½	1½	2	2	2½	2½
TEXAS CITY 515	1½	1½	2	2	2½	2½
TAFT 519	1½	1½	2	2	2½	2½
BROWNSVILLE 526	1½	1½	2	2	2½	2½
TORRANCE 513	2	2½	3	3	3	3½
WHITING 517	1½	2	2½	2½	2½	3
MONTREAL 053	2	2	2½	3	3	3
SISTERSVILLE	2	2	2½	3	3	3
SILICONE NIAGARA FALLS 516	2	2	2½	3	3	3
BOUND BROOK	1½	2	2	2½	2½	2½
CARTERSVILLE	2	2½	2½	3	3	3½
MARIETTA	1½	2	2	2½	2½	2½
OTTAWA	2	2	2½	3	3	3
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 353
	OPERATING TEMPERATURE • F					

ECONOMIC INSULATION THICKNESSES

SPEC. NO'S: 19-H ALUMINUM JACKETED MINERAL FIBER
SERVICE: STORAGE VESSEL (LOW FIRE HAZARD AREAS)

PLANT	OPERATING TEMPERATURE • C							
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239
INSTITUTE 512	1½	2	2	2½	3	3	3	3½	3½
S. CHAS. 514	1½	2	2	2½	3	3	3	3½	3½
SEADRIFT 510	1½	1½	2	2½	3	3	3	3	3½
TEXAS CITY 515	1½	1½	2	2½	3	3	3	3	3½
TAFT 519	1½	1½	2	2½	3	3	3	3	3½
BROWNSVILLE 526	1½	1½	2	2½	3	3	3	3	3½
TORRANCE 513	2	2½	2½	3	3½	4	4	4½	4½
WHITING 517	1½	2	2½	2½	3	3½	3½	3½	4
MONTREAL 053	2	2	2½	3	3½	3½	4	4	4½
SISTERSVILLE	2	2	2½	3	3½	3½	4	4	4½
SILICONE NIAGARA FALLS 516	2	2	2½	3	3½	3½	4	4	4½
BOUND BROOK	1½	2	2	2½	3	3	3	3½	3½
CARTERSVILLE	1½	2	2½	3	3½	3½	4	4	4
MARIETTA	1½	2	2	2½	3	3	3½	3½	3½
OTTAWA	2	2	2½	3	3½	4	4	4	4½
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 417	428 to 463
	OPERATING TEMPERATURE • F								

INSULATION THICKNESS REQUIREMENTS

Service Designation E-38

ECONOMIC INSULATION THICKNESSES

PLANTS: TORRANCE PLANT 513
SPEC. NO'S: 15-H, 21-H, 21-HSS, 22-H, 22-HSS, 23-H, 23-HSS

SERVICE: STEAM AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																														
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599
½	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
¾	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3
1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3
1¼	1	1	1	1	1	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½
1½	1	1	1	1	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½
2	1	1	1	1	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½
2½	1	1	1	1	1½	1½	1½	2	2	2	2	2	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4	4
3	1	1	1	1½	1½	1½	2	2	2	2	2½	2½	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4	4	4	4	4	4
3½	1	1	1½	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3½	3½	3½	3½	3½	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½
4	1	1½	1½	1½	2	2	2	2	2	2	2½	2½	3	3	3	3½	3½	4	4	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½
6	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3½	3½	3½	4	4	4½	4½	4½	4½	4½	5	5	5	5	5	5	5	5	5
8	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	4½	4½	5	5	5	5½	5½	5½	5½	5½	5½	5½
10	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4	4½	4½	4½	4½	5	5	5½	5½	5½	5½	5½	5½	5½	5½
12	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4	4½	4½	4½	4½	5	5	5½	5½	5½	5½	5½	5½	5½	6
14	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4	4½	4½	4½	4½	5	5	5½	5½	5½	5½	5½	5½	6	6
16	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4	4½	4½	4½	4½	5	5	5½	5½	5½	5½	5½	6	6	6
18	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	4½	4½	4½	5	5	5	5	5½	6	6	6	6	6	6½
20	1½	2	2	2	2½	2½	3	3	3	3	3½	3½	4	4	4½	4½	5	5	5	5	5	5½	5½	6	6	6½	6½	6½	6½	6½	6½
22	1½	2	2	2	2½	2½	3	3	3	3	3½	3½	4	4	4½	4½	5	5	5	5	5	5½	6	6	6½	7	7	7	7	7	7	7
24	1½	2	2	2	2½	2½	3	3	3	3	3½	4	4	4½	4½	5	5	5	5	5½	5½	6	6	6½	7	7½	7½	8	8	8	8
26	1½	2	2	2	2½	2½	3	3	3½	3½	4	4	4	4½	5	5	5	5½	5½	6	6	6	6½	7	7	7	7	7	7	7	7	7
28	1½	2	2	2½	2½	3	3	3½	3½	4	4	4	4½	5	5	5	5	5½	5½	6	6	6	6½	7	7	7½	8	8	8	8	8	8
30	1½	2	2½	2½	3	3	3½	4	4	4	4½	4½	5	5	5	5½	6	6	6	6½	6½	7	7	7½	8	8	8	8	8	8	8	8
33	1½	2	2½	2½	3	3	3½	4	4	4	4½	5	5	5	5½	5½	6	6	6	6½	6½	7	7	7½	8	8	8	8	8	8	8	8
EQUIP	OPERATING TEMPERATURE ° F																														
FLAT	1½ to 140	2 to 176	2½ to 212	3 to 248	3½ to 284	3½ to 320	3½ to 356	4 to 392	4 to 428	4½ to 464	5 to 500	5½ to 536	5½ to 572	6 to 608	6 to 644	6 to 680	6 to 716	6½ to 752	6½ to 788	6½ to 824	7 to 860	7 to 896	7½ to 932	8 to 968	8 to 1004	8 to 1040	8 to 1076					
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039	1040 to 1075	1076 to 1111					

Spec. 21-H Temp. Limit 540 C, 1000 F
Spec. 23-H Temp. Limit 400 C, 750 F
Spec. 15-H Temp. Limit 400 C, 750 F

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INSULATION THICKNESS REQUIREMENTS

Service Designation E-39

ECONOMIC INSULATION THICKNESSES

PLANTS: MONTREAL 053, NIAGARA FALLS 516
SPEC. NO'S: 15-H, 21-H, 21-HSS, 22-H, 22-HSS, 23-H, 23-HSS

SERVICE: STEAM AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE • C																												
	30 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599
¼	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3
⅜	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3
½	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3½
¾	1	1	1	1	1	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3½	3½	3½
1	1	1	1	1	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3½	3½	3½	4
1¼	1	1	1	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3½	3½	4	4	4
1½	1	1	1	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3½	3½	4	4	4	4
2	1	1	1	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3½	3½	4	4	4	4	4½
2½	1	1	1	1½	1½	1½	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3½	3½	4	4	4½	4½	4½
3	1	1	1½	1½	1½	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3½	3½	4	4	4½	4½	5	5
3½	1	1	1½	1½	1½	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3½	3½	4	4	4½	5	5	5	5½
4	1	1	1½	1½	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3½	3½	4	4	4½	5	5	5	5½	5½
5	1	1½	1½	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5½	5½	6
6	1	1½	1½	2	2	2	2	2	2	2	2	3	3	3	3½	3½	4	4	4	4	4	4½	4½	5	5	5	6	6	6
8	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4	4½	4½	4½	5	5	5	5½	6	6	6½	6½
10	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4	4	4½	4½	5	5	5	5½	6	6	6½	6½
12	1½	2	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4	4	4	4½	4½	5	5	5	5½	6	6	6½	7
14	1½	2	2	2	2	2½	2½	3	3	3	3	3½	3½	4	4	4	4	4½	4½	5	5	5	5½	5½	6	6	6½	7	7
16	2	2	2	2½	2½	3	3	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5	5½	5½	6	6	6	6½	7	7	7½
18	2	2	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5	5	5½	6	6	6	6½	7	7	7½
20	2	2	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5	5	5½	6	6	6	6½	7	7	7½
22	2	2	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5	5	5½	6	6	6	6½	7	7	7½
24	2	2	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5	5	5½	6	6	6	6½	7	7	7½
26	2	2	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5	5	5½	6	6	6	6½	7	7	7½
28	2	2	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5	5	5½	6	6	6	6½	7	7	7½
30	2	2	2½	3	3	3	3½	3½	3½	4	4	4	4½	5	5	5	5	5	5	5	6	6	6	6½	6½	7	7	7½	8
36	2	2½	2½	3	3	3	3½	3½	4	4	4	4	4½	5	5	5	5	5	5½	5½	6	6	6	6½	6½	7	7	7½	8
EQUIP FLAT	1½	2	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5	5½	5½	5½	6	6	6	6½	6½	7	7	7	7
	OPERATING TEMPERATURE • F																												
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039	1040 to 1075	1076 to 1111

Spec. 21-H Temperature Limit 540 C, 1000 F
Spec. 23-H Temperature Limit 400 C, 750 F
Spec. 15-H Temperature Limit 400 C, 750 F

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ECONOMIC INSULATION THICKNESSES

PLANTS: BOUND BROOK PLANT, PLASTICS DIVISION
SPEC. NO'S: 15-H, 21-H, 21-HSS, 22-H, 22-HSS, 23-H, 23-HSS

SERVICE: STEAM AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

INSULATION THICKNESS REQUIREMENTS

Service Designation E-42

NOM PIPE SIZE	OPERATING TEMPERATURE °C																														
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599
½	1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
¾	1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
1	1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2	2
1¼	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2	2½	2½	2½
1½	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2	2½	2½	2½
2	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2	2½	2½	2½
2½	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	2½	3	3	3	3
3	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	2½	3	3	3	3	3
3½	1	1	1	1	1	1	1	1	1	1	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3½
4	1	1	1	1	1	1	1	1	1	1	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	2½	3	3	3	3	3½	4
5	1	1	1	1	1	1	1	1	1	1	1½	1½	2	2	2	2½	2½	2½	2½	2½	2½	3	3	3	3	3½	4	4
6	1	1	1	1	1	1	1	1	1	1	1½	1½	2	2	2	2½	2½	2½	2½	2½	3	3	3	3½	3½	4	4	4
8	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3	3	3½	3½	4	4	4	4	4½
10	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3	3½	3½	3½	3½	3½	4	4	4	4	4	4½	4½
12	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3	3½	3½	3½	3½	3½	4	4	4	4	4½	4½	5
14	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3	3½	4	4	4	4	4	4	4½	4½	5	5	5
16	1½	1½	1½	1½	2	2	2	2	2	2	2½	2½	3	3	3	3½	4	4	4	4	4	4	4½	5	5	5	5	5
18	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3	3½	3½	4	4	4	4	4	4	4½	5	5	5	5	5
20	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3	3½	3½	4	4	4	4	4	4	4	4½	5	5	5	5	5
22	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3	3½	3½	4	4	4	4	4	4	4	4½	5	5	5	5	5
24	1½	1½	2	2	2	2	2½	2½	2½	2½	3	3	3½	3½	3½	4	4	4	4	4	4	4	4½	5	5	5	5	5
26	1½	1½	2	2	2	2	2½	2½	2½	2½	3	3	3½	3½	3½	4	4	4	4	4	4	4	4½	5	5	5	5	5
28	1½	1½	2	2	2	2	2½	2½	2½	2½	3	3	3½	3½	3½	4	4	4	4	4	4	4	4½	5	5	5	5	5
30	1½	1½	2	2	2	2	2½	2½	2½	2½	3	3	3½	3½	3½	4	4	4	4	4	4	4	4½	5	5	5	5	5
36	1½	2	2	2	2	2½	2½	2½	2½	3	3	3	3½	3½	3½	4	4	4	4	4	4	4½	4½	5	5	5	5	5
EQUIP FLAT	1½ to 140	2 to 176	2 to 212	2 to 248	2½ to 284	2½ to 320	3 to 356	3 to 392	3 to 428	3 to 464	3½ to 500	4 to 536	4 to 572	4 to 608	4 to 644	4 to 680	4½ to 716	4½ to 752	4½ to 788	4½ to 824	4½ to 860	5 to 896	5 to 932	5½ to 968	5½ to 1004	5½ to 1040	6 to 1076	
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039	1040 to 1075	1076 to 1111	
	OPERATING TEMPERATURE °F																											

Spec. No. 21-H - Temp. limit 540C-1000F
Spec. No. 23-H - Temp. limit 400C-750F
Spec. No. 15-H - Temp. limit 400C-750F

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ECONOMIC INSULATION THICKNESSES

PLANTS: MARIETTA PLANT - PLASTICS DIVISION
SPEC. NO'S: 15-H, 21-H, 21-HSS, 22-H, 22-HSS, 23-H, 23-HSS

SERVICE: STEAM AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE °C																										
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599
½	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2
¾	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2
1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2
1¼	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2
1½	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½
2	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½
2½	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½
3	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½
3½	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	3	3	3
4	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	3	3	3	3
6	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½
8	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	4	4	4
10	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	4	4	4
12	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	4	4	4
14	1½	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4
16	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4	4½	4½
18	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4	4½	4½
20	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4	4½	4½
22	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4	4½	4½
24	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4½	4½	4½	4½	4½
26	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4½	4½	4½	4½	4½
28	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4½	4½	4½	4½	4½
30	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3	3	3	3½	3½	3½	3½	4	4	4	4	4½	4½	4½	4½	4½
36	1½	1½	1½	2	2	2	2½	2½	2½	2½	2½	3	3	3½	3½	3½	3½	3½	4	4	4	4	4½	4½	4½	5	5
EQUIP FLAT	1½	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½	3½	4	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039	1040 to 1075	1076 to 1111
	OPERATING TEMPERATURE °F																										

Spec. No. 21-H - Temp. limit 540C - 1000F
Spec. No. 23-H - Temp limit 400C - 750F
Spec. No. 15-H - Temp. limit 400C - 750F

Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation D...
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INSULATION THICKNESS REQUIREMENTS

Service Designation E-44

ECONOMIC INSULATION THICKNESSES

PLANTS: TORRANCE PLANT 513
SPEC. NO'S: 22-H, 22-HSS EXPANDED SILICA, 25-H HIGH AND STD. CALCIUM SILICATE SERVICE: PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																														
	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599	600 to 619	620 to 639	640 to 659	660 to 679	680 to 699	700 to 719	720 to 739	740 to 759	760 to 779	780 to 799	800 to 819	820 to 839	840 to 859	860 to 879
¼	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
⅜	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
½	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
¾	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1¼	2½	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4	4	4	4	4	4
1½	2½	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4	4	4	4	4	4	4	4	4	4
2	3	3	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½	4½	4½
2½	3	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½	4½	5
3	3½	3½	3½	3½	3½	3½	3½	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5½	5½
3½	3½	3½	3½	3½	3½	3½	4	4	4	4	4½	4½	4½	5	5	5	5	5	5	5	5	5½	5½	5½	5½
4	3½	3½	3½	4	4	4	4	4	4	4	4½	4½	5	5	5	5	5½	5½	5½	5½	6	6	6	6	6
6	4	4	4	4½	4½	4½	5	5	5	5	5½	5½	6	6	6	6	6	6	6½	6½	6½	6½	6½	6½	6½
8	4	4	4	4½	4½	4½	5	5	5	5	5½	6	6	6	6½	6½	7	7	7	7	7	7	7	7	7
10	4	4	4	4½	4½	4½	5	5	5	5½	6	6	6	6½	7	7	7	7½	7½	7½	7½	7½	7½	7½	7½
12	4½	4½	5	5	5	5	5½	5½	5½	6	6	6	6½	7	7	7½	7½	8	8	8	8	8	8	8	8
14	4½	4½	5	5	5	5½	5½	5½	5½	6	6	6½	6½	7	7	7½	7½	8	8	8	8	8	8	8	8
16	4½	4½	5	5	5	5½	5½	5½	5½	6	6	6½	7	7	7½	7½	8	8	8	8	8	8	8	8	8½
18	5	5	5	5½	5½	5½	5½	6	6	6	6	6½	7	7	7½	7½	8	8	8	8	8	8	8½	8½	8½
20	5	5½	5½	5½	5½	6	6	6	6	6	6½	6½	7	7	7	7½	8	8	8	8	8	8½	8½	8½	9
22	5	5½	5½	5½	5½	6	6	6	6	6½	6½	7	7	7½	7½	7½	8	8	8	8	8½	8½	9	9	9
24	5	5½	5½	5½	6	6	6	6	6½	6½	7	7	7½	7½	8	8	8	8½	8½	8½	8½	9	9	9	9
26	5½	5½	5½	6	6	6	6½	6½	6½	7	7	7	7½	7½	8	8	8	8	8	8	8	8	8½	8½	9½
28	5½	5½	5½	6	6	6	6½	6½	6½	7	7	7	7½	7½	8	8	8	8	8	8	8	8	8½	8½	9½
30	6	6	6	6	6	6½	6½	6½	7	7	7½	7½	8	8	8	8	8	8	8½	8½	8½	9	9	9	9½
36	6	6	6	6	6	6½	6½	6½	7	7	7½	7½	8	8	8	8	8	8	8½	8½	8½	9	9	9	9½
EQUIP FLAT	6	6	6	6½	6½	7	7	7½	7½	8	8	8	8	8½	8½	8½	8½	9	9	9	9	9	9½	9½	9½
	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039	1040 to 1075	1076 to 1111	1112 to 1147	1148 to 1183	1184 to 1219	1220 to 1255	1256 to 1291	1292 to 1327	1328 to 1363	1364 to 1399	1400 to 1435	1436 to 1471	1472 to 1507	1508 to 1543	1544 to 1579	1580 to 1616
	OPERATING TEMPERATURE ° F																								

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INSULATION THICKNESS REQUIREMENTS

Service Designation E-45

ECONOMIC INSULATION THICKNESSES

PLANTS: WHITING PLANT 517
SPEC. NO'S: 22-H, 22-HSS EXPANDED SILICA, 25-H HIGH AND STD. CALCIUM SILICATE

SERVICE: PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																														
	360 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599	600 to 619	620 to 639	640 to 659	660 to 679	680 to 699	700 to 719	720 to 739	740 to 759	760 to 779	780 to 799	800 to 819	820 to 839	840 to 859	860 to 879
¼	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
½	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4
1¼	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	3½	3½	4	4	4
1½	2½	2½	2½	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4	4	4	4	4
2	2½	2½	2½	2½	3	3	3	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4	4	4	4	4½	4½
2½	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4	4	4	4	4	4½	4½	4½	4½
3	2½	3	3	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4	4	4	4	4½	4½	4½	4½	5	5
3½	3	3	3	3	3	3	3½	3½	4	4	4	4	4	4	4	4½	4½	4½	4½	4½	4½	5	5	5	5	5
4	3	3	3	3	3½	3½	4	4	4	4	4	4½	4½	4½	4½	5	5	5	5	5	5	5½	5½	5½	5½	6
6	3½	3½	3½	4	4	4	4½	4½	4½	4½	5	5	5	5	5	5	5½	5½	5½	5½	5½	6	6	6	6	6
8	3½	3½	3½	4	4	4	4½	4½	4½	4½	5	5	5	5	5	5½	5½	5½	5½	5½	5½	6	6	6	6	6
10	4	4	4	4	4½	4½	4½	4½	4½	5	5	5	5½	5½	5½	5½	5½	6	6	6	6	6	6	6½	6½	6½
12	4	4	4	4	4½	4½	4½	4½	5	5	5	5½	5½	5½	5½	5½	6	6	6	6	6½	6½	6½	6½	6½	6½
14	4	4	4½	4½	4½	4½	5	5	5	5½	5½	5½	6	6	6	6	6½	6½	6½	6½	6½	6½	6½	6½	6½	7
16	4½	4½	4½	4½	5	5	5	5	5½	5½	5½	6	6	6	6	6½	6½	6½	6½	6½	7	7	7	7	7	7
18	4½	5	5	5	5	5	5	5½	5½	5½	6	6	6	6½	6½	6½	6½	6½	7	7	7	7	7	7	7	7½
20	4½	5	5	5	5	5	5	5	5½	5½	6	6	6	6½	6½	6½	6½	7	7	7	7	7	7	7½	7½	7½
22	4½	5	5	5	5	5	5	5	5½	6	6	6	6	6½	6½	6½	6½	7	7	7	7	7½	7½	7½	7½	7½
24	4½	5	5	5	5	5	5½	5½	5½	6	6	6	6	6½	6½	6½	6½	7	7	7	7½	7½	7½	7½	7½	7½
26	4½	5	5	5	5	5	5½	5½	5½	6	6	6	6	6½	6½	6½	6½	7	7	7	7	7½	7½	7½	7½	7½
28	4½	5	5	5	5	5	5½	5½	5½	6	6	6	6	6½	6½	6½	6½	7	7	7	7	7½	7½	7½	7½	8
30	5	5	5	5½	5½	5½	5½	5½	6	6	6	6	6	6½	6½	6½	6½	7	7	7	7	7½	7½	7½	8	8
36	5	5	5	5½	5½	5½	5½	5½	6	6	6	6	6	6½	6½	6½	6½	7	7	7	7½	7½	7½	8	8	8
EQUIP FLAT	5	5	5½	5½	6	6	6	6	6½	6½	7	7	7	7½	7½	7½	7½	8	8	8	8	8	8½	8½	8½	8½
	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039	1040 to 1075	1076 to 1111	1112 to 1147	1148 to 1183	1184 to 1219	1220 to 1255	1256 to 1291	1292 to 1327	1328 to 1363	1364 to 1399	1400 to 1435	1436 to 1471	1472 to 1507	1508 to 1543	1544 to 1579	1580 to 1616

OPERATING TEMPERATURE ° F

INSULATION THICKNESS REQUIREMENTS

Service Designation E-46

ECONOMIC INSULATION THICKNESSES

PLANTS: GULF COAST PLANTS: SEADRIFT 510, TEXAS CITY 515, TAFT 519, BROWNSVILLE 526
SPEC. NO'S: 22H, 22-HSS EXPANDED SILICA, 25-H HIGH AND STANDARD CALCIUM SILICATE SERVICE: PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																												
	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599	600 to 619	620 to 639	640 to 659	660 to 679	680 to 699	700 to 719	720 to 739	740 to 759	760 to 779	780 to 799	800 to 819	820 to 839	840 to 859	860 to 879
½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	3
¾	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3
1	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3
1¼	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3
1½	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3½
2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3½	3½	3½
2½	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½
3	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	4
3½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	3½	3½	4	4
4	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4	4	4	4	4	4
6	2½	2½	3	3	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4	4	4	4	4	4	4	4	4	4½
8	3	3	3	3	3½	3½	3½	3½	3½	4	4	4	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½	5
10	3	3	3	3	3½	3½	3½	3½	3½	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½	4½	4½	4½	5
12	3½	3½	3½	3½	3½	3½	3½	4	4	4	4	4	4	4½	4½	5	5	5	5	5	5	5	5	5	5
14	3½	3½	3½	3½	4	4	4	4	4	4	4	4	4½	4½	5	5	5	5	5	5	5	5	5	5	5½
16	3½	3½	3½	3½	4	4	4	4	4	4	4½	4½	4½	5	5	5	5	5	5	5	5	5	5	5½	5½
18	3½	3½	3½	3½	4	4	4	4	4	4½	4½	4½	5	5	5	5	5	5	5	5	5	5	5½	5½	5½
20	3½	3½	3½	4	4	4	4	4	4	4	4½	4½	5	5	5	5	5	5	5	5½	5½	5½	5½	5½	6
22	3½	3½	3½	4	4	4	4	4	4½	4½	4½	5	5	5	5	5	5½	5½	5½	5½	6	6	6	6	6½
24	4	4	4	4	4	4½	4½	4½	4½	5	5	5½	5½	5½	5½	5½	6	6	6	6	6	6½	6½	6½	6½
26	4	4	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½	5½	6	6	6	6	6	6	6½	6½	6½	7
28	4	4	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½	5½	6	6	6	6	6	6	6½	6½	7	7
30	4	4	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½	6	6	6	6	6	6	6	6½	6½	7	7
36	4	4	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½	6	6	6	6	6	6	6½	6½	7	7	7½
EQUIP FLAT	4½	4½	5	5	5	5	5	5½	5½	5½	5½	6	6	6½	6½	6½	6½	6½	6½	6½	7	7	7	7½	7½
	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039	1040 to 1075	1076 to 1111	1112 to 1147	1148 to 1183	1184 to 1219	1220 to 1255	1256 to 1291	1292 to 1327	1328 to 1363	1364 to 1399	1400 to 1435	1436 to 1471	1472 to 1507	1508 to 1543	1544 to 1579	1580 to 1616
	OPERATING TEMPERATURE ° F																								

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INSULATION THICKNESS REQUIREMENTS

Service Designation E-47

ECONOMIC INSULATION THICKNESSES

PLANTS: KANAWHA VALLEY PLANTS: INSTITUTE 512, SOUTH CHARLESTON 514
SPEC. NO'S: 22H, 22HSS EXPANDED SILICA, 25-H HIGH AND STANDARD CALCIUM SILICATE · SERVICE: PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																											
	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599	600 to 619	620 to 639	640 to 659	660 to 679	680 to 699	700 to 719	720 to 739	740 to 759	760 to 779	780 to 799	800 to 819	820 to 839	840 to 859	860 to 879
¼	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	3	3
½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	3	3	3	3
1	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3
1¼	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3
1½	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3	3	3½	3½	3½
2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3½	3½	3½	3½	3½
2½	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½
3	2	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	3½	4
3½	2	2½	2½	2½	2½	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4	4	4	4	4
4	2½	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4	4	4	4	4	4½	4½	4½
6	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½	4½
8	3	3	3½	3½	3½	3½	3½	4	4	4	4	4	4	4	4½	4½	4½	5	5	5	5	5	5	5	5
10	3½	3½	3½	3½	3½	4	4	4	4	4	4	4	4½	4½	4½	4½	5	5	5	5	5	5	5	5	5
12	3½	3½	3½	3½	4	4	4	4	4½	4½	4½	4½	4½	5	5	5	5	5½	5½	5½	5½	5½	5½	5½	5½
14	3½	3½	3½	4	4	4	4	4	4½	4½	4½	4½	5	5	5	5	5½	5½	5½	5½	5½	5½	5½	5½	6
16	3½	3½	3½	4	4	4	4	4	4½	4½	5	5	5	5½	5½	5½	5½	5½	6	6	6	6	6	6	6
18	3½	3½	3½	4	4	4	4	4	4½	4½	4½	4½	5	5	5	5½	5½	5½	5½	5½	5½	6	6	6	6
20	3½	4	4	4	4	4	4½	4½	4½	4½	4½	4½	5	5	5½	5½	5½	5½	5½	5½	5½	6	6	6	6
22	3½	4	4	4	4	4	4½	4½	4½	4½	4½	5	5	5	5½	5½	5½	5½	5½	5½	6	6	6	6	6
24	4	4	4	4	4	4½	4½	4½	5	5	5	5	5½	5½	5½	5½	5½	6	6	6	6	6	6	6	6
26	4	4	4	4	4	4½	4½	4½	5	5	5	5	5½	5½	5½	5½	5½	6	6	6	6	6	6	6	6
28	4	4	4	4	4	4½	4½	4½	5	5	5	5	5½	5½	5½	5½	6	6	6	6	6	6	6	6½	6½
30	4	4½	4½	4½	4½	5	5	5	5	5½	5½	5½	6	6	6	6	6	6½	6½	6½	6½	6½	6½	6½	7
36	4	4½	4½	4½	4½	5	5	5	5	5½	5½	5½	6	6	6	6	6	6½	6½	6½	6½	7	7	7	7
EQUIP FLAT	4½	5	5	5	5	5	5½	5½	5½	5½	6	6	6	6½	6½	6½	7	7	7	7	7	7	7½	7½	7½
	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039	1040 to 1075	1076 to 1111	1112 to 1147	1148 to 1183	1184 to 1219	1220 to 1255	1256 to 1291	1292 to 1327	1328 to 1363	1364 to 1399	1400 to 1435	1436 to 1471	1472 to 1507	1508 to 1543	1544 to 1579	1580 to 1616
	OPERATING TEMPERATURE ° F																								

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Service Designation E-48

INSULATION THICKNESS REQUIREMENTS

ECONOMIC INSULATION THICKNESSES

PLANTS: MONTREAL 053, SILICONES-SISTERSVILLE
SPEC. NO'S: 22-H, 22-HSS EXPANDED SILICA, 25-H HIGH AND STANDARD CALCIUM SILICATE

SERVICE: PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE °C																												
	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599	600 to 619	620 to 639	640 to 659	660 to 679	680 to 699	700 to 719	720 to 739	740 to 759	760 to 779	780 to 799	800 to 819	820 to 839	840 to 859	860 to 879
½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	3½	3½	3½
¾	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4	4	4	4	4
1	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	4	4	4	4	4	4	4	4	4
1¼	2½	2½	2½	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	3½	3½	3½	4	4	4	4	4	4	4	4	4
1½	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	3½	3½	3½	4	4	4	4	4	4	4	4	4
2	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½	4½
2½	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½
3	3	3	3	3	3½	3½	4	4	4	4	4	4	4	4	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½
3½	3	3	3	3½	3½	3½	4	4	4	4	4	4	4	4½	4½	4½	4½	5	5	5	5	5	5	5	5	5
4	3½	3½	3½	3½	4	4	4½	4½	4½	4½	4½	4½	4½	5	5	5	5	5	5½	5½	5½	5½	5½	5½	5½	5½
6	4	4	4	4	4½	4½	5	5	5	5	5	5	5	5	5	5	5	5½	5½	5½	5½	6	6	6	6	6
8	4	4	4	4	4½	5	5	5	5	6	6	6	6	6	6½	6½	6½	6½	6½	6½	6½	6½	6½	6½	6½	6½
10	4	4	4½	4½	5	5	5	5	5	6	6½	6½	6½	6½	6½	6½	6½	7	7	7	7	7	7½	7½	7½	7½
12	4	4	4½	4½	5	5	5	5	5	6	6½	6½	6½	6½	6½	6½	7	7	7	7	7½	7½	7½	8	8	8
14	4	4	4½	4½	5	5	5	5	5½	6	6½	6½	6½	6½	6½	7	7	7	7	7½	7½	7½	8	8	8	8
16	4½	4½	4½	4½	5	5	5½	5½	6	6	6	6	6½	6½	6½	6½	7	7	7	7½	7½	7½	8	8	8	8
18	4½	4½	5	5	5	5	5½	6	6	6	6½	6½	6½	6½	6½	6½	7	7	7	7	7	7½	7½	8	8	8
20	4½	4½	5	5	5	5½	5½	6	6	6	6½	6½	6½	6½	6½	7	7	7	7	7½	7½	7½	8	8	8	8
22	4½	4½	5	5	5	5½	5½	6	6	6	6½	6½	6½	6½	6½	7	7	7	7	7½	7½	7½	8	8	8	8
24	4½	4½	5	5	5½	5½	5½	6	6	6	6½	6½	6½	6½	6½	7	7	7	7	7½	7½	7½	8	8	8	8
26	4½	4½	5	5½	5½	5½	5½	6	6	6	6½	6½	6½	6½	6½	7	7	7	7	7½	7½	7½	8	8	8	8
28	4½	4½	5	5½	5½	5½	5½	6	6	6	6½	6½	6½	6½	6½	7	7	7	7	7½	7½	7½	8	8	8	8
30	5	5	5½	5½	6	6	6	6½	6½	6½	7	7	7	7	7	7	7	7½	7½	8	8	8	8	8	8½	8½
36	5	5	5½	5½	6	6	6	6½	6½	6½	7	7	7	7	7½	7½	7½	7½	7½	8	8	8	8	8½	8½	8½
EQUIP FLAT	5	5½	6	6	6	6½	6½	6½	7	7	7	7	7	7½	7½	7½	7½	8	8	8	8½	8½	8½	8½	9	
	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039	1040 to 1075	1076 to 1111	1112 to 1147	1148 to 1183	1184 to 1219	1220 to 1255	1256 to 1291	1292 to 1327	1328 to 1363	1364 to 1399	1400 to 1435	1436 to 1471	1472 to 1507	1508 to 1543	1544 to 1579	1580 to 1616	
	OPERATING TEMPERATURE °F																									

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INSULATION THICKNESS REQUIREMENTS

Service Designation E-49

ECONOMIC INSULATION THICKNESSES

PLANTS: PONCE
SPEC. NO'S: 22-H, 22-HSS EXPANDED SILICA, 25-H HIGH & LOW CAL. SIL. SERVICE: PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE °C																												
	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599	600 to 619	620 to 639	640 to 659	660 to 679	680 to 699	700 to 719	720 to 739	740 to 759	760 to 779	780 to 799	800 to 819	820 to 839	840 to 859	860 to 879
¼	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3	3	3	3	3	3½	3½	3½	3½
¾	1½	1½	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	3½
1	2	2	2	2	2	2	2	2½	2½	2½	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	3½
1¼	2	2	2	2½	2½	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	4	4	4	4	4
1½	2	2½	2½	2½	2½	2½	3	3	3	3	3	3½	3½	3½	4	4	4	4	4	4	4	4	4	4	4	4
2	2	2½	2½	2½	2½	2½	3	3	3	3	3	3½	3½	4	4	4	4	4	4	4	4	4	4	4	4	4½
2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3½	3½	4	4	4	4	4	4	4½	4½	4½	4½	4½	4½	4½
3	2½	2½	2½	2½	2½	3	3	3	3	3	3½	3½	3½	4	4	4	4	4	4	4	4½	4½	4½	4½	4½	4½
3½	2½	3	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4½	4½	4½	4½	4½	5	5	5	5	5	5	5
4	2½	3	3	3	3	3	3	3½	3½	3½	3½	4	4	4½	4½	4½	4½	4½	4½	5	5	5	5	5	5	5
6	3	3	3	3	3	3½	3½	4	4	4	4	4	4½	4½	5	5	5	5	5	5	5	5	5	5	5	5
8	3½	3½	3½	3½	4	4	4	4½	4½	4½	4½	4½	5	5	5	5	5	5	5½	5½	5½	5½	5½	5½	5½	5½
10	3½	3½	3½	4	4	4	4	4½	4½	4½	4½	5	5	5	5	5½	5½	5½	5½	5½	5½	5½	5½	5½	5½	5½
12	3½	3½	3½	4	4	4	4	4½	4½	5	5	5	5	5½	5½	5½	5½	5½	6	6	6	6	6	6	6	6
14	3½	4	4	4	4	4	4½	4½	5	5	5	5	5½	5½	6	6	6	6	6	6	6	6	6	6	6	6
16	3½	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½	6	6	6	6½	6½	6½	6½	6½	6½	6½	6½	6½	6½
18	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½	5½	6	6	6	6½	6½	6½	6½	6½	6½	6½	6½	6½	6½
20	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½	5½	6	6	6	6½	6½	6½	7	7	7	7	7	7	7
22	4	4	4½	4½	4½	5	5	5	5	5½	5½	5½	5½	6	6	6	6½	6½	6½	7	7	7	7	7	7	7
24	4	4	4½	4½	4½	5	5	5	5	5½	5½	6	6	6½	6½	6½	6½	7	7	7	7	7	7	7	7	7½
26	4	4	4½	4½	4½	5	5	5	5	5½	5½	6	6	6	6½	6½	6½	7	7	7	7	7	7	7	7	7½
28	4	4	4½	4½	4½	5	5	5	5	5½	5½	6	6	6	6½	6½	6½	7	7	7	7	7	7½	7½	7½	7½
30	4	4½	4½	5	5	5	5	5½	5½	5½	6	6	6	6	6½	6½	6½	7	7	7	7	7	7½	7½	7½	7½
36	4	4½	4½	5	5	5	5	5½	5½	5½	6	6	6	6	6½	6½	6½	7	7	7	7	7	7½	7½	7½	7½
EQUIP FLAT	5	5	5½	5½	5½	6	6	6	6½	7	7	7	7	7½	7½	7½	7½	8	8	8	8	8	8½	8½	8½	8½
	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039	1040 to 1075	1076 to 1111	1112 to 1147	1148 to 1183	1184 to 1219	1220 to 1255	1256 to 1291	1292 to 1327	1328 to 1363	1364 to 1399	1400 to 1435	1436 to 1471	1472 to 1507	1508 to 1543	1544 to 1579	1580 to 1616
	OPERATING TEMPERATURE °F																												

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ECONOMIC INSULATION THICKNESSES

INSULATION THICKNESS REQUIREMENTS

Service Designation E-50

PLANTS: BOUND BROOK PLANT, PLASTICS DIVISION
SPEC. NO'S: 22-H, 22-HSS EXPANDED SILICA, 25-H HIGH & STANDARD CALCIUM SILICATE SERVICE: PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE °C																												
	360 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599	600 to 619	620 to 639	640 to 659	660 to 679	680 to 699	700 to 719	720 to 739	740 to 759	760 to 779	780 to 799	800 to 819	820 to 839	840 to 859	860 to 879
¼	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½
3/4	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3	3	3
1	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3
1¼	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	3½
1½	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½
2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½
2½	2	2	2	2½	2½	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	3½	3½	3½	3½
3	2	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	4	4	4	4	4	4
3½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	3½	4	4	4	4	4	4	4	4
4	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	3½	3½	4	4	4	4	4	4	4	4	4
6	2½	2½	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½
8	3	3	3½	3½	3½	3½	3½	4	4	4	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½	4½	4½	4½
10	3	3	3½	3½	3½	3½	3½	4	4	4	4	4	4	4½	4½	5	5	5	5	5	5	5	5	5	5
12	3	3	3½	3½	3½	3½	3½	4	4	4	4	4½	4½	4½	5	5	5	5	5	5	5	5	5	5	5
14	3	3	3½	3½	3½	3½	3½	4	4	4	4	4½	5	5	5	5	5	5	5	5	5	5	5	5	5
16	3½	3½	3½	3½	3½	3½	3½	4	4	4½	4½	4½	5	5	5	5½	5½	5½	5½	5½	5½	5½	5½	5½	5½
18	3½	3½	3½	4	4	4	4	4½	4½	4½	4½	4½	5	5	5½	5½	5½	5½	5½	5½	5½	5½	5½	5½	5½
20	3½	4	4	4	4	4	4	4½	5	5	5	5	5	5½	5½	5½	5½	5½	5½	6	6	6	6	6	6
22	3½	4	4	4	4	4	4	4½	5	5	5	5	5	5½	5½	5½	5½	6	6	6	6	6	6	6	6
24	4	4	4	4	4	4	4½	5	5	5	5	5	5	5½	5½	6	6	6	6	6	6	6	6	6	6
26	4	4	4	4	4	4	4½	5	5	5	5	5½	5½	6	6	6	6	6	6	6	6	6	6½	6½	6½
28	4	4	4	4	4	4	4½	5	5	5	5	5½	5½	6	6	6	6	6	6	6	6	6½	6½	6½	6½
30	4	4	4	4	4½	4½	4½	5	5	5	5	5½	5½	6	6	6	6	6½	6½	6½	6½	6½	7	7	7
36	4	4	4	4	4½	4½	4½	5	5	5	5½	6	6	6½	6½	6½	6½	7	7	7	7	7	7½	7½	7½
EQUIP FLAT	4½	4½	4½	4½	4½	5	5	5½	5½	6	6	6	6½	6½	6½	6½	7	7	7	7½	7½	7½	7½	7½	7½
	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039	1040 to 1075	1076 to 1111	1112 to 1147	1148 to 1183	1184 to 1219	1220 to 1255	1256 to 1291	1292 to 1327	1328 to 1363	1364 to 1399	1400 to 1435	1436 to 1471	1472 to 1507	1508 to 1543	1544 to 1579	1580 to 1616

OPERATING TEMPERATURE °F

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INSULATION THICKNESS REQUIREMENTS

Service Designation E-51

ECONOMIC INSULATION THICKNESSES

PLANTS: CARTERSVILLE PLANT, OTTAWA PLANT - PLASTICS DIVISION
SPEC. NO'S: 22-H, 22-HSS EXPANDED SILICA, 25-H HIGH & STANDARD CALCIUM SILICATE

SERVICE: PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE °C																													
	330 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599	600 to 619	620 to 639	640 to 659	660 to 679	680 to 699	700 to 719	720 to 739	740 to 759	760 to 779	780 to 799	800 to 819	820 to 839	840 to 859	860 to 879
½	2	2	2	2	2	2	2	2½	2½	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	3½
3/4	2	2	2	2	2½	2½	2½	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	3½
1	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	3½
1½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	3½
1½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	3½	4	4	4	4	4	4	4	4	4
2	2½	2½	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	3½	4	4	4	4	4	4	4	4	4
2½	3	3	3	3	3	3½	3½	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
3	3	3	3	3½	3½	3½	4	4	4	4	4	4	4	4	4	4	4	4	4	4½	4½	4½	4½	4½	4½
3½	3	3	3	3½	3½	3½	4	4	4	4	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	5	5	5	5
4	3	3	3½	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½	4½	4½	4½	5	5	5	5	5	5	5	5
6	3½	3½	4	4	4	4½	4½	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
8	4	4	4	4	4½	4½	5	5	5	5½	5½	5½	5½	5½	5½	5½	5½	5½	5½	5½	5½	5½	5½	5½	5½
10	4	4½	4½	4½	4½	5	5	5½	5½	5½	5½	5½	5½	5½	5½	5½	5½	5½	6	6	6	6	6	6	6
12	4	4½	4½	4½	5	5	5½	5½	5½	5½	5½	5½	6	6	6	6	6	6	6	6	6	6	6½	6½	6½
14	4½	4½	4½	5	5	5	5½	5½	6	6	6	6	6	6½	6½	6½	6½	6½	6½	6½	6½	6½	6½	6½	7
16	4½	4½	4½	5	5	5	5½	5½	6	6	6	6	6	6½	6½	6½	6½	6½	6½	6½	7	7	7	7	7
18	4½	4½	4½	5	5	5	5	5½	6	6	6	6	6½	6½	7	7	7	7	7	7	7½	7½	7½	7½	7½
20	4½	4½	4½	5	5	5	5	5½	6	6	6	6½	7	7	7	7	7	7	7½	7½	7½	7½	7½	7½	7½
22	4½	4½	5	5	5	5	5½	5½	6	6	6	6½	7	7	7	7	7	7	7½	7½	7½	7½	7½	7½	7½
24	5	5	5	5½	5½	5½	6	6	6½	6½	7	7	7	7	7	7	7	7½	7½	7½	7½	7½	7½	7½	8
26	5	5	5	5½	5½	6	6	6½	6½	7	7	7	7	7	7½	7½	7½	7½	7½	7½	8	8	8	8	8
28	5	5	5	5½	5½	6	6	6½	6½	7	7	7	7	7	7½	7½	7½	7½	7½	8	8	8	8	8	8½
30	5	5	5½	5½	5½	6	6½	6½	6½	7	7	7	7	7½	7½	7½	7½	8	8	8	8	8	8	8½	8½
36	5½	5½	6	6	6	6½	6½	6½	7	7	7	7	7½	7½	7½	8	8	8	8	8	8½	8½	8½	8½	9
EQUIP FLAT	5½	5½	6	6	6	6	6½	7	7	7½	7½	7½	8	8	8	8	8½	8½	8½	8½	9	9	9	9	9½
	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039	1040 to 1075	1076 to 1111	1112 to 1147	1148 to 1183	1184 to 1219	1220 to 1255	1256 to 1291	1292 to 1327	1328 to 1363	1364 to 1399	1400 to 1435	1436 to 1471	1472 to 1507	1508 to 1543	1544 to 1579	1580 to 1616

OPERATING TEMPERATURE °F

INSULATION THICKNESS REQUIREMENTS

Service Designation E-52

ECONOMIC INSULATION THICKNESSES

PLANTS MARIETTA PLANT - PLASTICS DIVISION
SPEC. NO'S 22-H, 22-H55 EXPANDED SILICA, 25-H HIGH AND STANDARD CALCIUM SILICATE SERVICE PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE °C																												
	390 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599	600 to 619	620 to 639	640 to 659	660 to 679	680 to 699	700 to 719	720 to 739	740 to 759	760 to 779	780 to 799	800 to 819	820 to 839	840 to 859	860 to 879
¼	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3/4	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½
1	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	2½
1¼	1½	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3
1½	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3
2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3	3
2½	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3½	3½	3½	3½	3½
3	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½
3½	2	2	2	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	3½	3½
4	2	2	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4	4	4
6	2½	2½	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	4	4	4	4	4	4	4	4	4	4	4
8	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4	4	4	4	4	4	4	4	4½	4½	4½	4½
10	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½	4½	4½	4½
12	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½	4½	4½	4½
14	3	3	3	3½	3½	3½	4	4	4	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½	4½	5	5	5
16	3½	3½	3½	3½	3½	4	4	4	4	4½	4½	4½	4½	5	5	5	5	5	5	5	5	5	5	5	5
18	3½	3½	3½	3½	3½	4	4	4	4	4½	4½	4½	4½	5	5	5	5	5	5	5	5	5	5	5	5
20	3½	3½	3½	3½	3½	4	4	4	4	4½	4½	4½	4½	5	5	5	5	5	5	5	5	5	5	5	5
22	3½	3½	3½	3½	3½	4	4	4	4	4½	4½	4½	4½	5	5	5	5	5	5	5½	5½	5½	5½	5½	5½
24	3½	3½	3½	3½	4	4	4½	4½	4½	4½	4½	4½	4½	5	5	5	5	5	5	5½	5½	5½	5½	5½	5½
26	3½	3½	3½	3½	4	4	4½	4½	4½	4½	4½	4½	4½	5	5	5	5½	5½	5½	5½	5½	5½	5½	5½	5½
28	3½	3½	3½	3½	4	4	4½	4½	4½	4½	4½	4½	4½	5	5	5	5½	5½	5½	5½	5½	5½	5½	5½	5½
30	3½	3½	4	4	4	4	4½	4½	4½	4½	4½	5	5	5½	5½	5½	5½	5½	6	6	6	6	6	6	6
36	3½	3½	4	4	4	4	4½	4½	4½	5	5	5	5	5½	5½	5½	5½	5½	6	6	6	6	6	6	6
EQUIP FLAT	4	4	4½	4½	5	5	5	5	5½	5½	5½	5½	6	6	6	6	6	6	6½	6½	6½	6½	6½	6½	7
	716 to 751	732 to 767	768 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039	1040 to 1075	1076 to 1111	1112 to 1147	1148 to 1183	1184 to 1219	1220 to 1255	1256 to 1291	1292 to 1327	1328 to 1363	1364 to 1399	1400 to 1435	1436 to 1471	1472 to 1507	1508 to 1543	1544 to 1579	1580 to 1616
	OPERATING TEMPERATURE °F																								

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INSULATION THICKNESS REQUIREMENTS

Service Designation E-53

ECONOMIC INSULATION THICKNESSES

SERVICE: EQUIPMENT AND VESSELS

SPEC. NO'S: 41-H, 42-H SPRAYED ASBESTOS FIBER

PLANT	OPERATING TEMPERATURE °C																														
	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599	600 to 619
INSTITUTE	2	2½	2½	3	3	3½	3½	3½	3½	3½	4	4	4	4½	4½	5	5	5	5½	5½	5½	5½	6	6	6	6
512 S. CHARLESTON	2	2½	2½	3	3	3½	3½	3½	3½	3½	4	4	4	4½	4½	5	5	5	5½	5½	5½	5½	6	6	6	6
514 SEADRIFT	2	2	2½	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4	4½	4½	5	5	5	5	5	5½	5½	5½	5½
510 TEXAS CITY	2	2	2½	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4½	4½	5	5	5	5	5	5½	5½	5½	5½
515 TAFT	2	2	2½	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4½	4½	5	5	5	5	5	5½	5½	5½	5½
519 BROWNSVILLE	2	2	2½	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4½	4½	5	5	5	5	5	5½	5½	5½	5½
526 TORRANCE	2	2	2½	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4½	4½	5	5	5	5	5	5½	5½	5½	5½
513	2½	3	3	3½	4	4½	4½	5	5	5½	5½	6	6	6	6½	7	7½	7½	7½	8	8	8	8	8½	8½	8½
WHITING 517	2½	2½	2½	3	3½	3½	3½	4	4	4	4½	4½	5	5	5	5½	6	6	6	6	6	6½	6½	6½	7	7
MONTREAL 053	2½	2½	2½	3	3½	3½	4	4	4½	4½	4½	5	5	5	5½	6	6	6	6½	6½	6½	7	7	7	7	7½
SISTERSVILLE	2½	2½	2½	3	3½	3½	4	4	4½	4½	4½	5	5	5	5½	6	6	6	6½	6½	6½	7	7	7	7	7½
SILICONE NIAGARA FALLS 516	2½	2½	2½	3	3½	3½	4	4	4½	4½	4½	5	5	5	5½	6	6	6	6½	6½	6½	7	7	7	7	7½
PONCE	2	2	2½	3	3½	3½	4	4	4½	4½	4½	4½	5	5	5½	6	6	6	6	6½	6½	7	7	7	7	7½
BOUND BROOK	2½	2½	2½	3	3½	3½	4	4	4½	4½	4½	5	5	5	5½	6	6	6	6½	6½	6½	7	7	7	7	7½
CARTERSVILLE	2½	3	3	3½	4	4½	4	5	5	5½	5½	6	6	6	6½	7	7	7½	7½	8	8	8	8	8	8	8½
MARIETTA	2	2½	2½	3	3	3½	3½	3½	3½	3½	4	4	4	4½	4½	5	5	5	5½	5½	5½	5½	6	6	6	6
OTTAWA	2½	2½	2½	3	3½	3½	4	4	4½	4½	4½	5	5	5	5½	6	6	6	6½	6½	7	7	7	7	7	7½
	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 417	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039	1040 to 1075	1076 to 1111	1112 to 1147
OPERATING TEMPERATURE °F																										

INSULATION THICKNESS REQUIREMENTS

Service Designation E-54

ECONOMIC INSULATION THICKNESS

PLANTS: INSTITUTE 512 S. CHARLESTON 514 SEADRIFT 510 TAFT 519 TEXAS CITY 515 TORRANCE 513 MARIETTA 314

SPEC. NO'S 21-H, 21-HSS, 22-H, 22-HSS, 23-H, 23-HSS

SERVICE: ELECTRIC HEATED PROCESS PIPE AND EQUIPMENT

OPERATING TEMPERATURE °C

NOM PIPE SIZE	0 to 19	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239
1/2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5
3/4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5
1 1/4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5
1 1/2	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	2.0	2.0
2	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	2.0	2.0	2.0
2 1/2	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.0
3	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.0
3 1/2	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.0
4	1.0	1.0	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.5
6	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.5	2.5	2.5	3.0
8	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.5	2.5	2.5	3.0	3.0
10	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.5	2.5	2.5	3.0	3.0
12	1.5	1.5	1.5	1.5	2.0	2.0	2.5	2.5	3.0	3.0	3.0	3.5
14	1.5	1.5	1.5	1.5	2.0	2.0	2.5	2.5	3.0	3.0	3.0	3.5
16	1.5	1.5	2.0	2.0	2.0	2.5	2.5	3.0	3.0	3.0	3.5	3.5
18	1.5	1.5	2.0	2.0	2.5	2.5	3.0	3.0	3.5	3.5	3.5	4.0
20	1.5	1.5	2.0	2.0	2.5	2.5	3.0	3.0	3.5	3.5	3.5	4.0
22	1.5	1.5	2.0	2.0	2.5	2.5	3.0	3.0	3.5	3.5	3.5	4.0
24	2.0	2.0	2.0	2.0	2.5	2.5	3.0	3.0	3.5	3.5	3.5	4.0
26	2.0	2.0	2.0	2.0	2.5	2.5	3.0	3.0	3.5	3.5	3.5	4.0
28	2.0	2.0	2.0	2.0	2.5	2.5	3.0	3.0	3.5	3.5	3.5	4.0
30	2.0	2.0	2.0	2.0	2.5	2.5	3.0	3.0	3.5	3.5	4.0	4.0
36	2.0	2.0	2.0	2.5	2.5	2.5	3.0	3.0	3.5	3.5	4.0	4.0
EQUIP. FLAT	2.0	2.0	2.0	2.5	2.5	2.5	3.0	3.0	3.5	3.5	4.0	4.0
	32 to 67	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463

OPERATING TEMPERATURE °F

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INSULATION THICKNESS REQUIREMENTS

Service Designation E-55

ECONOMIC INSULATION THICKNESS

PLANTS: BROWNSVILLE 526 PONCE 293

SPEC. NO'S 21-H, 21-HSS, 22-H, 22-HSS, 23-H, 23-HSS

SERVICE: ELECTRIC HEATED PROCESS PIPE AND EQUIPMENT

OPERATING TEMPERATURE °C

NOM PIPE SIZE	0 to 19	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239
1/2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3/4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5
1 1/4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5
1 1/2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5
2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5
2 1/2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	2.0
3	1.0	1.0	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0
3 1/2	1.0	1.0	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.5
4	1.0	1.0	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.5
6	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.5
8	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.5
10	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.5	2.5
12	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.5	2.5	2.5
14	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.5	2.5	2.5	3.0
16	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.5	2.5	2.5	3.0
18	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.5	2.5	3.0	3.0	3.0
20	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.5	2.5	3.0	3.0	3.0
22	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.5	2.5	3.0	3.0	3.0
24	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.5	2.5	3.0	3.0	3.0
26	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.5	2.5	3.0	3.0	3.0
28	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.5	2.5	3.0	3.0	3.0
30	1.5	1.5	1.5	1.5	2.0	2.0	2.5	2.5	3.0	3.0	3.0	3.0
36	2.0	2.0	2.0	2.0	2.0	2.5	2.5	3.0	3.0	3.0	3.5	3.5
EQUIP FLAT	2.0	2.0	2.0	2.0	2.0	2.5	2.5	3.0	3.0	3.5	3.5	3.5

OPERATING TEMPERATURE °F

32 to 67	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463

INSULATION THICKNESS REQUIREMENTS

Service Designation E-5x

ECONOMIC INSULATION THICKNESS

PLANTS: SISTERSVILLE 380 WHITING 517 MONTREAL 503

SPEC. NO'S 21-H, 21-HSS, 22-H, 22-HSS, 23-H, 23-HSS

SERVICE: ELECTRIC HEATED PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE °C												OPERATING TEMPERATURE °F											
	0 to 19	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	32 to 67	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463
1/2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5												
3/4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5												
1	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5	2.0	2.0												
1 1/4	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5	2.0	2.0												
1 1/2	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5	2.0	2.0												
2	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	2.0	2.0	2.0												
2 1/2	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	2.0	2.0	2.0												
3	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.0												
3 1/2	1.0	1.0	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.5												
4	1.0	1.0	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.5												
6	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.5	2.5	3.0												
8	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.5	3.0	3.0	3.0	3.5												
10	1.5	1.5	1.5	1.5	2.0	2.0	2.5	2.5	2.5	3.0	3.0	3.5												
12	1.5	1.5	1.5	1.5	2.0	2.0	2.5	2.5	2.5	3.0	3.0	3.5												
14	1.5	1.5	1.5	1.5	2.0	2.0	2.5	2.5	3.0	3.0	3.0	3.5												
16	1.5	1.5	1.5	2.0	2.0	2.5	2.5	3.0	3.0	3.0	3.5	3.5												
18	1.5	1.5	1.5	2.0	2.0	2.5	2.5	3.0	3.0	3.5	3.5	4.0												
20	1.5	1.5	1.5	2.0	2.0	2.5	2.5	3.0	3.0	3.5	3.5	4.0												
22	1.5	1.5	1.5	2.0	2.0	2.5	2.5	3.0	3.0	3.5	3.5	4.0												
24	2.0	2.0	2.0	2.0	2.5	2.5	3.0	3.0	3.5	3.5	4.0	4.0												
26	2.0	2.0	2.0	2.0	2.5	2.5	3.0	3.0	3.5	3.5	4.0	4.0												
28	2.0	2.0	2.0	2.0	2.5	2.5	3.0	3.0	3.5	3.5	4.0	4.0												
30	2.0	2.0	2.0	2.0	2.5	2.5	3.0	3.0	3.5	3.5	4.0	4.0												
36	2.0	2.0	2.0	2.0	2.5	2.5	3.0	3.0	3.5	3.5	4.0	4.0												
EQUIP. FLAT	2.0	2.0	2.0	2.5	2.5	3.0	3.5	3.5	4.0	4.0	4.5	4.5												

INSULATION THICKNESS REQUIREMENTS

Service Designation F-1

INSULATION THICKNESSES FOR
FREEZE CONTROL OF OUTDOOR WATER LINES

PLANTS: ALL PLANTS
SPEC. NO'S: 10-L, 10-J

SERVICE: BASED ON WATER TEMPERATURE OF 40F(5C) AT ENTRY

MINIMUM FLOW OF WATER IN GALLONS PER HOUR, PER 100 LIN. FT. OF PIPE TO PREVENT FREEZING

NOM PIPE SIZE	1" Nominal Thick Insulation					1½" Nominal Thick Insulation					2" Nominal Thick Insulation				
	Ambient Temperature ° C					Ambient Temperature ° C					Ambient Temperature ° C				
	-1	-7	-12	-23	-29	-1	-7	-12	-17	-23	-29	-1	-7	-12	-17	-23	-29
¼	1.91	2.87	3.81	4.76	5.73	6.65	1.45	2.18	2.91	3.64	4.25	5.09	1.35	2.10	2.71	3.41	4.10	4.80
⅜	2.25	3.46	4.59	5.78	6.93	8.05	1.70	2.55	3.40	4.25	5.10	5.93	1.64	2.55	3.30	4.21	5.10	6.01
1	2.52	3.62	4.90	5.95	7.22	8.40	1.91	2.87	3.81	4.77	5.72	6.68	1.69	2.53	3.21	4.04	4.90	5.77
1¼	3.08	4.67	6.15	7.75	9.34	11.0	2.12	3.18	4.24	5.28	6.34	7.40	1.86	2.87	3.87	4.88	5.73	6.73
1½	3.27	4.85	6.33	7.90	9.70	11.0	2.42	3.63	4.83	6.05	7.25	8.46	1.80	2.82	3.62	4.64	5.63	6.82
2	3.69	5.68	7.35	9.25	11.2	13.0	2.71	4.04	5.40	6.72	8.08	9.40	2.61	4.02	5.22	6.64	7.83	9.25
2½	4.23	6.35	8.48	10.6	12.7	14.9	3.19	4.19	5.80	7.00	8.38	9.77	2.31	3.70	4.86	6.02	7.17	8.32
3	5.07	7.58	0.3	12.7	15.2	17.9	3.59	5.38	7.20	8.98	10.8	12.6	3.00	4.62	6.23	7.85	9.23	10.9
3½	5.83	8.61	10.5	13.6	16.0	20.1	3.69	5.64	7.38	9.25	10.9	12.7	2.73	4.36	5.72	7.11	8.45	9.83
4	6.23	9.40	12.4	15.2	18.8	21.5	4.38	6.70	8.78	10.9	13.2	15.3	3.83	5.72	7.38	9.28	11.2	13.1
6	6.92	10.2	13.9	17.1	20.4	24.0	6.30	9.58	13.5	16.0	19.2	22.4	4.88	7.15	9.74	11.9	14.7	17.2
8							7.45	10.4	14.9	18.8	22.8	26.7	5.95	9.28	12.0	15.2	18.2	21.3
10							8.91	13.7	17.9	22.5	26.7	31.5	7.28	10.9	14.2	17.8	21.5	25.0
12							10.2	15.5	20.8	26.2	31.0	35.8	8.23	12.4	16.5	20.5	24.7	28.7
14							11.9	18.0	23.6	29.3	35.5	41.7	8.70	13.1	17.5	20.8	25.8	30.5
16							13.9	20.8	27.7	33.5	42.0	49.0	10.9	15.9	21.3	26.2	32.1	37.6
18							15.3	23.1	31.1	38.9	46.5	55.2	11.3	17.3	23.4	28.6	35.2	41.3
20							16.7	25.0	34.2	42.5	50.2	59.3	13.1	19.7	26.2	32.8	39.1	45.6
22							18.2	27.3	37.1	46.0	55.2	64.3	14.4	21.3	28.3	35.4	42.6	49.6
24							20.6	30.1	41.0	51.3	61.0	71.7	15.3	23.9	30.4	38.1	45.7	54.3
26							21.9	32.5	43.7	55.1	65.5	76.9	16.3	24.5	32.6	40.8	50.0	58.0
28							23.3	35.0	47.2	59.2	70.5	82.5	17.5	26.2	34.9	43.5	53.3	62.0
30							25.1	36.8	49.0	62.7	74.7	87.8	18.7	27.8	37.9	47.3	57.5	67.8
36							28.3	42.0	56.6	71.3	85.8	102.0	21.9	32.7	44.8	55.8	67.8	80.1
	30	20	10	0	-10	-20	30	20	10	0	-10	-20	30	20	10	0	-10	-20
	Ambient Temperature ° F						Ambient Temperature ° F						Ambient Temperature ° F					

EXAMPLE: If outdoor line is 50 feet long, one-half of flow listed above is required.
If line is 200 feet, twice the flow listed above is required.

Service Designation PS-1

INSULATION THICKNESS REQUIREMENTS

FIRE PROTECTION INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: ALL PLANTS
SPEC. NO'S: 32-H

SERVICE: FIRE PROTECTION AND SAFE SURFACE TEMPERATURE - MASTIC OR JACKETS OF 0.9 EMITTANCE

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																													
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559
½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
¾	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1¼	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½
3½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½
4	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½
6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
8	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
10	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
12	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
14	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
16	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
18	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
22	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
24	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
26	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
28	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
30	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
36	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½
EQUIP FLAT	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½
	OPERATING TEMPERATURE ° F																													
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039

NOTE: For temperatures above those listed, use thickness chart for safe surface temperatures - mastics or jackets of 0.9 emittance.

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Service Designation

INSULATION THICKNESS REQUIREMENTS

FIRE PROTECTION INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

SERVICE: FIRE PROTECTION AND SAFE SURFACE TEMPERATURE – STAINLESS STEEL JACKETS

PLANTS: ALL PLANTS
SPEC. NO'S: 32-H

NOM PIPE SIZE	OPERATING TEMPERATURE °C																														
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559
½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½
¾	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½
1¼	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½
1½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½
2½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½
3½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½
4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½
6	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½
8	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
10	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
12	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½
14	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½
16	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4
18	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4
20	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4
22	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4½	4½
24	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4½	4½
26	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4½	4½
28	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4½	4½
30	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4½	4½
36	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4½	4½
EQUIP FLAT	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4½	4½	5	5
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039
	OPERATING TEMPERATURE °F																										

NOTE: For temperatures above those listed, use thickness chart for safe surface temperatures – stainless steel jackets.

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INSULATION THICKNESS REQUIREMENTS

Service Designation PE-3

FIRE PROTECTION INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: TORRANCE PLANT 513
SPEC. NO'S: 32-H - EXPANDED SILICA

SERVICE: FIRE PROTECTION AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																													
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559
½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½
¾	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	3	3	3
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	3	3	3	3
1¼	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½
1½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3	3	3½	3½	4
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3	3	3½	3½	4
2½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	3	3	3	3	3	3½	3½	4	4	4	4
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	3	3	3	3	3	3½	3½	4	4	4	4	4
3½	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4½	4½
4	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3½	3½	4	4	4	4	4	4½	4½	5	5
6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4	4½	4½	5	5	5	5
8	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4	4	4	4½	4½	5	5	5½	5½
10	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½
12	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½
14	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½
16	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½
18	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4	4½	4½	4½	5	5	5	5	5½	5½	6
20	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4½	4½	4½	5	5	5	5	5½	5½	5½	6	6	6
22	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4½	4½	4½	5	5	5	5	5½	5½	6	6	6	6
24	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4½	4½	5	5	5	5½	5½	6	6	6	6	6½	7	7
26	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4½	4½	5	5	5	5½	5½	6	6	6	6	6½	7	7
28	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4½	4½	5	5	5	5½	5½	6	6	6	6	6½	7	7
30	3	3	3	3	3	3	3	3	3	4	4	4	4½	4½	5	5	5½	5½	6	6	6	6½	6½	7	7	7½	7½	7½
36	3	3	3	3	3	3	3	3	3	4	4	4	4½	4½	5	5	5½	5½	6	6	6	6½	6½	7	7	7½	7½	7½
EQUIP FLAT	3	3	3	3	3	3	3½	3½	4	4	4	4½	5	5	5½	5½	5½	6	6	6½	6½	7	7	7½	8	8	8	8
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039
	OPERATING TEMPERATURE ° F																													

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INSULATION THICKNESS REQUIREMENTS

Service Designation PE-4

FIRE PROTECTION INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: WHITING PLANT 517
SPEC. NO's: 32-H EXPANDED SILICA

SERVICE: FIRE PROTECTION AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																														
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559				
½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½				
¾	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	3				
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	3	3				
1¼	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	3	3				
1½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	3	3				
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	3	3	3				
2½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	3	3	3	3				
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3½				
3½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	3	3	3	3	3	3	3	3	3½	3½				
4	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3	3½	3½	4	4½				
5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4½				
6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4½				
8	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4½				
10	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4½				
12	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4½				
14	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4½				
16	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4½				
18	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4½				
20	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4½				
22	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4½				
24	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4½				
26	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4½				
28	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4½				
30	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4½				
36	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4½				
EQUIP FLAT	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	4	4½	4½	5	5	5	5½	5½	5½	6	6	6½	6½				
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039				
	OPERATING TEMPERATURE ° F																														

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INSULATION THICKNESS REQUIREMENTS

Service Designation PE-5

FIRE PROTECTION INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

SERVICE: FIRE PROTECTION AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

PLANTS:
SPEC. NO'S: SILICONE, SISTERSVILLE
32-H EXPANDED SILICA

NOM PIPE SIZE	OPERATING TEMPERATURE °C																														
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559
½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½
¾	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	3
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	3	3	3
1¼	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	3	3	3
1½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	3	3	3	3½
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	3	3	3	3½	3½
2½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	3	3	3	3½	3½	3½
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	3	3	3	3	3½	3½	4	4
3½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	3	3	3	3	3½	3½	3½	4	4	4
4	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	4	4	4	4
6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4	4	4½	4½	4½
8	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4	4	4½	4½	5	5	5
10	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4	4	4½	4½	5	5	5	5
12	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4	4	4½	4½	5	5	5	5½	5½
14	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4	4	4½	4½	5	5	5	5½	6	6
16	3	3	3	3	3	3	3	3	3	3	3	3	3½	4	4	4	4½	5	5	5	5	5	5½	6	6	6	6½
18	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5	5	5½	5½	6	6	6	6½
20	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5	5	5	5½	6	6	6	6½	6½
22	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5	5	5	6	6	6	6½	6½	7
24	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5	5	5	6	6	6	6½	7	7
26	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5	5	5½	6	6	6½	7	7	7
28	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5	5	5½	6	6	6½	7	7	7
30	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5	5	5½	6	6	6½	7	7	7
36	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5	5	5½	6	6	6½	7	7	7
EQUIP FLAT	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4½	5	5	5	5½	5½	6	6	6	6	6½	7	7	7
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039
	OPERATING TEMPERATURE °F																										

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INSULATION THICKNESS REQUIREMENTS

Service Designation PE-6

FIRE PROTECTION INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: KANAWHA VALLEY PLANTS - INSTITUTE 512, SOUTH CHARLESTON 514
SPEC. NO'S: 32-H EXPANDED SILICA
SERVICE: PROTECTION AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																														
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559
¼	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½
1¼	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½
1½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	3
2½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	3	3
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3
3½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	3	3	3	3
4	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3	3½	4
6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	4	4
8	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	4	4	4
10	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	4	4	4
12	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4
14	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	4	4	4	4½
16	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4	4½	4½
18	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4½	4½	4½
20	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4	4	4½	4½	4½
22	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4	4	4½	4½	4½
24	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4	4	4	4	4½	5
26	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4	4	4	4½	4½	5
28	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4	4	4	4½	4½	5
30	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4	4	4	4½	4½	5	5
36	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	4	4	4	4	4	4½	4½	4½	5	5	5½	6
EQUIP FLAT	3 to 38	3 to 104	3 to 140	3 to 176	3 to 212	3 to 248	3 to 284	3 to 320	3 to 356	3 to 392	3 to 428	3½ to 464	3½ to 500	4 to 536	4 to 572	4 to 608	4 to 644	4½ to 680	4½ to 716	4½ to 752	4½ to 788	5 to 824	5 to 860	5 to 896	5 to 932	5½ to 968	6 to 1004
	OPERATING TEMPERATURE ° F																										
	103 to 139	139 to 175	175 to 211	211 to 247	247 to 283	283 to 319	319 to 355	355 to 391	391 to 427	427 to 463	463 to 499	499 to 535	535 to 571	571 to 607	607 to 643	643 to 679	679 to 715	715 to 751	751 to 787	787 to 823	823 to 859	859 to 895	895 to 931	931 to 967	967 to 1003	1003 to 1039	

Service Designation PE-7

INSULATION THICKNESS REQUIREMENTS

FIRE PROTECTION INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: GULF COAST PLANTS - SEADRIFT 510, TEXAS CITY 515, TAFT 519, BROWNSVILLE 526
SPEC. NO'S: 32-H EXPANDED SILICA
SERVICE: FIRE PROTECTION AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																												
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559
½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
¾	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1¼	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½
2½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	3
3½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	3	3	3½
4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	3	3	3½	3½
6	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3½	3½	3½	4
8	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4
10	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4
12	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4
14	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4	4
16	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	4	4	4½	4½	4½	4½
18	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4½	4½	4½
20	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	4	4	4½	4½	4½	4½
22	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	4	4	4½	4½	4½	4½
24	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4½	4½	4½	4½	4½
26	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	4	4	4½	4½	4½	4½
28	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4	4½	4½	4½	4½
30	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	4	4	4	4	4½	4½	4½	4½
36	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	4	4	4	4	4½	4½	4½	4½
EQUIP FLAT	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	4	4	4	4	4½	4½	4½	5	5	5	5	5
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039		
	OPERATING TEMPERATURE ° F																												

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INSULATION THICKNESS REQUIREMENTS

Service Designation PE-8

FIRE PROTECTION INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

SERVICE: FIRE PROTECTION AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

PLANTS: MONTREAL 053, NIAGARA FALLS 516
SPEC. NO'S: 32-H EXPANDED SILICA

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																														
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559
¼	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½
½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	3
¾	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	3	3	3
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	3	3	3	3	3½	3½
1¼	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½
1½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	3	3	3	3	3	3	3	3½	3½	3½
2½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	3½
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	3	3	3	3	3	3	3½	3½	4	4	4
3½	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	4	4	4
4	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3½	3½	3½	3½	3½	4	4	4	4½	4½	4½
6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4	4	4	4½	4½	5	5
8	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4	4	4	4½	4½	5	5	5
10	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4	4	4	4½	4½	5	5	5	5
12	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4	4	4	4½	4½	5	5	5½	5½
14	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4½	4½	4½	4½	5	5	5	5½	6	6	6
16	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5	5	5½	6	6	6
18	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5	5	5½	6	6	6	6
20	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5	5	5½	6	6	6	6
22	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5	5	5½	6	6	6	6
24	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5	5	5½	6	6	6	6
26	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5	5	5	5½	6	6	6
28	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5	5	5	5½	6	6½	6½
30	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5	5	5½	6	6	6	6½	6½	6½
36	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4	4½	5	5	5	5	5½	6	6	6	6½	6½	6½
EQUIP FLAT	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5	5½	5½	5½	6	6	6	6½	7
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039
	OPERATING TEMPERATURE ° F																										

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INSULATION THICKNESS REQUIREMENTS

Service Designation PE-9

FIRE PROTECTION INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: PONCE
SPEC. NO'S: 32-H EXPANDED SILICA

SERVICE: FIRE PROTECTION AND STEAM HEATED PROCESS PIPE & EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE °C												
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279
½	2	2	2	2	2	2	2	2	2	2	2	2	2
3/4	2	2	2	2	2	2	2	2	2	2	2	2	2
1	2	2	2	2	2	2	2	2	2	2	2	2	2
1¼	2	2	2	2	2	2	2	2	2	2	2	2	2
1½	2	2	2	2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2	2	2	2	2
2½	2	2	2	2	2	2	2	2	2	2	2	2	2
3	2	2	2	2	2	2	2	2	2	2	2	2	2
3½	2	2	2	2	2	2	2	2	2	2	2	2	2
4	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½
6	3	3	3	3	3	3	3	3	3	3	3	3	3
8	3	3	3	3	3	3	3	3	3	3	3	3	3
10	3	3	3	3	3	3	3	3	3	3	3	3	3
12	3	3	3	3	3	3	3	3	3	3	3	3	3
14	3	3	3	3	3	3	3	3	3	3	3	3	3
16	3	3	3	3	3	3	3	3	3	3	3	3	3
18	3	3	3	3	3	3	3	3	3	3	3	3	3
20	3	3	3	3	3	3	3	3	3	3	3	3	3
22	3	3	3	3	3	3	3	3	3	3	3	3	3
24	3	3	3	3	3	3	3	3	3	3	3	3	3
26	3	3	3	3	3	3	3	3	3	3	3	3	3
28	3	3	3	3	3	3	3	3	3	3	3	3	3
30	3	3	3	3	3	3	3	3	3	3	3	3	3
36	3	3	3	3	3	3	3	3	3	3	3	3	3
EQUIP FLAT	3	3	3	3	3	3	3	3	3	3	3	3	3½
OPERATING TEMPERATURE °F	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535

NOM PIPE SIZE	OPERATING TEMPERATURE °C													
	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559
½	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3/4	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½
1	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½
1¼	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	3	3
1½	2	2	2	2½	2½	2½	2½	2½	2½	2½	3	3	3	3
2	2	2	2	2½	2½	2½	2½	2½	2½	2½	3	3	3	3
2½	2	2	2	2½	2½	2½	2½	2½	2½	2½	3	3	3	3
3	2	2	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3½
3½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½
4	2½	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½
6	3	3	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4
8	3	3	3	3	3	3½	3½	3½	4	4	4	4½	4½	4½
10	3	3	3	3	3	3½	3½	4	4	4	4	4½	4½	4½
12	3	3	3½	3½	3½	3½	3½	4	4	4	4	4½	4½	4½
14	3	3½	3½	3½	3½	4	4	4	4	4	4½	4½	5	5
16	3½	3½	3½	3½	3½	4	4	4	4½	4½	4½	5	5	5
18	3½	3½	3½	3½	4	4	4	4½	4½	4½	5	5	5	5½
20	3½	3½	3½	3½	4	4	4	4½	4½	4½	5	5	5	5½
22	3	3½	3½	3½	4	4	4½	4½	4½	4½	5	5	5	5½
24	3	3½	3½	4	4	4	4½	4½	4½	4½	5	5	5	5½
26	3	3½	3½	4	4	4	4½	4½	4½	4½	5	5	5	5½
28	3	3½	3½	4	4	4	4½	4½	4½	4½	5	5	5	5½
30	3	3½	3½	4	4	4½	4½	5	5	5	5	5½	5½	5½
36	3	3½	4	4	4	4½	4½	5	5	5	5	5½	5½	5½
EQUIP FLAT	4	4	4	4½	5	5	5½	5½	5½	5½	6	6	6½	6½
OPERATING TEMPERATURE °F	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1103	1004 to 1039

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INSULATION THICKNESS REQUIREMENTS

Service Designation PE-10

FIRE PROTECTION INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: BOUND BROOK PLANT - PLASTICS DIVISION
SPEC. NO'S: 32-H EXPANDED SILICA

SERVICE: FIRE PROTECTION AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE °C													
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 119	220 to 239	240 to 259	260 to 279	280 to 299
½	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3/4	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1¼	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1½	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2½	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3½	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½
5	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6	3	3	3	3	3	3	3	3	3	3	3	3	3	3
10	3	3	3	3	3	3	3	3	3	3	3	3	3	3
12	3	3	3	3	3	3	3	3	3	3	3	3	3	3
14	3	3	3	3	3	3	3	3	3	3	3	3	3	3
16	3	3	3	3	3	3	3	3	3	3	3	3	3	3
18	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20	3	3	3	3	3	3	3	3	3	3	3	3	3	3
22	3	3	3	3	3	3	3	3	3	3	3	3	3	3
24	3	3	3	3	3	3	3	3	3	3	3	3	3	3
26	3	3	3	3	3	3	3	3	3	3	3	3	3	3
28	3	3	3	3	3	3	3	3	3	3	3	3	3	3
30	3	3	3	3	3	3	3	3	3	3	3	3	3	3
36	3	3	3	3	3	3	3	3	3	3	3	3	3	3
EQUIP FLAT	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½
OPERATING TEMPERATURE °F	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571

NOM PIPE SIZE	OPERATING TEMPERATURE °C												
	300 to 319	320 to 339	340 to 359	350 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559
½	2	2	2	2	2	2	2	2	2	2	2	2	2
3/4	2	2	2	2	2	2	2	2	2	2	2	2	2
1	2	2	2	2	2	2	2	2	2	2	2	2	2
1¼	2	2	2	2	2	2	2	2	2	2	2	2	2½
1½	2	2	2	2	2	2	2	2	2	2	2	2½	2½
2	2	2	2	2	2	2	2	2	2	2	2	2½	2½
2½	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	3
3	2	2	2	2	2	2½	2½	2½	2½	2½	2½	3	3
3½	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	3	3
4	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3
5	3	3	3	3	3	3	3	3	3	3	3	3½	3½
6	3	3	3	3	3	3	3½	3½	3½	3½	3½	4	4
10	3	3	3	3	3	3	3½	3½	3½	3½	3½	4	4
12	3	3	3	3	3	3	3½	3½	3½	3½	3½	4	4
14	3	3	3	3	3	3	3½	3½	3½	3½	3½	4	4
16	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	4	4
18	3	3	3½	3½	3½	3½	3½	4	4	4	4	4½	4½
20	3	3½	3½	3½	3½	4	4	4	4	4	4	4½	4½
22	3	3½	3½	3½	3½	4	4	4	4	4	4	4½	4½
24	3½	3½	3½	3½	4	4	4	4	4	4	4½	5	5
26	3½	3½	3½	3½	4	4	4	4	4	4	4½	5	5
28	3½	3½	3½	3½	4	4	4	4	4	4	4½	5	5
30	3½	3½	3½	4	4	4	4	4	4½	4½	4½	5	5
36	3½	3½	3½	4	4	4	4	4	4½	4½	4½	5	5
EQUIP FLAT	4	4	4	4	4½	4½	4½	4½	4½	5	5	5½	5½
OPERATING TEMPERATURE °F	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039

FIRE PROTECTION INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: CARTERSVILLE PLANT, OTTAWA PLANT - PLASTICS DIVISION
SPEC. NO'S: 32-H EXPANDED SILICA

SERVICE: FIRE PROTECTION AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

NOM PIPE SIZE	OPERATING TEMPERATURE °C																										
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559
½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½
3/4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	3	3
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	3	3
1¼	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	3	3
1½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3½	3½
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3½	3½
2½	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	4	4
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	4	4
3½	2	2	2	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	4	4
4	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	4	4
6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	4	4	4	4	4	4
8	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4	4½	4½	4½	4½	4½	4½
10	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	4½	4½	4½	5	5	5
12	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4	4½	4½	4½	4½	4½	5	5	5
14	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4	4½	4½	4½	4½	5	5	5	5½	5½
16	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4	4½	4½	4½	4½	5	5	5	5½	5½
18	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	4½	4½	5	5	5	5	5½	6
20	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½	4	4	4	4½	4½	4½	4½	5	5	5	5	5½	6
22	3	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4½	4½	4½	4½	5	5	5	5	5½	5½	6
24	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4½	4½	4½	5	5	5	5½	5½	5½	6	6	6½
26	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4½	4½	4½	5	5	5	5½	5½	5½	6	6	6½
28	3	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4½	4½	4½	5	5	5	5½	5½	5½	6	6	6½
30	3	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4½	4½	4½	5	5	5	5½	5½	5½	5½	6	6½	6½
36	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4½	5	5	5	5½	5½	5½	6	6	6	6	6½	6½	6½
EQUIP FLAT	3	3	3	3	3	3	3	3	3½	3½	3½	4	4	4½	5	5	5	5½	5½	5½	6	6	6	6	6½	7	7
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039
	OPERATING TEMPERATURE °F																										

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INSULATION THICKNESS REQUIREMENTS

Service Designation PE-12

FIRE PROTECTION INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: MARIETTA PLANT - PLASTICS DIVISION
SPEC. NO'S: 32-H EXPANDED SILICA

SERVICE: FIRE PROTECTION AND STEAM HEATED PROCESS PIPE AND EQUIPMENT

OPERATING TEMPERATURE °C

NOM PIPE SIZE	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319
½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3/4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1¼	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3½	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½
6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
8	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
10	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
12	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
14	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
16	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
18	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
22	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
24	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
26	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
28	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
30	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
36	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
EQUIP FLAT	3	3	3	3	3	3	3	3	3	3	3	3	3	3½	3½
OPERATING TEMPERATURE °F	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607

NOM PIPE SIZE	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559
½	2	2	2	2	2	2	2	2	2	2	2	2
3/4	2	2	2	2	2	2	2	2	2	2	2	2
1	2	2	2	2	2	2	2	2	2	2	2	2
1¼	2	2	2	2	2	2	2	2	2	2	2	2
1½	2	2	2	2	2	2	2	2	2½	2½	2½	2½
2	2	2	2	2	2	2	2	2	2½	2½	2½	2½
2½	2	2	2	2	2	2	2	2	2½	2½	2½	2½
3	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½
3½	2	2	2	2	2	2	2½	2½	2½	2½	2½	3
4	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3
6	3	3	3	3	3	3	3	3	3	3	3	3
8	3	3	3	3	3	3	3	3	3½	3½	3½	3½
10	3	3	3	3	3	3	3	3	3½	3½	3½	3½
12	3	3	3	3	3	3	3	3	3½	3½	3½	3½
14	3	3	3	3	3	3	3½	3½	3½	4	4	4
16	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4
18	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4
20	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4
22	3	3	3	3½	3½	3½	3½	3½	3½	4	4	4
24	3	3½	3½	3½	3½	3½	3½	4	4	4½	4½	4½
26	3	3½	3½	3½	3½	3½	3½	4	4	4½	4½	4½
28	3	3½	3½	3½	3½	3½	3½	4	4	4½	4½	4½
30	3	3½	3½	3½	3½	4	4	4	4	4½	4½	4½
36	3½	3½	3½	3½	3½	4	4	4	4	4½	4½	4½
EQUIP FLAT	3½	4	4	4	4	4½	4½	4½	5	5	5	5½
OPERATING TEMPERATURE °F	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039

Service Designation PC-13

INSULATION THICKNESS REQUIREMENTS

FIRE PROTECTION INSULATION THICKNESSES
LOW TEMPERATURE SERVICE

PLANTS: ALL PLANTS
SPEC. NO'S: 32-L CELLULAR GLASS - EXPANDED SILICA

SERVICE: INDOORS - AIR CONDITIONED BUILDING (75F-60%R.H.)

OPERATING TEMPERATURE ° C

NOM PIPE SIZE	19 to 10	9 to 5	4 to 0	-1 to -5	-6 to 10	-11 to -15	-16 to -20	-21 to -25	-26 to -30	-31 to -35	-36 to -40	-41 to -45	-46 to -50	-51 to -55	-56 to -60	-61 to -65	-66 to -70	-71 to -75	-76 to -80	-81 to -85	-86 to -90	-91 to -95	-96 to -100	-101 to -105	-106 to -110	-111 to -115	-116 to -120	-121 to -125
½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½
¾	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	3½	3½	3½
1	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	3½	4½	4½	4½
1¼	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½	4½
1½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3	4	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½	5
2	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	4	4	4	4	4½	4½	4½	4½	4½	4½	5	5	5	5	5
2½	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4½	4½	4½	4½	4½	4½	5	5	5	5	5	5½
3	3	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4½	4½	4½	4½	5	5	5	5	5	5	5	5½	5½	5½	5½
3½	3	3	3	3	3	3½	3½	3½	3½	3½	4	4	4	4½	4½	4½	5	5	5	5	5	5	5½	5½	5½	5½	5½	6
4	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4½	4½	5	5	5	5	5	5½	5½	5½	6	6	6	6	6½
5	3	3	3	3	3	3½	3½	3½	4	4	4	4½	4½	5	5	5	5	5½	5½	6	6	6	6	6	6	6½	6½	6½
6	3	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5	5½	5½	6	6	6	6	6½	6½	6½	7	7	7	7	7
8	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5	5½	5½	6	6	6	6	6½	6½	7	7	7	7	7½	7½	7½
10	3	3	3	3½	3½	4	4	4½	4½	5	5	5	5½	5½	6	6	6	6½	6½	6½	7	7	7	7½	7½	8	8	8
12	3	3	3	3½	3½	4	4	4½	5	5	5	5½	5½	6	6	6	6½	6½	7	7	7	7	7½	7½	8	8	8	8
14	3	3	3	3½	4	4	4½	4½	5	5	5½	5½	6	6	6	6½	6½	7	7	7	7½	7½	8	8	8	8	8½	8½
16	3	3	3	3½	4	4	4½	5	5	5½	5½	6	6	6	6½	6½	7	7	7½	7½	8	8	8	8½	8½	9	9	9½
18	3	3	3	3½	4	4	4½	5	5	5½	5½	6	6	6	6½	6½	7	7	7½	7½	8	8	8½	9	9	9½	9½	10
20	3	3	3	3½	4	4	5	5	5½	5½	6	6	6	6½	6½	7	7	7½	7½	8	8	8½	9	9	9½	9½	10	10
22	3	3	3	3½	4	4	5	5	5½	5½	6	6	6	6½	6½	7	7	7½	7½	8	8	8½	9	9	9½	10	10	10½
24	3	3	3	3½	4	4	5	5	5½	5½	6	6	6	6½	6½	7	7	7½	7½	8	8	8½	9	9	9½	10	10	10½
26	3	3	3	3½	4	4	5	5	5½	5½	6	6	6	6½	6½	7	7	7½	7½	8	8	8½	9	9	9½	10	10	10½
28	3	3	3	3½	4	4	5	5	5½	5½	6	6	6	6½	6½	7	7	7½	7½	8	8	8½	9	9	9½	10	10	10½
30	3	3	3	3½	4	4	5	5	5½	5½	6	6	6	6½	6½	7	7	7½	7½	8	8	8½	9	9	9½	10	10	10½
36	3	3	3	3½	4	4	5	5	5½	5½	6	6	6	6½	6½	7	7	7½	7½	8	8	8½	9	9	9½	10	10	10½
EQUIP FLAT	3	3	3	3½	3½	4	4½	5	5	5½	5½	6	6	6½	6½	7	7	7½	7½	8	8	8½	9	9	9½	10	10	10½

	67 to 50	47 to 41	40 to 32	31 to 23	22 to 14	13 to 5	4 to -4	-5 to -13	-14 to -22	-23 to -31	-32 to -40	-41 to -49	-50 to -58	-59 to -67	-68 to -76	-77 to -85	-85 to -94	-93 to -103	-104 to -112	-113 to -121	-122 to -130	-131 to -139	-140 to -148	-149 to -157	-158 to -166	-167 to -175	-176 to -184	-185 to -193

OPERATING TEMPERATURE ° F

INSULATION THICKNESS REQUIREMENTS

Service Designation PC-14

FIRE PROTECTION INSULATION THICKNESSES
LOW TEMPERATURE SERVICE

PLANTS: MONTREAL 053, NIAGARA FALLS 516, OTTAWA
SPEC. NO'S: 32-L CELLULAR GLASS - EXPANDED SILICA

SERVICE: FIRE PROTECTION AND LOW TEMPERATURE SERVICE - OUTDOORS

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																												
	19 to 10	9 to 5	4 to 0	-1 to -5	-6 to -10	-11 to -15	-16 to -20	-21 to -25	-26 to -30	-31 to -35	-36 to -40	-41 to -45	-46 to -50	-51 to -55	-56 to -60	-61 to -65	-66 to -70	-71 to -75	-76 to -80	-81 to -85	-86 to -90	-91 to -95	-96 to -100	-101 to -105	-106 to -110	-111 to -115	-116 to -120	-121 to -125
½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	3½	3½	4½	4½	4½	4½
¾	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	3½	3½	3½	3½	4½	4½	4½	4½	4½	4½	4½
1	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3½	3½	4	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½
1¼	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	4	4	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½	4½
1½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	4	4	4	4	4½	4½	4½	4½	4½	4½	4½	4½	4½	4½	4½	4½
2	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	4	4	4	4	4½	4½	4½	4½	4½	4½	5	5	5	5	5	5	5
2½	3	3	3	3	3	3	3	3½	3½	3½	4	4	4	4	4½	4½	4½	4½	4½	5	5	5	5	5	5	5	5	5
3	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4½	4½	4½	4½	4½	5	5	5	5	5	5	5	5	5½	5½	5½
3½	3	3	3	3	3	3½	3½	3½	4	4	4	4½	4½	4½	4½	5	5	5	5	5	5	5½	5½	5½	5½	5½	5½	5½
4	3	3	3	3	3½	3½	3½	4	4	4	4	4½	4½	5	5	5	5	5	5	5	5½	5½	5½	5½	5½	5½	5½	5½
5	3	3	3	3	3½	3½	3½	4	4	4	4½	4½	5	5	5	5½	5½	5½	5½	5½	5½	6	6	6	6	6	6	6
6	3	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5	5	5½	5½	5½	6	6	6	6	6	6	6	6	6	6
8	3	3	3	3½	3½	3½	4	4	4	4½	4½	5	5	5	5	5½	5½	5½	6	6	6	6	6	6	6	6½	6½	6½
10	3	3	3	3½	3½	3½	4	4	4	4½	4½	5	5	5	5	5½	5½	5½	6	6	6	6	6	6	6½	6½	6½	6½
12	3	3	3	3½	3½	3½	4	4	4	4½	4½	5	5	5	5	5½	5½	5½	6	6	6	6	6	6½	6½	6½	6½	6½
14	3	3	3	3½	3½	3½	4	4	4	4½	4½	5	5	5	5	5½	5½	5½	6	6	6	6	6½	6½	6½	6½	6½	6½
16	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5	5	5	5½	5½	5½	6	6	6	6½	6½	6½	6½	6½	6½	6½
18	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5	5	5	5½	5½	5½	6	6	6	6½	6½	6½	6½	6½	6½	6½
20	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5	5	5	5½	5½	5½	6	6	6	6½	6½	6½	6½	6½	6½	7
22	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5	5	5	5½	5½	5½	6	6	6	6½	6½	6½	6½	6½	7	7
24	3	3	3½	3½	3½	4	4	4	4½	4½	5	5	5	5	5	5½	5½	6	6	6	6	6½	6½	6½	6½	7	7	7
26	3	3	3½	3½	3½	4	4	4	4½	4½	5	5	5	5	5½	5½	5½	6	6	6	6½	6½	6½	6½	7	7	7	7
28	3	3	3½	3½	4	4	4	4	4½	4½	5	5	5	5½	5½	5½	5½	6	6	6	6½	6½	6½	6½	7	7	7	7
30	3	3	3½	3½	4	4	4	4	4½	4½	5	5	5	5½	5½	5½	5½	6	6	6	6½	6½	6½	6½	7	7	7	7
36	3	3	3½	3½	4	4	4	4	4½	4½	5	5	5	5½	5½	5½	6	6	6	6	6½	6½	6½	7	7	7	7	7
EQUIP FLAT	3	3	3½	3½	3½	4	4	4	4½	4½	5	5½	5½	5½	6	6	6	6½	6½	6½	6½	7	7½	7½	7½	7½	8	
	67 to 50	49 to 41	40 to 32	31 to 23	22 to 14	13 to 5	4 to -4	-5 to -13	-14 to -22	-23 to -31	-32 to -40	-41 to -49	-50 to -58	-59 to -67	-68 to -76	-77 to -85	-86 to -94	-95 to -103	-104 to -112	-113 to -121	-122 to -130	-131 to -139	-140 to -148	-149 to -157	-158 to -166	-167 to -175	-176 to -184	-185 to -193
	OPERATING TEMPERATURE ° F																											

INSULATION THICKNESS REQUIREMENTS

Service Designation PC-15

FIRE PROTECTION INSULATION THICKNESSES
LOW TEMPERATURE SERVICE

PLANTS: SEADRIFT 510, INSTITUTE 512, TORRANCE 513, SO. CHAS. 514, TAFT 519, BROWNSVILLE 526, PONCE, SILICONE-SISTERSVILLE, PLASTICS-MARIETTA, BOUND BROOK, CARTERSVILLE
SPEC. NO'S: 32-L CELLULAR GLASS - EXPANDED SILICA

SERVICE: FIRE PROTECTION AND LOW TEMPERATURE SERVICE - OUTDOORS

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																															
	19 to 10	9 to 5	4 to 0	-1 to -5	-6 to -10	-11 to -15	-16 to -20	-21 to -25	-26 to -30	-31 to -35	-36 to -40	-41 to -45	-46 to -50	-51 to -55-	-56 to -60	-61 to -65	-66 to -70	-71 to -75	-76 to -80	-81 to -85	-86 to -90	-91 to -95	-96 to -100	-101 to -105	-106 to -110	-111 to -115	-116 to -120	-121 to -125
½	2½	2½	2½	2½	2½	3	3	3	3½	3½	3½	4½	4½	4½	4½	4½	4½	5	5	5	5	5	5	5	5	5	5	5½
¾	2½	2½	2½	2½	3	3	3	3	3½	3½	4	4½	4½	4½	5	5	5	5	5	5	5	5	5	5	5½	5½	5½	5½	5½
1	2½	2½	2½	2½	3	3	3	4	4	4	4	4½	4½	4½	5	5	5	5	5	5	5½	5½	5½	5½	5½	5½	5½	5½	6
1¼	2½	2½	2½	2½	3	3	3	4	4	4	4½	4½	4½	5	5	5	5	5	5	5	5½	5½	5½	5½	5½	6	6	6	6
1½	2½	2½	3	3	3	3	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½	5½	6	6	6	6	6	6	6	6	6	6
2	2½	3	3½	3½	3½	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½	5½	6	6	6	6	6	6	6½	6½	6½	6½	6½
2½	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½	6	6	6	6½	6½	6½	6½	6½	6½	6½	6½	7	7
3	3	3	3½	4	4	4	4½	5	5	5	5½	5	5	5½	5½	6	6	6	6	6½	7	7	7	7	7	7½	7½	7½	7½
3½	3	3	3½	4	4	4	4½	5	5	5	5½	5½	6	6	6½	6½	7	7	7	7	7½	7½	7½	7½	7½	8	8	8	8
4	3	3½	3½	4	4	4	4½	5	5	5	5½	6	6	6	6½	7	7	7	7	7½	7½	8	8	8	8	8	8	8	8
5	3	3½	4	4	4	4	4½	5	5	5½	6	6	6½	6½	7	7	7	7½	8	8	8	8½	8½	8½	8½	8½	8½	8½	8½
6	3½	3½	4	4	4	4½	5	5	5½	6	6	6½	6½	7	7	7	7½	8	8	8	8½	8½	8½	8½	8½	9	9	9	9
8	3½	4	4	4½	4½	5	5	5½	6	6	6½	6½	7	7	7	7½	7½	8	8	8	8½	8½	8½	8½	8½	9	9	9	9
10	4	4	4½	4½	5	5	5½	6	6½	7	7	7½	8	8	8½	8½	9	9	9½	9½	10	10	10½	10½	10½	10½	10½	10½	10½
EQUIP FLAT	3 to 67	4 to 49	4½ to 40	4½ to 31	5 to 22	5½ to 13	5½ to 4	6 to -5	6½ to -14	6½ to -23	7 to -32	7½ to -41	7½ to -50	8 to -59	8 to -68	8½ to -77	8½ to -86	9 to -95	9 to -104	9½ to -113	9½ to -122	10 to -131	10 to -140	10 to -149	10½ to -158	10½ to -167	10½ to -176	10½ to -185
								OPERATING TEMPERATURE ° F																				
								10 to 50	-15 to -45	-46 to -85	-86 to -125	-126 to -165	-166 to -205	-206 to -245	-246 to -285	-286 to -325	-326 to -365	-366 to -405	-406 to -445	-446 to -485	-486 to -525	-526 to -565	-566 to -605	-606 to -645	-646 to -685	-686 to -725	-726 to -765	-766 to -805

INSULATION THICKNESS REQUIREMENTS

Service Designation P-1(

SIZES OF INSULATION LAYERS TO OBTAIN SPECIFIED THICKNESS
SPECIFICATION 32L, LOW TEMPERATURE
FIRE PROTECTION

NOM PIPE SIZE	SPECIFIED THICKNESSES															
	2½		3		3½		4		4½		5					
	1st Layer Foamglas	2nd Layer Careytemp	1st Layer Foamglas	2nd Layer Careytemp	1st Layer Foamglas	2nd Layer Careytemp	1st Layer Foamglas	2nd Layer Careytemp	1st Layer Foamglas	2nd Layer Careytemp	1st Layer Foamglas	2nd Layer Foamglas	3rd Layer Careytemp			
1	1 × 1½	3½ × 1	1 × 2	4 × 1	1 × 2½	5 × 1			1 × 3	6 × 1½	1 × 1½	3½ × 2	8 × 1½			
1¼	3/4 × 1½	3½ × 1	3/4 × 2	4½ × 1	3/4 × 2½	5 × 1			3/4 × 3	6 × 1½	3/4 × 1½	3½ × 2	8 × 1½			
1	1 × 1½	4 × 1	1 × 2	5 × 1			1 × 2½	6 × 1½	1 × 3	7 × 1½	1 × 1½	4 × 2	8 × 1½			
1¼	1¼ × 1½	4 × 1	1¼ × 2	5 × 1			1¼ × 2½	6 × 1½	1¼ × 3	7 × 1½	1¼ × 1½	4 × 2	8 × 1½			
1½	1½ × 1½	4½ × 1	1½ × 2	5 × 1			1½ × 2½	6 × 1½	1½ × 3	7 × 1½	1½ × 1½	4½ × 2	9 × 1½			
2	2 × 1½	5 × 1			2 × 2	6 × 1½	2 × 2½	7 × 1½	2 × 3	8 × 1½	2 × 1½	5 × 2	9 × 1½			
2½			2½ × 1½	6 × 1½	2½ × 2	6 × 1½	2½ × 2½	7 × 1½	2½ × 3	8 × 1½	2½ × 1½	6 × 2	10 × 1½			
3			3 × 1½	6 × 1½	3 × 2	7 × 1½	3 × 2½	8 × 1½	3 × 3	9 × 1½	3 × 1½	6 × 2	10 × 1½			
3½	3½ × 1½	7 × 1½	3½ × 2	8 × 1½	3½ × 2½	9 × 1½	3½ × 3	10 × 1½	3½ × 1½	7 × 2	11 × 1½					
4	4 × 1½	7 × 1½	4 × 2	8 × 1½	4 × 2½	9 × 1½	4 × 3	10 × 1½	4 × 1½	7 × 2	11 × 1½					
6	6 × 1½	9 × 1½	6 × 2	10 × 1½	6 × 2½	11 × 1½	6 × 3	12 × 1½	6 × 1½	9 × 2	14 × 1½					
8	8 × 1½	11 × 1½	8 × 2	12 × 1½	8 × 2½	14 × 1½	8 × 3	15 × 1½	8 × 1½	11 × 2	16 × 1½					
10	10 × 1½	14 × 1½	10 × 2	15 × 1½	10 × 2½	16 × 1½	10 × 3	17 × 1½	10 × 1½	14 × 2	18 × 1½					
12	12 × 1½	16 × 1½	12 × 2	17 × 1½	12 × 2½	18 × 1½	12 × 3	19 × 1½	12 × 1½	16 × 2	20 × 1½					
14	14 × 1½	17 × 1½	14 × 2	18 × 1½	14 × 2½	19 × 1½	14 × 3	20 × 1½	14 × 1½	17 × 2	21 × 1½					
16	16 × 1½	19 × 1½	16 × 2	20 × 1½	16 × 2½	21 × 1½	16 × 3	22 × 1½	16 × 1½	19 × 2	23 × 1½					
18	18 × 1½	21 × 1½	18 × 2	22 × 1½	18 × 2½	23 × 1½	18 × 3	24 × 1½	18 × 1½	21 × 2	25 × 1½					
20	20 × 1½	23 × 1½	20 × 2	24 × 1½	20 × 2½	25 × 1½	20 × 3	26 × 1½	20 × 1½	23 × 2	27 × 1½					
22	22 × 1½	25 × 1½	22 × 2	26 × 1½	22 × 2½	27 × 1½	22 × 3	28 × 1½	22 × 1½	25 × 2	29 × 1½					
24	24 × 1½	27 × 1½	24 × 2	28 × 1½	24 × 2½	29 × 1½	24 × 3	30 × 1½	24 × 1½	27 × 2	31 × 1½					
26	26 × 1½	29 × 1½	26 × 2	30 × 1½	26 × 2½	31 × 1½	26 × 3	32 × 1½	26 × 1½	29 × 2	33 × 1½					
28	28 × 1½	31 × 1½	28 × 2	32 × 1½	28 × 2½	33 × 1½	28 × 3	34 × 1½	28 × 1½	31 × 2	35 × 1½					
30	30 × 1½	33 × 1½	30 × 2	34 × 1½	30 × 2½	35 × 1½	30 × 3	36 × 1½	30 × 1½	33 × 2	37 × 1½					
36	36 × 1½	39 × 1½	36 × 2	40 × 1½	36 × 2½	39 × 1½	36 × 3	42 × 1½	36 × 1½	39 × 2	43 × 1½					
EQUIP FLAT	1½	1½	2	1½	2½	1½	3	1½	1½	2	1½					

NOTE: The above tables are provided to show the multiple layers required for fire protection of low temperature insulated pipe.

EXAMPLE: When total thickness of 4" thickness on a 3" NPS was required, the inner layer cellular glass would be 3" NPS pipe size 2½" thick. The outer layer Carey temp would be 8" NPS pipe size 1½" thick.

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INSULATION THICKNESS REQUIREMENTS

Service Designation P-17

SIZES OF INSULATION LAYERS TO OBTAIN SPECIFIED THICKNESS
SPECIFICATION 32-L LOW TEMPERATURE
FIRE PROTECTION

NOM. PIPE SIZE	SPECIFIED THICKNESSES																	
	5½			6			6½			7			7½					
	1st Layer Foamglas	2nd Layer Foamglas	3rd Layer Careytemp	1st Layer Foamglas	2nd Layer Foamglas	3rd Layer Careytemp	1st Layer Foamglas	2nd Layer Foamglas	3rd Layer Careytemp	1st Layer Foamglas	2nd Layer Foamglas	3rd Layer Careytemp	1st Layer	2nd Layer	3rd Layer			
¼	½ x 2	4 x 2	8 x 1½	½ x 2	4 x 2½	9 x 1½	½ x 2½	5 x 2½	10 x 1½	½ x 2½	5 x 3	11 x 1½	½ x 3	6 x 3	12 x 1½			
½	3/4 x 2	4½ x 2	9 x 1½	3/4 x 2	4½ x 2½	10 x 1½	3/4 x 2½	5 x 2½	10 x 1½	3/4 x 2½	5 x 3	11 x 1½	3/4 x 3	6 x 3	12 x 1½			
1	1 x 2	5 x 2	9 x 1½	1 x 2	5 x 2½	10 x 1½	1 x 2½	6 x 2½	11 x 1½	1 x 2½	6 x 3	12 x 1½	1 x 3	7 x 3	14 x 1½			
1¼	1¼ x 2	5 x 2	9 x 1½	1¼ x 2	5 x 2½	10 x 1½	1¼ x 2½	6 x 2½	11 x 1½	1¼ x 2½	6 x 3	12 x 1½	1¼ x 3	7 x 3	14 x 1½			
1½	1½ x 2	5 x 2	9 x 1½	1½ x 2	5 x 2½	10 x 1½	1½ x 2½	6 x 2½	11 x 1½	1½ x 2½	6 x 3	12 x 1½	1½ x 3	7 x 3	14 x 1½			
2	2 x 2	6 x 2	10 x 1½	2 x 2	6 x 2½	11 x 1½	2 x 2½	7 x 2½	12 x 1½	2 x 2½	7 x 3	14 x 1½	2 x 3	8 x 3	15 x 1½			
2½	2½ x 2	6 x 2	10 x 1½	2½ x 2	6 x 2½	11 x 1½	2½ x 2½	7 x 2½	12 x 1½	2½ x 2½	7 x 3	14 x 1½	2½ x 3	8 x 3	15 x 1½			
3	3 x 2	7 x 2	11 x 1½	3 x 2	7 x 2½	12 x 1½	3 x 2½	8 x 2½	14 x 1½	3 x 2½	8 x 3	15 x 1½	3 x 3	9 x 3	16 x 1½			
3½	3½ x 2	8 x 2	12 x 1½	3½ x 2	8 x 2½	14 x 1½	3½ x 2½	9 x 2½	15 x 1½	3½ x 2½	9 x 3	16 x 1½	3½ x 3	10 x 3	17 x 1½			
4	4 x 2	8 x 2	12 x 1½	4 x 2	8 x 2½	14 x 1½	4 x 2½	9 x 2½	15 x 1½	4 x 2½	9 x 3	16 x 1½	4 x 3	10 x 3	17 x 1½			
6	6 x 2	10 x 2	15 x 1½	6 x 2	10 x 2½	16 x 1½	6 x 2½	11 x 2½	17 x 1½	6 x 2½	11 x 3	18 x 1½	6 x 3	12 x 3	19 x 1½			
8	8 x 2	12 x 2	17 x 1½	8 x 2	12 x 2½	18 x 1½	8 x 2½	14 x 2½	19 x 1½	8 x 2½	14 x 3	20 x 1½	8 x 3	15 x 3	21 x 1½			
10	10 x 2	15 x 2	19 x 1½	10 x 2	15 x 2½	20 x 1½	10 x 2½	16 x 2½	21 x 1½	10 x 2½	16 x 3	22 x 1½	10 x 3	17 x 3	23 x 1½			
12	12 x 2	17 x 2	21 x 1½	12 x 2	17 x 2½	22 x 1½	12 x 2½	18 x 2½	23 x 1½	12 x 2½	18 x 3	24 x 1½	12 x 3	19 x 3	25 x 1½			
14	14 x 2	18 x 2	22 x 1½	14 x 2	18 x 2½	23 x 1½	14 x 2½	19 x 2½	24 x 1½	14 x 2½	19 x 3	25 x 1½	14 x 3	20 x 3	26 x 1½			
16	16 x 2	20 x 2	24 x 1½	16 x 2	20 x 2½	25 x 1½	16 x 2½	21 x 2½	26 x 1½	16 x 2½	21 x 3	27 x 1½	16 x 3	22 x 3	28 x 1½			
18	18 x 2	22 x 2	26 x 1½	18 x 2	22 x 2½	27 x 1½	18 x 2½	23 x 2½	28 x 1½	18 x 2½	23 x 3	29 x 1½	18 x 3	24 x 3	30 x 1½			
20	20 x 2	24 x 2	28 x 1½	20 x 2	24 x 2½	29 x 1½	20 x 2½	25 x 2½	30 x 1½	20 x 2½	25 x 3	31 x 1½	20 x 3	26 x 3	32 x 1½			
22	22 x 2	26 x 2	30 x 1½	22 x 2	26 x 2½	31 x 1½	22 x 2½	27 x 2½	32 x 1½	22 x 2½	27 x 3	33 x 1½	22 x 3	28 x 3	34 x 1½			
24	24 x 2	28 x 2	32 x 1½	24 x 2	28 x 2½	33 x 1½	24 x 2½	29 x 2½	34 x 1½	24 x 2½	29 x 3	35 x 1½	24 x 3	30 x 3	36 x 1½			
26	26 x 2	30 x 2	34 x 1½	26 x 2	30 x 2½	35 x 1½	26 x 2½	31 x 2½	36 x 1½	26 x 2½	31 x 3	37 x 1½	26 x 3	32 x 3	38 x 1½			
28	28 x 2	32 x 2	36 x 1½	28 x 2	32 x 2½	37 x 1½	28 x 2½	33 x 2½	38 x 1½	28 x 2½	33 x 3	39 x 1½	28 x 3	34 x 3	40 x 1½			
30	30 x 2	34 x 2	38 x 1½	30 x 2	34 x 2½	41 x 1½	30 x 2½	35 x 2½	40 x 1½	30 x 2½	35 x 3	41 x 1½	30 x 3	36 x 3	42 x 1½			
36	36 x 2	40 x 2	44 x 1½	36 x 2	40 x 2½	45 x 1½	36 x 2½	41 x 2½	46 x 1½	36 x 2½	41 x 3	47 x 1½	36 x 3	42 x 3	48 x 1½			
EQUIP FLAT	2	2	1½	2	2½	1½	2½	2½	1½	2½	3	1½	3	3	1½			

INSULATION THICKNESS REQUIREMENTS

Service Designation P-18

SIZES OF INSULATION LAYERS TO OBTAIN SPECIFIED THICKNESS
SPECIFICATION 32-L, LOW TEMPERATURE
FIRE PROTECTION

NOM PIPE SIZE	SPECIFIED THICKNESSES											
	8			8½			9			9½		
	1st Layer Foamglas	2nd Layer Foamglas	3rd Layer Careytemp	1st Layer Foamglas	2nd Layer Foamglas	3rd Layer Careytemp	1st Layer Foamglas	2nd Layer Foamglas	3rd Layer Careytemp	1st Layer Foamglas	2nd Layer Foamglas	3rd Layer Careytemp
¼	1½ x 3	6 x 3½	14 x 1½	¼ x 3½	7 x 3½	15 x 1½	¼ x 3½	7 x 4	16 x 1½	¼ x 4	9 x 4	18 x 1½
¾	¾ x 3	6 x 3½	14 x 1½	¾ x 3½	8 x 3½	16 x 1½	¾ x 3½	8 x 4	17 x 1½	¾ x 4	9 x 4	18 x 1½
1	1 x 3	7 x 3½	15 x 1½	1 x 3½	8 x 3½	16 x 1½	1 x 3½	8 x 4	17 x 1½	1 x 4	9 x 4	18 x 1½
1¼	1¼ x 3	7 x 3½	15 x 1½	1¼ x 3½	8 x 3½	16 x 1½	1¼ x 3½	8 x 4	17 x 1½	1¼ x 4	9 x 4	18 x 1½
1½	1½ x 3	7 x 3½	15 x 1½	1½ x 3½	8 x 3½	16 x 1½	1½ x 3½	8 x 4	17 x 1½	1½ x 4	9 x 4	18 x 1½
2	2 x 3	8 x 3½	16 x 1½	2 x 3½	9 x 3½	17 x 1½	2 x 3½	9 x 4	18 x 1½	2 x 4	10 x 4	19 x 1½
2½	2½ x 3	8 x 3½	16 x 1½	2½ x 3½	9 x 3½	17 x 1½	2½ x 3½	9 x 4	18 x 1½	2½ x 4	10 x 4	19 x 1½
3	3 x 3	9 x 3½	17 x 1½	3 x 3½	10 x 3½	18 x 1½	3 x 3½	10 x 4	19 x 1½	3 x 4	11 x 4	20 x 1½
3½	3½ x 3	10 x 3½	18 x 1½	3½ x 3½	11 x 3½	19 x 1½	3½ x 3½	11 x 4	20 x 1½	3½ x 4	12 x 4	21 x 1½
4	4 x 3	10 x 3½	18 x 1½	4 x 3½	11 x 3½	19 x 1½	4 x 3½	11 x 4	20 x 1½	4 x 4	12 x 4	21 x 1½
6	6 x 3	12 x 3½	20 x 1½	6 x 3½	14 x 3½	21 x 1½	6 x 3½	14 x 4	22 x 1½	6 x 4	15 x 4	23 x 1½
8	8 x 3	15 x 3½	22 x 1½	8 x 3½	16 x 3½	23 x 1½	8 x 3½	16 x 4	24 x 1½	8 x 4	17 x 4	25 x 1½
10	10 x 3	17 x 3½	24 x 1½	10 x 3½	18 x 3½	25 x 1½	10 x 3½	18 x 4	26 x 1½	10 x 4	19 x 4	27 x 1½
12	12 x 3	19 x 3½	26 x 1½	12 x 3½	20 x 3½	27 x 1½	12 x 3½	20 x 4	28 x 1½	12 x 4	21 x 4	29 x 1½
14	14 x 3	20 x 3½	27 x 1½	14 x 3½	21 x 3½	28 x 1½	14 x 3½	21 x 4	29 x 1½	14 x 4	22 x 4	30 x 1½
16	16 x 3	22 x 3½	29 x 1½	16 x 3½	23 x 3½	30 x 1½	16 x 3½	23 x 4	31 x 1½	16 x 4	24 x 4	32 x 1½
18	18 x 3	24 x 3½	31 x 1½	18 x 3½	25 x 3½	32 x 1½	18 x 3½	25 x 4	33 x 1½	16 x 4	26 x 4	34 x 1½
20	20 x 3	26 x 3½	33 x 1½	20 x 3½	27 x 3½	34 x 1½	20 x 3½	27 x 4	35 x 1½	20 x 4	28 x 4	36 x 1½
22	22 x 3	28 x 3½	35 x 1½	22 x 3½	29 x 3½	36 x 1½	22 x 3½	29 x 4	37 x 1½	22 x 4	30 x 4	38 x 1½
24	24 x 3	30 x 3½	37 x 1½	24 x 3½	31 x 3½	38 x 1½	24 x 3½	31 x 4	39 x 1½	24 x 4	32 x 4	40 x 1½
26	26 x 3	32 x 3½	39 x 1½	26 x 3½	33 x 3½	40 x 1½	26 x 3½	33 x 4	41 x 1½	26 x 4	34 x 4	42 x 1½
28	28 x 3	34 x 3½	41 x 1½	28 x 3½	35 x 3½	42 x 1½	28 x 3½	35 x 4	43 x 1½	28 x 4	36 x 4	44 x 1½
30	30 x 3	36 x 3½	43 x 1½	30 x 3½	37 x 3½	44 x 1½	30 x 3½	37 x 4	45 x 1½	30 x 4	38 x 4	46 x 1½
36	36 x 3	42 x 3½	49 x 1½	36 x 3½	43 x 3½	50 x 1½	36 x 3½	43 x 4	51 x 1½	36 x 4	44 x 4	52 x 1½
EQUIP FLAT	3	3½	1½	3½	3½	1½	3½	4	1½	4	4	1½

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INSULATION THICKNESS REQUIREMENTS — Service Designation R-1

REFLECTIVE INSULATION THICKNESSES
½ INCH SPACING

PLANTS: SEADRIFT-510, INSTITUTE-512, TORRANCE-513, S. CHARLESTON-514, TAFT-519, BROWNSVILLE-526, BOUND BROOK, MARIETTA, CARTERSVILLE, PONCE
SPEC. NO'S: 31-H
SERVICE PROCESS: NON-ABSORBANT INSULATION REQUIRED

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																														
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599
½	—	—	—	—	—	—	—	—	—	—	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2½
¾	—	—	—	—	—	—	—	—	—	—	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2½
1	—	—	—	—	—	—	—	—	—	—	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2½
1¼	—	—	—	—	—	—	—	—	—	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2½	2½
1½	—	—	—	—	—	—	—	—	—	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2½	2½	2½
2	—	—	—	—	—	—	—	—	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½
2½	—	—	—	—	—	—	—	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½
3	—	—	—	—	—	—	—	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2½	2½	3	3	3	3
3½	—	—	—	—	—	—	—	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2½	2½	3	3	3½	3½	4
4	—	—	—	—	—	—	—	1	1	1	1	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3½	3½	4	4	4
6	—	—	—	—	—	—	—	1	1	1	2	2	2	2	2	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4
8	—	—	—	—	—	—	—	1	1	2	2	2	2	2	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4	4½
10	—	—	—	—	—	—	—	1	2	2	2	2	2	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4	4½	4½
12	—	—	—	—	—	—	—	2	2	2	2	2	2½	2½	2½	3	3	3	3	3½	3½	3½	4	4	4	4½	4½	4½
14	—	—	—	—	—	—	—	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	4	4	4	4½	4½	4½
16	—	—	—	—	—	—	—	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	4	4	4	4½	4½	4½
18	—	—	—	—	—	—	—	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4	4½	4½	4½
20	—	—	—	—	—	—	—	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3½	4	4	4	4	4½	4½	4½	5
22	—	—	—	—	—	—	—	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3½	4	4	4	4½	4½	4½	5	5
24	—	—	—	—	—	—	—	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3½	4	4	4	4½	4½	4½	5	5
26	—	—	—	—	—	—	—	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3½	4	4	4	4½	4½	5	5	5
28	—	—	—	—	—	—	—	2	2	2	2	2½	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5
30	—	—	—	—	—	—	—	2	2	2	2	2½	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5
36	—	—	—	—	—	—	—	2	2	2	2	2½	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5
EQUIP FLAT	1 to 140	1 to 176	1½ to 212	1½ to 248	1½ to 284	1½ to 320	1½ to 356	2 to 392	2 to 428	2 to 464	2½ to 500	2½ to 536	2½ to 572	3 to 608	3 to 644	3 to 680	3½ to 716	3½ to 752	3½ to 788	4 to 824	4 to 860	4 to 896	4½ to 932	4½ to 968	4½ to 1004	5 to 1040	5 to 1076	
	OPERATING TEMPERATURE ° F																											
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	732 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039	1040 to 1075	1076 to 1111	

INSULATION THICKNESS REQUIREMENTS

Service Designation R-2

REFLECTIVE INSULATION THICKNESSES
3/8 INCH SPACING

PLANTS: WHITING-517, MONTREAL-053, OTTAWA
SPEC., NO'S: 31-H

SERVICE PROCESS: NON-ABSORBANT INSULATION REQUIRED

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																																							
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599
½	—	—	—	—	—	—	—	—	—	—	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2½	2½
¾	—	—	—	—	—	—	—	—	—	—	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2½	2½
1	—	—	—	—	—	—	—	—	—	—	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2½	2½	2½
1¼	—	—	—	—	—	—	—	—	—	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2½	2½	2½
1½	—	—	—	—	—	—	—	—	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2½	2½	3	3
2	—	—	—	—	—	—	—	—	1½	1½	1½	1½	2	2	2	2	2	2	2	2½	2½	3	3	3	3	3	3
2½	—	—	—	—	—	—	—	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3½	3½	3½	3½
3	—	—	—	—	—	—	—	1½	1½	1½	2	2	2	2	2	2	2½	2½	3	3	3	3	3½	4	4	4	4
3½	—	—	—	—	—	—	—	1½	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3½	3½	4	4	4	4	4
4	—	—	—	—	—	—	1½	1½	1½	2	2	2	2	2	2	2½	2½	3	3	3	3½	4	4	4	4	4	4
6	—	—	—	—	—	1½	1½	1½	2	2	2	2	2	2	2½	2½	3	3	3	3½	4	4	4	4	4	4	4½
8	—	—	—	1½	1½	1½	1½	2	2	2	2	2	2	2½	2½	3	3	3	3½	4	4	4	4	4	4	4½	4½
10	—	—	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4	4½	4½
12	—	—	1½	1½	1½	1½	1½	2	2	2	2	2	2	2½	2½	3	3	3	3	3½	3½	4	4	4	4	4½	4½
14	—	—	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4	4½	4½
16	—	—	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4	4½	4½
18	—	—	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4	4½	4½
20	—	—	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4	4½	4½
22	—	—	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4	4½	4½
24	—	—	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4	4½	4½
26	—	—	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4	4½	5
28	—	—	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	3	3	3	3½	3½	3½	4	4	4	4	4½	5
30	—	—	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	3	3	3	3½	3½	3½	4	4	4	4	4½	5
36	—	—	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3	3	3	3½	3½	3½	4	4	4	4	4½	5
EQUIP FLAT	1 to 140	1 to 176	1½ to 212	1½ to 248	1½ to 284	1½ to 320	1½ to 356	2 to 392	2 to 428	2 to 464	2½ to 500	2½ to 536	2½ to 572	3 to 608	3 to 644	3 to 680	3½ to 716	3½ to 752	3½ to 788	4 to 824	4 to 860	4 to 896	4½ to 932	4½ to 968	4½ to 1004	5 to 1040	5 to 1076
	175 to 211	211 to 247	247 to 283	283 to 319	319 to 355	355 to 391	391 to 417	417 to 463	463 to 499	499 to 535	535 to 571	571 to 607	607 to 643	643 to 679	679 to 715	715 to 751	751 to 787	787 to 823	823 to 859	859 to 895	895 to 931	931 to 967	967 to 1003	1003 to 1039	1039 to 1075	1075 to 1111	
	OPERATING TEMPERATURE ° F																										

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INSULATION THICKNESS REQUIREMENTS

Service Designation S-1

SAFETY INSULATION THICKNESSES

PLANTS: ALL PLANTS
SPEC. NO'S: 21-H, 22-H, 23-H, 25-H

OUTER COVERING: MASTIC OR JACKET WITH EMISSIVITY 0.9

NOM PIPE SIZE	OPERATING TEMPERATURE °C																										
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599
½	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
¾	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2
1¼	1	1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2
1½	1	1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2
2½	1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2½	2½
3	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	2½
3½	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	2½
4	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	2½	2½
6	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	2½	3	3
8	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	2½	3	3
10	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	3	3	3
12	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	3	3	3
14	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	3	3	3	3½
16	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3½
18	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3	3	3	3½	3½
20	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3	3	3	3½	3½
22	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3	3	3	3½	3½
24	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3	3	3½	3½
26	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3	3	3½	3½
28	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3	3	3½	3½
30	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3	3	3½	3½
36	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3	3½	3½	3½
EQUIP FLAT	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3	3	3	3½	3½	4
OPERATING TEMPERATURE °F	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039	1040 to 1075	1076 to 1111

Service Designation S-2

INSULATION THICKNESS REQUIREMENTS

SAFETY INSULATION THICKNESSES

PLANTS: ALL PLANTS
SPEC. NO'S: 21-H, 22-H, 23-H, 25-H OUTER COVERING: MASTIC OR JACKET WITH EMISSIVITY 0.90

NOM PIPE SIZE	OPERATING TEMPERATURE ° C														
	600 to 619	620 to 639	640 to 659	660 to 679	680 to 699	700 to 719	720 to 739	740 to 759	760 to 779	780 to 799	800 to 819	820 to 839	840 to 859	860 to 879
½	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½
¾	2	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3
1	2	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3	3
1¼	2½	2½	2½	2½	2½	3	3	3	3	3	3	3	3	3
1½	2½	2½	2½	2½	3	3	3	3	3	3	3	3	3	3½
2	2½	2½	2½	3	3	3	3	3	3	3	3½	3½	3½	3½
2½	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	3½	4
3	2½	3	3	3	3	3	3	3½	3½	3½	3½	4	4	4
3½	2½	3	3	3	3	3	3	3½	3½	3½	3½	4	4	4
4	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4
6	3	3	3½	3½	3½	3½	3½	4	4	4	4	4	4½	4½
8	3	3	3½	3½	3½	4	4	4	4	4½	4½	4½	4½	4½
10	3	3½	3½	3½	3½	4	4	4	4	4½	4½	4½	5	5
12	3½	3½	3½	3½	4	4	4	4	4½	4½	4½	5	5	5
14	3½	3½	3½	4	4	4	4	4½	4½	4½	5	5	5	5½
16	3½	3½	4	4	4	4	4½	4½	4½	5	5	5	5½	5½
18	3½	3½	4	4	4	4½	4½	4½	4½	5	5	5	5½	5½
20	3½	3½	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½
22	3½	3½	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½
24	3½	4	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½
26	3½	4	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½
28	3½	4	4	4	4½	4½	4½	5	5	5	5	5½	5½	5½
30	3½	4	4	4	4½	4½	4½	5	5	5	5½	5½	5½	6
36	3½	4	4	4½	4½	4½	4½	5	5	5	5½	5½	6	6
EQUIP FLAT	4	4	4½	4½	5	5	5	5½	5½	6	6	6½	6½	6½
	1112 to 1147	1148 to 1183	1184 to 1219	1220 to 1255	1256 to 1291	1292 to 1327	1328 to 1363	1364 to 1399	1400 to 1435	1436 to 1471	1472 to 1507	1508 to 1543	1544 to 1579	1580 to 1616
	OPERATING TEMPERATURE ° F													

INSULATION THICKNESS REQUIREMENTS

Service Designation S-3

SAFETY INSULATION THICKNESSES

PLANTS: ALL PLANTS
SPEC. NO's: 21-H, 22-H, 23-H, 25-H

OUTER COVERING: STAINLESS STEEL JACKET EMISSIVITY 0.40

OPERATING TEMPERATURE ° C

NOM PIPE SIZE	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599
½	–	–	–	–	–	–	–	–	–	–	–	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2½	2½	2½	2½
¾	–	–	–	–	–	–	–	–	–	–	–	1½	1½	1½	1½	2	2	2	2	2	2	2	2½	2½	2½	2½	2½
1	–	–	–	–	–	–	–	–	–	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	2½	2½	3
1¼	–	–	–	–	–	–	–	–	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	3	3
1½	–	–	–	–	–	–	–	–	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3
2	–	–	–	–	–	–	–	–	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	2½	3	3	3	3	3	3½	3½
2½	–	–	–	–	–	–	–	–	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½
3	–	–	–	–	–	–	–	–	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	3½	3½	4	4	4
3½	–	–	–	–	–	–	–	–	1½	1½	1½	2	2	2	2½	2½	3	3	3	3½	3½	3½	3½	4	4	4	4
4	–	–	–	–	–	–	–	–	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4	4	4½
6	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	3	3	3	3½	3½	4	4	4	4	4½	4½	4½	5
8	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	4½	5	5
10	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5
12	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5
14	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5
16	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5
18	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5
20	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5
22	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5
24	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5
26	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5
28	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5
30	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5
36	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	5	5½	6
EQUIP FLAT	1½ to 140	1½ to 176	1½ to 212	1½ to 248	1½ to 284	1½ to 320	1½ to 356	1½ to 392	1½ to 428	2 to 464	2 to 500	2 to 536	2½ to 572	2½ to 608	3 to 644	3 to 680	3½ to 716	3½ to 752	3½ to 788	4 to 824	4 to 860	4½ to 896	4½ to 932	5 to 968	5 to 1004	5½ to 1040	6 to 1076
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039	1040 to 1075	1076 to 1111

OPERATING TEMPERATURE ° F

INSULATION THICKNESS REQUIREMENTS

Service Designation S-4

SAFETY INSULATION THICKNESSES

PLANTS: ALL PLANTS
SPEC. NO's: 22-H, 25-H

OUTER COVERING: STAINLESS STEEL JACKET EMISSIVITY 0.40

NOM PIPE SIZE	OPERATING TEMPERATURE ° C														
	600 to 619	620 to 639	640 to 659	660 to 679	680 to 699	700 to 719	720 to 739	740 to 759	760 to 779	780 to 799	800 to 819	820 to 839	840 to 859	860 to 879	
½	2½	2½	2½	2½	3	3	3	3	3	3½	3½	3½	3½	4	
¾	2½	3	3	3	3	3	3½	3½	3½	3½	3½	4	4	4	
1	3	3	3	3½	3½	3½	3½	3½	4	4	4	4	4½	4½	
1¼	3	3	3	3½	3½	3½	3½	4	4	4	4½	4½	4½	4½	
1½	3	3	3	3½	3½	3½	4	4	4	4	4½	4½	4½	4½	
2	3½	3½	3½	4	4	4	4	4	4½	4½	4½	4½	5	5	
2½	3½	3½	3½	4	4	4	4	4	4½	4½	4½	4½	5	5	
3	3½	4	4	4	4	4	4½	4½	4½	4½	5	5	5	5½	
3½	3½	4	4	4	4	4	4½	4½	4½	5	5	5½	5½	5½	
4	4	4	4	4½	4½	4½	4½	5	5	5	5	5½	5½	5½	
6	4	4½	4½	5	5	5	5	5½	5½	5½	6	6	6	6	
8	4½	4½	4½	5	5	5½	5½	5½	6	6	6	6½	6½	6½	
10	4½	5	5	5	5½	5½	6	6	6	6	6½	6½	7	7	
12	4½	5	5	5	5½	5½	6	6	6	6½	6½	7	7	7	
14	5	5	5½	5½	5½	6	6	6	6½	6½	7	7	7½	7½	
16	5	5	5½	5½	5½	6	6	6½	6½	6½	7	7	7½	7½	
18	5	5½	5½	5½	6	6	6	6½	6½	7	7	7½	7½	8	
20	5	5½	5½	6	6	6	6½	6½	6½	7	7	7½	8	8	
22	5	5½	5½	6	6	6	6½	6½	6½	7	7	7½	8	8	
24	5	5½	5½	6	6	6½	6½	6½	7	7	7½	8	8	8	
26	5	5½	5½	6	6	6½	6½	6½	7	7	7	7½	8	8	
28	5	5½	5½	6	6	6½	6½	6½	7	7	7	7½	8	8	
30	5½	5½	6	6	6	6½	6½	7	7	7	7½	8	8	8½	
36	5½	5½	6	6	6½	6½	7	7	7½	7½	8	8	8½	8½	
EQUIP FLAT	6	6½	6½	7	7	7½	8	8	8½	9	9	9½	10	10½	
	1112 to 1147	1148 to 1183	1184 to 1219	1220 to 1255	1256 to 1291	1292 to 1327	1328 to 1363	1364 to 1399	1400 to 1435	1436 to 1471	1472 to 1507	1508 to 1543	1544 to 1579	1580 to 1616	
	OPERATING TEMPERATURE ° F														

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INSULATION THICKNESS REQUIREMENTS

Service Designation S-5

SAFETY INSULATION THICKNESSES

PLANTS: ALL PLANTS
SPEC. NO'S: 21-H, 22-H, 23-H, 25-H

OUTER COVERING: ALUMINUM JACKET EMISSIVITY 0.05

NOM PIPE SIZE	OPERATING TEMPERATURE °C																										
	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559	560 to 579	580 to 599
½	1	1	1	1	1	1	1	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	3	3	3	3½	3½
¾	1	1	1	1	1	1	1	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	2½	3	3	3	3	3½	3½	3½
1	1	1	1	1	1	1	1	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	3½	4
1¼	1	1	1	1	1	1	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	3	3½	3½	3½	4	4	4
1½	1	1	1	1	1	1	1½	1½	1½	2	2	2	2	2	2½	2½	2½	3	3	3	3½	3½	3½	3½	4	4	4
2	1	1	1	1	1	1	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	3½	3½	4	4	4	4½	4½
2½	1	1	1	1	1	1	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	3½	3½	4	4	4	4½	4½
3	1	1	1	1	1	1	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	3½	4	4	4	4½	4½	4½	5
3½	1	1	1	1	1	1	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	3½	4	4	4	4½	4½	4½	5½
4	1	1	1	1	1	1	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	4½	5	5	5½
6	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	4	4	4	4½	4½	5	5	5½	5½	5½
8	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3½	3½	3½	4	4	4½	4½	5	5	5	5½	6	6
10	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	3	3	3	3½	3½	4	4	4½	4½	5	5	5½	5½	6	6	6½
12	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	3	3	3½	3½	4	4	4½	4½	5	5	5	5½	5½	6	6½	6½
14	1½	1½	1½	1½	1½	1½	2	2	2½	2½	3	3	3	3½	3½	4	4	4½	4½	5	5	5½	5½	6	6	6½	7
16	1½	1½	1½	1½	1½	1½	2	2	2½	2½	3	3	3½	3½	3½	4	4	4½	5	5	5½	5½	6	6	6½	6½	7
18	1½	1½	1½	1½	1½	1½	2	2	2½	2½	3	3	3½	3½	4	4	4½	4½	5	5	5½	5½	6	6	6½	7	7
20	1½	1½	1½	1½	1½	1½	2	2	2½	2½	3	3	3½	3½	4	4	4½	4½	5	5	5½	5½	6	6½	6½	7	7
22	1½	1½	1½	1½	1½	1½	2	2	2½	2½	3	3	3½	3½	4	4	4½	4½	5	5	5½	5½	6	6½	6½	7	7
24	1½	1½	1½	1½	1½	1½	2	2	2½	2½	3	3	3½	3½	4	4	4½	4½	5	5½	5½	6	6	6½	6½	7	7½
26	1½	1½	1½	1½	1½	1½	2	2	2½	2½	3	3	3½	3½	4	4	4½	4½	5	5½	5½	6	6	6½	6½	7	7½
28	1½	1½	1½	1½	1½	1½	2	2	2½	2½	3	3	3½	3½	4	4	4½	4½	5	5½	5½	6	6	6½	6½	7	7½
30	1½	1½	1½	1½	1½	1½	2	2	2½	2½	3	3½	3½	3½	4	4½	4½	5	5	5½	6	6	6½	6½	7	7	7½
36	1½	1½	1½	1½	1½	1½	2	2	2½	2½	3	3½	3½	3½	4	4½	4½	5	5	5½	6	6	6½	7	7	7½	8
EQUIP FLAT	1½	1½	1½	1½	1½	1½	2	2	2½	3	3	3½	3½	4	4½	4½	5	5½	6	6	6½	7	7½	7½	8	8½	9
	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039	1040 to 1075	1076 to 1111
	OPERATING TEMPERATURE °F																										

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INSULATION THICKNESS REQUIREMENTS

Service Designation S-6

SAFETY INSULATION THICKNESSES

PLANTS: ALL PLANTS
SPEC. NO'S: 22-H, 25-H

OUTER COVERING: ALUMINUM JACKET EMISSIVITY 0.05

NOM PIPE SIZE	OPERATING TEMPERATURE ° C													
	600 to 619	620 to 639	640 to 659	660 to 679	680 to 699	700 to 719	720 to 739	740 to 759	760 to 779	780 to 799	800 to 819	820 to 839	840 to 859	860 to 879
¼	3½	3½	4	4	4	4	4½	4½	4½	4½	5	5	5	5½
½	4	4	4	4½	4½	4½	4½	5	5	5	5½	5½	5½	6
1	4	4½	4½	4½	4½	5	5	5	5½	5½	5½	6	6	6
1¼	4½	4½	4½	5	5	5	5½	5½	6	6	6	6	6½	6½
1½	4½	4½	5	5	5	5	5½	5½	6	6	6½	6½	6½	7
2	4½	5	5	5½	5½	5½	5½	6	6	6	6½	6½	7	7
2½	4½	5	5	5½	5½	5½	6	6	6½	6½	7	7	7½	7½
3	5	5½	5½	6	6	6	6	6½	6½	7	7	7½	7½	7½
3½	5½	5½	6	6	6½	6½	6½	7	7	7½	7½	8	8	8
4	5½	5½	6	6	6½	6½	7	7	7½	7½	8	8	8	8
6	6	6	6½	6½	7	7	7½	7½	8	8	8½	8½	8½	8½
8	6	6½	6½	7	7	7½	7½	8	8	8½	8½	9	9	9
10	6½	6½	7	7½	7½	8	8	8½	8½	9	9	9½	9½	9½
12	7	7	7½	8	8	8	8½	8½	9	9	9½	10	10	10
14	7	7½	7½	8	8	8½	8½	9	9	9½	10	10	-	-
16	7	7½	8	8	8½	8½	9	9	9½	9½	10	-	-	-
18	7½	7½	8	8	8½	9	9	9½	9½	10	-	-	-	-
20	7½	8	8	8½	8½	9	9	9½	10	10	-	-	-	-
22	7½	8	8	8½	8½	9	9	9½	10	-	-	-	-	-
24	7½	8	8	8½	9	9½	9½	10	10	-	-	-	-	-
26	7½	8	8	8½	9	9½	9½	10	-	-	-	-	-	-
28	7½	8	8	8½	9	9½	9½	10	-	-	-	-	-	-
30	8	8	8½	9	9½	10	10	10	-	-	-	-	-	-
36	8	8½	8½	9	9½	10	10	-	-	-	-	-	-	-
EQUIP FLAT	9½	10	-	-	-	-	-	-	-	-	-	-	-	-

OPERATING TEMPERATURE ° F														
1112 to 1147	1148 to 1183	1184 to 1219	1220 to 1255	1256 to 1291	1292 to 1327	1328 to 1363	1364 to 1399	1400 to 1435	1436 to 1471	1472 to 1507	1508 to 1543	1544 to 1579	1580 to 1616
9½	10	-	-	-	-	-	-	-	-	-	-	-	-
9½	10	10½	11	11½	12	12½	13	13½	14	14½	15	15½	16
10	10½	11	11½	12	12½	13	13½	14	14½	15	15½	16	16½
10½	11	11½	12	12½	13	13½	14	14½	15	15½	16	16½	17
11	11½	12	12½	13	13½	14	14½	15	15½	16	16½	17	17½
11½	12	12½	13	13½	14	14½	15	15½	16	16½	17	17½	18
12	12½	13	13½	14	14½	15	15½	16	16½	17	17½	18	18½
12½	13	13½	14	14½	15	15½	16	16½	17	17½	18	18½	19
13	13½	14	14½	15	15½	16	16½	17	17½	18	18½	19	19½
13½	14	14½	15	15½	16	16½	17	17½	18	18½	19	19½	20
14	14½	15	15½	16	16½	17	17½	18	18½	19	19½	20	20½
14½	15	15½	16	16½	17	17½	18	18½	19	19½	20	20½	21
15	15½	16	16½	17	17½	18	18½	19	19½	20	20½	21	21½
15½	16	16½	17	17½	18	18½	19	19½	20	20½	21	21½	22
16	16½	17	17½	18	18½	19	19½	20	20½	21	21½	22	22½

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-1

SPACED STEAM TRACER SYSTEM AND DEFINITION OF SYMBOLS - Continued

DEFINITIONS OF SYMBOLS

T_1 = Minimum temperature (°F) that the tracer will maintain in the process line, based on an ambient temperature of -20F. The calculations are based on static conditions, i.e., no fluid flow, and are independent of the viscosity, density, and thermal conductivity of the process fluid.

T_2 = Same as T_1 except based on an ambient temperature of 30F.

T_3 = Same as T_1 except based on an ambient temperature of 50F.

Approximate process line temperatures for other ambient temperatures may be determined by interpolation or extrapolation based on temperatures T_1 and T_3. If the upper temperature limit of the process line is critical, the effect of solar radiation should be investigated, since it was not considered in calculating the temperatures given in the table.

L_1 = Maximum length (feet) of straight run of tracer, based on an ambient temperature of -20F. It is applicable at all plant locations except 513 and 526.

L_2 = Same as L_1, except based on an ambient temperature of 30F. It is applicable at Plant Locations 513 and 526.

L_1 and L_2 represent total lengths of tracers, including all branches, and apply to straight runs only. In utilizing them in actual tracer layouts, the following limitations and requirements shall be considered:

1. Lengths shall be reduced as necessary to compensate for friction losses caused by bends, tees, valves, and other constrictions.

2. In general, all low points and pockets in tracers shall be trapped. However, under certain conditions, installation of traps at these points may be impracticable. If so, the length of the tracer shall be reduced sufficiently to offset pressure drop caused by the condensate head.

3. Steam tracer feed lines shall be sized properly so that pressure drop will not require a reduction in the tracer length.

4. Traps shall be installed at the ends of all tracers, including ends of all branches, and at all other condensate removal points.

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-1

SPACED STEAM TRACER SYSTEM AND DEFINITION OF SYMBOLS

NOTE:

The tabulated data on this Standard applies to steam tracing systems in which the tracer is separated from the process line by spacers, using air as the heat-conductive medium, as detailed and specified on Standard P-140. Insulation sizes and assembly dimensions are given on Standard P-140A.

This Standard provides steam tracing data based on static conditions only. Information compiled is based on heat loss from the insulation and does not provide for addition of any heat to the material in the process line.

Data in these tables can be used for selection of tracers and insulation thickness under two general conditions, as follows:

1. Where temperature to be maintained in the process line determines selection of insulation thickness, tracer size and steam pressure.

   When temperature to be maintained completely determines selection, the most economical selection of insulation thickness and tracer size is above the heavy line. Where temperature requirements permit, combinations above the heavy line should be used. Where temperature requirements dictate combinations below the heavy line, and a choice is possible, it is more economical to use the larger size tracer than to increase the insulation thickness.

2. Where operating temperature determines insulation thickness, and temperature to be maintained during down time determines selection of tracer size and steam pressure.

   When operating temperature dictates the insulation thickness, this thickness may be greater than necessary for most economical selection of insulation thickness and tracer size. However, under these conditions the applicable tracer data can be obtained from the table, based on the predetermined insulation thickness and temperature to be maintained during down time.

Under either condition, the final selection of tracer size, i.e., 3/8 inch or 5/8 inch, may be influenced by physical requirements as to length of tracer that can be run between traps.

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-2

STEAM TRACING DATA
SPACED TRACER SYSTEM

15 psig (250 F) STEAM

PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)

INSULATION THICKNESS	TRACER SIZE (OD)	SEE NOTE[1] BELOW	3/8 (1/2 OD, 3/8 OD, 3/4 OD)	1/2 (7/8 OD, 1 1/8 OD)	3/4 (1 OD, 1 3/8 OD)	1 (1 1/4 OD)	1 1/4 (1 5/8 OD)	1 1/2 (2 OD, 2 1/8 OD)	2 (2 1/2 OD)	2 1/2 (3 OD)	3 (3 1/2 OD)	4 (4 OD)	6 (5 OD, 6 OD)	8 (8 OD)	10 (10 OD)	12 (12 OD)	14	16	18	20	24
1	3/8	T_1	90	90	100	90	90	82	72	73	61	51									
		L_1	81	81	84	81	81	78	75	76	72	70									
		T_2	120	120	128	120	120	113	105	106	96	88									
		L_2	93	93	97	93	93	90	86	87	83	80									
		T_3	132	132	139	132	132	125	118	119	110	103									
	5/8	T_1	125	125	134	125	116	112	105	107	93	81									
		L_1	198	198	209	198	189	185	179	181	170	162									
		T_2	148	148	156	148	140	137	132	133	122	112									
		L_2	227	227	239	227	216	212	206	207	195	185									
		T_3	157	157	164	157	150	147	142	144	134	125									
1 1/2	3/8	T_1	103	103	111	103	103	100	85	84	74	64	50	41	34	26	23	19	16	13	9
		L_1	86	86	89	86	86	84	79	79	76	73	70	67	66	64	64	63	63	62	61
		T_2	130	130	137	130	130	128	116	115	106	98	87	79	74	67	65	62	59	57	53
		L_2	98	98	102	98	98	97	91	91	87	84	80	77	76	74	73	73	72	71	70
		T_3	141	141	147	141	141	139	128	127	119	112	102	95	90	84	82	79	77	74	71
	5/8	T_1	137	137	145	137	134	131	119	118	107	96	80	68	60	48	45	40	35	31	25
		L_1	212	212	223	212	209	205	192	191	181	172	161	154	149	144	142	140	138	137	134
		T_2	158	158	165	158	156	153	143	143	133	124	111	102	95	86	83	79	75	72	66
		L_2	243	243	256	243	239	235	220	219	208	197	185	177	171	165	163	160	158	157	154
		T_3	166	166	172	166	164	162	153	152	144	135	124	115	109	101	98	94	91	88	83
2	3/8	T_1	112	112	124	112	112	108	95	93	84	74	60	52	42	34	31	27	23	20	15
		L_1	89	89	95	89	89	88	83	82	79	76	72	70	68	66	65	65	64	63	62
		T_2	138	138	147	138	138	134	124	122	114	106	95	88	81	74	72	68	65	62	58
		L_2	102	102	109	102	102	100	95	94	90	87	83	80	78	76	75	74	73	73	72
		T_3	148	148	157	148	148	145	135	134	127	119	109	103	96	90	88	84	82	79	76
	5/8	T_1	146	146	157	146	142	140	129	127	118	107	91	82	70	59	56	50	45	41	33
		L_1	224	224	242	224	219	215	203	201	191	181	169	162	155	149	147	144	142	141	138
		T_2	165	165	174	165	162	160	151	150	142	133	121	113	103	94	92	87	83	79	73
		L_2	257	257	277	257	251	247	232	230	219	207	193	186	178	171	169	166	163	162	158
		T_3	173	173	181	173	170	168	160	159	152	144	132	125	117	108	106	102	98	95	89
2 1/2	3/8	T_1	119	119	130	119	119	115	103	100	92	83	68	59	50	41	38	33	29	26	20
		L_1	92	92	98	92	92	90	85	85	81	78	74	72	70	68	67	66	65	64	63
		T_2	143	143	152	143	143	140	130	128	121	114	101	94	87	79	77	73	70	67	63
		L_2	106	106	112	106	106	104	98	97	93	90	85	82	80	77	77	76	75	74	73
		T_3	153	153	161	153	153	150	141	139	133	126	115	109	102	95	93	89	86	84	80
	5/8	T_1	152	152	162	152	148	146	137	135	126	117	100	91	79	68	65	59	53	49	41
		L_1	234	234	251	234	228	224	212	209	199	190	176	168	161	154	152	149	146	145	141
		T_2	170	170	178	170	167	165	158	156	149	141	128	120	111	102	99	94	90	86	80
		L_2	268	268	286	268	261	257	243	240	228	217	201	193	184	177	174	171	168	166	162
		T_3	178	178	185	178	175	173	166	164	158	151	139	132	123	115	113	108	104	101	95
3	3/8	T_1	124	124	134	124	124	120	109	107	99	89	76	66	56	47	44	39	35	31	25
		L_1	95	95	101	95	95	93	88	87	84	81	76	74	71	69	68	67	66	66	64
		T_2	148	148	156	148	148	144	135	133	127	119	108	100	92	85	82	78	75	72	67
		L_2	109	109	115	109	109	107	101	100	96	93	88	84	82	79	78	77	76	75	74
		T_3	157	157	164	157	157	153	145	144	138	131	121	113	106	100	98	94	91	88	83
	5/8	T_1	157	157	166	157	153	151	143	141	133	124	110	98	87	76	73	66	61	56	48
		L_1	242	242	259	242	235	232	220	217	207	197	183	174	166	159	157	153	150	149	144
		T_2	175	175	182	175	171	169	163	161	155	147	136	126	117	108	105	100	96	92	85
		L_2	278	278	297	278	270	266	252	249	238	225	210	199	190	182	180	175	172	170	166
		T_3	181	181	188	181	178	177	171	169	163	156	146	137	129	121	118	114	110	106	100

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-3

STEAM TRACING DATA
SPACED TRACER SYSTEM

25 psig (267 F) STEAM

PROCESS LINE NOMINAL PIPE SIZE
(APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)

INSULATION THICKNESS	TRACER SIZE (OD)	SEE NOTE[1] BELOW	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
			1/2 OD 3/8 OD 3/4 OD	3/8 OD 1/2 OD 3/4 OD	1 OD 3/4 OD 1/2 OD	3/4 OD 1 OD	1 1/4 OD 1 OD 3/4 OD	2 OD 1 1/2 OD 1 1/4 OD	2 1/2 OD 2 OD	3 OD	3 1/2 OD	4 OD	5 OD 6 OD	8 OD	10 OD	12 OD					
1	3/8	T_1	97	97	108	97	97	88	78	79	67	56									
		L_1	101	101	105	101	101	97	94	94	90	87									
		T_2	127	127	135	127	127	119	111	112	101	92									
		L_2	115	115	120	115	115	111	107	107	103	99									
		T_3	139	139	146	139	139	132	124	125	115	107									
	5/8	T_1	134	134	144	134	124	120	113	115	100	87									
		L_1	244	244	258	244	233	228	221	223	210	200									
		T_2	157	157	165	157	149	146	140	141	129	119									
		L_2	277	277	293	277	265	259	251	253	238	227									
		T_3	166	166	174	166	159	156	150	152	141	131									
1 1/2	3/8	T_1	111	111	120	111	111	108	92	91	80	69	55	44	38	28	26	22	18	15	11
		L_1	107	107	111	107	107	105	99	98	94	91	87	84	82	80	80	79	78	77	76
		T_2	138	138	145	138	138	135	122	122	112	103	92	83	77	70	68	64	62	59	55
		L_2	121	121	126	121	121	120	112	112	107	103	99	96	94	91	91	90	89	88	87
		T_3	149	149	156	149	149	146	135	134	125	117	106	99	93	87	85	81	79	77	73
	5/8	T_1	147	147	156	147	144	141	128	127	115	103	86	74	65	53	49	44	39	35	25
		L_1	262	262	275	262	258	253	237	236	223	212	199	190	184	177	176	173	170	171	167
		T_2	168	168	175	168	166	163	152	151	141	131	118	107	100	90	87	82	78	75	69
		L_2	298	298	313	298	293	288	270	268	254	241	226	216	210	202	200	196	193	194	190
		T_3	176	176	183	176	174	172	162	161	152	143	130	121	114	105	102	98	94	91	86
2	3/8	T_1	120	120	133	120	120	116	102	100	90	80	65	56	46	37	34	30	26	22	17
		L_1	111	111	119	111	111	109	103	102	98	94	90	87	85	82	82	81	80	79	78
		T_2	146	146	156	146	146	142	131	129	121	112	100	93	85	77	75	71	68	65	60
		L_2	127	127	135	127	127	124	117	116	112	107	102	99	96	94	93	92	91	90	88
		T_3	156	156	166	156	156	153	142	141	133	125	114	108	100	93	91	87	84	82	78
	5/8	T_1	157	157	168	157	152	150	139	137	126	115	98	88	76	64	61	54	49	44	37
		L_1	277	277	298	277	270	266	250	248	235	223	208	200	192	184	182	178	175	176	172
		T_2	176	176	185	176	172	170	161	159	151	141	128	119	109	95	96	91	87	83	77
		L_2	315	315	339	315	307	302	284	281	267	253	237	228	218	209	207	203	199	200	195
		T_3	183	183	192	183	180	178	170	168	161	152	139	132	122	113	111	106	102	99	93
2 1/2	3/8	T_1	128	128	139	128	128	123	110	108	99	89	73	64	54	45	42	37	32	29	23
		L_1	115	115	122	115	115	113	106	105	101	98	92	90	87	84	83	82	81	80	79
		T_2	152	152	161	152	152	148	138	135	128	120	107	99	91	83	81	77	73	70	65
		L_2	131	131	139	131	131	128	121	120	115	111	105	102	99	96	95	93	92	91	90
		T_3	162	162	170	162	162	158	148	147	140	132	121	114	106	99	97	93	89	87	82
	5/8	T_1	163	163	174	163	159	157	147	144	135	125	108	98	86	74	70	64	58	53	45
		L_1	289	289	310	289	281	277	261	258	246	234	217	209	198	190	188	184	180	180	176
		T_2	181	181	190	181	178	176	168	166	158	150	136	127	117	107	104	99	94	90	83
		L_2	328	328	352	328	319	314	297	293	279	266	246	236	225	216	213	209	205	205	200
		T_3	189	189	196	189	185	183	176	174	167	160	147	139	130	121	118	113	109	105	99
3	3/8	T_1	134	134	144	134	134	129	117	115	107	96	82	71	61	51	48	43	36	34	28
		L_1	119	119	125	119	119	116	110	109	105	101	95	92	89	86	85	84	83	82	80
		T_2	157	157	165	157	157	153	143	141	134	126	114	105	97	89	86	82	78	75	70
		L_2	135	135	142	135	135	132	125	123	119	114	108	104	101	98	97	95	94	93	91
		T_3	166	166	174	166	166	162	153	152	146	138	127	119	111	104	102	98	94	91	86
	5/8	T_1	169	169	178	169	164	162	153	151	143	133	118	106	94	82	78	72	66	61	52
		L_1	299	299	320	299	290	286	271	268	256	243	226	214	205	196	193	189	185	185	180
		T_2	186	186	193	186	182	180	173	171	165	156	144	134	124	114	111	106	101	97	89
		L_2	340	340	363	340	330	325	309	304	291	276	257	244	232	223	220	215	210	210	205
		T_3	193	193	200	193	189	186	181	179	173	165	154	145	136	127	124	119	115	111	104

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-4

STEAM TRACING DATA
SPACED TRACER SYSTEM

35 psig (281 F) STEAM

PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)

INSULATION THICKNESS	TRACER SIZE (OD)	SEE NOTE[1] BELOW	3/8 (1/2 00, 3/8 00, 3/4 00)	1/2 (3/8 00, 1/2 00, 1 00)	3/4 (1 00, 1 1/4 00)	1 (1 1/4 00)	1 1/4 (1 1/2 00)	1 1/2 (2 00)	2 (2 1/2 00)	2 1/2 (3 00)	3 (3 1/2 00)	4 (4 00)	6 (5 00, 6 00)	8 (8 00)	10 (10 00)	12 (12 00)	14	16	18	20	24
1	3/8	T_1	103	103	114	103	103	93	83	84	71	59									
		L_1	117	117	122	117	117	113	109	110	105	101									
		T_2	133	133	142	133	133	125	115	117	106	96									
		L_2	133	133	138	133	133	128	123	124	118	114									
		T_3	144	144	153	144	144	137	129	130	120	111									
	5/8	T_1	141	141	152	141	131	127	119	121	106	93									
		L_1	287	287	302	287	273	268	260	262	246	234									
		T_2	165	165	173	165	156	152	146	148	135	124									
		L_2	323	323	341	323	309	303	293	295	278	264									
		T_3	174	174	182	174	166	163	157	158	147	136									
1 1/2	3/8	T_1	117	117	127	117	117	114	97	96	85	73	58	48	40	31	28	24	20	17	12
		L_1	124	124	129	124	124	122	115	115	110	106	101	98	96	93	93	92	91	90	89
		T_2	144	144	152	144	144	142	128	127	117	108	95	86	80	72	70	66	63	61	57
		L_2	140	140	146	140	140	138	130	129	124	119	114	110	108	105	105	104	103	102	100
		T_3	155	155	162	155	155	153	140	139	130	121	110	102	96	89	87	84	81	78	74
	5/8	T_1	155	155	164	155	152	149	135	134	122	109	92	78	69	56	53	47	42	37	30
		L_1	307	307	323	307	302	297	278	277	262	249	233	223	216	208	206	203	200	198	195
		T_2	176	176	184	176	174	171	159	159	148	137	123	112	104	94	91	86	81	78	72
		L_2	347	347	365	347	341	336	314	313	296	281	264	252	244	235	233	229	225	224	220
		T_3	184	184	191	184	182	180	169	168	159	149	135	125	118	108	106	101	97	94	88
2	3/8	T_1	127	127	141	127	127	123	108	106	96	84	69	60	50	40	37	32	28	24	19
		L_1	129	129	138	129	129	127	120	119	114	110	104	101	98	96	95	94	93	92	90
		T_2	153	153	164	153	153	149	137	135	126	117	104	97	88	80	77	73	70	67	62
		L_2	146	146	155	146	146	143	135	134	129	124	118	115	111	108	107	106	105	104	102
		T_3	163	163	173	163	163	159	148	147	139	130	118	111	103	96	94	90	87	84	80
	5/8	T_1	165	165	177	165	161	158	146	144	133	121	104	93	81	68	65	58	52	48	40
		L_1	325	325	350	325	317	312	294	291	276	262	244	235	225	216	214	209	206	204	200
		T_2	184	184	195	184	181	178	169	167	158	148	133	125	114	104	100	95	90	86	80
		L_2	367	367	395	367	358	352	331	328	312	296	276	265	254	244	241	236	232	231	225
		T_3	192	192	201	192	189	187	178	176	168	158	145	137	127	118	115	110	105	102	96
2 1/2	3/8	T_1	135	135	147	135	135	130	117	114	105	95	78	68	58	48	45	39	35	31	25
		L_1	134	134	142	134	134	131	124	122	118	114	107	104	101	98	97	96	94	93	92
		T_2	159	159	169	159	159	155	144	142	134	125	112	104	95	86	84	80	76	72	67
		L_2	151	151	160	151	151	148	140	138	133	128	121	118	114	111	110	108	107	105	104
		T_3	169	169	178	169	169	165	155	153	145	138	125	118	110	102	100	96	92	89	84
	5/8	T_1	172	172	183	172	168	165	155	152	143	132	114	103	91	78	75	68	62	57	48
		L_1	339	339	364	339	330	325	307	303	288	275	254	244	233	223	220	216	212	210	205
		T_2	190	190	199	190	186	184	176	174	166	151	142	133	122	112	109	103	98	94	87
		L_2	383	383	410	383	372	367	346	342	325	310	287	275	263	252	249	243	239	237	231
		T_3	197	197	206	197	194	192	184	182	175	167	153	145	135	125	122	117	113	109	102
3	3/8	T_1	141	141	152	141	141	136	124	121	113	102	87	76	65	55	52	46	41	37	30
		L_1	138	138	146	138	138	135	127	126	122	117	111	107	103	100	99	97	96	95	93
		T_2	164	164	174	164	164	160	150	148	141	132	119	110	101	92	90	85	81	78	72
		L_2	156	156	165	156	156	152	144	143	138	132	125	120	116	113	112	110	109	107	105
		T_3	174	174	182	174	174	170	160	158	152	144	132	123	115	107	105	101	97	94	89
	5/8	T_1	178	178	188	178	173	171	162	160	151	140	125	112	99	87	83	76	70	65	56
		L_1	351	351	375	351	341	336	318	314	301	285	266	252	240	230	227	222	217	215	209
		T_2	195	195	203	195	191	189	181	180	173	163	151	140	129	119	116	110	105	101	93
		L_2	396	396	424	396	385	379	359	355	339	321	300	284	271	260	256	250	245	243	236
		T_3	202	202	209	202	198	196	189	188	181	173	161	151	141	132	129	124	119	115	108

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-5

STEAM TRACING DATA
SPACED TRACER SYSTEM

50 psig (298 F) STEAM

PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)

INSULATION THICKNESS	TRACER SIZE (OD)	SEE NOTE BELOW	3/8 (1/2 OD, 3/4 OD)	1/2 (3/4 OD, 1 OD)	3/4 (1 OD)	1 (1 1/4 OD)	1 1/4 (1 1/2 OD, 2 OD)	1 1/2 (2 OD, 2 1/2 OD)	2 (2 1/2 OD)	2 1/2 (3 OD)	3 (3 1/2 OD)	4 (4 OD)	6 (5 OD, 6 OD)	8 (8 OD)	10 (10 OD)	12 (12 OD)	14	16	18	20	24
1	3/8	T_1	110	110	121	110	110	100	88	90	76	64									
		L_1	139	139	145	139	139	134	129	130	124	120									
		T_2	139	139	149	139	139	131	121	122	110	100									
		L_2	156	156	162	156	156	150	145	145	139	134									
		T_3	151	151	160	151	151	143	134	135	124	115									
	5/8	T_1	150	150	161	150	139	135	127	129	113	99									
		L_1	338	338	357	338	323	317	307	309	291	277									
		T_2	173	173	183	173	164	160	154	155	142	130									
		L_2	380	380	400	380	362	355	344	347	326	310									
		T_3	182	182	191	182	174	170	164	166	153	142									
1 1/2	3/8	T_1	124	124	134	124	124	121	104	103	90	78	63	51	44	34	31	26	22	19	14
		L_1	146	146	152	146	146	145	136	135	130	125	119	116	113	110	110	108	107	106	105
		T_2	152	152	160	152	152	149	135	133	123	113	99	90	83	75	73	69	66	63	58
		L_2	164	164	171	164	164	162	152	152	146	140	134	130	127	124	123	122	120	119	118
		T_3	162	162	170	162	162	160	146	145	136	126	114	105	99	92	90	86	83	80	76
	5/8	T_1	165	165	174	163	161	158	144	143	129	116	97	83	74	60	57	50	45	40	33
		L_1	363	363	382	363	357	351	329	327	310	294	276	264	256	246	244	239	236	234	230
		T_2	186	186	194	186	183	180	168	167	156	144	129	117	109	98	95	89	85	81	74
		L_2	407	407	428	407	401	394	369	367	347	330	309	296	287	276	273	268	265	263	258
		T_3	194	194	201	194	191	189	177	177	166	156	141	131	123	113	110	105	101	97	91
2	3/8	T_1	135	135	149	135	135	130	115	113	102	90	74	64	53	43	40	35	30	27	21
		L_1	153	153	163	153	153	150	141	140	135	130	123	120	116	113	112	111	109	108	107
		T_2	161	161	172	161	161	157	144	142	133	123	109	101	92	83	81	76	72	69	64
		L_2	172	172	182	172	172	168	159	157	151	145	138	134	130	127	126	124	123	122	120
		T_3	171	171	182	171	171	167	155	153	145	136	123	116	107	99	97	93	89	86	82
	5/8	T_1	175	175	188	175	171	168	155	153	142	129	111	100	86	73	69	62	56	51	43
		L_1	384	384	414	384	374	369	347	343	326	309	289	278	266	255	252	247	243	241	236
		T_2	194	194	205	194	190	188	178	176	166	155	140	131	119	108	105	99	94	90	83
		L_2	430	430	464	430	420	413	389	385	366	347	324	311	298	286	283	277	273	271	265
		T_3	202	202	212	202	198	196	186	185	176	166	152	143	133	122	119	114	109	105	99
2 1/2	3/8	T_1	143	143	156	143	143	138	124	121	111	101	83	73	62	51	48	43	38	34	27
		L_1	158	158	168	158	158	155	146	145	139	134	127	123	119	116	115	113	112	110	109
		T_2	167	167	178	167	167	163	151	149	140	132	117	108	99	99	87	83	79	75	70
		L_2	178	178	188	178	178	174	164	162	156	151	142	138	134	130	129	127	125	124	122
		T_3	177	177	187	177	177	173	162	160	152	144	130	122	114	106	103	99	95	92	87
	5/8	T_1	193	193	204	193	178	175	164	162	151	140	121	110	97	84	80	72	66	61	52
		L_1	400	400	430	400	389	384	362	357	341	324	301	288	275	264	260	255	250	248	242
		T_2	201	201	210	201	196	194	185	183	174	165	149	139	128	117	114	108	102	98	90
		L_2	449	449	482	449	437	430	406	401	382	364	337	323	308	296	292	286	281	278	271
		T_3	208	208	217	208	204	202	193	191	183	175	160	151	141	131	128	122	117	113	106
3	3/8	T_1	150	150	161	150	150	144	131	129	120	109	93	81	70	59	56	50	45	40	33
		L_1	163	163	172	163	163	159	151	149	144	138	131	126	122	119	117	115	114	112	110
		T_2	173	173	183	173	173	168	157	155	148	138	125	115	105	96	94	89	84	81	75
		L_2	183	183	193	183	183	178	169	167	161	155	147	141	137	132	131	129	127	126	124
		T_3	192	182	191	182	182	178	168	166	159	150	138	128	120	111	109	104	100	97	91
	5/8	T_1	188	188	199	188	184	181	171	169	160	149	132	119	106	93	89	81	75	69	60
		L_1	415	415	444	415	403	397	376	372	355	336	314	297	284	272	268	262	257	254	247
		T_2	206	206	214	206	201	199	191	189	182	172	158	147	136	125	122	115	110	105	97
		L_2	465	465	497	465	451	445	422	417	398	377	352	334	318	305	301	294	288	285	277
		T_3	212	212	220	212	208	207	199	197	190	181	169	158	148	138	135	129	124	119	112

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
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INSULATION THICKNESS REQUIREMENTS

Service Designation T-6

STEAM TRACING DATA
SPACED TRACER SYSTEM

75 psig (320 F) STEAM

PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)

INSULATION THICKNESS	TRACER SIZE (OD)	SEE NOTE[1] BELOW	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
			1/2 OD 3/8 OD 3/4 OD	3/8 OD 1/2 OD	1 OD 3/4 OD	1/4 OD	1 5/8 OD 1 1/2 OD 1 3/8 OD	2 OD 2 1/8 OD	2 1/2 OD	3 OD	3 1/2 OD	4 OD	5 OD 6 OD	8 OD	10 OD	12 OD					
1	3/8	T_1	119	119	131	119	119	108	96	98	83	70									
		L_1	168	168	175	168	168	162	156	157	150	145									
		T_2	149	149	159	149	149	139	129	130	117	106									
		L_2	187	187	195	187	187	180	174	175	167	161									
		T_3	160	160	170	160	160	152	142	143	131	121									
	5/8	T_1	162	162	175	162	151	146	137	139	122	107									
		L_1	410	410	432	410	391	383	371	374	352	335									
		T_2	186	186	196	186	176	171	164	166	151	138									
		L_2	456	456	481	456	435	426	413	416	392	373									
		T_3	195	195	204	195	186	182	175	177	163	151									
1 1/2	3/8	T_1	135	135	146	135	135	131	113	112	98	85	69	56	48	38	35	30	25	22	16
		L_1	177	177	185	177	177	175	164	164	157	151	144	140	137	134	133	131	130	129	127
		T_2	162	162	171	162	162	159	143	142	131	120	106	95	88	79	77	72	69	66	61
		L_2	197	197	205	197	197	195	183	182	175	168	161	156	153	149	148	146	145	143	142
		T_3	173	173	181	173	173	170	155	154	144	134	120	111	104	96	93	89	86	83	79
	5/8	T_1	178	178	188	178	175	171	156	154	140	126	106	91	80	66	62	56	50	45	37
		L_1	440	440	462	440	433	425	398	396	375	356	334	319	310	298	295	290	286	284	278
		T_2	199	199	208	199	196	193	180	179	167	154	137	125	116	104	100	94	89	85	78
		L_2	489	489	514	489	481	473	443	441	417	396	371	355	344	331	328	322	318	316	310
		T_3	207	207	215	207	204	201	189	188	177	166	150	138	130	118	115	110	105	101	95
2	3/8	T_1	147	147	162	147	147	141	125	123	111	98	81	70	59	48	44	39	34	30	24
		L_1	195	185	197	185	185	182	171	170	163	157	149	145	141	137	136	134	133	131	129
		T_2	172	172	185	172	172	168	153	152	141	131	116	107	97	88	85	80	76	73	67
		L_2	206	206	219	206	206	202	190	189	182	175	166	161	157	152	151	149	147	146	144
		T_3	182	162	194	182	182	178	165	163	154	144	130	122	112	104	101	97	93	90	85
	5/8	T_1	189	189	203	189	184	181	168	166	153	140	120	108	94	80	76	68	62	56	47
		L_1	465	465	501	465	453	446	420	416	395	374	350	336	322	309	305	299	294	292	286
		T_2	208	208	220	208	204	202	190	188	178	166	150	139	127	115	111	105	100	95	87
		L_2	517	517	557	517	504	496	467	462	439	416	389	374	358	344	340	333	327	325	318
		T_3	216	216	227	216	212	210	199	197	188	177	161	152	140	129	126	120	115	111	103
2 1/2	3/8	T_1	155	155	169	155	155	150	135	132	121	109	91	80	68	57	53	47	42	38	31
		L_1	192	192	203	192	192	187	177	175	169	163	154	149	144	140	139	137	135	134	131
		T_2	179	179	191	179	179	175	162	159	150	140	124	115	105	95	92	87	83	79	73
		L_2	213	213	226	213	213	208	197	195	188	181	171	166	160	156	154	152	150	149	146
		T_3	189	189	200	189	189	185	173	170	162	153	138	129	120	111	108	103	99	96	90
	5/8	T_1	197	197	210	197	192	189	178	175	164	152	132	119	105	91	87	79	72	67	57
		L_1	485	485	520	485	471	464	439	433	412	393	364	349	333	319	315	308	303	300	293
		T_2	215	215	226	215	211	208	198	196	187	177	159	149	137	125	121	114	109	104	96
		L_2	539	539	578	539	524	516	488	481	459	437	405	388	370	355	351	343	337	334	325
		T_3	222	222	232	222	218	216	207	205	196	187	170	161	149	138	135	129	123	119	111
3	3/8	T_1	162	162	175	162	162	156	142	140	130	118	101	88	76	65	61	55	49	45	37
		L_1	197	197	209	197	197	193	182	181	174	167	159	153	147	143	142	139	138	136	133
		T_2	185	185	196	185	185	180	166	166	158	148	133	122	112	102	99	94	89	85	78
		L_2	219	219	232	219	219	214	203	201	194	186	176	170	164	159	158	155	153	151	148
		T_3	194	194	204	194	194	190	179	177	169	159	146	136	126	117	114	109	105	101	95
	5/8	T_1	204	204	215	204	198	196	185	183	173	161	144	129	115	101	97	89	82	76	66
		L_1	502	502	537	502	487	481	455	450	430	407	380	360	343	329	325	317	311	307	299
		T_2	221	221	230	221	216	214	205	203	195	184	169	157	145	133	130	123	117	112	103
		L_2	558	558	597	558	542	534	506	500	478	453	422	400	382	366	361	353	346	342	333
		T_3	227	227	236	227	223	221	213	211	203	194	180	168	157	146	143	136	131	126	118

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
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INSULATION THICKNESS REQUIREMENTS

Service Designation T-7

STEAM TRACING DATA
SPACED TRACER SYSTEM

200 psig (388 F) STEAM

PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)

INSULATION THICKNESS	TRACER SIZE (OD)	SEE NOTE BELOW	3/8 (1/2 OD, 5/8 OD, 3/4 OD)	1/2 (3/4 OD, 1 OD)	3/4 (1 OD, 1 1/4 OD)	1	1 1/4 (1 1/2 OD, 1 5/8 OD)	1 1/2 (2 OD)	2 (2 1/2 OD)	2 1/2 (3 OD)	3 (3 1/2 OD)	4	6 (5 OD, 6 OD)	8 (8 OD)	10 (10 OD)	12 (12 OD)	14	16	18	20	24
1	3/8	T_1	147	147	161	147	147	134	119	121	103	88									
		L_1	273	273	284	273	273	263	253	255	244	235									
		T_2	176	176	189	176	176	165	152	154	138	124									
		L_2	298	298	310	298	298	287	277	278	266	257									
		T_3	188	188	200	188	188	177	165	167	152	139									
	5/8	T_1	198	198	213	198	185	179	169	171	151	132									
		L_1	665	665	702	665	635	622	603	607	572	544									
		T_2	222	222	234	222	210	204	195	197	180	164									
		L_2	726	726	766	726	693	679	658	663	624	594									
		T_3	231	231	243	231	219	214	206	206	191	176									
1 1/2	3/8	T_1	166	166	178	166	166	161	139	138	122	106	86	72	62	49	45	39	34	30	23
		L_1	288	288	300	288	288	284	267	266	255	246	235	227	223	217	216	213	211	209	207
		T_2	193	193	204	193	193	189	169	168	154	141	123	110	102	90	87	82	78	74	69
		L_2	314	314	327	314	314	310	291	290	279	268	256	248	243	237	235	233	230	228	226
		T_3	204	204	214	204	204	200	182	180	167	154	138	126	118	107	104	99	95	92	86
	5/8	T_1	217	217	230	217	213	209	190	189	172	154	131	113	100	83	79	71	64	58	48
		L_1	714	714	750	714	702	690	646	643	609	578	542	518	503	484	479	470	464	461	452
		T_2	238	238	249	238	234	230	214	213	198	183	162	147	135	121	117	109	103	98	89
		L_2	779	779	819	779	766	753	706	702	664	631	592	565	549	528	523	513	506	503	493
		T_3	246	246	257	246	243	239	224	223	209	194	175	160	150	136	132	125	119	114	106
2	3/8	T_1	179	179	197	179	179	173	153	151	137	121	101	88	74	61	57	51	45	40	32
		L_1	301	301	320	301	301	295	278	276	265	255	242	236	229	222	221	218	215	213	210
		T_2	205	205	221	205	205	199	182	180	167	154	136	125	113	101	98	92	87	83	76
		L_2	328	328	349	328	328	322	303	301	289	278	265	257	250	243	241	238	235	233	229
		T_3	215	215	230	215	215	210	194	191	180	167	150	140	128	117	114	108	104	100	93
	5/8	T_1	231	231	247	231	225	221	205	202	188	171	148	134	116	100	94	86	78	71	61
		L_1	754	754	813	754	736	724	681	675	641	608	568	546	522	502	496	486	478	474	463
		T_2	250	250	264	250	245	241	227	225	212	198	177	165	150	135	130	123	118	110	101
		L_2	823	823	887	823	803	790	744	736	700	663	619	596	570	547	541	531	522	517	506
		T_3	257	257	271	257	253	249	236	234	222	208	189	177	163	149	145	137	131	126	117
2 1/2	3/8	T_1	190	190	206	190	190	183	165	162	149	135	113	100	85	72	68	61	54	49	41
		L_1	311	311	330	311	311	304	288	285	274	264	250	242	234	227	226	222	219	217	214
		T_2	214	214	228	214	214	208	192	189	178	166	146	135	122	111	107	101	95	91	83
		L_2	339	339	360	339	339	332	314	311	299	288	272	264	256	248	246	242	239	237	233
		T_3	224	224	237	224	224	218	203	200	190	178	160	149	137	126	123	117	112	107	100
	5/8	T_1	240	240	255	240	234	231	217	213	200	196	162	147	130	113	108	99	91	84	72
		L_1	787	787	844	787	765	754	712	702	669	637	591	566	541	518	512	501	492	487	475
		T_2	258	258	271	258	253	250	238	234	223	211	189	176	161	147	142	134	127	121	111
		L_2	858	858	921	858	835	823	777	767	731	696	645	618	590	566	559	547	537	531	518
		T_3	265	254	278	265	260	257	246	243	232	221	200	188	174	160	156	148	142	136	126
3	3/8	T_1	198	198	213	198	198	191	175	171	160	145	125	110	95	82	77	70	63	57	48
		L_1	320	320	338	320	320	313	296	293	283	272	258	248	239	232	230	226	223	221	217
		T_2	221	221	234	221	221	215	201	198	188	175	157	144	131	119	115	109	103	98	90
		L_2	349	349	369	349	349	341	323	320	309	296	281	270	261	253	251	247	244	241	237
		T_3	230	230	243	230	230	225	211	208	199	187	170	157	145	134	130	124	119	114	106
	5/8	T_1	248	248	261	248	241	236	226	223	211	197	176	158	142	125	120	110	102	95	82
		L_1	815	815	871	815	791	780	739	730	698	661	617	585	558	534	527	515	505	499	485
		T_2	265	265	276	265	259	257	246	243	233	220	202	186	172	157	153	144	137	131	120
		L_2	889	889	951	889	863	851	806	797	761	721	673	638	608	583	575	562	551	545	530
		T_3	272	272	283	272	266	264	253	251	242	229	212	198	184	170	166	158	151	145	135

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-8

HEAT TRANSFER CEMENT BONDED STEAM TRACING SYSTEMS AND DEFINITIONS OF SYMBOLS

NOTE:

The tabulated data on this Standard applies to steam tracing systems using heat transfer cement as the heat-conductive medium, as detailed and specified on Standard P-140. Insulation sizes and assembly dimensions are given on Standard P-140A.

This Standard provides steam tracing data based on static conditions only. Information compiled is based on heat loss from the insulation and does not provide for addition of any heat to the material in the process line.

This Standard is for use where required temperatures are higher than those that can be maintained with air as the heat-conductive medium.

Data in these tables can be used for selection of tracers under two general conditions, as follows:

1. Where temperature to be maintained in the process line determines selection of insulation thickness, tracer size and steam pressure.

   When temperature to be maintained completely determines selection, frequently the most economical selection is the combination using only one tracer and the thickness of insulation which is consistent with "Economic Thickness of Insulation." In some instances it may be desirable to have two tracers for use in coldest weather so that one can be turned off in mild weather to prevent overheating. Where a choice is possible, it is more economical to use the larger size tracer than to increase the insulation thickness.

2. Where operating temperature determines insulation thickness, and temperature to be maintained during down time determines selection of tracer size and steam pressure.

   When operating temperature dictates the insulation thickness, this thickness may be greater than necessary for most economical selection of insulation thickness and tracer size. However, under these conditions the applicable tracer data can be obtained from the table, based on the predetermined insulation thickness and temperature to be maintained during down time.

Under either of the conditions, the final selection of tracer size, i.e., 3/8 inch or 5/8 inch, may be influenced by physical requirements as to length of tracer that can be run between traps.

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INSULATION THICKNESS REQUIREMENTS -

Service Designation T-8

HEAT TRANSFER CEMENT BONDED STEAM TRACING SYSTEMS AND DEFINITIONS OF SYMBOLS - Continued

DEFINITIONS OF SYMBOLS

T = Minimum temperature (°F) that the tracer will maintain in the process line, based on an ambient temperature of -20F. The calculations are based on static conditions, i. e., no fluid flow, and are independent of the viscosity, density, and thermal conductivity of the process fluid.

Higher ambient temperatures will result in slightly higher process line temperatures.

If the upper temperature limit of the process line is critical, the effect of solar radiation should be investigated, since it was not considered in calculating the temperatures given in the table.

L_1 = Maximum length (feet) of straight run of tracer, based on an ambient temperature of -20F. It is applicable at all plant locations except 513 and 526.

L_2 = Same as L_1, except based on an ambient temperature of 30F. It is applicable at Plant Locations 513 and 526.

L_1 and L_2 represent total lengths of tracers, including all branches, and apply to straight runs only. In utilizing them in actual tracer layouts, the following limitations and requirements shall be considered:

1. Lengths shall be reduced as necessary to compensate for friction losses caused by bends, tees, valves, and other constrictions.

2. In general, all low points and pockets in tracers shall be trapped. However, under certain conditions, installation of traps at these points may be impracticable. If so, the length of the tracer shall be reduced sufficiently to offset pressure drop caused by the condensate head.

3. Steam tracer feed lines shall be sized properly so that pressure drop will not require a reduction in the tracer length.

4. Traps shall be installed at the ends of all tracers, including ends of branches, and at all other condensate removal points.

Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation D...
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INSULATION THICKNESS REQUIREMENTS

Service Designation T-9

STEAM TRACING DATA
TRACER BONDED TO PIPE WITH HEAT TRANSFER CEMENT

15 psig (250 F) STEAM

PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)

INSULATION THICKNESS	TRACER SIZE (OD)	NUMBER OF TRACERS	SEE NOTE BELOW	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
1	3/8	1	T	240	237	232	229	224	223	218	212	210	203									
			L_1	78	75	66	63	57	56	51	46	46	42									
			L_2	90	86	75	72	65	64	59	53	53	48									
		2	T		248	245	243	240	239	235	232	231	226									
			L_1		117	102	97	87	85	78	70	70	62									
			L_2		134	117	111	100	98	89	80	80	72									
	5/8	1	T	248	245	242	239	235	234	229	228	222	215									
			L_1	208	195	175	168	152	149	134	133	118	103									
			L_2	239	224	200	192	174	171	154	152	135	119									
		2	T				249	246	245	242	241	238	234									
			L_1				262	236	231	207	204	180	157									
			L_2				301	270	265	237	234	206	180									
1 1/2	3/8	1	T	241	238	235	231	227	226	224	217	215	209	191	181	172	160	156	149	142	136	125
			L_1	83	80	74	68	62	61	59	52	50	46	36	33	31	28	27	26	25	24	22
			L_2	95	92	85	78	71	70	67	59	58	52	42	38	35	32	31	30	28	27	26
		2	T		248	246	244	241	240	238	235	233	229	218	211	206	197	194	189	183	178	169
			L_1		126	115	105	96	94	90	78	77	69	54	48	44	39	38	36	34	32	30
			L_2		144	132	121	110	108	103	90	88	79	61	55	50	45	43	41	39	37	34
	5/8	1	T	249	246	243	240	238	237	232	231	226	221	212	205	198	189	185	179	173	168	158
			L_1	231	210	190	183	174	171	149	145	131	116	101	90	83	75	72	68	65	62	58
			L_2	265	241	218	210	199	196	171	167	150	133	116	103	95	86	83	78	74	71	66
		2	T				249	247	246	244	242	240	236	231	227	222	217	214	210	206	203	196
			L_1				288	272	267	231	225	201	177	152	135	123	109	105	98	93	88	81
			L_2				320	312	306	265	257	231	203	175	155	141	125	121	113	107	101	93
2	3/8	1	T	242	239	236	234	230	228	226	221	219	213	198	190	181	170	167	160	154	148	137
			L_1	88	85	76	75	66	66	62	56	54	49	40	36	33	30	29	28	27	26	24
			L_2	101	97	87	86	76	75	72	64	62	56	45	42	38	35	34	32	31	29	28
		2	T		248	246	244	242	241	239	236	235	231	222	218	211	204	202	197	192	188	179
			L_1		133	119	116	103	101	96	85	82	74	59	54	48	43	42	39	37	35	33
			L_2		152	136	133	118	116	110	97	95	85	67	61	53	50	48	45	43	41	38
	5/8	1	T	249	246	243	241	239	238	234	233	229	224	217	212	205	197	194	188	183	178	169
			L_1	238	229	203	196	185	182	161	156	142	127	111	101	91	82	79	75	71	68	63
			L_2	273	263	233	225	212	209	184	179	163	145	127	116	104	94	91	86	82	78	72
		2	T				249	247	246	244	243	241	238	234	230	226	221	220	216	213	210	203
			L_1				308	289	285	250	242	219	194	168	152	136	121	117	109	103	98	90
			L_2				354	332	327	287	277	252	223	193	175	156	139	134	126	118	112	103
2 1/2	3/8	1	T	242	240	237	235	231	230	226	223	221	216	203	196	188	178	175	169	163	157	147
			L_1	91	89	80	78	70	69	66	59	57	53	42	39	35	32	31	30	28	27	26
			L_2	105	102	92	89	80	79	75	68	66	60	49	45	41	37	36	34	33	31	29
		2	T		249	246	245	242	242	240	237	236	233	225	221	215	209	207	203	199	195	187
			L_1		139	125	121	108	107	101	90	88	80	63	58	52	47	45	43	40	38	35
			L_2		159	144	139	124	123	116	104	100	92	73	66	60	54	52	49	46	44	41
	5/8	1	T	249	246	244	242	240	239	236	234	231	227	220	215	209	202	200	195	190	186	178
			L_1	250	239	213	207	195	192	171	165	152	137	119	109	98	89	86	81	77	73	68
			L_2	266	274	244	237	223	220	196	190	174	157	137	124	112	102	98	93	88	84	78
		2	T				249	247	247	245	244	242	239	236	233	229	225	223	220	217	214	209
			L_1				325	305	300	266	257	235	211	182	165	148	132	129	119	113	107	98
			L_2				373	349	344	305	295	270	242	208	189	169	152	146	137	129	123	112
3	3/8	1	T	242	240	237	236	232	231	229	225	223	219	208	200	193	184	181	175	170	165	155
			L_1	95	92	83	81	73	72	69	62	60	55	46	41	38	34	33	32	30	29	27
			L_2	108	105	96	93	84	83	79	71	69	63	52	47	43	39	38	36	35	33	31
		2	T		249	247	245	243	242	241	238	237	235	228	223	219	213	211	207	204	200	193
			L_1		144	130	126	113	112	106	95	93	84	69	61	55	50	49	46	43	41	38
			L_2		165	150	145	130	129	122	109	106	97	79	71	64	58	56	52	50	47	44
	5/8	1	T	249	247	244	242	240	239	237	235	233	229	224	218	213	207	205	200	196	192	184
			L_1	259	247	222	216	203	201	180	175	162	146	128	115	104	95	92	86	82	78	72
			L_2	297	284	254	247	233	230	206	200	185	167	147	132	120	109	105	99	94	90	83
		2	T				249	248	247	245	244	243	240	237	234	231	227	226	223	221	219	213
			L_1				339	318	314	281	272	251	225	197	176	158	142	137	129	122	115	105
			L_2				389	365	360	322	312	287	258	226	202	181	163	157	148	139	132	121

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-10

STEAM TRACING DATA
TRACER BONDED TO PIPE WITH HEAT TRANSFER CEMENT

INSULATION THICKNESS	TRACER SIZE (OD)	NUMBER OF TRACERS	SEE NOTE¹ BELOW	25 psig (267F) STEAM — PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)																	
				3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
1	3/8	1	T	257	253	248	245	240	238	233	226	225	217									
			L_1	97	93	82	78	71	69	64	58	58	52									
			L_2	111	106	93	89	80	79	72	66	66	59									
		2	T		265	262	259	256	255	251	248	246	242									
			L_1		146	127	120	108	106	97	87	87	78									
			L_2		166	144	137	123	121	110	99	99	88									
	5/8	1	T	263	262	258	255	251	250	245	244	238	230									
			L_1	260	243	217	209	189	185	167	165	147	129									
			L_2	295	276	247	237	215	211	190	188	167	146									
		2	T				266	263	262	259	258	254	250									
			L_1				327	294	288	257	255	224	195									
			L_2				371	334	327	293	289	253	222									
1 1/2	3/8	1	T	257	255	251	247	243	242	239	232	230	223	205	193	184	172	167	159	152	146	134
			L_1	104	100	92	85	77	76	73	64	63	57	45	41	38	35	34	32	31	30	28
			L_2	118	114	104	96	88	87	83	73	72	65	52	47	43	39	38	37	35	34	32
		2	T		265	263	260	258	256	254	251	249	245	233	226	220	211	208	202	196	191	181
			L_1		156	143	131	119	117	112	98	93	86	67	59	55	49	47	44	42	40	37
			L_2		178	163	149	134	133	127	111	108	98	76	68	62	56	54	51	48	46	42
	5/8	1	T	265	262	259	257	254	253	249	246	242	236	227	219	212	202	198	192	186	180	169
			L_1	288	262	237	228	217	213	186	181	163	145	126	112	104	93	90	85	81	77	72
			L_2	327	297	269	259	246	243	211	206	185	164	143	128	118	106	102	97	92	88	82
		2	T				266	264	263	260	259	256	253	247	242	238	232	229	225	221	217	209
			L_1				358	339	333	298	280	251	220	190	168	153	136	131	123	116	110	101
			L_2				407	385	378	327	318	285	251	216	191	174	155	149	139	132	125	115
2	3/8	1	T	258	256	252	250	245	244	241	236	234	228	212	204	194	183	179	171	165	158	147
			L_1	109	106	95	93	83	82	78	69	67	61	49	45	41	38	37	35	33	32	30
			L_2	124	120	108	106	94	93	89	79	77	70	56	52	47	43	42	40	38	36	34
		2	T		265	263	261	258	257	256	252	251	247	238	233	226	218	216	210	206	201	192
			L_1		166	148	144	128	126	120	106	103	93	73	67	60	54	52	49	46	44	41
			L_2		188	168	164	145	143	136	120	117	105	83	76	68	61	59	56	53	50	46
	5/8	1	T	266	263	260	258	255	254	250	248	245	240	232	226	219	210	207	201	196	191	181
			L_1	297	286	253	245	230	227	200	194	177	158	138	126	113	102	99	93	89	85	78
			L_2	337	323	287	278	262	258	228	221	201	180	157	143	129	116	112	106	101	96	89
		2	T				266	264	263	261	260	257	254	250	246	242	237	235	231	227	224	217
			L_1				384	360	355	311	301	273	242	209	190	169	151	146	136	129	122	112
			L_2				436	410	403	354	342	311	275	238	216	192	172	166	155	146	139	127
2 1/2	3/8	1	T	259	256	253	251	247	246	243	238	236	231	217	210	201	191	187	181	174	169	158
			L_1	114	110	100	97	87	86	82	74	71	66	53	49	44	40	39	37	36	34	32
			L_2	130	126	114	110	99	98	93	84	81	74	60	55	50	46	45	42	41	39	36
		2	T		266	263	261	259	258	256	254	252	249	241	236	230	224	221	217	212	208	200
			L_1		173	156	151	135	133	126	113	109	100	79	72	65	58	56	53	50	48	44
			L_2		197	177	172	154	152	143	128	124	113	90	82	74	66	64	60	57	55	50
	5/8	1	T	266	263	260	258	256	255	252	250	247	243	236	230	224	216	214	209	204	199	190
			L_1	311	298	265	257	242	239	213	206	189	171	149	135	132	111	107	101	96	91	85
			L_2	353	338	302	293	275	272	242	234	215	194	169	154	139	126	122	115	109	104	96
		2	T				266	264	263	261	260	258	256	252	248	245	240	239	235	232	229	223
			L_1				405	379	374	332	320	293	263	226	205	184	165	159	149	141	133	122
			L_2				460	431	425	377	364	333	299	257	233	209	187	181	169	160	152	139
3	3/8	1	T	259	257	254	252	248	247	245	240	239	234	222	214	206	197	194	186	182	177	167
			L_1	118	114	104	101	91	90	86	77	75	69	57	53	47	43	42	40	38	36	34
			L_2	134	130	118	115	104	103	97	88	86	78	65	59	53	49	47	45	43	41	38
		2	T		265	263	262	260	259	257	255	253	251	244	239	234	229	226	222	218	214	207
			L_1		179	163	157	141	140	132	119	115	105	86	77	69	63	61	57	54	51	47
			L_2		204	185	178	161	159	150	135	131	119	97	87	79	71	69	65	61	58	54
	5/8	1	T	266	263	261	259	257	256	253	251	249	245	239	234	228	221	219	214	210	205	197
			L_1	322	308	277	269	253	250	224	218	201	181	160	144	130	118	114	108	102	98	90
			L_2	366	350	314	305	287	284	255	247	229	206	182	163	148	134	130	123	116	111	103
		2	T				266	264	264	262	261	259	257	253	250	247	243	241	239	236	233	228
			L_1				423	396	391	350	339	312	280	245	219	197	177	171	160	151	144	131
			L_2				480	450	444	397	385	355	318	279	249	224	202	194	182	172	163	149

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-11

STEAM TRACING DATA
TRACER BONDED TO PIPE WITH HEAT TRANSFER CEMENT

INSULATION THICKNESS	TRACER SIZE (OD)	NUMBER OF TRACERS	SEE NOTE[1] BELOW	35 psig (281F) STEAM — PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)																	
				3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
1	3/8	1	T	270	267	261	258	252	251	245	238	237	229									
			L_1	113	109	95	91	82	81	74	67	67	61									
			L_2	128	123	108	102	93	91	84	76	76	68									
		2	T		279	276	273	270	268	265	261	259	254									
			L_1		170	148	140	126	124	112	102	101	90									
			L_2		192	167	158	142	140	127	115	114	102									
	5/8	1	T	279	276	272	269	264	263	258	256	250	242									
			L_1	302	262	253	243	220	215	194	192	170	150									
			L_2	341	319	285	274	248	243	219	217	192	169									
		2	T				280	277	276	273	271	268	263									
			L_1				380	342	334	299	296	260	227									
			L_2				429	386	377	338	334	294	256									
1 1/2	3/8	1	T	271	268	264	260	256	254	252	244	242	235	215	204	194	181	176	168	161	154	141
			L_1	121	116	107	98	90	89	85	75	73	66	53	48	44	40	39	37	36	35	33
			L_2	136	131	121	111	102	100	96	84	83	75	60	54	50	46	44	42	41	39	37
		2	T		279	277	274	271	270	268	264	262	258	246	238	232	222	219	213	207	201	191
			L_1		152	166	152	138	136	130	114	111	100	78	69	64	57	55	52	49	47	43
			L_2		205	183	172	156	154	147	128	125	113	88	78	72	64	62	58	55	53	49
	5/8	1	T	279	276	273	270	267	266	262	259	255	248	239	230	223	213	209	202	196	190	178
			L_1	335	304	275	265	252	248	216	210	190	168	146	131	120	108	105	99	94	90	84
			L_2	378	343	311	300	284	280	244	238	214	190	165	148	136	122	118	112	106	102	94
		2	T				280	278	277	274	272	270	266	260	255	250	244	241	237	233	228	220
			L_1				416	393	387	334	325	291	256	221	195	178	158	152	143	135	128	117
			L_2				470	444	436	377	367	329	289	249	220	201	179	172	161	152	144	132
2	3/8	1	T	272	269	265	263	258	257	254	248	246	240	223	215	204	192	188	181	174	167	155
			L_1	127	123	110	108	96	95	91	91	78	71	58	53	48	44	43	41	39	37	35
			L_2	144	139	125	122	109	107	102	91	89	81	65	60	54	50	48	46	44	42	39
		2	T		279	277	275	272	271	269	266	264	260	250	245	238	230	227	222	217	212	202
			L_1		193	172	168	149	147	139	123	119	108	85	78	70	63	61	57	54	52	48
			L_2		217	194	190	168	166	157	139	135	122	96	88	79	71	68	64	61	58	54
	5/8	1	T	279	277	274	271	269	267	263	262	258	252	244	238	230	222	218	212	207	201	191
			L_1	345	332	294	294	265	264	233	226	206	184	160	146	132	119	115	108	103	99	91
			L_2	389	375	331	321	302	298	263	255	232	207	181	165	149	134	130	122	116	111	103
		2	T				280	278	277	275	273	271	268	263	259	255	249	247	243	240	236	229
			L_1				446	419	412	362	350	318	282	243	221	197	176	169	159	150	142	130
			L_2				504	473	466	408	395	359	318	275	249	222	198	191	179	169	160	147
2 1/2	3/8	1	T	272	270	266	264	260	259	256	251	249	244	229	221	211	201	197	190	184	178	167
			L_1	133	129	116	113	102	100	95	86	83	78	62	57	51	47	46	43	41	40	37
			L_2	150	145	131	128	115	113	108	97	94	86	70	64	58	53	52	49	47	45	42
		2	T		279	277	275	273	272	270	267	266	262	254	249	243	236	233	228	224	219	211
			L_1		201	181	176	157	155	147	131	127	116	92	84	75	66	66	62	59	56	51
			L_2		227	205	198	177	175	166	148	143	131	104	95	85	77	74	70	66	63	58
	5/8	1	T	290	277	274	272	269	268	265	263	260	256	248	243	236	228	225	220	215	210	201
			L_1	361	316	308	299	282	278	248	240	220	199	172	157	142	129	124	117	111	106	96
			L_2	408	390	348	338	318	314	280	270	248	225	195	177	160	145	140	132	126	120	111
		2	T				290	278	277	275	274	272	269	265	262	258	253	251	248	245	241	235
			L_1				470	441	435	386	372	340	306	263	238	214	192	185	173	163	155	142
			L_2				531	498	491	435	420	384	346	297	269	241	216	209	195	184	175	160
3	3/8	1	T	273	270	267	265	261	260	256	253	251	246	234	226	217	208	204	196	192	186	176
			L_1	137	133	121	117	106	105	99	90	85	80	66	60	55	50	49	46	44	42	39
			L_2	155	150	137	132	120	118	112	102	99	90	75	68	62	56	55	52	50	48	44
		2	T		279	277	276	273	272	271	269	267	264	256	251	246	240	238	234	229	225	218
			L_1		209	189	183	164	162	154	138	134	122	99	89	80	73	70	66	63	60	55
			L_2		235	213	206	185	183	173	156	152	138	112	101	91	82	80	75	71	68	62
	5/8	1	T	280	277	274	272	270	269	266	265	262	258	252	246	240	233	230	226	221	216	206
			L_1	375	338	321	312	294	290	261	253	234	211	186	167	151	137	133	125	119	114	105
			L_2	423	404	363	353	332	329	284	286	264	238	210	189	171	155	150	142	134	128	118
		2	T				290	278	277	276	274	273	270	267	263	260	256	254	251	248	246	240
			L_1				501	461	454	406	399	363	325	285	255	229	206	199	186	176	167	153
			L_2				555	520	513	459	444	410	367	322	287	258	233	224	210	199	189	172

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-12

STEAM TRACING DATA
TRACER BONDED TO PIPE WITH HEAT TRANSFER CEMENT

50 psig (298F) STEAM

PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)

INSULATION THICKNESS	TRACER SIZE (OD)	NUMBER OF TRACERS	SEE NOTE BELOW	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
1	3/8	1	T	285	282	276	273	267	265	259	252	251	242									
			L_1	134	128	113	107	97	96	87	80	79	72									
			L_2	150	144	126	120	109	107	98	89	89	80									
		2	T		295	292	289	285	284	280	276	274	269									
			L_1		201	175	165	149	146	133	120	119	107									
			L_2		225	196	185	167	164	149	135	134	120									
	5/8	1	T	295	292	287	284	280	278	277	271	265	256									
			L_1	357	333	299	287	259	255	229	227	201	177									
			L_2	400	374	335	321	291	286	257	255	226	199									
		2	T				296	293	291	288	287	283	278									
			L_1				449	403	395	354	350	308	268									
			L_2				503	452	443	396	392	345	300									
1 1/2	3/8	1	T	286	283	280	275	270	269	266	258	256	249	228	216	206	192	187	178	170	163	150
			L_1	143	137	126	116	106	105	101	88	86	78	63	57	53	48	46	44	42	41	38
			L_2	160	154	142	130	119	118	113	99	97	88	70	63	59	54	52	50	48	46	43
		2	T		295	292	290	287	285	283	279	277	273	260	252	245	235	232	225	219	213	202
			L_1		215	197	180	164	161	154	134	131	118	92	82	75	67	65	61	58	55	51
			L_2		241	220	202	183	181	173	151	147	132	103	92	84	75	73	69	65	62	58
	5/8	1	T	295	292	288	286	283	281	276	274	269	263	253	244	236	225	221	214	207	201	189
			L_1	395	359	325	314	298	293	253	249	224	199	173	154	142	128	124	117	111	106	99
			L_2	443	403	364	352	334	329	286	279	251	223	194	173	160	143	139	131	125	119	111
		2	T				296	294	292	290	288	285	281	275	270	263	258	255	251	246	242	233
			L_1				492	465	457	395	384	344	303	261	231	211	187	180	169	159	151	138
			L_2				551	521	512	443	431	386	339	293	259	236	210	202	189	178	170	155
2	3/8	1	T	287	285	280	278	273	272	269	262	260	254	236	227	216	204	199	191	184	177	165
			L_1	150	145	131	125	114	112	107	95	93	84	68	63	57	52	50	48	46	44	41
			L_2	169	163	146	143	128	126	120	107	104	95	76	70	64	58	57	54	51	50	46
		2	T		295	293	291	288	287	284	281	279	275	265	259	252	243	240	235	229	224	214
			L_1		227	203	198	176	173	165	145	141	128	101	92	82	74	72	67	64	61	56
			L_2		255	226	222	197	194	184	163	158	143	113	103	93	83	80	76	72	68	63
	5/8	1	T	295	293	289	287	284	283	278	277	273	267	258	252	244	234	231	225	219	213	202
			L_1	407	392	347	336	316	312	275	267	243	217	189	173	156	140	136	129	122	116	105
			L_2	457	440	389	376	355	350	309	299	273	243	212	194	175	157	152	144	137	131	121
		2	T				296	294	293	290	289	287	283	278	274	269	264	261	257	253	250	242
			L_1				527	495	487	427	414	373	333	287	261	233	208	200	187	177	168	154
			L_2				591	555	546	479	464	421	373	322	292	261	233	224	210	198	188	172
2 1/2	3/8	1	T	298	295	292	279	275	274	271	265	263	258	242	234	224	213	209	202	195	188	177
			L_1	157	152	137	133	120	119	113	101	98	90	73	67	61	56	54	51	49	47	44
			L_2	176	170	154	150	135	133	126	113	110	101	82	75	68	62	61	58	55	53	49
		2	T		295	293	291	288	287	285	282	281	277	268	263	257	249	247	242	237	232	223
			L_1		239	214	208	186	183	174	155	150	137	101	99	89	80	78	69	63	66	61
			L_2		267	240	233	208	206	195	174	168	154	122	111	100	90	87	82	78	74	65
	5/8	1	T	295	293	290	287	285	284	280	278	275	270	262	257	249	241	238	233	227	222	212
			L_1	427	409	364	353	333	329	293	293	260	235	204	186	168	152	147	139	132	126	116
			L_2	478	458	409	396	373	368	329	317	292	264	229	208	188	170	165	155	148	141	130
		2	T				296	294	293	291	289	287	285	280	277	272	268	266	262	259	255	249
			L_1				556	521	513	455	439	402	362	311	282	252	226	218	205	193	183	168
			L_2				623	584	576	511	493	451	405	349	316	283	254	245	229	216	206	188
3	3/8	1	T	286	286	282	280	276	275	272	268	266	260	247	239	230	220	216	210	203	197	186
			L_1	162	157	143	139	125	124	118	106	103	95	78	71	65	59	57	54	52	50	47
			L_2	182	176	160	155	141	139	132	119	116	106	88	79	72	66	64	61	58	56	52
		2	T		295	293	291	289	288	286	283	282	279	271	266	260	254	252	247	243	238	230
			L_1		246	223	216	194	192	181	163	159	144	118	105	95	86	83	78	74	71	65
			L_2		276	250	242	218	215	204	183	178	162	132	119	107	97	93	88	83	79	73
	5/8	1	T	296	293	290	288	286	285	281	280	277	272	266	260	254	247	244	239	234	229	220
			L_1	443	423	380	369	347	343	308	299	277	249	220	198	179	162	157	148	141	134	124
			L_2	496	474	426	414	389	385	345	335	310	279	247	222	201	182	176	166	158	151	139
		2	T				296	294	293	291	290	288	286	282	278	275	271	269	266	263	260	254
			L_1				580	544	537	480	465	429	384	337	301	270	244	235	220	208	197	180
			L_2				651	612	602	538	521	481	431	378	337	303	273	263	247	233	221	202

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-13

STEAM TRACING DATA
TRACER BONDED TO PIPE WITH HEAT TRANSFER CEMENT

INSULATION THICKNESS	TRACER SIZE (OD)	NUMBER OF TRACERS	SEE NOTE¹ BELOW	75 psig (320F) STEAM — PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)																		
				3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
1	3/8	1	T	308	304	298	294	288	286	279	272	270	261									
			L_1	162	155	136	130	118	116	106	97	96	87									
			L_2	180	173	152	144	131	129	118	107	107	97									
		2	T		318	314	311	307	306	302	297	296	290									
			L_1		243	211	200	180	177	161	145	145	129									
			L_2		270	235	223	200	197	179	162	161	144									
	5/8	1	T	318	314	310	306	301	300	294	292	285	276									
			L_1	431	404	361	347	314	308	278	275	244	214									
			L_2	480	449	402	386	349	343	309	306	271	238									
		2	T				319	316	314	311	309	305	300									
			L_1				543	488	478	428	423	372	324									
			L_2				604	543	531	478	471	414	361									
1 1/2	3/8	1	T	309	306	301	297	292	290	287	279	276	268	246	233	222	207	202	193	184	176	162
			L_1	173	166	153	141	129	127	122	107	105	95	76	68	64	58	56	54	51	50	47
			L_2	192	185	170	157	143	141	135	119	117	106	84	76	71	64	63	60	57	55	52
		2	T		318	315	312	309	308	305	301	299	294	280	272	264	254	250	243	236	230	218
			L_1		260	238	218	198	195	137	163	159	143	111	99	91	81	79	74	70	67	62
			L_2		289	265	242	220	217	207	191	177	159	124	110	101	91	88	82	78	75	69
	5/8	1	T	318	315	311	308	305	303	296	296	290	283	273	263	255	243	239	231	224	217	205
			L_1	478	435	393	379	360	355	309	301	271	240	209	187	172	155	150	141	135	129	120
			L_2	532	483	437	422	401	394	343	335	301	267	233	208	192	172	167	157	150	143	133
		2	T				319	316	315	312	310	307	303	297	291	285	279	275	270	265	261	252
			L_1				595	562	553	478	465	417	366	316	279	255	226	218	204	193	183	168
			L_2				662	625	615	531	517	463	407	351	310	284	252	242	227	214	204	186
2	3/8	1	T	310	307	302	300	294	293	290	283	281	274	255	245	235	220	215	207	199	192	178
			L_1	182	176	158	155	138	136	130	115	112	102	82	76	69	63	61	58	56	53	50
			L_2	202	195	176	172	153	151	144	128	125	114	92	84	77	70	68	65	62	60	56
		2	T		318	315	313	310	309	307	303	301	297	285	279	271	263	259	253	247	242	231
			L_1		275	246	240	213	210	199	176	171	154	122	111	100	90	87	82	77	74	68
			L_2		306	274	267	237	233	221	196	190	172	136	124	111	100	97	91	86	82	76
	5/8	1	T	318	315	312	309	306	305	300	298	294	288	279	272	263	253	249	242	236	230	219
			L_1	493	475	420	406	383	378	333	323	294	263	229	209	188	170	164	155	148	141	131
			L_2	548	528	467	452	426	420	370	359	327	292	255	233	210	189	183	173	164	157	145
		2	T				319	317	315	313	311	309	305	300	295	290	284	282	277	273	269	261
			L_1				638	599	590	517	501	454	403	348	315	282	251	242	227	214	203	186
			L_2				709	666	655	575	557	505	448	387	351	313	279	269	252	238	226	207
2 1/2	3/8	1	T	310	307	303	301	296	295	292	286	284	278	261	252	241	230	226	218	210	203	191
			L_1	190	184	166	162	145	144	136	123	119	109	88	81	74	67	65	62	59	57	53
			L_2	211	204	185	180	162	160	152	136	132	121	98	90	82	75	73	69	66	64	59
		2	T		318	316	314	311	310	308	304	303	299	289	283	277	269	266	261	255	250	241
			L_1		298	259	251	225	222	210	188	182	166	132	120	108	97	94	89	84	80	74
			L_2		320	298	279	250	247	234	209	202	184	146	133	120	108	105	99	93	89	82
	5/8	1	T	318	316	312	310	307	306	302	300	296	291	283	277	269	260	257	251	245	240	229
			L_1	516	495	441	428	403	398	354	342	315	291	247	225	203	184	178	168	159	152	141
			L_2	574	550	490	476	448	442	394	381	350	316	274	250	226	204	198	187	177	169	157
		2	T				319	317	316	313	312	310	307	302	298	294	288	286	283	279	275	268
			L_1				672	630	621	551	532	487	439	376	341	305	274	264	248	234	272	203
			L_2				748	701	691	613	591	541	487	418	379	340	305	294	275	260	247	226
3	3/8	1	T	311	308	304	302	298	297	294	289	286	281	267	258	248	237	234	226	219	213	201
			L_1	196	190	173	168	152	150	142	129	125	115	93	86	78	72	70	66	63	61	56
			L_2	218	211	192	187	169	167	158	143	139	127	105	95	87	80	77	73	70	67	63
		2	T		318	316	314	311	310	308	305	304	301	292	287	281	274	271	266	262	257	249
			L_1		298	270	261	235	232	220	198	192	175	142	128	115	104	101	95	90	86	79
			L_2		332	300	290	261	258	244	220	214	194	158	142	128	116	112	106	100	95	98
	5/8	1	T	318	316	313	310	308	307	303	301	298	294	287	280	273	266	263	257	252	247	238
			L_1	536	512	459	447	420	415	373	362	335	302	268	239	216	197	190	179	170	163	150
			L_2	595	569	511	497	467	462	415	402	372	335	296	266	241	219	211	199	189	181	167
		2	T				319	317	316	314	313	311	309	304	300	296	292	290	286	283	280	274
			L_1				702	658	649	551	562	519	465	408	364	327	295	284	267	252	239	219
			L_2				751	732	722	616	625	577	517	454	405	364	328	316	296	280	266	243

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-14

STEAM TRACING DATA
TRACER BONDED TO PIPE WITH HEAT TRANSFER CEMENT

200 psig (388 F) STEAM

INSULATION THICKNESS	TRACER SIZE (OD)	NUMBER OF TRACERS	SEE NOTE BELOW	PROCESS LINE NOMINAL PIPE SIZE (APPLICABLE OD SIZES LISTED UNDER NOMINAL IPS)																	
				3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
1	3/8	1	T	372	368	361	356	348	346	338	329	328	316									
			L_1	263	252	221	211	191	188	172	157	156	141									
			L_2	287	275	242	230	208	205	188	171	170	154									
		2	T		385	380	377	372	370	365	360	358	351									
			L_1		394	343	325	292	287	261	236	235	210									
			L_2		430	374	355	319	313	285	258	256	229									
	5/8	1	T	385	380	375	371	365	363	356	354	346	335									
			L_1	700	655	586	563	510	500	450	446	396	348									
			L_2	764	715	640	614	556	546	492	487	432	380									
		2	T				386	382	380	376	374	369	363									
			L_1				881	792	775	694	687	604	526									
			L_2				961	863	846	758	749	659	574									
1 1/2	3/8	1	T	374	370	365	359	353	351	347	338	335	325	299	283	270	252	246	235	224	215	196
			L_1	280	270	248	229	209	206	198	174	170	154	123	111	104	94	92	87	84	81	76
			L_2	306	295	271	249	228	225	216	190	186	169	135	122	113	103	100	95	91	88	83
		2	T		385	381	378	374	372	369	364	362	356	340	329	320	308	303	295	287	279	265
			L_1		422	366	353	321	317	303	264	258	232	181	161	148	132	128	121	114	109	101
			L_2		461	422	386	351	346	331	288	281	253	197	176	161	145	140	132	125	119	110
	5/8	1	T	383	381	376	373	369	367	361	358	352	343	331	319	309	295	290	281	272	264	249
			L_1	776	705	638	616	585	576	501	488	440	390	340	303	280	251	243	230	219	209	194
			L_2	847	770	697	672	638	628	547	533	480	426	371	331	305	274	265	251	239	228	212
		2	T				386	383	381	378	376	372	367	359	352	346	337	334	327	322	316	305
			L_1				966	912	897	775	754	676	595	512	453	414	367	354	331	313	297	272
			L_2				1054	996	979	846	823	737	649	559	494	452	401	386	362	341	324	297
2	3/8	1	T	373	371	366	363	356	355	351	343	340	332	309	297	283	267	262	252	242	233	217
			L_1	295	285	257	251	224	221	211	187	182	166	134	123	112	102	99	95	90	87	82
			L_2	322	311	280	274	244	241	230	204	199	181	146	135	122	112	109	103	99	95	89
		2	T		385	382	379	375	374	371	366	364	359	346	338	329	318	314	307	300	293	281
			L_1		447	399	390	345	341	323	286	277	251	198	181	162	146	141	133	126	120	111
			L_2		488	436	425	377	372	353	312	303	274	216	197	177	159	154	145	137	131	121
	5/8	1	T	385	381	377	374	370	369	363	361	356	348	338	329	319	307	302	294	287	279	266
			L_1	799	770	681	659	621	613	541	524	478	426	372	339	306	276	267	252	240	229	212
			L_2	872	840	743	719	678	669	590	572	521	465	406	371	334	301	291	275	261	250	232
		2	T				386	383	382	379	377	374	369	363	358	351	344	341	336	331	326	317
			L_1				1035	971	956	839	812	737	653	564	512	457	408	393	368	348	330	302
			L_2				1129	1060	1044	916	886	804	713	616	559	499	445	429	402	379	360	329
2 1/2	3/8	1	T	375	372	367	364	359	357	353	347	344	337	316	306	293	279	274	265	256	248	232
			L_1	308	298	270	262	236	233	221	199	193	177	143	132	120	110	107	101	97	93	87
			L_2	336	325	295	286	257	255	242	217	211	193	157	144	131	120	116	110	106	101	95
		2	T		385	382	379	376	375	372	368	366	362	350	343	335	326	323	316	310	304	293
			L_1		467	421	407	365	360	341	304	295	269	214	195	175	158	153	144	136	130	120
			L_2		510	459	445	398	393	372	332	322	294	233	212	191	173	167	157	149	142	131
	5/8	1	T	385	382	378	375	372	370	365	363	359	353	343	333	326	316	312	304	297	291	278
			L_1	838	802	715	694	654	645	575	556	511	462	400	365	330	298	289	272	259	247	229
			L_2	914	875	781	757	713	704	627	606	557	504	437	398	360	326	315	297	282	270	249
		2	T				386	383	382	379	378	375	371	365	361	355	349	347	342	338	334	325
			L_1				1091	1023	1008	894	862	790	710	611	553	496	445	429	402	379	360	329
			L_2				1190	1116	1100	976	941	862	775	666	604	541	485	468	438	414	393	359
3	3/8	1	T	376	373	368	366	360	359	356	349	347	340	323	312	301	288	284	275	267	259	245
			L_1	318	309	281	272	246	244	231	209	204	186	154	139	127	116	113	107	102	98	92
			L_2	347	337	307	297	269	266	252	228	222	203	168	152	139	127	123	117	112	107	100
		2	T		395	382	380	377	375	373	370	368	364	354	347	340	332	329	323	317	312	302
			L_1		484	438	424	381	377	357	321	312	284	231	207	187	169	164	154	146	139	128
			L_2		528	479	462	416	411	389	350	340	310	252	226	204	185	179	168	160	152	140
	5/8	1	T	385	382	378	376	372	371	367	365	361	356	347	340	331	322	319	312	306	300	288
			L_1	869	831	745	724	682	674	605	587	543	489	432	398	351	319	309	291	276	264	244
			L_2	948	906	813	791	744	735	660	640	593	534	471	434	383	348	337	318	302	288	266
		2	T				386	384	382	380	378	376	373	368	363	358	353	351	347	343	339	332
			L_1				1139	1068	1050	942	912	842	755	662	591	531	479	461	433	409	388	355
			L_2				1243	1165	1150	1028	996	919	824	722	645	580	522	504	472	446	423	387

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-15
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TEMPERATURE MAINTENANCE IN CEMENTED STEAM TRACED STORAGE VESSELS TRACER BONDED TO VESSEL WITH HEAT TRANSFER CEMENT

1" THICK SPEC. NO. 22-H, 23-H
-20° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	132	154	185	208	217	220
25	140	168	205	230	240	244
50	150	186	227	256	268	274
100	65	210	257	288	302	311
150	175	226	275	311	328	337
200	185	241	289	331	347	357

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With ½" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	140	165	195	214	220	223
25	150	183	215	238	244	245
50	162	202	238	265	273	276
100	180	227	271	298	310	314
150	195	245	290	323	336	341
200	205	259	306	342	356	362

1" THICK SPEC. NO. 22-H, 23-H
0° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	135	160	191	212	219	222
25	144	178	211	235	243	245
50	155	197	233	262	272	275
100	174	221	266	293	307	312
150	185	239	284	318	332	339
200	195	253	298	338	352	360

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With ½" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	144	171	200	217	222	224
25	155	190	221	241	245	246
50	170	211	244	268	275	278
100	192	237	277	302	312	316
150	206	255	298	328	339	343
200	217	269	316	347	360	365

1" THICK SPEC. NO. 22-H, 23-H
30° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	145	171	205	217	222	223
25	155	190	221	242	245	245
50	172	210	245	269	275	278
100	193	238	278	303	313	316
150	208	257	298	329	340	343
200	221	270	316	349	360	364

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With ½" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	153	183	207	220	223	
25	168	203	230	245	245	
50	185	225	255	275	277	
100	210	255	288	310	316	
150	227	274	312	337	343	
200	241	287	341	357	365	

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-18
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TEMPERATURE MAINTENANCE IN CEMENTED STEAM TRACED STORAGE VESSELS
TRACER BONDED TO VESSEL WITH HEAT TRANSFER CEMENT

1" THICK SPEC. NO. 22-H, 23-H
50° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	150	181	205	219	223	225
25	163	202	227	243	245	248
50	180	223	252	272	277	282
100	203	252	284	308	314	320
150	218	271	306	334	342	347
200	232	284	326	353	363	370

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With ½" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	162	192	213	222	225	227
25	180	212	236	245	248	250
50	199	235	263	275	281	285
100	222	267	295	313	319	324
150	240	286	320	340	346	351
200	255	301	340	361	368	375

1-½" THICK SPEC. 22-H, 23-H
-20° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	32	168	197	217	223	225
25	150	190	220	243	250	251
50	165	212	245	269	275	276
100	187	235	277	304	315	318
150	200	254	299	332	343	348
200	215	272	317	349	362	369

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With ½" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	145	181	206	222	225	227
25	168	203	230	248	251	253
50	184	225	255	275	276	278
100	205	251	288	312	318	320
150	220	271	312	340	348	350
200	242	288	330	358	368	372

1-½" THICK SPEC. 22-H, 23-H
0° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	140	175	202	219	224	226
25	163	196	225	246	251	252
50	180	218	250	272	276	277
100	202	242	283	308	317	319
150	217	262	306	336	346	349
200	240	280	324	354	366	370

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With ½" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	150	186	210	223	225	227
25	173	208	234	250	252	253
50	190	232	260	275	277	278
100	212	260	293	315	318	321
150	227	282	319	343	348	350
200	250	298	336	362	370	373

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-21
T-22
T-23

TEMPERATURE MAINTENANCE IN CEMENTED STEAM TRACED STORAGE VESSELS TRACER BONDED TO VESSEL WITH HEAT TRANSFER CEMENT

1-½" THICK SPEC. 22-H, 23-H
30°F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	155	185	210	223	225	227
25	176	208	233	249	251	253
50	194	230	260	266	277	279
100	215	260	293	314	320	320
150	232	280	318	343	350	350
200	253	297	335	362	370	374

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With ½" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
1	167	191	215	225	227	
10	190	218	240	250	253	
50	211	243	267	277	279	
100	234	275	302	318	320	
150	252	296	328	347	350	
200	271	314	347	368	373	

1½" THICK SPEC. 22-H, 23-H
50° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	160	192	213	224	227	229
25	182	215	238	250	252	255
50	201	238	265	276	277	280
100	224	268	299	317	320	324
150	241	290	325	346	349	351
200	260	312	342	366	371	374

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With ½" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	175	202	219	225	229	230
25	196	225	245	252	255	255
50	217	250	272	277	280	281
100	242	282	312	318	323	324
150	262	305	335	348	351	351
200	280	322	353	370	374	375

2" THICK SPEC. 22-H, 23-H
-20° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	155	187	208	223	228	229
25	170	207	232	248	254	256
50	190	229	257	276	280	281
100	220	260	290	312	318	320
150	235	277	316	337	343	346
200	255	293	333	358	366	370

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With ½" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	170	196	215	227	229	230
25	184	218	329	253	255	257
50	209	241	267	278	280	282
100	235	272	300	316	320	322
150	250	294	326	342	346	350
200	268	310	344	364	369	373

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-24
T-25
T-26

TEMPERATURE MAINTENANCE IN CEMENTED STEAM TRACED STORAGE VESSELS
TRACER BONDED TO VESSEL WITH HEAT TRANSFER CEMENT

2" THICK SPEC. 22-H, 23-H
0° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	160	190	212	225	228	229
25	175	210	235	250	255	256
50	200	233	265	277	280	282
100	225	263	294	314	318	320
150	240	282	321	338	345	347
200	260	297	338	361	367	371

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With ½" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	175	199	217	227	229	230
25	190	222	242	254	256	257
50	215	245	270	279	282	283
100	242	277	303	317	320	323
150	258	298	329	342	347	351
200	274	316	348	366	370	375

2" THICK SPEC. 22-H, 23-H
30° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	172	196	215	227	229	230
25	186	217	241	253	255	257
50	211	242	268	280	280	283
100	239	273	300	317	320	323
150	255	296	327	342	347	350
200	272	311	346	365	370	373

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With ½" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	182	205	221	229	230	
25	200	227	246	255	257	
50	224	253	274	280	283	
100	253	285	308	320	322	
150	272	311	334	345	350	
200	287	327	354	369	373	

2" THICK SPEC. 22-H, 23-H
50° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	177	201	218	228	229	230
25	195	223	243	254	256	257
50	217	247	271	279	282	284
100	245	280	305	318	321	324
150	262	303	330	343	348	352
200	278	320	350	367	371	375

Steam Pressure Psig	Feet of Tubing per Square Foot of Heated Surface With ½" O.D. Tubing					
	.25	.50	1.0	2.0	3.0	4.0
10	187	208	223	229	229	232
25	208	232	249	256	257	259
50	230	257	276	280	282	286
100	260	290	312	320	321	326
150	278	316	337	346	348	354
200	294	333	358	370	372	377

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-27
T-28

TEMPERATURE MAINTENANCE IN CEMENTED STEAM TRACED STORAGE VESSELS
TRACER BONDED TO VESSEL WITH HEAT TRANSFER CEMENT

3" THICK SPEC. 22-H, 23-H
30° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
Psig	.25	.50	1.0	2.0	3.0	4.0
10	192	206	221	230	230	232
25	204	224	245	260	260	262
50	231	255	276	285	287	288
100	261	287	313	325	327	329
150	280	312	338	350	353	355
200	298	330	356	372	375	378
250	322	345	374	390	392	395

Steam Pressure	Feet of Tubing per Square Foot of Heated Surface With ½" O.D. Tubing					
Psig	.25	.50	1.0	2.0	3.0	4.0
10	197	212	226	230	232	
25	210	232	252	260	262	
50	240	264	280	286	288	
100	271	299	317	325	329	
150	293	325	343	351	355	
200	310	342	362	373	378	
250	325	358	380	391	395	

3" THICK SPEC. 22-H, 23-H
50° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
Psig	.25	.50	1.0	2.0	3.0	4.0
10	194	209	223	230	231	232
25	208	227	248	259	260	262
50	235	259	277	286	287	289
100	263	292	314	325	327	329
150	281	317	340	350	353	356
200	300	335	358	372	376	379
250	315	350	375	389	392	395

Steam Pressure	Feet of Tubing per Square Foot of Heated Surface With ½" O.D. Tubing					
Psig	.25	.50	1.0	2.0	3.0	4.0
10	199	215	227	231	232	234
25	214	235	255	260	262	264
50	245	267	282	287	288	291
100	272	303	319	326	329	330
150	295	330	345	352	356	358
200	312	346	365	374	379	381
250	326	362	383	391	395	397

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-29
T-30

TEMPERATURE MAINTENANCE IN CEMENTED STEAM TRACED STORAGE VESSELS
TRACER BONDED TO PIPE WITH HEAT TRANSFER CEMENT

3" THICK SPEC. 22-H, 23-H
-20° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
Psig	.25	.50	1.0	2.0	3.0	4.0
10	185	201	217	228	230	231
25	200	217	238	257	260	260
50	220	249	270	283	286	287
100	255	277	307	321	325	327
150	270	300	333	347	351	353
200	290	318	350	367	373	375
250	302	332	366	385	390	392

Steam Pressure	Feet of Tubing per Square Foot of Heated Surface With ½" O.D. Tubing					
Psig	.25	.50	1.0	2.0	3.0	4.0
10	191	207	222	230	231	232
25	206	225	246	260	260	261
50	227	257	276	285	287	289
100	260	289	313	325	327	329
150	276	315	339	350	353	355
200	296	331	357	372	375	378
250	310	347	374	390	392	395

3" THICK SPEC. 22-H, 23-H
0° F AMBIENT TEMPERATURE

TEMPERATURE MAINTAINED ° F

Steam Pressure	Feet of Tubing per Square Foot of Heated Surface With 3/8" O.D. Tubing					
Psig	.25	.50	1.0	2.0	3.0	4.0
10	187	203	218	229	230	232
25	202	220	240	258	260	260
50	222	251	272	284	287	287
100	257	280	309	322	325	328
150	272	305	335	348	352	354
200	292	322	353	369	373	376
250	304	336	370	387	390	393

Steam Pressure	Feet of Tubing per Square Foot of Heated Surface With ½" O.D. Tubing					
Psig	.25	.50	1.0	2.0	3.0	4.0
10	194	210	223	230	231	232
25	208	228	248	260	260	262
50	234	260	277	286	287	289
100	264	293	315	325	327	330
150	282	320	340	351	353	357
200	300	336	359	372	376	380
250	315	352	376	390	392	395

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-31

ELECTRIC HEAT TRACING - MI CABLE, BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

1" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP-20.0 F (-28.9 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
4C	PIPE TEMP	55.5	55.0	54.5	53.6	52.4	51.8	50.3	50.1	47.9	45.2									
	MAX.W /FT	3.4	3.6	3.8	4.3	4.9	5.2	6.0	6.0	7.3	8.7									
	MIN.W /FT	3.1	3.4	3.6	4.0	4.5	4.7	5.3	5.4	6.5	7.6									
8C	PIPE TEMP	74.1	73.6	72.9	71.7	70.3	69.6	67.6	67.6	64.5	61.2									
	MAX.W /FT	4.3	4.6	4.9	5.6	6.3	6.6	7.6	7.7	9.4	11.0									
	MIN.W /FT	4.0	4.3	4.5	5.1	5.7	6.0	6.8	6.9	8.2	9.6									
12C	PIPE TEMP	92.7	92.1	91.3	89.8	88.0	87.2	84.8	84.6	81.1	77.1									
	MAX.W /FT	5.4	5.7	6.0	6.9	7.8	8.1	9.4	9.4	11.5	13.5									
	MIN.W /FT	5.0	5.3	5.6	6.3	7.0	7.3	8.3	8.5	10.1	11.7									
16C	PIPE TEMP	111.3	110.6	109.6	107.8	105.7	104.8	101.9	101.7	97.3	92.8									
	MAX.W /FT	6.4	6.8	7.2	8.2	9.3	9.7	11.2	11.2	13.6	16.1									
	MIN.W /FT	6.0	6.3	6.6	7.5	8.4	8.7	9.9	10.1	11.9	13.9									
20C	PIPE TEMP	129.7	129.0	127.8	125.8	123.3	122.2	118.8	118.7	113.5	108.4									
	MAX.W /FT	7.6	8.0	8.5	9.6	10.9	11.4	13.1	13.1	15.9	18.7									
	MIN.W /FT	7.0	7.4	7.8	8.8	9.8	10.2	11.6	11.7	13.9	16.1									
24C	PIPE TEMP	148.1	147.3	145.9	143.6	140.7	139.6	135.7	135.6	130.2	123.9									
	MAX.W /FT	8.7	9.2	9.7	11.1	12.5	13.1	15.0	15.0	18.2	21.4									
	MIN.W /FT	8.1	8.5	8.9	10.1	11.3	11.7	13.3	13.4	15.9	18.4									
28C	PIPE TEMP	166.4	165.5	164.0	161.4	158.1	156.9	152.5	152.4	146.4	139.3									
	MAX.W /FT	10.0	10.5	11.1	12.6	14.3	14.8	17.1	17.0	20.6	24.2									
	MIN.W /FT	9.2	9.6	10.1	11.4	12.8	13.2	15.0	15.1	17.9	20.8									
32C	PIPE TEMP	184.7	183.7	182.0	179.0	175.4	174.0	169.2	169.1	162.4	154.6									
	MAX.W /FT	11.3	11.9	12.5	14.2	16.1	16.6	19.2	19.0	23.1	27.1									
	MIN.W /FT	10.3	10.9	11.4	12.9	14.4	14.8	16.8	16.9	20.0	23.2									
40C	PIPE TEMP	202.9	201.9	199.9	196.6	192.6	191.2	185.7	185.6	178.6	169.7									
	MAX.W /FT	12.6	13.1	13.9	15.9	17.9	18.5	21.3	21.1	25.6	30.1									
	MIN.W /FT	11.6	12.1	12.7	14.3	16.0	16.5	18.7	18.8	22.1	25.6									
48C	PIPE TEMP	221.0	219.9	217.8	214.1	209.8	208.2	202.2	202.3	194.3	184.8									
	MAX.W /FT	14.0	14.7	15.4	17.6	19.8	20.5	23.6	23.3	28.2	33.1									
	MIN.W /FT	12.8	13.4	14.0	15.8	17.7	18.1	20.8	20.6	24.3	28.1									
56C	PIPE TEMP	239.0	237.8	235.6	231.6	226.8	225.1	218.7	218.8	210.0	199.4									
	MAX.W /FT	15.5	16.2	16.9	19.4	21.8	22.5	25.7	25.5	30.9	36.3									
	MIN.W /FT	14.1	14.7	15.3	17.4	19.4	19.9	22.6	22.5	26.6	31.7									
64C	PIPE TEMP	257.0	255.7	253.4	249.0	243.8	242.0	235.0	235.2	225.7	214.7									
	MAX.W /FT	17.0	17.7	18.5	21.2	23.9	24.6	28.3	27.5	33.7	39.5									
	MIN.W /FT	15.6	16.1	16.7	19.0	21.1	21.7	24.8	24.5	28.8	33.3									
72C	PIPE TEMP	274.9	273.4	271.1	266.3	260.6	258.8	251.2	251.6	241.4	229.5									
	MAX.W /FT	18.6	19.3	20.2	23.1	26.0	26.7	30.7	30.1	36.5	42.3									
	MIN.W /FT	16.8	17.5	18.2	20.6	22.9	23.5	26.6	26.5	31.2	36.0									
80C	PIPE TEMP	319.3	317.6	315.0	309.2	302.5	300.5	291.4	292.1	280.0	266.0									
	MAX.W /FT	22.7	23.6	24.5	28.0	31.5	32.3	37.1	36.2	43.9	51.3									
	MIN.W /FT	20.5	21.2	22.0	24.9	27.7	28.2	31.9	31.7	37.2	42.9									
88C	PIPE TEMP	363.3	361.7	358.5	351.7	343.9	341.7	331.2	332.2	318.2	302.0									
	MAX.W /FT	27.2	28.1	29.1	33.3	37.4	38.2	43.9	42.7	51.7	60.1									
	MIN.W /FT	24.4	25.1	26.0	29.4	32.6	33.2	37.5	37.1	43.5	50.0									
96C	PIPE TEMP	407.0	405.1	401.7	393.9	384.9	382.6	370.5	371.7	355.9	337.6									
	MAX.W /FT	32.0	33.0	34.0	39.0	43.7	44.5	51.1	49.6	59.9	69.7									
	MIN.W /FT	28.5	29.3	30.2	34.1	37.8	38.4	43.4	42.8	50.0	57.4									
104C	PIPE TEMP	450.3	448.4	444.6	435.6	425.5	423.0	409.4	411.2	393.3	372.7									
	MAX.W /FT	37.1	38.1	39.2	44.9	50.3	51.0	58.6	56.4	68.3	79.5									
	MIN.W /FT	32.4	33.3	34.6	39.1	43.3	43.8	49.4	48.6	56.8	65.0									
112C	PIPE TEMP	493.3	491.5	487.2	477.1	465.9	463.2	447.9	450.2	430.3	407.5									
	MAX.W /FT	42.4	43.5	44.7	51.1	57.2	57.9	66.4	63.8	77.1	90.6									
	MIN.W /FT	37.4	38.2	39.3	44.3	48.9	49.4	55.6	54.7	63.7	72.8									
120C	PIPE TEMP	536.1	534.2	529.5	518.3	505.9	503.1	486.2	489.0	466.9	441.9									
	MAX.W /FT	48.1	49.2	50.4	57.6	64.3	65.0	74.5	71.3	86.3	100.1									
	MIN.W /FT	42.2	43.2	44.0	49.8	54.7	55.2	62.1	60.9	70.9	80.8									
128C	PIPE TEMP	578.6	576.6	571.6	559.3	545.6	542.7	524.2	527.5	503.4	476.0									
	MAX.W /FT	54.0	55.1	56.3	64.3	71.8	72.6	83.0	79.1	95.7	110.9									
	MIN.W /FT	47.1	47.9	49.0	55.2	60.7	61.1	68.7	67.2	78.2	89.0									
136C	PIPE TEMP	620.6	618.9	613.5	600.1	585.2	582.2	562.0	565.8	539.6	509.9									
	MAX.W /FT	60.2	61.4	62.5	71.3	79.5	80.1	91.7	87.2	105.4	122.1									
	MIN.W /FT	52.3	53.1	54.1	60.8	66.9	67.3	75.5	73.7	85.7	97.4									
144C	PIPE TEMP	663.1	661.0	655.3	640.7	624.7	621.5	599.6	604.0	575.6	543.7									
	MAX.W /FT	66.7	67.9	68.9	78.6	87.5	88.0	100.7	95.5	115.5	133.6									
	MIN.W /FT	57.6	58.4	59.4	68.7	73.2	73.6	82.4	80.4	93.3	106.0									
152C	PIPE TEMP	705.1	703.0	697.0	681.3	664.0	660.6	637.1	642.0	611.6	577.3									
	MAX.W /FT	73.6	74.7	75.7	86.2	95.8	96.3	110.1	104.1	125.9	145.5									
	MIN.W /FT	63.2	64.0	64.9	72.8	79.8	80.1	89.6	87.3	101.2	114.8									
160C	PIPE TEMP	747.2	745.0	738.7	721.8	703.2	699.8	674.8	679.9	647.4	610.8									
	MAX.W /FT	80.8	81.9	82.7	94.2	104.5	105.3	119.9	113.0	136.8	157.8									
	MIN.W /FT	69.0	69.8	70.7	79.1	86.6	86.8	97.0	94.3	109.3	123.8									
168C	PIPE TEMP	789.1	787.0	780.3	762.2	742.4	738.8	712.0	717.8	683.2	644.7									
	MAX.W /FT	88.6	89.7	90.3	102.6	113.7	114.1	130.2	122.3	146.1	170.0									
	MIN.W /FT	75.2	76.0	76.7	85.8	93.7	93.9	106.4	101.6	117.7	133.1									
176C	PIPE TEMP	831.1	829.0	821.9	802.6	781.6	777.9	749.6	755.7	719.0	677.7									
	MAX.W /FT	97.0	98.2	98.8	111.7	123.5	123.9	141.2	132.1	160.2	184.6									
	MIN.W /FT	81.9	82.8	83.7	92.8	101.2	101.3	115.0	109.3	126.5	142.9									

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-32

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

1-1/2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP-20.0 F (-28.9 C)

CABLE TEMP DEG F		PIPE SIZE																	
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
40C	PIPE TEMP	56.1	55.8	55.0	54.3	53.6	53.2	51.5	51.1	49.3	47.0	42.8	39.1	35.7	32.6	30.9	28.6	26.7	24.8	21.6
	MAX.W /FT	2.8	2.9	3.3	3.7	3.9	4.1	5.0	5.2	6.2	7.3	9.0	10.4	11.5	13.0	13.6	14.8	15.8	16.6	18.2
	MIN.W /FT	2.6	2.8	3.1	3.5	3.7	3.8	4.6	4.8	5.8	6.6	8.2	9.7	11.0	12.4	13.0	14.1	15.0	15.8	17.3
60C	PIPE TEMP	75.0	74.6	73.7	72.7	71.8	71.3	69.1	68.7	66.4	63.5	58.3	53.6	49.3	45.1	43.3	40.4	38.1	35.6	31.7
	MAX.W /FT	3.5	3.7	4.2	4.8	5.0	5.2	6.4	6.7	7.9	9.2	11.4	13.2	14.5	16.4	17.2	18.7	19.9	21.0	22.9
	MIN.W /FT	3.4	3.6	4.0	4.5	4.7	4.9	5.9	6.2	7.2	8.3	10.4	12.2	13.4	15.6	16.4	17.8	18.9	19.9	21.7
80C	PIPE TEMP	93.8	93.9	92.2	91.0	90.0	89.4	86.7	86.2	83.4	79.9	73.6	67.9	62.8	57.7	55.6	52.2	49.4	46.4	41.7
	MAX.W /FT	4.4	4.6	5.2	5.9	6.2	6.4	7.8	8.2	9.6	11.3	13.9	16.0	17.6	19.9	20.8	22.6	24.1	25.3	27.7
	MIN.W /FT	4.1	4.4	4.9	5.5	5.8	6.0	7.2	7.5	8.7	10.2	12.6	14.8	16.4	18.9	19.8	21.5	22.9	24.0	26.2
100C	PIPE TEMP	112.6	112.1	110.7	109.3	108.1	107.4	104.2	103.6	100.4	96.2	88.8	82.2	76.2	70.2	67.6	63.8	60.5	57.1	51.6
	MAX.W /FT	5.2	5.4	6.2	7.0	7.4	7.6	9.3	9.7	11.6	13.6	16.6	19.4	20.8	23.4	24.5	26.6	28.3	29.8	32.5
	MIN.W /FT	4.9	5.2	5.8	6.5	6.9	7.1	8.5	8.9	10.4	12.0	14.9	17.5	19.8	22.3	23.3	25.2	26.9	28.2	30.8
120C	PIPE TEMP	131.3	130.7	129.1	127.5	126.1	125.3	121.6	121.0	117.2	112.4	103.9	96.4	89.4	82.6	80.0	75.3	71.6	67.7	61.4
	MAX.W /FT	6.1	6.4	7.2	8.2	8.6	8.9	10.9	11.3	13.3	15.6	19.0	21.8	24.0	27.1	28.2	30.7	32.6	34.2	37.3
	MIN.W /FT	5.8	6.0	6.8	7.6	8.0	8.3	10.0	10.4	12.0	14.0	17.2	20.2	22.9	25.7	26.8	29.1	30.9	32.4	35.4
140C	PIPE TEMP	149.9	149.4	147.5	145.6	144.0	143.2	138.9	138.3	134.0	128.5	119.0	110.4	102.6	94.6	92.0	86.7	82.5	78.2	71.2
	MAX.W /FT	7.0	7.4	8.3	9.4	9.9	10.2	12.5	12.9	15.2	17.8	21.7	24.8	27.5	30.7	32.0	34.8	37.0	38.8	42.3
	MIN.W /FT	6.6	6.9	7.8	8.7	9.2	9.5	11.4	11.8	13.7	15.9	19.6	22.9	25.9	29.2	30.4	32.9	35.0	36.7	40.0
160C	PIPE TEMP	168.6	167.9	165.9	163.7	161.9	161.0	156.2	155.5	150.7	144.5	133.9	124.4	115.7	107.0	103.9	98.0	93.6	88.6	80.8
	MAX.W /FT	8.0	8.4	9.4	10.7	11.2	11.5	14.1	14.6	17.2	20.1	24.6	27.9	30.6	34.5	35.8	38.9	41.4	43.6	47.2
	MIN.W /FT	7.5	7.9	8.8	9.9	10.4	10.7	12.9	13.4	15.5	17.9	22.0	25.7	29.1	32.7	34.0	36.8	39.1	41.0	44.7
200C	PIPE TEMP	187.1	186.4	184.1	181.7	179.8	178.8	173.4	172.6	167.3	160.5	148.7	138.2	128.7	119.0	115.7	109.2	104.2	98.9	90.4
	MAX.W /FT	9.0	9.4	10.6	12.0	12.6	12.9	15.8	16.3	19.2	22.4	27.2	31.0	33.9	38.3	39.7	43.1	45.8	48.0	52.2
	MIN.W /FT	8.5	8.9	9.9	11.1	11.7	11.9	14.4	14.9	17.3	20.0	24.4	28.6	32.3	36.3	37.6	40.8	43.3	45.4	49.4
220C	PIPE TEMP	205.6	204.9	202.4	199.6	197.5	196.5	190.5	189.7	183.8	176.3	163.5	152.0	141.6	131.0	127.4	120.4	114.8	109.1	99.9
	MAX.W /FT	10.0	10.4	11.8	13.3	14.0	14.3	17.6	18.1	21.3	24.8	30.0	34.2	37.4	42.1	43.7	47.4	50.3	52.7	57.3
	MIN.W /FT	9.4	9.9	11.0	12.3	12.9	13.2	16.0	16.5	19.1	22.1	27.0	31.4	35.5	39.9	41.3	44.8	47.6	49.8	54.1
240C	PIPE TEMP	224.1	223.3	220.5	217.5	215.2	214.1	207.5	206.7	200.3	192.1	178.1	165.6	154.3	142.8	139.1	131.4	125.4	119.3	109.3
	MAX.W /FT	11.1	11.5	13.0	14.7	15.4	15.8	19.4	19.9	23.4	27.3	32.9	37.5	40.8	46.0	47.7	51.7	54.9	57.4	62.4
	MIN.W /FT	10.4	10.9	12.1	13.6	14.3	14.6	17.6	18.1	20.9	24.2	29.5	34.4	38.8	43.6	45.1	48.9	51.8	54.3	58.9
260C	PIPE TEMP	242.5	241.6	238.6	235.3	232.9	231.7	224.5	223.6	216.7	207.8	192.7	179.2	167.0	154.5	150.6	142.3	135.9	129.3	118.6
	MAX.W /FT	12.2	12.7	14.3	16.2	16.9	17.3	21.2	21.8	25.6	29.8	35.9	40.8	44.4	50.0	51.7	56.1	59.5	62.2	67.6
	MIN.W /FT	11.5	11.9	13.3	14.9	15.6	15.9	19.2	19.8	22.9	26.4	32.1	37.4	42.1	47.3	48.9	53.0	56.1	58.7	63.8
280C	PIPE TEMP	260.8	260.0	256.7	253.1	250.4	249.2	241.4	240.5	233.0	223.4	207.2	192.7	179.6	166.2	162.1	153.2	146.4	139.3	127.9
	MAX.W /FT	13.4	13.9	15.6	17.7	18.4	18.8	23.1	23.7	27.8	32.4	38.9	44.1	47.9	54.0	55.8	60.5	64.1	67.1	72.8
	MIN.W /FT	12.5	12.9	14.5	16.2	17.0	17.3	20.9	21.5	24.8	28.7	34.7	40.4	45.5	51.0	52.7	57.1	60.5	63.3	68.6
300C	PIPE TEMP	279.1	278.2	274.7	270.8	268.0	266.7	258.2	257.3	249.2	238.9	221.6	206.1	192.2	177.7	173.5	164.0	156.7	149.2	137.0
	MAX.W /FT	14.6	15.0	17.0	19.2	20.0	20.4	25.1	25.6	30.1	35.0	42.0	47.5	51.6	58.1	59.9	65.0	68.8	72.0	78.0
	MIN.W /FT	13.6	14.0	15.7	17.6	18.4	18.7	22.6	23.3	26.8	30.9	37.4	43.5	48.9	54.8	56.6	61.3	64.9	67.9	73.6
350C	PIPE TEMP	324.7	323.7	319.9	316.8	314.5	310.1	300.0	299.0	289.6	277.4	257.2	239.2	223.1	206.2	201.5	190.5	182.2	173.5	159.7
	MAX.W /FT	17.7	18.2	20.5	23.-	24.0	24.6	30.1	30.7	36.0	41.8	49.9	56.3	60.4	68.5	70.5	76.4	80.8	84.4	91.3
	MIN.W /FT	16.5	16.9	18	21.2	22.1	22.4	27.0	27.8	31.9	36.8	44.3	51.3	57.6	64.6	66.5	71.9	76.1	79.5	86.0
400C	PIPE TEMP	370.0	368.9	364.0	359.5	356.4	353.2	341.4	340.4	329.5	315.5	292.4	271.6	253.4	234.1	229.1	216.6	207.1	197.4	181.4
	MAX.W /FT	21.0	21.5	24.3	27.4	28.4	28.8	35.5	36.0	42.2	48.9	58.1	65.3	70.4	79.2	81.3	88.0	93.1	97.1	104.9
	MIN.W /FT	19.5	20.0	22.3	25.0	26.0	26.3	31.7	32.5	37.2	42.8	51.4	59.4	66.5	74.5	76.6	82.8	87.5	91.3	98.7
450C	PIPE TEMP	415.0	413.9	408.2	401.9	397.7	396.1	382.4	381.4	369.0	353.1	327.1	303.9	283.3	261.6	256.2	242.1	231.7	220.9	203.6
	MAX.W /FT	24.5	25.1	28.2	31.9	32.9	33.3	41.1	41.6	48.7	56.3	66.6	74.7	80.2	90.2	92.4	100.0	105.6	110.1	118.8
	MIN.W /FT	22.7	23.2	25.8	28.9	30.0	30.3	36.5	37.3	42.8	49.1	58.8	67.7	75.7	84.7	86.9	93.9	99.1	103.3	111.5
500C	PIPE TEMP	459.8	458.6	452.2	445.0	440.4	438.6	423.1	422.2	408.2	390.4	361.4	335.6	312.4	288.6	282.8	267.3	255.8	244.0	225.0
	MAX.W /FT	28.2	28.8	32.4	36.6	37.8	38.0	46.9	47.4	55.4	64.0	75.5	84.3	90.1	101.4	103.8	112.2	118.4	123.3	132.8
	MIN.W /FT	26.0	26.6	29.5	33.0	34.2	34.5	41.5	42.4	48.5	55.6	66.3	76.3	85.1	95.1	97.5	105.2	111.0	115.6	124.6
550C	PIPE TEMP	504.3	503.1	495.9	487.9	482.8	480.9	463.6	462.6	447.1	427.3	395.4	366.9	341.8	315.1	309.1	292.0	279.5	266.6	246.0
	MAX.W /FT	32.1	32.7	36.8	41.5	42.6	42.9	53.0	53.4	62.4	72.0	84.5	94.2	100.6	112.9	115.4	124.6	131.4	136.7	147.1
	MIN.W /FT	29.5	30.0	33.4	37.3	38.6	38.8	46.7	47.6	54.4	62.2	74.0	83.0	94.6	105.8	108.2	116.7	123.0	128.0	137.9
600C	PIPE TEMP	548.7	547.4	539.5	530.5	525.0	523.0	503.7	502.8	485.7	464.0	429.0	397.9	370.5	341.3	334.9	316.4	302.9	289.0	266.7
	MAX.W /FT	36.2	36.9	41.4	46.6	47.7	48.0	59.3	59.6	69.6	80.2	93.9	104.3	111.2	124.7	127.2	137.3	144.6	150.4	161.6
	MIN.W /FT	33.2	33.7	37.4	41.8	43.0	43.3	52.0	53.0	60.4	69.1	81.9	93.9	104.4	116.6	119.1	128.3	135.2	140.6	151.2
650C	PIPE TEMP	592.8	591.5	582.8	573.0	567.0	564.9	543.7	542.8	524.1	501.3	462.3	428.4	394.7	367.1	360.4	340.4	325.9	310.9	287.0
	MAX.W /FT	40.5	41.1	46.1	51.9	52.9	53.3	65.9	66.1	77.0	89.6	103.4	116.7	122.0	136.7	139.3	150.2	158.1	164.3	176.6
	MIN.W /FT	37.0	37.5	41.5	46.3	47.7	47.9	57.5	58.5	66.6	76.0	89.9	103.0	114.9	127.6	130.2	140.2	147.6	153.4	164.8
700C	PIPE TEMP	636.4	635.5	626.0	615.3	608.9	606.6	583.4	582.6	562.3	538.5	495.4	459.7	426.6	392.5	385.6	364.1	348.5	332.6	307.1
	MAX.W /FT	44.9	45.5	51.0	57.3	58.4	58.7	72.4	72.7	84.7	97.1	113.3	125.3	133.0	148.9	151.6	163.4	171.8	178.6	191.3
	MIN.W /FT	40.9	41.4	45.8	51.1	52.4	52.6	63.1	64.2	73.0	83.2	98.2	112.1	124.8	138.8	141.6	152.3	160.2	166.4	178.5
750C	PIPE TEMP	680.2	679.4	669.0	657.4	650.6	648.2	623.0	622.2	600.3	572.5	528.2	488.8	454.3	417.7	410.4	387.4	370.9	353.9	326.8
	MAX.W /FT	49.4	50.0	56.1	63.0	64.3	64.7	79.7	79.9	92.5	106.2	121.3	134.3	144.3	161.3	164.1	176.8	185.8	192.8	206.5
	MIN.W /FT	44.9	45.6	50.2	55.9	57.3	57.5	68.9	69.9	79.5	90.4	106.6	121.7	134.9	150.2	153.0	164.5	173.0	179.6	192.5
800C	PIPE TEMP	724.6	723.7	712.0	699.5	692.1	689.6	662.5	661.7	638.2	608.3	560.9	518.6	481.7	442.5	435.0	410.5	393.0	375.0	346.4
	MAX.W /FT	54.1	54.8	61.3	68.8	69.8	70.0	86.4	86.6	100.6	115.4	133.6	147.2	155.7	174.0	176.9	190.4	200.0	207.3	221.9
	MIN.W /FT	49.0	49.5	54.7	60.9	62.3	62.5	74.8	75.9	86.1	97.9	115.1	131.3	145.4	161.8	164.7	177.0	185.9	192.9	206.6
850C	PIPE TEMP	768.3	766.9	754.9	741.6	733.6	731.0	701.9	701.1	676.0	644.0	593.6	548.2	508.9	467.2	459.4	433.4	414.9	395.9	365.7
	MAX.W /FT	59.1	59.7	66.8	74.9	75.8	76.0	93.8	93.6	109.0	124.8	144.2	158.6	167.4	188.9	189.9	206.2	216.4	222.2	237.5
	MIN.W /FT	53.3	53.9	59.5	66.0	67.5	67.6	80.9	81.9	93.0	105.5	123.9	141.1	156.1	173.5	176.6	189.6	199.1	206.4	220.9
900C	PIPE TEMP	812.0	810.4	797.7	783.6	775.0	772.3	741.2	740.5	713.7	679.6	625.7	577.7	535.9	491.7	483.6	456.1	436.5	416.6	384.8
	MAX.W /FT	64.2	64.9	72.8	81.2	82.0	82.2	101.1	101.1	117.6	134.6	155.1	170.2	179.3	200.1	203.1	218.4	229.1	237.3	253.1
	MIN.W /FT	57.8	58.5	64.4	71.4	72.6	72.9	87.2	88.2	100.0	113.4	132.8	151.1	167.0	185.5	188.7	202.5	212.5	220.2	235.4
950C	PIPE TEMP	855.7	854.2	840.5	825.2	816.4	813.5	780.5	779.7	751.3	715.2	658.1	607.1	562.7	516.0	507.6	478.6	458.0	437.1	403.7
	MAX.W /FT	69.2	70.1	78.6	87.9	88.5	88.6	109.5	108.9	126.7	144.7	166.4	182.2	191.8	213.6	216.7	232.8	244.1	252.7	269.6
	MIN.W /FT	62.5	63.2	69.5	77.0	78.3	78.6	93.8	94.7	107.3	121.5	142.0	161.4	176.2	197.8	201.0	215.6	226.1	234.7	250.7

INSULATION THICKNESS REQUIREMENTS

Service Designation T-33

ELECTRIC HEAT TRACING - MI CABLE - BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP-20.0 F (-28.9 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
60	PIPE TEMP	56.2	56.0	55.6	54.8	54.1	53.7	52.3	51.9	50.3	48.3	44.5	41.4	38.2	35.2	33.9	31.7	30.5	28.1	25.0
	MAX.W /FT	2.6	2.8	2.8	3.3	3.6	3.7	4.5	4.7	5.5	6.4	7.9	8.8	10.2	11.5	12.1	13.1	14.1	14.8	16.3
	MIN.W /FT	2.5	2.6	2.7	3.2	3.4	3.5	4.2	4.4	5.1	5.9	7.4	8.5	9.8	11.0	11.6	12.6	13.5	14.2	15.7
80	PIPE TEMP	75.2	74.9	74.4	73.3	72.4	72.0	70.1	69.7	67.7	65.1	60.4	56.5	52.5	48.7	47.1	44.4	42.2	39.9	36.0
	MAX.W /FT	3.4	3.7	3.6	4.3	4.6	4.8	5.7	6.0	6.9	8.1	10.0	11.2	12.9	14.5	15.2	16.4	17.7	18.7	20.5
	MIN.W /FT	3.2	3.4	3.5	4.0	4.3	4.5	5.3	5.6	6.4	7.5	9.3	10.8	12.4	13.9	14.6	15.9	17.0	17.9	19.7
100	PIPE TEMP	94.0	93.6	93.2	91.8	90.7	90.2	87.9	87.4	85.1	81.9	76.2	71.5	66.7	62.1	60.2	57.0	54.3	51.5	46.9
	MAX.W /FT	4.1	4.3	4.4	5.2	5.6	5.8	7.0	7.3	8.5	9.9	12.1	13.6	15.6	17.6	18.4	20.0	21.4	22.6	24.8
	MIN.W /FT	3.9	4.1	4.2	4.9	5.3	5.5	6.5	6.8	7.9	9.1	11.3	13.1	15.0	16.9	17.7	19.2	20.5	21.8	23.7
120	PIPE TEMP	112.9	112.4	111.8	110.2	109.0	108.4	105.7	105.0	102.3	98.6	91.9	86.5	80.8	75.4	73.2	69.5	66.4	63.1	57.8
	MAX.W /FT	4.6	5.1	5.3	6.2	6.7	6.9	8.3	8.7	10.0	11.7	14.3	16.0	18.4	20.7	21.6	23.5	25.1	26.5	29.1
	MIN.W /FT	4.7	4.9	5.0	5.9	6.3	6.5	7.7	8.1	9.3	10.8	13.3	15.4	17.7	19.9	20.8	22.6	24.1	25.4	27.9
140	PIPE TEMP	131.6	131.1	130.5	128.6	127.2	126.5	123.3	122.6	119.5	115.2	107.5	101.3	94.8	88.5	86.2	81.9	78.3	74.6	68.5
	MAX.W /FT	5.8	6.5	6.1	7.3	7.8	8.0	9.6	10.1	11.6	13.5	16.6	18.5	21.2	23.9	24.9	27.1	28.9	30.5	33.4
	MIN.W /FT	5.5	5.7	5.9	6.8	7.4	7.6	9.0	9.4	10.8	12.5	15.4	17.8	20.4	22.9	23.9	26.0	27.7	29.2	32.0
160	PIPE TEMP	150.4	149.8	149.1	146.9	145.3	144.6	141.0	140.2	136.6	131.8	123.1	116.1	108.7	101.6	99.0	94.2	90.2	86.0	79.2
	MAX.W /FT	6.6	6.9	7.0	8.3	8.9	9.2	11.0	11.5	13.3	15.5	18.8	21.0	24.0	27.1	28.2	30.7	32.8	34.5	37.8
	MIN.W /FT	6.3	6.5	6.7	7.9	8.4	8.7	10.2	10.8	12.3	14.2	17.5	20.2	23.1	26.0	27.1	29.4	31.4	33.0	36.2
180	PIPE TEMP	169.1	168.6	167.7	165.2	163.4	162.6	158.5	157.6	153.7	148.2	138.6	130.7	122.5	114.6	111.8	106.4	102.0	97.3	89.8
	MAX.W /FT	7.5	7.9	8.0	9.4	10.1	10.4	12.4	13.0	15.0	17.4	21.2	23.5	26.9	30.4	31.6	34.4	36.7	38.6	42.2
	MIN.W /FT	7.2	7.4	7.6	8.9	9.5	9.8	11.6	12.1	13.8	16.0	19.7	22.7	25.9	29.1	30.3	32.9	35.1	36.9	40.4
200	PIPE TEMP	187.7	187.0	186.2	183.4	181.4	180.5	176.0	175.1	170.7	164.6	154.0	145.3	136.3	127.5	124.5	118.5	113.7	108.6	100.3
	MAX.W /FT	8.5	8.9	8.9	10.6	11.3	11.6	13.9	14.5	16.7	19.4	23.6	26.1	29.9	33.7	35.0	38.1	40.6	42.7	46.7
	MIN.W /FT	8.0	8.3	8.5	9.9	10.7	10.9	12.9	13.5	15.4	17.8	21.9	25.2	28.7	32.3	33.6	36.5	38.8	40.8	44.7
220	PIPE TEMP	206.3	205.6	204.7	201.6	199.3	198.4	193.4	192.4	187.6	180.9	169.3	159.8	149.9	140.3	137.1	130.5	125.3	119.7	110.7
	MAX.W /FT	9.5	9.8	9.9	11.8	12.6	12.9	15.4	16.1	18.5	21.5	26.0	28.8	32.9	37.1	38.5	41.8	44.6	46.8	51.2
	MIN.W /FT	8.9	9.3	9.4	11.0	11.8	12.1	14.3	15.0	17.0	19.7	24.1	27.7	31.6	35.5	36.9	40.0	42.6	44.8	49.0
240	PIPE TEMP	224.8	224.1	223.1	219.7	217.3	216.3	210.8	209.7	204.6	197.2	184.5	174.2	163.5	153.0	149.6	142.5	136.8	130.8	121.1
	MAX.W /FT	10.5	10.9	10.9	13.0	13.9	14.1	17.0	17.6	20.3	23.6	28.5	31.5	35.9	40.5	42.0	45.6	48.6	51.0	55.8
	MIN.W /FT	9.9	10.3	10.4	12.2	13.0	13.3	15.7	16.4	18.7	21.6	26.4	30.3	34.5	38.8	40.2	43.6	46.4	48.8	53.3
260	PIPE TEMP	243.3	242.5	241.5	237.8	235.1	234.1	228.1	227.0	221.2	213.3	199.6	188.6	177.0	165.7	162.1	154.4	148.2	141.8	131.4
	MAX.W /FT	11.5	11.9	12.0	14.2	15.2	15.5	18.6	19.3	22.2	25.7	31.0	34.2	39.0	44.0	45.5	49.5	52.8	55.3	60.4
	MIN.W /FT	10.9	11.2	11.3	13.3	14.2	14.5	17.2	17.9	20.6	23.5	28.7	32.9	37.4	42.1	43.6	47.3	50.3	52.8	57.7
280	PIPE TEMP	261.8	261.0	259.9	255.8	252.9	251.9	245.3	244.1	238.0	229.5	214.7	202.8	190.4	178.2	174.4	166.2	159.6	152.8	141.6
	MAX.W /FT	12.6	13.0	13.0	15.5	16.5	16.8	20.2	20.9	24.1	27.9	33.6	37.0	42.1	47.5	49.1	53.4	56.8	59.6	65.0
	MIN.W /FT	11.8	12.2	12.3	14.5	15.5	15.7	18.7	19.4	22.1	25.5	31.0	35.5	40.4	45.4	47.0	51.0	54.2	56.9	62.1
300	PIPE TEMP	280.2	279.4	278.2	273.7	270.7	269.6	262.5	261.3	254.6	245.5	229.7	217.0	203.7	190.7	186.7	177.9	170.9	163.6	151.7
	MAX.W /FT	13.7	14.1	14.1	16.8	17.9	18.2	21.9	22.7	26.0	30.1	36.2	39.8	45.3	51.0	52.7	57.3	60.9	63.9	69.7
	MIN.W /FT	12.9	13.3	13.4	15.7	16.8	17.0	20.2	21.0	23.8	27.5	33.4	38.2	43.4	48.8	50.4	54.7	58.1	61.0	66.5
350	PIPE TEMP	326.0	325.1	323.8	318.5	314.9	313.6	305.2	303.8	296.0	285.3	266.9	252.2	236.7	221.4	217.0	206.8	198.8	190.4	176.7
	MAX.W /FT	16.6	17.0	17.0	20.2	21.5	21.8	26.2	27.1	31.1	35.9	42.9	47.0	53.4	60.1	62.0	67.3	71.5	74.9	81.6
	MIN.W /FT	15.5	16.0	16.0	18.9	20.1	20.3	24.1	25.0	28.4	32.8	39.5	45.1	51.1	57.4	59.2	64.2	68.2	71.5	77.8
400	PIPE TEMP	371.5	370.6	369.2	362.9	358.8	357.4	347.6	346.1	337.1	324.7	303.7	286.8	269.2	251.7	246.9	235.3	226.2	216.7	201.3
	MAX.W /FT	19.6	20.1	20.0	23.9	25.3	25.6	30.8	31.7	36.3	41.9	49.9	54.5	61.8	69.5	71.5	77.6	82.3	86.2	93.7
	MIN.W /FT	18.4	18.8	18.9	22.2	23.6	23.8	28.2	29.2	33.1	38.0	45.8	52.2	59.1	66.2	68.2	73.9	78.4	82.1	89.3
450	PIPE TEMP	416.8	415.9	414.3	407.1	402.4	401.0	389.6	388.1	377.8	363.8	340.0	321.0	301.3	281.5	276.4	263.3	253.2	242.7	225.5
	MAX.W /FT	22.9	23.4	23.2	27.7	29.3	29.6	35.5	36.5	41.8	48.1	57.1	62.2	70.4	79.1	81.3	88.1	93.3	97.7	106.1
	MIN.W /FT	21.4	21.9	21.8	25.7	27.2	27.4	32.5	33.6	38.0	43.5	52.4	59.5	67.2	75.3	77.4	83.6	88.8	92.9	100.9
500	PIPE TEMP	461.9	460.9	459.2	451.0	445.8	444.2	431.4	429.7	418.3	402.5	376.0	354.9	332.9	310.9	305.6	290.9	279.8	268.2	249.4
	MAX.W /FT	26.4	26.9	26.6	31.7	33.4	33.7	40.5	41.6	47.5	54.6	64.6	70.1	79.2	88.9	91.2	98.8	104.6	109.4	118.7
	MIN.W /FT	24.5	25.0	24.9	29.3	31.0	31.2	36.9	38.1	43.0	49.2	59.1	67.0	75.6	84.6	86.8	93.9	99.5	104.0	112.6
550	PIPE TEMP	506.8	505.7	504.0	494.7	489.0	487.3	472.9	471.2	458.6	440.9	411.6	388.3	364.1	339.9	334.0	318.1	305.9	293.3	272.8
	MAX.W /FT	30.0	30.5	30.1	35.9	37.7	38.0	45.7	46.8	53.6	61.3	72.3	78.2	88.2	99.0	101.4	109.8	116.1	121.3	131.4
	MIN.W /FT	27.6	28.2	28.1	33.0	34.9	35.1	41.5	42.8	48.2	55.1	66.0	74.7	84.1	94.0	96.4	104.2	110.3	115.2	124.8
600	PIPE TEMP	551.5	550.4	548.6	538.2	531.9	530.1	514.2	512.3	498.3	479.0	446.9	421.3	395.0	368.5	362.2	344.9	331.8	318.1	295.9
	MAX.W /FT	33.7	34.2	33.7	40.2	42.2	42.5	51.0	52.2	59.5	68.2	80.2	86.5	97.5	109.2	111.8	120.9	127.8	133.5	144.4
	MIN.W /FT	31.2	31.7	31.4	36.9	38.9	39.1	46.2	47.6	53.6	61.2	73.0	82.6	92.8	103.7	106.2	114.7	121.3	126.6	137.0
650	PIPE TEMP	596.6	594.9	593.0	581.6	574.7	572.8	555.3	553.3	538.0	516.9	481.9	454.1	425.5	396.8	390.1	371.4	357.2	342.5	318.7
	MAX.W /FT	37.6	38.2	37.5	44.7	46.8	47.1	56.5	57.7	65.8	75.3	88.3	95.0	106.9	119.7	122.4	132.3	139.8	145.8	157.6
	MIN.W /FT	34.7	35.3	34.9	40.9	43.1	43.3	51.0	52.6	59.1	67.3	80.2	90.6	101.7	113.5	116.2	125.4	132.5	138.2	149.4
700	PIPE TEMP	640.4	639.2	637.3	624.7	617.3	615.3	596.2	594.1	577.5	554.6	516.7	486.5	455.7	424.7	417.7	397.5	382.4	366.6	341.1
	MAX.W /FT	41.7	42.2	41.4	49.3	51.6	51.8	62.2	63.4	72.3	82.6	96.6	103.8	116.6	130.4	133.2	143.9	151.9	158.4	171.0
	MIN.W /FT	38.4	38.9	38.4	45.1	47.4	47.5	56.0	57.6	64.7	73.6	87.6	98.8	110.8	123.5	126.3	136.2	143.8	150.0	161.9
750	PIPE TEMP	694.7	693.4	691.4	677.8	669.8	667.6	646.9	644.8	626.8	602.0	561.3	528.7	495.0	462.3	453.6	432.3	415.7	398.4	370.9
	MAX.W /FT	45.9	46.6	45.6	54.0	56.5	56.7	69.0	69.3	78.9	90.0	105.1	112.6	126.4	141.2	144.2	155.7	164.2	171.1	184.5
	MIN.W /FT	42.1	42.6	42.0	49.3	51.8	51.9	61.1	62.8	70.4	AC.1	95.1	107.2	120.0	133.6	136.6	147.2	155.6	161.9	174.6
800	PIPE TEMP	728.9	727.6	725.5	710.8	702.1	699.9	677.5	675.3	655.9	629.4	585.6	550.7	515.3	479.7	472.0	449.0	431.8	414.0	385.3
	MAX.W /FT	50.2	50.7	49.5	58.9	61.5	61.7	74.0	75.3	85.7	97.7	113.7	121.7	136.4	152.3	155.4	167.6	176.8	184.1	198.3
	MIN.W /FT	46.0	46.4	45.8	53.6	56.3	56.4	66.3	68.1	76.3	86.7	102.7	115.7	129.3	144.0	147.1	158.4	167.0	174.0	187.5
850	PIPE TEMP	773.0	771.7	769.5	753.6	744.4	742.1	718.1	715.7	695.0	666.6	619.8	582.4	544.8	506.9	498.9	476.4	456.2	437.3	407.0
	MAX.W /FT	54.7	55.3	53.8	64.0	66.7	66.9	80.2	81.5	92.7	105.6	122.6	130.9	146.6	163.6	166.8	179.8	189.5	197.2	212.3
	MIN.W /FT	50.0	50.4	49.6	58.1	60.9	61.0	71.6	73.6	82.3	93.4	110.5	124.3	138.9	154.4	157.7	169.7	178.9	186.2	200.5
900	PIPE TEMP	817.1	815.9	813.4	796.6	786.6	784.1	758.5	756.0	734.0	703.7	653.9	614.0	574.1	533.9	525.5	499.6	480.4	460.5	428.5
	MAX.W /FT	59.4	59.9	58.2	69.3	72.1	72.2	86.6	87.8	99.9	113.6	131.7	140.4	157.0	175.0	178.4	192.2	202.4	210.6	226.5
	MIN.W /FT	54.1	54.4	53.6	62.7	65.6	65.7	77.1	79.1	88.5	100.3	118.5	133.2	148.6	165.1	168.5	181.3	190.9	198.6	213.7
950	PIPE TEMP	861.1	859.7	857.3	839.2	828.7	826.1	798.9	796.3	772.9	740.7	687.8	645.4	603.2	560.7	551.9	524.6	504.4	483.5	449.8
	MAX.W /FT	64.3	64.8	62.8	74.8	77.8	77.7	93.2	94.4	107.4	122.0	141.1	150.1	167.6	186.8	190.3	204.8	215.6	224.1	240.9
	MIN.W /FT	58.5	58.9	57.8	67.5	70.5	70.6	82.8	84.9	94.9	107.5	126.7	142.2	158.5	176.0	179.5	193.0	203.2	211.3	227.1

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-34

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

2-1/2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP-20.0 F (-28.9 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
4C	PIPe TEMP	56.5	56.2	55.9	55.1	54.4	54.1	52.8	52.4	51.1	49.3	45.8	43.0	40.1	37.4	36.2	34.2	32.5	30.8	27.8
	MAX.W /FT	2.4	2.4	2.6	3.1	3.3	3.5	4.1	4.3	4.9	5.7	7.1	8.0	9.2	10.4	10.9	11.9	12.7	13.4	14.9
	MIN.W /FT	2.3	2.4	2.6	2.9	3.2	3.3	3.9	4.1	4.7	5.4	6.7	7.8	8.9	10.0	10.5	11.5	12.3	13.0	14.4
8C	PIPE TEMP	75.5	75.2	74.7	73.7	72.9	72.5	70.9	70.4	68.7	66.5	62.0	58.6	54.9	51.5	50.0	47.6	45.5	43.2	39.6
	MAX.W /FT	3.1	3.2	3.4	3.9	4.2	4.4	5.2	5.5	6.3	7.2	8.9	10.1	11.6	13.1	13.7	14.9	16.0	16.9	18.7
	MIN.W /FT	3.0	3.1	3.2	3.8	4.1	4.2	4.9	5.2	5.9	6.8	8.5	9.8	11.3	12.7	13.3	14.4	15.5	16.3	18.0
12C	PIPE TEMP	94.4	94.1	93.5	92.3	91.3	90.8	88.8	88.3	86.2	83.6	78.2	74.1	69.7	65.5	63.8	60.8	58.3	55.6	51.2
	MAX.W /FT	3.8	4.0	4.1	4.8	5.2	5.4	6.3	6.7	7.6	8.7	10.8	12.2	14.0	15.8	16.6	18.1	19.3	20.4	22.5
	MIN.W /FT	3.6	3.8	4.0	4.6	5.0	5.1	6.0	6.3	7.2	8.2	10.3	11.9	13.6	15.3	16.0	17.5	18.7	19.7	21.8
16C	PIPE TEMP	113.3	112.9	112.3	110.9	109.7	109.1	106.8	106.1	103.7	100.6	94.3	89.5	84.3	79.4	77.4	74.0	71.0	67.9	62.6
	MAX.W /FT	4.5	4.7	4.9	5.7	6.2	6.4	7.5	7.9	9.0	10.3	12.8	14.4	16.5	18.6	19.5	21.2	22.7	24.0	26.4
	MIN.W /FT	4.3	4.5	4.7	5.5	5.9	6.1	7.1	7.5	8.5	9.7	12.2	14.0	16.0	18.0	18.8	20.5	21.9	23.2	25.5
20C	PIPE TEMP	132.2	131.9	131.0	129.4	128.0	127.4	124.6	123.9	121.2	117.5	110.3	104.8	98.9	93.2	91.0	87.0	83.7	80.2	74.3
	MAX.W /FT	5.3	5.4	5.7	6.7	7.2	7.4	8.7	9.2	10.5	12.0	14.8	16.6	19.1	21.5	22.4	24.4	26.1	27.6	30.4
	MIN.W /FT	5.1	5.3	5.5	6.4	6.9	7.1	8.2	8.7	9.9	11.3	14.1	16.1	18.5	20.8	21.7	23.6	25.2	26.6	29.3
24C	PIPE TEMP	151.0	150.9	149.7	147.8	146.2	145.6	142.4	141.6	138.5	134.4	126.2	120.0	113.4	106.9	104.6	100.0	96.3	92.3	85.7
	MAX.W /FT	6.1	6.3	6.5	7.6	8.2	8.5	10.0	10.5	12.0	13.6	16.8	18.9	21.6	24.4	25.4	27.7	29.6	31.2	34.4
	MIN.W /FT	5.8	6.1	6.3	7.3	7.9	8.1	9.4	9.9	11.2	12.8	16.0	18.3	20.9	23.6	24.6	26.7	28.5	30.1	33.1
28C	PIPE TEMP	169.8	169.5	168.4	166.2	164.4	163.7	160.2	159.3	155.8	151.3	142.1	135.2	127.8	120.6	118.0	113.0	108.8	104.4	97.1
	MAX.W /FT	6.9	7.2	7.4	8.7	9.3	9.5	11.3	11.8	13.5	15.3	18.9	21.2	24.2	27.3	28.4	31.0	33.1	34.9	38.4
	MIN.W /FT	6.6	6.9	7.1	8.2	8.9	9.1	10.6	11.2	12.7	14.4	17.9	20.5	23.5	26.4	27.5	29.9	31.9	33.7	37.0
32C	PIPE TEMP	188.5	188.0	187.0	184.6	182.6	181.8	177.9	176.9	173.1	168.0	157.9	150.3	142.1	134.1	131.4	125.8	121.2	116.4	108.4
	MAX.W /FT	7.7	8.2	8.3	9.7	10.4	10.7	12.6	13.2	15.0	17.1	21.0	23.6	26.9	30.3	31.5	34.3	36.6	38.6	42.5
	MIN.W /FT	7.4	7.7	7.9	9.2	9.9	10.1	11.9	12.5	14.1	16.1	19.9	22.8	26.0	29.2	30.4	33.1	35.3	37.2	40.9
36C	PIPE TEMP	207.2	206.6	205.6	202.9	200.7	199.9	195.5	194.5	190.3	184.7	173.7	165.3	156.4	147.6	144.6	138.6	133.6	128.3	119.6
	MAX.W /FT	8.6	8.9	9.2	10.8	11.6	11.8	13.9	14.6	16.6	18.9	23.1	25.9	29.6	33.3	34.6	37.7	40.2	42.4	46.8
	MIN.W /FT	8.2	8.5	8.8	10.2	11.0	11.2	13.1	13.8	15.6	17.7	22.0	25.1	28.6	32.2	33.4	36.3	38.8	40.8	44.8
40C	PIPE TEMP	225.9	225.5	224.1	221.1	218.8	217.9	213.1	212.0	207.4	201.3	189.3	180.3	170.5	161.0	157.9	151.2	145.8	140.1	130.7
	MAX.W /FT	9.5	9.7	10.1	11.9	12.7	13.0	15.3	16.0	18.2	20.7	25.3	28.3	32.3	36.4	37.7	41.1	43.8	46.2	50.7
	MIN.W /FT	9.1	9.4	9.7	11.2	12.1	12.3	14.4	15.1	17.1	19.4	24.0	27.4	31.2	35.1	36.4	39.6	42.2	44.9	48.8
44C	PIPE TEMP	244.5	243.9	242.7	239.4	236.8	235.9	230.6	229.5	224.5	217.9	204.9	195.2	184.6	174.3	171.0	163.9	158.0	151.9	141.4
	MAX.W /FT	10.5	10.8	11.1	13.0	13.9	14.2	16.7	17.5	19.9	22.5	27.5	30.7	35.0	39.5	40.9	44.5	47.5	50.0	54.9
	MIN.W /FT	10.0	10.3	10.6	12.3	13.2	13.4	15.7	16.5	18.6	21.1	26.1	29.8	33.9	38.1	39.5	42.9	45.7	48.2	52.8
48C	PIPE TEMP	263.1	262.4	261.1	257.5	254.8	253.8	248.1	246.9	241.6	234.4	220.4	210.0	198.7	187.6	184.1	176.4	170.2	163.6	152.8
	MAX.W /FT	11.4	11.8	12.1	14.1	15.1	15.4	18.2	19.0	21.5	24.4	29.8	33.2	37.8	42.6	44.1	48.0	51.2	53.9	59.1
	MIN.W /FT	10.9	11.2	11.5	13.4	14.4	14.6	17.1	17.9	20.1	22.9	28.2	32.2	36.6	41.1	42.6	46.2	49.3	51.9	56.9
52C	PIPE TEMP	281.6	280.9	279.6	275.7	272.7	271.7	265.6	264.2	258.5	250.9	235.9	224.7	212.6	200.7	197.0	188.8	182.2	175.2	163.7
	MAX.W /FT	12.4	12.8	13.1	15.3	16.4	16.7	19.7	20.5	23.3	26.4	32.1	35.7	40.7	45.8	47.4	51.5	54.9	57.8	63.3
	MIN.W /FT	11.8	12.1	12.5	14.5	15.5	15.8	18.4	19.3	21.7	24.7	30.4	34.6	39.3	44.1	45.7	49.6	52.9	55.6	60.9
56C	PIPE TEMP	327.8	327.0	325.5	320.8	317.4	316.2	308.9	307.4	300.7	291.8	274.3	261.3	247.2	233.3	229.2	219.7	212.0	203.9	190.7
	MAX.W /FT	15.0	15.4	15.7	18.4	19.7	19.9	23.5	24.5	27.7	31.3	38.0	42.2	47.9	53.9	55.7	60.5	64.4	67.7	74.1
	MIN.W /FT	14.2	14.6	14.9	17.4	18.6	18.8	22.0	23.0	25.8	29.3	35.9	40.8	46.3	51.9	53.6	58.2	62.0	65.1	71.3
60C	PIPE TEMP	373.8	372.9	371.2	365.7	361.7	360.5	352.0	350.3	342.6	332.3	312.2	297.4	281.3	265.4	260.9	250.0	241.4	232.3	217.3
	MAX.W /FT	17.7	18.1	18.5	21.7	23.1	23.3	27.6	28.6	32.3	36.5	44.1	48.9	55.6	62.3	64.2	69.7	74.2	77.9	85.1
	MIN.W /FT	16.8	17.2	17.5	20.4	21.8	22.0	25.7	26.9	30.1	34.1	41.7	47.2	53.4	59.9	61.8	67.0	71.3	74.9	81.8
64C	PIPE TEMP	419.5	418.4	416.7	410.4	405.9	404.5	394.8	393.0	384.2	372.5	349.8	333.1	315.0	297.1	292.1	280.0	270.3	260.1	243.5
	MAX.W /FT	20.6	21.0	21.4	25.1	26.7	26.9	31.8	33.0	37.2	41.9	50.5	55.7	63.1	70.9	73.0	79.2	84.1	88.3	96.3
	MIN.W /FT	19.5	19.9	20.3	23.6	25.1	25.4	29.6	30.9	34.5	39.0	47.6	53.8	60.6	68.1	70.2	76.1	80.8	84.8	92.5
68C	PIPE TEMP	465.0	464.1	462.0	454.8	449.8	448.3	437.3	435.3	425.5	412.3	387.0	368.4	348.4	328.3	323.0	309.5	298.8	287.6	269.9
	MAX.W /FT	23.7	24.1	24.4	28.7	30.4	30.7	36.2	37.5	42.2	47.5	57.0	62.4	71.0	79.7	81.9	88.8	94.3	98.9	107.6
	MIN.W /FT	22.4	22.7	23.1	26.9	28.6	28.8	33.6	35.0	39.1	44.1	53.7	60.6	68.4	76.5	78.7	85.3	90.5	94.9	103.4
72C	PIPE TEMP	510.4	509.4	507.1	499.1	493.4	491.9	479.6	477.4	466.5	451.9	423.9	403.3	381.3	359.2	353.5	338.6	327.0	314.7	294.7
	MAX.W /FT	26.9	27.3	27.8	32.4	34.3	34.5	40.7	42.1	47.4	53.3	63.8	70.1	79.1	88.7	91.1	98.7	104.7	109.7	119.4
	MIN.W /FT	25.3	25.7	26.1	30.3	32.2	32.4	37.8	39.3	43.8	49.4	60.0	67.6	76.1	85.1	87.4	94.6	100.4	105.2	114.5
76C	PIPE TEMP	555.6	554.6	552.1	543.1	536.9	535.3	521.6	519.3	507.3	491.2	460.4	437.9	413.8	389.7	383.6	367.4	354.8	341.5	319.8
	MAX.W /FT	30.2	30.6	30.9	36.2	38.3	38.6	45.5	46.9	52.8	59.3	70.7	77.6	87.4	97.9	100.5	108.8	115.3	120.7	131.3
	MIN.W /FT	28.4	28.8	29.2	33.8	35.9	36.1	42.0	43.7	48.7	54.8	66.4	74.7	84.0	93.8	96.3	104.2	110.5	115.6	125.7
80C	PIPE TEMP	600.6	599.4	596.9	587.0	580.3	578.5	563.5	561.0	547.9	530.3	496.7	472.2	446.1	419.8	413.4	395.8	382.2	367.9	344.5
	MAX.W /FT	33.7	34.1	34.3	40.2	42.5	42.7	50.3	51.9	58.3	65.4	77.6	85.2	95.9	107.3	110.0	119.0	126.1	131.9	143.3
	MIN.W /FT	31.6	31.9	32.3	37.5	39.8	39.9	46.4	48.2	53.7	60.3	73.0	82.0	92.1	102.8	105.4	113.9	120.7	126.3	137.1
84C	PIPE TEMP	645.6	644.5	641.6	630.8	623.4	621.6	605.2	602.6	588.3	569.2	532.8	506.3	478.0	449.7	442.8	424.0	409.3	394.0	369.0
	MAX.W /FT	37.2	37.7	37.8	44.3	46.8	47.0	55.3	57.0	64.0	71.6	85.1	93.0	104.5	116.8	119.7	129.4	137.0	143.3	155.5
	MIN.W /FT	34.8	35.2	35.6	41.3	43.7	43.9	50.9	52.9	58.8	66.0	79.7	89.4	100.3	111.4	114.6	123.8	131.1	137.0	148.7
88C	PIPE TEMP	690.6	689.3	686.2	674.4	666.5	664.5	646.7	644.0	628.6	607.9	568.6	540.0	509.7	479.3	472.0	451.8	436.2	419.8	393.2
	MAX.W /FT	40.9	41.3	41.5	48.6	51.2	51.4	60.4	62.2	69.8	78.0	92.5	101.0	113.3	126.6	129.6	140.3	148.2	154.8	167.6
	MIN.W /FT	38.2	38.6	39.0	45.1	47.7	47.9	55.5	57.6	64.0	71.8	86.5	97.0	108.7	121.1	124.4	133.9	141.6	148.0	160.4
92C	PIPE TEMP	735.1	734.0	730.7	718.0	709.4	707.4	688.2	685.2	668.7	646.5	604.2	573.6	541.2	509.7	501.0	479.4	462.8	445.4	417.1
	MAX.W /FT	44.7	45.1	45.2	52.9	55.7	55.9	65.7	67.6	75.8	84.6	100.1	109.1	122.3	136.5	139.7	150.8	159.5	166.6	180.4
	MIN.W /FT	41.7	42.1	42.4	49.1	51.9	52.0	60.3	62.5	69.3	77.7	93.5	104.7	117.2	130.4	133.5	144.1	152.3	159.1	172.3
96C	PIPE TEMP	779.7	778.4	775.1	761.4	752.3	750.1	729.5	726.3	708.6	684.9	639.7	607.0	572.4	537.8	529.7	506.8	489.2	470.7	440.0
	MAX.W /FT	48.8	49.2	49.3	57.4	60.4	60.5	71.1	73.1	81.9	91.4	107.9	117.4	131.5	146.6	149.9	161.8	171.0	178.5	193.1
	MIN.W /FT	45.3	45.6	45.9	53.1	56.1	56.2	65.1	67.5	74.8	83.8	100.6	112.6	125.6	139.9	143.2	154.4	163.2	170.3	184.3
100C	PIPE TEMP	824.3	823.1	819.4	804.8	795.0	792.7	770.7	767.4	748.5	723.2	675.0	640.1	603.5	566.7	558.3	534.0	515.4	495.9	464.3
	MAX.W /FT	52.7	53.1	53.0	62.1	65.2	65.3	76.7	78.7	88.2	98.3	115.8	125.8	140.8	156.8	160.3	172.9	182.7	190.6	206.0
	MIN.W /FT	49.0	49.3	49.6	57.3	60.5	60.5	70.1	72.6	80.4	89.9	107.9	120.6	134.7	149.8	153.1	164.9	174.2	181.7	196.5
104C	PIPE TEMP	868.8	867.6	863.7	848.1	837.7	835.3	811.9	808.4	788.3	761.4	710.2	673.2	634.4	595.5	586.6	561.0	541.4	520.8	487.6
	MAX.W /FT	56.9	57.4	57.2	66.9	70.1	70.2	82.5	84.5	94.7	105.4	124.0	134.5	150.3	167.3	171.0	184.3	194.6	202.9	219.1
	MIN.W /FT	52.8	53.2	53.6	61.7	64.9	65.0	75.2	77.8	86.1	96.3	115.3	128.8	143.7	159.5	163.1	175.6	185.4	193.3	208.9

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-35

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP-200 F (-289 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
60	PIPE TEMP	56.6	56.4	56.0	55.4	54.7	54.4	53.2	52.9	51.7	50.0	46.9	44.3	41.7	39.2	38.1	36.2	34.7	33.0	30.1
	MAX.W /FT	2.3	2.4	2.5	2.9	3.1	3.2	3.8	4.0	4.5	5.2	6.3	7.3	8.4	9.5	10.0	10.9	11.7	12.3	13.7
	MIN.W /FT	2.2	2.3	2.4	2.8	3.0	3.1	3.6	3.8	4.3	5.0	6.2	7.2	8.2	9.2	9.7	10.6	11.3	12.0	13.3
80	PIPE TEMP	75.7	75.4	75.0	74.1	73.3	72.9	71.4	71.0	69.5	67.4	63.5	60.2	56.9	53.7	52.4	50.1	48.1	46.0	42.5
	MAX.W /FT	2.9	3.0	3.2	3.7	4.0	4.1	4.8	5.0	5.7	6.6	8.0	9.3	10.6	12.0	12.5	13.7	14.7	15.5	17.2
	MIN.W /FT	2.8	2.9	3.1	3.5	3.8	4.0	4.6	4.9	5.5	6.3	7.8	9.0	10.4	11.6	12.2	13.3	14.2	15.1	16.7
100	PIPE TEMP	94.7	94.4	93.8	92.7	91.8	91.3	89.5	89.0	87.3	84.7	80.0	76.1	72.0	68.2	66.6	63.9	61.5	59.0	54.8
	MAX.W /FT	3.6	3.7	3.9	4.5	4.9	5.0	5.9	6.1	7.0	8.0	9.7	11.2	12.9	14.5	15.2	16.5	17.7	18.7	20.7
	MIN.W /FT	3.4	3.6	3.8	4.3	4.7	4.8	5.6	5.9	6.7	7.7	9.5	10.9	12.5	14.1	14.7	16.1	17.2	18.2	20.1
120	PIPE TEMP	113.7	113.3	112.7	111.4	110.2	109.7	107.6	107.0	105.0	101.9	96.4	91.9	87.1	82.6	80.8	77.6	74.8	71.9	67.0
	MAX.W /FT	4.2	4.4	4.6	5.3	5.8	6.0	6.9	7.3	8.2	9.5	11.4	13.2	15.1	17.0	17.8	19.4	20.8	22.0	24.3
	MIN.W /FT	4.1	4.3	4.5	5.1	5.6	5.7	6.6	7.0	7.9	9.1	11.2	12.9	14.7	16.6	17.3	18.9	20.2	21.4	23.6
140	PIPE TEMP	132.6	132.2	131.5	130.0	128.6	128.1	125.6	125.0	122.6	119.1	112.8	107.6	102.1	96.9	94.9	91.2	88.1	84.7	79.1
	MAX.W /FT	5.0	5.2	5.4	6.2	6.7	6.9	8.1	8.4	9.5	11.0	13.2	15.2	17.4	19.6	20.5	22.3	23.9	25.3	28.0
	MIN.W /FT	4.8	5.0	5.2	6.0	6.5	6.6	7.7	8.1	9.1	10.5	12.9	14.9	17.0	19.1	19.9	21.7	23.2	24.5	27.1
160	PIPE TEMP	151.5	151.0	150.2	148.5	147.0	146.4	143.6	142.9	140.2	136.2	129.1	123.2	117.1	111.2	109.0	104.8	101.2	97.4	91.1
	MAX.W /FT	5.7	5.9	6.2	7.1	7.7	7.9	9.2	9.6	10.8	12.5	15.0	17.3	19.8	22.3	23.2	25.3	27.1	28.6	31.6
	MIN.W /FT	5.5	5.7	5.9	6.8	7.4	7.6	8.8	9.2	10.4	11.9	14.6	16.9	19.2	21.6	22.5	24.6	26.3	27.8	30.6
180	PIPE TEMP	170.3	169.9	169.0	167.0	165.3	164.6	161.5	160.7	157.7	153.3	145.3	138.8	131.9	125.3	123.0	118.3	114.3	110.1	103.1
	MAX.W /FT	6.5	6.7	7.0	8.1	8.7	8.9	10.4	10.8	12.2	14.0	16.8	19.4	22.1	24.9	26.0	28.3	30.3	32.0	35.3
	MIN.W /FT	6.2	6.5	6.7	7.7	8.4	8.6	9.9	10.4	11.8	13.4	16.4	18.9	21.5	24.2	25.2	27.5	29.4	31.0	34.2
200	PIPE TEMP	189.1	188.4	187.7	185.5	183.6	182.9	179.3	178.5	175.2	170.3	161.5	154.3	146.7	139.4	136.9	131.7	127.4	122.7	115.1
	MAX.W /FT	7.2	7.5	7.8	9.0	9.7	9.9	11.6	12.1	13.6	15.6	18.7	21.5	24.5	27.6	28.7	31.3	33.5	35.4	39.0
	MIN.W /FT	7.0	7.3	7.5	8.6	9.4	9.5	11.0	11.6	13.0	14.9	18.2	21.0	23.9	26.8	27.9	30.4	32.5	34.3	37.8
220	PIPE TEMP	207.9	207.4	206.3	203.9	201.8	201.1	197.1	196.3	192.6	187.2	177.6	169.7	161.5	153.5	150.7	145.0	140.3	135.3	126.9
	MAX.W /FT	8.1	8.3	8.6	10.0	10.8	11.0	12.8	13.4	15.0	17.2	20.6	23.7	27.0	30.4	31.6	34.4	36.8	38.8	42.8
	MIN.W /FT	7.8	8.0	8.3	9.6	10.4	10.5	12.2	12.8	14.3	16.4	20.0	23.1	26.2	29.5	30.6	33.4	35.6	37.6	41.5
240	PIPE TEMP	226.7	226.1	224.9	222.2	220.0	219.2	214.9	214.0	210.0	204.1	193.7	185.1	176.1	167.4	164.5	158.3	153.2	147.7	138.7
	MAX.W /FT	8.9	9.2	9.5	11.0	11.9	12.1	14.1	14.7	16.5	18.9	22.5	25.9	29.5	33.2	34.4	37.5	40.1	42.3	46.6
	MIN.W /FT	8.6	8.9	9.2	10.5	11.4	11.6	13.4	14.0	15.7	18.0	21.9	25.2	28.6	32.2	33.4	36.4	38.8	41.0	45.1
260	PIPE TEMP	245.4	244.8	243.5	240.6	238.1	237.3	232.6	231.6	227.3	220.9	209.6	200.4	190.7	181.3	178.1	171.5	166.0	160.1	150.4
	MAX.W /FT	9.8	10.1	10.4	12.1	13.0	13.2	15.4	16.0	17.9	20.5	24.4	28.1	32.0	36.0	37.3	40.6	43.4	45.8	50.4
	MIN.W /FT	9.4	9.7	10.0	11.5	12.4	12.6	14.6	15.3	17.1	19.6	23.8	27.3	31.1	34.9	36.2	39.4	42.1	44.4	48.8
280	PIPE TEMP	264.0	263.4	262.1	258.9	256.2	255.4	250.3	249.2	244.6	237.7	225.6	215.6	205.2	195.1	191.6	184.6	178.7	172.5	162.1
	MAX.W /FT	10.7	11.0	11.3	13.1	14.1	14.3	16.7	17.3	19.4	22.3	26.4	30.3	34.5	38.8	40.3	43.8	46.8	49.5	54.5
	MIN.W /FT	10.2	10.5	10.9	12.5	13.5	13.7	15.9	16.6	18.5	21.2	25.8	29.5	33.5	37.7	39.0	42.5	45.3	47.8	52.6
300	PIPE TEMP	282.7	282.0	280.6	277.1	274.3	273.4	267.9	266.8	261.9	254.4	241.4	230.8	219.7	208.8	205.3	197.7	191.4	184.7	173.6
	MAX.W /FT	11.6	11.9	12.2	14.2	15.3	15.5	18.1	18.7	21.0	24.0	28.5	32.6	37.1	41.7	43.2	47.0	50.2	52.9	58.2
	MIN.W /FT	11.1	11.4	11.8	13.6	14.6	14.8	17.1	17.9	19.9	22.9	27.7	31.8	36.0	40.5	41.9	45.6	48.6	51.2	56.3
350	PIPE TEMP	329.1	328.4	326.8	322.6	319.3	318.3	311.7	310.5	304.7	296.0	280.8	268.4	255.5	242.6	238.9	230.0	222.8	215.1	202.1
	MAX.W /FT	14.0	14.3	14.7	17.0	18.3	18.5	21.6	22.3	24.9	28.5	33.7	38.5	43.7	49.1	50.8	55.2	58.9	62.0	68.1
	MIN.W /FT	13.4	13.7	14.1	16.3	17.5	17.7	20.4	21.3	23.7	27.1	32.4	37.4	42.6	47.6	49.2	53.5	57.0	60.0	65.9
400	PIPE TEMP	375.3	374.5	372.7	367.9	364.0	362.9	355.3	354.0	347.3	337.2	319.8	305.6	290.3	276.3	272.0	261.9	253.7	245.0	230.5
	MAX.W /FT	16.5	16.9	17.3	20.0	21.6	21.8	25.2	26.1	29.1	33.2	39.0	44.8	50.5	56.7	58.6	63.6	67.8	71.4	78.2
	MIN.W /FT	15.8	16.1	16.5	19.1	20.5	20.7	23.9	24.8	27.6	31.5	38.0	43.3	49.0	54.9	56.7	61.6	65.6	69.0	75.6
450	PIPE TEMP	421.3	420.4	418.5	412.9	408.5	407.3	398.6	397.2	389.6	378.2	358.5	342.5	326.0	309.5	304.6	293.6	284.2	274.5	258.4
	MAX.W /FT	19.2	19.5	20.0	23.2	24.7	24.9	29.1	30.0	33.4	38.1	44.6	50.9	57.5	64.5	66.5	72.3	76.9	80.9	89.6
	MIN.W /FT	18.3	18.6	19.1	22.0	23.6	23.8	27.4	28.5	31.6	36.1	43.4	49.4	55.9	62.4	64.4	69.9	74.3	78.2	85.6
500	PIPE TEMP	467.1	466.1	464.1	457.7	452.8	451.5	441.7	440.1	431.6	418.8	396.8	379.0	360.6	342.2	337.1	324.5	314.4	303.6	285.8
	MAX.W /FT	22.0	22.3	22.8	26.6	28.2	28.4	33.0	34.0	37.9	43.1	50.4	57.3	64.7	72.6	74.7	81.1	86.2	90.6	99.1
	MIN.W /FT	20.9	21.2	21.8	25.1	26.8	27.0	31.2	32.4	35.6	40.4	48.9	55.8	62.7	70.1	72.3	78.3	83.3	87.5	95.7
550	PIPE TEMP	512.8	512.0	509.5	502.3	496.9	495.5	484.6	482.8	473.4	459.1	434.5	415.1	394.8	374.6	369.1	355.2	344.1	332.3	312.9
	MAX.W /FT	24.5	25.2	25.7	29.8	31.8	31.9	37.2	38.2	42.5	48.3	56.3	64.0	72.1	80.8	83.1	90.1	95.7	100.5	109.8
	MIN.W /FT	23.7	24.0	24.6	28.3	30.2	30.4	35.0	36.3	40.1	45.7	54.7	62.0	69.6	78.0	80.3	87.0	92.4	97.0	106.0
600	PIPE TEMP	558.3	557.6	554.7	546.8	540.8	539.3	527.2	525.3	515.0	499.2	472.5	451.0	429.8	408.6	402.7	385.6	373.5	360.7	339.6
	MAX.W /FT	27.9	28.3	28.8	33.4	35.5	35.6	41.4	42.6	47.3	53.7	62.4	70.8	79.7	89.2	91.6	99.3	105.5	110.7	120.8
	MIN.W /FT	26.5	26.9	27.4	31.6	33.7	33.8	38.9	40.4	44.6	50.7	60.5	68.6	77.1	86.1	88.5	95.8	101.7	106.7	116.4
650	PIPE TEMP	603.7	602.9	599.9	591.1	584.5	582.9	569.6	567.7	556.3	539.1	509.9	486.3	462.4	438.3	432.0	415.6	402.6	388.7	366.0
	MAX.W /FT	31.1	31.6	31.9	37.0	39.3	39.4	45.8	47.0	52.2	59.2	68.8	77.7	87.4	97.7	100.4	108.7	115.4	121.0	131.9
	MIN.W /FT	29.5	29.9	30.4	34.9	37.2	37.4	43.0	44.5	49.1	55.8	66.5	75.3	84.5	94.3	96.9	104.6	111.2	116.6	127.1
700	PIPE TEMP	649.0	648.0	644.9	635.3	628.1	626.4	611.9	609.8	597.5	579.8	547.0	521.3	495.7	469.7	463.0	445.3	431.3	416.5	392.2
	MAX.W /FT	34.3	34.7	35.2	40.8	43.2	43.4	50.4	51.6	57.3	64.8	75.0	84.8	95.3	106.4	109.3	118.2	125.4	131.4	143.1
	MIN.W /FT	32.5	32.9	33.5	38.4	40.9	41.0	47.2	48.4	53.6	61.0	72.7	82.1	92.1	102.6	105.4	113.9	120.8	126.6	137.8
750	PIPE TEMP	694.1	693.1	689.8	679.4	671.6	669.8	654.1	651.8	638.5	618.3	584.0	556.8	528.8	500.8	493.7	474.8	459.8	443.9	418.0
	MAX.W /FT	37.7	38.1	38.6	44.6	47.3	47.4	55.0	56.3	62.5	70.6	81.6	92.1	103.4	115.3	118.6	127.9	135.8	142.1	154.6
	MIN.W /FT	35.6	36.0	36.6	42.0	44.7	44.8	51.5	53.2	58.6	66.4	79.0	89.1	99.6	111.1	114.0	123.2	130.8	136.7	148.8
800	PIPE TEMP	739.2	738.2	734.6	723.3	715.0	713.1	696.1	693.7	679.4	657.6	620.8	591.6	561.7	531.7	524.2	504.0	488.1	471.2	443.5
	MAX.W /FT	41.2	41.6	42.0	48.6	51.4	51.5	59.8	61.2	67.9	76.5	88.2	99.5	111.5	124.4	127.5	137.8	146.0	152.8	166.2
	MIN.W /FT	38.8	39.2	39.8	45.7	48.5	48.6	55.9	57.7	63.5	71.9	85.4	96.2	107.6	119.7	122.8	132.6	140.5	147.0	159.8
850	PIPE TEMP	784.2	783.1	779.3	767.2	758.3	756.2	738.0	735.5	720.2	698.0	657.3	626.2	594.3	562.4	554.5	533.0	516.1	498.2	468.9
	MAX.W /FT	44.7	45.1	45.5	52.7	55.7	55.8	64.7	66.1	73.2	82.6	95.0	107.0	119.9	133.6	136.9	147.6	156.6	163.8	177.9
	MIN.W /FT	42.1	42.5	43.2	49.5	52.5	52.6	60.3	62.3	68.5	77.5	91.3	103.4	115.8	128.5	131.8	142.2	150.5	157.5	171.4
900	PIPE TEMP	829.1	828.0	824.0	811.0	801.5	799.3	779.9	777.2	760.8	735.9	693.4	660.7	626.8	592.9	584.6	561.8	543.9	524.9	494.1
	MAX.W /FT	48.4	48.8	49.2	56.9	60.0	60.1	69.7	71.2	78.8	88.6	102.0	114.8	128.4	142.9	146.4	158.1	167.3	174.9	189.7
	MIN.W /FT	45.8	45.9	46.6	53.3	56.5	56.6	64.9	67.0	73.6	83.2	96.5	110.6	123.7	137.4	140.4	151.9	160.8	168.1	182.4
950	PIPE TEMP	874.0	872.9	868.6	854.7	844.6	842.3	821.6	818.8	801.4	774.9	730.1	695.0	659.1	623.2	614.5	590.4	571.5	551.5	519.6
	MAX.W /FT	52.2	52.6	53.0	61.2	64.5	64.6	74.9	76.4	84.5	95.2	109.1	122.6	137.1	152.5	156.1	168.6	178.2	186.3	202.0
	MIN.W /FT	49.1	49.6	50.1	57.3	60.7	60.8	69.6	71.8	78.2	89.1	103.4	116.3	130.0	144.5	150.1	161.8	171.1	178.9	193.9

INSULATION THICKNESS REQUIREMENTS

Service Designation T-36

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3-1/2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP-20.0 F (-28.9 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
6C	PIPE TEMP	56.8	56.5	56.2	55.6	55.0	54.7	53.6	53.3	52.2	50.6	47.8	45.4	42.9	40.6	39.6	37.9	36.4	34.8	32.1
	PARAM /FT	2.2	2.3	2.4	2.7	2.9	3.0	3.5	3.7	4.2	4.8	5.9	6.8	7.8	8.8	9.2	10.1	10.8	11.4	12.7
	PIN.M /FT	2.1	2.2	2.3	2.6	2.9	3.0	3.4	3.6	4.1	4.7	5.8	6.7	7.6	8.6	9.0	9.8	10.5	11.2	12.4
8C	PIPE TEMP	75.6	75.6	75.2	74.3	73.6	73.2	71.9	71.6	70.1	68.1	64.6	61.6	58.5	55.6	54.3	52.2	50.3	48.3	45.0
	PARAM /FT	2.8	2.9	3.0	3.5	3.8	3.9	4.5	4.7	5.3	6.1	7.4	8.6	9.8	11.1	11.6	12.7	13.6	14.4	16.0
	PIN.M /FT	2.7	2.8	3.0	3.4	3.6	3.8	4.3	4.6	5.2	5.9	7.3	8.4	9.6	10.8	11.3	12.5	13.2	14.0	15.6
10C	PIPE TEMP	94.5	94.4	94.1	93.1	92.2	91.8	90.1	89.6	88.0	85.6	81.3	77.7	74.0	70.4	69.0	66.4	64.2	61.8	57.7
	PARAM /FT	3.4	3.5	3.7	4.3	4.6	4.7	5.4	5.6	6.5	7.4	9.0	10.4	11.9	13.4	14.0	15.3	16.4	17.4	19.3
	PIN.M /FT	3.3	3.4	3.6	4.1	4.5	4.6	5.3	5.6	6.3	7.2	8.8	10.2	11.6	13.1	13.7	14.9	16.0	16.9	18.4
12C	PIPE TEMP	113.5	113.4	113.0	111.8	110.7	110.3	108.3	107.7	105.8	103.0	98.0	93.8	89.4	85.2	83.6	80.6	78.0	75.2	70.5
	PARAM /FT	4.0	4.2	4.4	5.1	5.4	5.6	6.4	6.8	7.7	8.8	10.6	12.2	14.0	15.7	16.5	17.9	19.2	20.4	22.6
	PIN.M /FT	3.9	4.1	4.3	4.9	5.3	5.4	6.2	6.6	7.4	8.5	10.4	12.0	13.7	15.4	16.1	17.5	18.8	19.9	22.0
14C	PIPE TEMP	132.5	132.4	131.8	130.4	129.2	128.7	126.5	125.7	123.6	120.3	114.6	109.8	104.8	100.0	98.1	94.7	91.7	88.5	83.1
	PARAM /FT	4.7	4.9	5.1	5.9	6.3	6.5	7.5	7.9	8.9	10.2	12.2	14.1	16.1	18.1	18.9	20.6	22.1	23.4	25.9
	PIN.M /FT	4.6	4.7	5.0	5.7	6.1	6.3	7.2	7.7	8.6	9.8	12.0	13.8	15.8	17.7	18.5	20.1	21.6	22.8	25.3
16C	PIPE TEMP	151.8	151.4	150.6	149.0	147.6	147.1	144.6	143.7	141.3	137.6	131.2	125.7	120.1	114.6	112.6	108.7	105.3	101.7	95.7
	PARAM /FT	5.4	5.6	5.9	6.7	7.2	7.4	8.5	9.0	10.1	11.6	13.9	16.0	18.3	20.6	21.6	23.4	25.0	26.5	29.3
	PIN.M /FT	5.2	5.4	5.7	6.5	7.0	7.2	8.2	8.8	9.7	11.2	13.4	15.7	17.9	20.1	20.9	22.8	24.4	25.8	28.6
18C	PIPE TEMP	170.2	170.3	169.6	167.6	166.1	165.5	162.6	161.7	159.0	154.9	147.7	141.6	135.3	129.2	127.0	122.6	118.9	114.9	108.2
	PARAM /FT	6.1	6.3	6.6	7.6	8.2	8.3	9.6	10.2	11.4	13.0	15.6	17.9	20.5	23.0	24.0	26.1	28.0	29.6	32.8
	PIN.M /FT	5.9	6.1	6.4	7.3	7.9	8.1	9.3	9.9	11.0	12.6	15.3	17.6	20.0	22.4	23.4	25.5	27.3	28.8	31.9
20C	PIPE TEMP	189.6	189.1	188.2	186.2	184.4	183.8	180.6	179.6	176.6	172.1	164.1	157.4	150.5	143.8	141.4	136.5	132.5	128.1	120.7
	PARAM /FT	6.9	7.1	7.4	8.5	9.1	9.3	10.7	11.3	12.6	14.4	17.3	19.9	22.7	25.5	26.5	28.9	31.0	32.8	36.2
	PIN.M /FT	6.7	6.9	7.2	8.2	8.8	9.0	10.3	11.0	12.2	14.0	16.9	19.5	22.2	24.9	25.9	28.2	30.2	31.9	35.2
22C	PIPE TEMP	208.4	208.0	206.9	204.7	202.8	202.1	199.6	197.5	194.2	189.2	180.5	173.2	165.6	158.2	155.6	150.4	145.9	141.1	133.1
	PARAM /FT	7.6	7.9	8.2	9.4	10.1	10.3	11.9	12.5	13.9	15.9	19.0	21.9	24.9	28.0	29.1	31.8	34.0	35.9	39.7
	PIN.M /FT	7.4	7.6	7.9	9.1	9.8	9.9	11.4	12.1	13.4	15.4	18.6	21.4	24.3	27.3	28.4	30.9	33.1	35.0	38.6
24C	PIPE TEMP	227.2	226.7	225.6	223.1	221.1	220.3	216.5	215.3	211.8	206.3	196.9	188.9	180.7	172.6	169.9	164.1	159.3	154.1	145.4
	PARAM /FT	8.4	8.7	9.0	10.4	11.1	11.3	13.0	13.7	15.3	17.4	20.8	23.9	27.2	30.6	31.8	34.4	37.0	39.1	43.2
	PIN.M /FT	8.1	8.4	8.7	10.0	10.7	10.9	12.5	13.3	14.7	16.9	20.4	23.4	26.6	29.8	31.0	33.7	36.0	38.1	42.1
26C	PIPE TEMP	246.0	245.4	244.2	241.5	239.3	238.5	234.3	233.1	229.3	223.4	213.1	204.6	195.7	186.9	184.0	177.8	172.6	167.0	157.7
	PARAM /FT	9.2	9.4	9.8	11.3	12.1	12.3	14.2	15.0	16.6	19.0	22.6	26.0	29.5	33.2	34.4	37.5	40.1	42.4	46.8
	PIN.M /FT	8.9	9.2	9.5	10.9	11.7	11.9	13.7	14.5	16.0	18.3	22.1	25.4	28.8	32.3	33.6	36.5	39.0	41.2	45.5
28C	PIPE TEMP	284.7	284.2	282.9	279.9	277.5	276.7	272.2	270.9	266.7	260.3	249.4	240.1	230.6	221.2	217.9	210.4	204.2	198.1	187.0
	PARAM /FT	10.1	10.3	10.7	12.3	13.2	13.4	15.4	16.2	18.0	20.6	24.5	28.1	31.9	35.8	37.2	40.4	43.2	45.7	50.4
	PIN.M /FT	9.7	10.0	10.4	11.9	12.7	12.9	14.8	15.7	17.4	19.9	23.9	27.4	31.1	34.9	36.2	39.4	42.1	44.6	49.0
30C	PIPE TEMP	283.4	282.9	281.5	278.3	275.7	274.9	270.0	268.6	264.1	257.3	245.5	235.6	225.6	215.3	212.1	205.0	199.0	192.6	182.0
	PARAM /FT	10.5	11.7	11.6	13.3	14.2	14.4	16.7	17.5	19.5	22.2	26.3	30.2	34.3	38.5	39.9	43.4	46.4	49.0	54.0
	PIN.M /FT	10.3	10.9	11.2	12.9	13.8	14.0	16.0	16.9	18.7	21.4	25.7	29.5	33.4	37.5	38.8	42.3	45.1	47.6	52.5
35C	PIPE TEMP	330.1	329.6	327.8	324.6	321.0	320.0	314.2	312.7	307.5	299.4	285.7	274.2	262.3	250.5	246.8	238.6	231.7	224.3	212.0
	PARAM /FT	13.1	13.6	13.9	16.0	17.0	17.2	19.9	20.8	23.1	26.3	31.1	35.6	40.3	45.3	46.9	51.0	54.4	57.4	63.2
	PIN.M /FT	12.7	13.2	13.4	15.6	16.5	16.6	19.1	20.1	22.2	25.4	30.4	34.7	39.3	44.1	45.6	49.6	52.9	55.8	61.4
40C	PIPE TEMP	376.5	375.9	373.9	369.5	366.0	365.0	358.3	356.5	350.5	341.2	325.5	312.3	298.7	285.2	281.2	271.7	263.9	255.6	241.7
	PARAM /FT	15.5	15.9	16.3	18.8	20.0	20.1	23.2	24.3	26.9	30.6	36.1	41.2	46.6	52.3	54.0	58.7	62.6	66.0	72.6
	PIN.M /FT	14.9	15.2	15.8	18.0	19.3	19.4	22.2	23.5	25.9	29.5	35.3	40.2	45.4	50.9	52.6	57.1	60.9	64.2	70.5
45C	PIPE TEMP	422.7	422.0	419.9	414.8	410.9	409.8	402.0	400.1	393.3	382.7	364.9	350.1	334.8	319.6	315.1	304.5	295.8	286.4	270.9
	PARAM /FT	18.0	18.3	18.8	21.7	23.0	23.2	26.7	27.9	30.9	35.0	41.2	47.0	53.1	59.5	61.4	66.7	71.1	74.9	82.7
	PIN.M /FT	17.3	17.6	18.2	20.8	22.2	22.3	25.6	26.9	29.6	33.7	40.3	45.8	51.7	57.8	59.7	64.8	69.0	72.7	79.8
50C	PIPE TEMP	468.8	468.0	465.7	460.0	455.5	454.3	445.6	443.6	435.8	423.9	404.1	387.5	370.5	353.5	348.7	336.9	327.2	316.9	299.8
	PARAM /FT	20.6	20.9	21.5	24.7	26.2	26.6	30.3	31.7	35.0	39.7	46.6	53.0	59.7	66.9	69.0	74.8	79.7	83.9	92.0
	PIN.M /FT	19.8	20.1	20.7	23.7	25.2	25.6	29.0	30.5	33.6	38.2	45.4	51.6	58.1	65.0	67.0	72.7	77.4	81.4	89.3
55C	PIPE TEMP	514.7	513.9	511.6	506.0	500.0	498.7	488.9	486.5	478.1	464.9	442.9	424.7	405.9	387.1	381.8	368.9	358.3	347.0	328.3
	PARAM /FT	23.3	23.7	24.3	27.9	29.5	29.7	34.1	35.6	39.3	44.5	52.0	59.1	66.6	74.5	76.7	83.2	88.5	93.1	102.0
	PIN.M /FT	22.4	22.7	23.4	26.7	28.4	28.5	32.6	34.2	37.6	42.7	50.7	57.5	64.6	72.3	74.5	80.7	85.9	90.3	98.9
60C	PIPE TEMP	560.4	559.4	556.9	549.7	544.2	542.8	532.1	529.5	520.1	505.6	481.5	461.5	440.9	420.4	414.7	400.5	389.0	376.7	356.6
	PARAM /FT	26.2	26.5	27.1	31.2	32.9	33.1	38.0	39.7	43.7	49.4	57.7	65.4	73.6	82.2	84.6	91.7	97.5	102.5	112.2
	PIN.M /FT	25.1	25.4	26.1	29.8	31.6	31.8	36.3	38.1	41.8	47.4	56.2	63.6	71.5	79.8	82.1	89.0	94.6	99.4	108.7
65C	PIPE TEMP	606.1	605.7	602.2	594.3	588.3	586.9	575.0	572.2	562.0	546.1	519.7	498.0	475.6	453.3	447.2	431.9	419.4	406.1	384.2
	PARAM /FT	29.1	29.4	30.1	34.5	36.5	36.6	42.0	43.8	48.2	54.4	63.4	71.8	80.7	90.1	92.7	100.4	106.7	112.1	122.5
	PIN.M /FT	27.9	28.2	28.9	33.0	35.0	35.1	40.0	42.0	46.1	52.2	61.8	69.9	78.6	87.6	89.9	97.3	103.4	108.6	118.7
70C	PIPE TEMP	651.8	650.7	647.5	639.8	632.3	630.7	617.8	614.8	603.7	586.4	557.8	534.3	510.1	486.0	479.5	462.9	449.5	435.2	411.7
	PARAM /FT	32.1	32.5	33.1	38.0	40.1	40.2	46.2	48.1	52.9	59.6	69.3	78.4	88.0	98.2	100.9	109.2	116.0	121.9	133.0
	PIN.M /FT	30.7	31.0	31.8	36.3	38.4	38.6	43.9	46.1	50.4	57.1	67.5	76.2	85.5	95.2	97.8	105.8	112.4	118.0	128.8
75C	PIPE TEMP	697.0	696.1	692.6	683.2	676.2	674.5	660.5	657.2	645.3	626.6	595.7	570.3	544.3	518.4	511.5	493.7	479.4	464.1	438.9
	PARAM /FT	35.3	35.6	36.3	41.6	43.8	43.9	50.6	52.6	57.7	64.9	75.3	85.1	95.4	106.6	109.3	118.2	125.5	131.7	143.7
	PIN.M /FT	33.6	34.0	34.8	39.6	42.0	42.1	47.9	50.2	54.9	62.1	73.3	82.7	92.6	103.1	105.9	114.5	121.6	127.5	139.0
80C	PIPE TEMP	742.4	741.6	737.7	727.5	719.9	718.2	703.0	699.6	686.7	666.5	633.3	606.1	578.3	550.6	543.3	524.3	509.0	492.7	465.9
	PARAM /FT	38.5	38.9	39.5	45.3	47.6	47.7	54.7	56.9	62.5	70.3	81.5	91.9	103.0	114.7	117.4	127.4	135.2	141.7	154.5
	PIN.M /FT	36.7	37.0	37.8	43.1	45.6	45.7	52.0	54.4	59.5	67.3	79.2	89.3	99.9	111.1	114.1	123.3	130.8	137.1	149.4
85C	PIPE TEMP	787.6	786.7	782.7	771.7	763.6	761.7	745.5	741.8	727.9	706.6	670.8	641.8	612.1	582.5	574.8	554.6	538.4	521.1	492.7
	PARAM /FT	41.8	42.1	42.8	49.1	51.6	51.6	59.2	61.5	67.5	75.9	87.8	98.9	110.7	123.2	126.5	136.7	145.0	151.9	165.5
	PIN.M /FT	39.8	40.1	41.0	46.6	49.3	49.4	56.1	58.8	64.2	72.5	85.3	96.0	107.3	119.3	122.6	132.2	140.2	146.9	160.0
90C	PIPE TEMP	832.8	831.9	827.6	815.8	807.2	805.2	787.8	783.9	769.1	746.1	708.2	677.3	645.8	614.3	606.2	584.7	567.5	549.2	519.2
	PARAM /FT	45.2	45.4	46.2	52.9	55.6	55.6	63.7	66.2	72.6	81.5	94.2	106.0	118.6	131.9	135.3	146.1	154.9	162.3	176.6
	PIN.M /FT	43.0	43.3	44.2	50.2	53.1	53.1	60.4	63.2	69.0	77.9	91.5	102.9	114.9	127.6	130.9	141.3	149.7	156.8	170.6
95C	PIPE TEMP	877.9	876.9	872.4	859.9	850.7	848.6	830.1	825.9	810.7	785.7	745.4	712.6	679.2	645.9	637.3	614.7	596.5	577.2	545.6
	PARAM /FT	48.7	49.0	49.7	56.9	59.7	59.8	68.4	71.0	77.9	87.4	100.7	113.3	126.6	140.7	144.3	155.8	165.0	172.9	187.9
	PIN.M /FT	46.3	46.6	47.5	54.0	57.0	57.0	64.8	67.7	73.9	83.3	97.8	109.9	122.6	136.0	139.5	150.5	159.4	166.9	181.5

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-37

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

4" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP -20.0 F (-28.9 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
60	PIPE TEMP	56.9	56.7	56.3	55.7	55.0	54.7	53.9	53.5	52.6	51.2	48.5	46.3	44.0	41.8	40.9	39.3	37.9	36.3	33.8
	MAX.W /FT	2.1	2.2	2.3	2.6	2.9	3.0	3.3	3.6	4.0	4.5	5.5	6.4	7.3	8.2	8.6	9.4	10.1	10.7	11.9
	MIN.W /FT	2.0	2.1	2.2	2.5	2.9	3.0	3.2	3.5	3.9	4.4	5.4	6.3	7.2	8.0	8.4	9.2	9.9	10.5	11.6
80	PIPE TEMP	76.0	75.7	75.3	74.6	73.6	73.2	72.3	71.8	70.6	68.8	65.5	62.7	59.8	57.1	55.9	53.9	52.2	50.3	47.1
	MAX.W /FT	2.6	2.8	2.9	3.3	3.8	3.9	4.2	4.5	5.0	5.7	7.0	8.1	9.2	10.3	10.8	11.6	12.7	13.4	14.9
	MIN.W /FT	2.6	2.7	2.8	3.2	3.6	3.8	4.1	4.4	4.9	5.6	6.8	7.9	9.0	10.1	10.6	11.6	12.4	13.1	14.6
100	PIPE TEMP	95.1	94.8	94.3	93.4	92.2	91.8	90.6	90.0	88.6	86.4	82.4	79.1	75.6	72.3	70.9	68.5	66.4	64.1	60.3
	MAX.W /FT	3.2	3.4	3.5	4.0	4.6	4.7	5.2	5.5	6.1	6.9	8.4	9.7	11.1	12.5	13.1	14.3	15.3	16.2	18.0
	MIN.W /FT	3.2	3.3	3.5	3.9	4.5	4.6	5.0	5.4	6.0	6.8	8.3	9.6	10.9	12.2	12.8	13.9	15.0	15.9	17.6
120	PIPE TEMP	114.1	113.8	113.2	112.1	110.7	110.3	108.9	108.2	106.5	104.0	99.3	95.4	91.3	87.4	85.9	83.1	80.6	77.9	73.5
	MAX.W /FT	3.9	4.0	4.2	4.8	5.4	5.6	6.1	6.5	7.2	8.1	9.9	11.5	13.1	14.7	15.3	16.7	17.9	19.0	21.1
	MIN.W /FT	3.8	3.9	4.1	4.7	5.3	5.4	5.9	6.3	7.0	8.0	9.8	11.2	12.8	14.4	15.0	16.4	17.6	18.6	20.6
140	PIPE TEMP	133.1	132.8	132.1	130.8	129.2	128.7	127.1	126.4	124.4	121.5	116.1	111.6	107.3	102.5	100.8	97.5	94.7	91.7	86.6
	MAX.W /FT	4.5	4.7	4.9	5.6	6.3	6.5	7.1	7.5	8.3	9.4	11.5	13.2	15.1	16.9	17.7	19.2	20.6	21.9	24.3
	MIN.W /FT	4.4	4.6	4.8	5.4	6.1	6.3	6.9	7.3	8.1	9.2	11.3	13.0	14.8	16.6	17.3	18.8	20.2	21.4	23.7
160	PIPE TEMP	152.1	151.7	151.0	149.5	147.6	147.1	145.3	144.5	142.2	139.0	132.9	127.6	122.6	117.5	115.6	112.0	108.8	105.4	99.6
	MAX.W /FT	5.2	5.3	5.6	6.4	7.2	7.4	8.1	8.5	9.5	10.7	13.0	15.0	17.1	19.2	20.0	21.4	23.3	24.7	27.4
	MIN.W /FT	5.0	5.2	5.4	6.2	7.0	7.2	7.8	8.4	9.2	10.5	12.8	14.7	16.7	18.8	19.6	21.3	22.8	24.2	26.8
180	PIPE TEMP	171.1	170.7	169.8	168.2	166.1	165.5	163.4	162.5	160.1	156.4	149.6	144.0	138.2	132.5	130.4	126.3	122.8	119.0	112.6
	MAX.W /FT	5.8	6.0	6.3	7.2	8.2	8.3	9.1	9.6	10.7	12.0	14.6	16.8	19.1	21.4	22.3	24.3	26.1	27.6	30.6
	MIN.W /FT	5.7	5.9	6.1	7.0	7.9	8.1	8.8	9.4	10.4	11.8	14.3	16.5	18.7	21.0	21.9	23.8	25.5	27.0	29.9
200	PIPE TEMP	190.0	189.6	188.7	186.8	184.4	183.8	181.5	180.6	177.8	173.8	166.3	160.1	153.6	147.4	145.1	140.6	136.7	132.5	125.5
	MAX.W /FT	6.6	6.8	7.0	8.0	9.1	9.3	10.1	10.7	11.9	13.3	16.2	18.6	21.2	23.8	24.7	26.9	28.9	30.6	33.9
	MIN.W /FT	6.4	6.6	6.9	7.8	8.8	9.0	9.8	10.5	11.6	13.1	15.9	18.2	20.7	23.3	24.2	26.3	28.2	29.9	33.1
220	PIPE TEMP	208.9	208.4	207.4	205.4	202.8	202.1	199.6	198.5	195.5	191.1	182.9	176.1	169.1	162.2	159.8	154.8	150.6	146.0	138.4
	MAX.W /FT	7.3	7.5	7.8	8.9	10.1	10.3	11.2	11.8	13.1	14.7	17.8	20.5	23.3	26.1	27.2	29.6	31.7	33.5	37.1
	MIN.W /FT	7.1	7.3	7.6	8.6	9.8	9.9	10.9	11.5	12.7	14.4	17.5	20.1	22.8	25.5	26.6	28.9	30.9	32.7	36.2
240	PIPE TEMP	227.7	227.2	226.2	223.9	221.1	220.3	217.6	216.5	213.2	208.4	199.5	192.1	184.4	177.0	174.4	169.0	164.4	159.5	151.2
	MAX.W /FT	8.0	8.2	8.6	9.8	11.1	11.3	12.3	13.0	14.3	16.1	19.5	22.3	25.4	28.5	29.6	32.2	34.5	36.5	40.4
	MIN.W /FT	7.8	8.0	8.4	9.5	10.7	10.9	11.9	12.7	14.0	15.8	19.1	21.9	24.9	27.9	28.9	31.5	33.7	35.7	39.4
260	PIPE TEMP	246.5	246.0	244.9	242.4	239.3	238.5	235.6	234.4	230.3	225.6	216.0	208.0	199.7	191.6	188.9	183.1	178.2	172.8	163.9
	MAX.W /FT	8.8	9.0	9.3	10.7	12.1	12.3	13.4	14.1	15.6	17.5	21.2	24.3	27.5	30.9	32.1	34.9	37.4	39.5	43.7
	MIN.W /FT	8.6	8.8	9.1	10.4	11.7	11.9	13.0	13.8	15.2	17.2	20.8	23.8	27.0	30.2	31.4	34.1	36.5	38.6	42.7
280	PIPE TEMP	265.3	264.8	263.6	260.9	257.5	256.7	253.5	252.2	248.4	242.8	232.5	223.9	215.0	206.3	203.3	197.1	191.8	186.1	176.6
	MAX.W /FT	9.6	9.8	10.2	11.6	13.2	13.4	14.5	15.3	16.9	18.9	22.9	26.2	29.7	33.4	34.6	37.7	40.3	42.6	47.1
	MIN.W /FT	9.3	9.5	9.9	11.3	12.7	12.9	14.1	14.9	16.4	18.6	22.4	25.7	29.1	32.6	33.8	36.8	39.3	41.6	45.9
300	PIPE TEMP	284.1	283.5	282.2	279.3	275.7	274.9	271.4	270.1	266.0	260.0	248.9	239.7	230.2	220.8	217.7	211.1	205.4	199.3	189.2
	MAX.W /FT	10.4	10.6	11.0	12.6	14.2	14.4	15.7	16.5	18.2	20.4	24.6	28.2	31.9	35.8	37.1	40.4	43.2	45.7	50.5
	MIN.W /FT	10.1	10.3	10.7	12.2	13.8	14.0	15.2	16.1	17.7	20.0	24.1	27.6	31.3	35.0	36.3	39.5	42.2	44.6	49.2
350	PIPE TEMP	330.8	330.1	328.7	325.3	321.0	320.0	316.0	314.4	309.7	302.6	289.7	278.9	267.9	256.9	253.5	245.7	239.2	232.1	220.4
	MAX.W /FT	12.5	12.8	13.2	15.0	17.0	17.2	18.7	19.6	21.6	24.2	29.1	33.2	37.6	42.2	43.6	47.5	50.7	53.6	59.1
	MIN.W /FT	12.1	12.4	12.8	14.6	16.5	16.6	18.1	19.1	21.0	23.7	28.5	32.5	36.8	41.2	42.6	46.3	49.5	52.2	57.6
400	PIPE TEMP	377.4	376.8	375.1	371.0	366.0	365.0	360.3	358.6	353.1	344.9	330.1	317.8	305.2	292.7	288.6	279.9	272.5	264.5	251.2
	MAX.W /FT	14.7	15.0	15.4	17.6	20.0	20.1	21.9	22.9	25.2	28.1	33.7	38.4	43.5	48.7	50.3	54.7	58.4	61.6	67.9
	MIN.W /FT	14.3	14.6	15.0	17.1	19.3	19.4	21.1	22.3	24.5	27.6	33.0	37.6	42.5	47.5	49.1	53.4	56.9	60.1	66.2
450	PIPE TEMP	423.8	423.2	421.2	416.6	410.9	409.8	404.4	402.5	396.3	387.0	370.2	356.4	342.1	328.0	323.7	313.8	305.5	296.5	281.6
	MAX.W /FT	17.1	17.4	17.8	20.3	23.0	23.2	25.1	26.3	28.9	32.2	38.5	43.8	49.5	55.4	57.2	62.1	66.3	69.7	76.9
	MIN.W /FT	16.6	16.9	17.3	19.7	22.2	22.3	24.3	25.6	28.0	31.6	37.7	42.9	48.4	54.0	55.8	60.6	64.6	68.1	74.9
500	PIPE TEMP	470.1	469.4	467.2	462.0	455.5	454.3	448.3	446.1	439.2	428.8	410.0	394.6	378.7	363.0	358.3	347.2	338.0	328.1	311.7
	MAX.W /FT	19.6	19.9	20.3	23.2	26.2	26.4	28.5	29.8	32.8	36.6	43.5	49.4	55.7	62.3	64.2	69.7	74.3	78.3	86.1
	MIN.W /FT	18.9	19.3	19.8	22.6	25.2	25.4	27.5	29.0	31.8	35.7	42.5	48.3	54.6	60.7	62.7	66.6	72.4	76.3	83.8
550	PIPE TEMP	516.2	515.4	513.1	507.2	500.0	498.7	492.0	489.6	481.9	470.3	449.6	432.5	415.0	397.6	392.5	380.3	370.2	359.4	341.3
	MAX.W /FT	22.1	22.4	22.9	26.1	29.5	29.7	32.0	33.5	36.7	40.8	49.6	55.1	62.1	69.3	71.5	77.5	82.6	87.0	95.5
	MIN.W /FT	21.4	21.7	22.3	25.3	28.4	28.5	30.9	32.6	35.6	40.0	47.5	53.9	60.6	67.6	69.7	75.5	80.4	84.7	92.9
600	PIPE TEMP	562.1	561.4	558.8	552.3	544.2	542.8	535.4	532.7	524.3	511.6	488.4	470.1	450.9	431.8	426.4	413.1	402.1	390.3	370.7
	MAX.W /FT	24.8	25.1	25.6	29.2	32.9	33.1	35.7	37.3	40.9	45.3	53.4	61.0	68.6	76.5	78.7	85.5	91.0	95.8	105.0
	MIN.W /FT	23.9	24.3	24.9	28.2	31.6	31.8	34.4	36.2	39.5	44.3	52.6	59.6	66.9	74.6	76.8	83.2	88.8	93.2	102.2
650	PIPE TEMP	608.0	607.2	604.4	597.2	588.3	586.9	578.7	576.0	566.6	552.7	527.8	507.5	486.6	465.3	460.0	445.5	433.6	420.9	399.7
	MAX.W /FT	27.6	27.9	28.4	32.3	36.5	36.6	39.4	41.2	45.1	49.9	59.2	67.0	75.3	83.9	86.4	93.6	99.6	104.7	114.7
	MIN.W /FT	26.6	26.9	27.5	31.2	35.0	35.1	38.0	39.9	43.6	48.3	57.9	65.4	73.4	81.7	84.1	91.1	96.9	101.9	111.6
700	PIPE TEMP	653.7	652.9	649.9	642.0	632.3	630.7	621.9	618.9	608.8	593.5	566.6	544.6	522.0	499.5	493.3	477.7	464.9	451.1	428.4
	MAX.W /FT	30.4	30.7	31.3	35.6	40.1	40.2	43.3	45.2	49.4	54.6	64.7	73.1	82.1	91.6	94.1	101.9	108.3	113.8	124.6
	MIN.W /FT	29.3	29.6	30.3	34.3	38.4	38.6	41.7	43.8	47.7	53.4	63.2	71.4	80.0	89.0	91.6	99.1	105.3	110.7	121.1
750	PIPE TEMP	699.3	698.8	695.2	686.7	676.2	674.5	664.9	661.7	650.7	634.3	605.2	581.4	557.2	533.0	526.3	509.6	495.9	481.2	456.8
	MAX.W /FT	33.3	33.6	34.2	38.9	43.8	43.9	47.2	49.2	53.8	59.4	70.3	79.4	89.0	99.1	101.9	110.1	117.2	123.1	134.6
	MIN.W /FT	32.1	32.4	33.1	37.5	42.0	42.1	45.4	47.7	52.0	58.2	68.7	77.5	86.7	96.4	99.2	107.2	113.9	119.6	130.8
800	PIPE TEMP	744.5	744.0	740.5	731.3	719.9	718.2	707.8	704.4	692.0	674.8	643.6	618.1	592.1	566.2	559.7	541.3	526.7	511.0	485.1
	MAX.W /FT	36.4	36.7	37.2	42.3	47.6	47.7	51.3	53.4	58.6	64.4	76.1	85.8	96.1	106.9	109.9	118.8	126.2	132.5	144.8
	MIN.W /FT	34.9	35.2	36.0	40.7	45.6	45.7	49.3	51.7	56.3	63.0	74.3	83.7	93.6	103.9	106.9	115.5	122.6	128.7	140.6
850	PIPE TEMP	790.3	789.6	785.7	775.8	763.6	761.7	750.6	746.9	734.3	715.2	681.8	654.6	626.9	599.3	591.8	572.7	557.2	540.5	513.0
	MAX.W /FT	39.5	39.8	40.3	45.8	51.6	51.6	55.6	57.7	63.0	69.5	81.9	92.3	103.3	114.8	118.0	127.5	135.4	142.1	155.1
	MIN.W /FT	37.9	38.2	39.0	44.1	49.3	49.4	53.7	55.9	60.8	67.9	79.9	90.0	100.3	111.6	114.7	123.9	131.5	137.9	150.6
900	PIPE TEMP	835.7	834.8	830.9	820.2	807.2	805.2	793.3	789.4	775.9	755.5	719.9	691.0	661.5	632.1	624.2	604.0	587.5	569.9	540.8
	MAX.W /FT	42.6	42.9	43.5	49.6	55.6	55.6	59.7	62.1	67.8	74.6	87.9	99.0	110.6	122.9	126.2	136.4	144.7	151.8	165.6
	MIN.W /FT	40.9	41.2	42.0	47.5	53.1	53.1	57.3	60.1	65.3	72.9	85.7	96.4	107.6	119.4	122.6	132.4	140.4	147.3	160.6
950	PIPE TEMP	881.1	880.1	875.9	864.5	850.7	848.6	835.0	831.8	817.4	795.7	757.5	727.2	695.9	664.8	656.5	635.1	617.7	599.0	568.4
	MAX.W /FT	45.9	46.1	46.8	53.1	59.7	59.8	64.0	66.6	72.6	79.9	94.0	105.7	118.1	131.1	134.6	145.4	154.2	161.6	176.2
	MIN.W /FT	44.0	44.3	45.2	51.0	57.0	57.0	61.4	64.4	69.9	78.3	91.7	103.0	114.9	127.3	130.7	141.1	149.6	156.8	170.9

INSULATION THICKNESS REQUIREMENTS

Service Designation T-38

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

1" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 0 F (-17.8 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
60	PIPE TEMP	56.5	56.2	55.8	55.1	54.3	53.8	52.6	52.5	50.8	48.8									
	MAX.W /FT	2.6	2.7	2.9	3.3	3.7	3.9	4.5	4.5	5.5	6.6									
	MIN.W /FT	2.4	2.5	2.7	3.0	3.4	3.5	4.0	4.1	4.9	5.7									
80	PIPE TEMP	75.3	74.9	74.3	73.3	72.2	71.6	70.0	69.8	67.5	64.8									
	MAX.W /FT	3.5	3.8	4.0	4.5	5.1	5.3	6.2	6.2	7.6	8.9									
	MIN.W /FT	3.3	3.5	3.7	4.1	4.6	4.8	5.5	5.6	6.6	7.7									
100	PIPE TEMP	93.9	93.4	92.7	91.5	89.9	89.3	87.2	87.1	84.1	80.7									
	MAX.W /FT	4.5	4.8	5.1	5.8	6.5	6.8	7.9	7.9	9.6	11.4									
	MIN.W /FT	4.2	4.4	4.7	5.3	5.9	6.2	7.0	7.1	8.4	9.8									
120	PIPE TEMP	112.5	111.9	111.0	109.5	107.6	106.8	104.3	104.2	100.6	96.5									
	MAX.W /FT	5.6	5.9	6.2	7.1	8.0	8.4	9.7	9.7	11.8	13.9									
	MIN.W /FT	5.2	5.4	5.7	6.5	7.3	7.5	8.6	8.7	10.3	12.0									
140	PIPE TEMP	130.9	130.3	129.2	127.4	125.2	124.3	121.3	121.2	117.0	112.1									
	MAX.W /FT	6.7	7.1	7.5	8.5	9.6	10.0	11.5	11.5	14.0	16.5									
	MIN.W /FT	6.2	6.5	6.8	7.7	8.7	9.0	10.2	10.3	12.2	14.2									
160	PIPE TEMP	149.3	148.6	147.4	145.3	142.7	141.7	138.2	138.1	133.3	127.7									
	MAX.W /FT	7.9	8.3	8.7	10.0	11.2	11.7	13.5	13.4	16.3	19.2									
	MIN.W /FT	7.2	7.6	8.0	9.0	10.1	10.5	11.9	12.0	14.2	16.5									
180	PIPE TEMP	167.7	166.9	165.5	163.1	160.2	159.0	155.0	155.0	149.5	143.1									
	MAX.W /FT	9.1	9.6	10.0	11.5	13.0	13.4	15.5	15.4	18.7	22.0									
	MIN.W /FT	8.3	8.7	9.2	10.4	11.6	12.0	13.6	13.7	16.2	18.8									
200	PIPE TEMP	186.0	185.0	183.5	180.8	177.5	176.2	171.7	171.7	165.6	158.4									
	MAX.W /FT	10.3	10.9	11.4	13.0	14.7	15.3	17.6	17.4	21.2	24.9									
	MIN.W /FT	9.5	9.9	10.4	11.8	13.2	13.6	15.4	15.5	18.3	21.2									
220	PIPE TEMP	204.2	203.2	201.5	198.4	194.7	193.4	188.4	188.4	181.6	173.6									
	MAX.W /FT	11.7	12.3	12.8	14.7	16.6	17.1	19.7	19.5	23.7	27.8									
	MIN.W /FT	10.7	11.2	11.7	13.2	14.8	15.2	17.3	17.3	20.6	23.7									
240	PIPE TEMP	222.3	221.2	219.4	216.0	211.9	210.6	204.9	205.0	197.5	188.7									
	MAX.W /FT	13.1	13.7	14.3	16.4	18.5	19.1	22.0	21.6	26.3	30.9									
	MIN.W /FT	11.9	12.4	13.0	14.7	16.4	16.9	19.2	19.2	22.6	26.2									
260	PIPE TEMP	240.3	239.2	237.2	233.4	229.0	227.4	221.3	221.5	213.3	203.7									
	MAX.W /FT	14.5	15.2	15.8	18.1	20.4	21.0	24.3	23.8	29.0	34.0									
	MIN.W /FT	13.2	13.7	14.3	16.2	18.1	18.6	21.1	21.1	24.8	28.7									
280	PIPE TEMP	258.3	257.1	255.0	250.8	245.9	244.3	237.7	238.0	229.0	218.6									
	MAX.W /FT	16.0	16.7	17.4	19.9	22.5	23.1	26.6	26.1	31.7	37.2									
	MIN.W /FT	14.5	15.1	15.7	17.8	19.9	20.3	23.1	23.0	27.8	31.3									
300	PIPE TEMP	276.3	275.0	272.7	268.2	262.9	261.1	253.9	254.3	244.7	233.4									
	MAX.W /FT	17.5	18.3	19.0	21.8	24.6	25.2	29.0	28.4	34.5	40.4									
	MIN.W /FT	15.9	16.5	17.2	19.4	21.7	22.1	25.1	25.0	29.4	34.0									
350	PIPE TEMP	320.8	319.4	316.7	311.2	304.8	302.9	296.2	296.9	283.6	270.0									
	MAX.W /FT	21.6	22.5	23.3	26.7	30.0	30.7	35.4	34.5	41.8	48.9									
	MIN.W /FT	19.5	20.1	20.9	23.7	26.3	26.8	30.4	30.2	35.4	40.8									
400	PIPE TEMP	364.9	363.4	360.3	353.8	346.3	344.2	336.0	335.1	321.6	306.1									
	MAX.W /FT	26.1	26.9	27.9	32.0	35.9	36.6	42.1	40.9	49.5	57.9									
	MIN.W /FT	23.4	24.1	24.9	28.2	31.3	31.8	36.0	35.6	41.7	47.9									
450	PIPE TEMP	408.6	407.0	403.5	396.0	387.4	385.1	373.4	374.9	359.5	341.8									
	MAX.W /FT	30.8	31.7	32.8	37.5	42.1	42.8	49.2	47.6	57.6	67.2									
	MIN.W /FT	27.4	28.2	29.1	32.9	36.4	36.9	41.7	41.2	48.2	55.3									
500	PIPE TEMP	452.0	450.3	446.5	437.8	428.1	425.7	412.4	414.3	396.9	377.0									
	MAX.W /FT	35.8	36.8	37.9	43.4	48.6	49.3	56.7	54.5	66.1	76.9									
	MIN.W /FT	31.8	32.5	33.5	37.8	41.8	42.3	47.7	47.0	54.9	62.8									
550	PIPE TEMP	495.1	493.3	489.1	479.4	468.5	465.9	451.1	453.6	434.0	411.8									
	MAX.W /FT	41.2	42.2	43.3	49.6	55.4	56.1	64.4	61.8	74.8	87.0									
	MIN.W /FT	38.3	37.0	38.0	42.9	47.4	47.9	53.9	52.9	61.8	70.6									
600	PIPE TEMP	537.9	536.1	531.5	520.7	508.6	505.9	489.4	492.2	470.8	446.4									
	MAX.W /FT	46.8	47.8	48.9	56.0	62.5	63.2	72.5	69.3	83.9	97.4									
	MIN.W /FT	41.0	41.8	42.8	48.2	53.2	53.6	60.3	59.1	68.8	78.6									
650	PIPE TEMP	580.5	578.6	573.7	561.8	548.5	545.6	527.5	530.8	507.3	480.6									
	MAX.W /FT	52.6	53.7	54.8	62.7	69.9	70.5	80.8	77.1	93.3	108.2									
	MIN.W /FT	45.9	46.7	47.7	53.7	59.1	59.5	66.9	65.4	76.1	86.7									
700	PIPL TEMP	622.9	620.9	615.7	602.6	588.1	585.1	565.4	569.2	543.6	514.6									
	MAX.W /FT	58.4	59.9	60.9	69.6	77.5	78.1	89.5	85.1	102.9	119.3									
	MIN.W /FT	51.0	51.8	52.8	59.3	65.2	65.6	73.6	71.9	83.5	95.0									
750	PIPL TEMP	665.1	663.1	657.6	643.4	627.7	624.5	603.2	607.5	579.7	548.6									
	MAX.W /FT	65.2	66.3	67.3	76.8	85.5	86.0	98.5	93.3	112.9	130.7									
	MIN.W /FT	56.3	57.1	58.0	65.2	71.5	71.9	80.5	78.5	91.2	103.6									
800	PIPE TEMP	707.3	705.3	699.4	684.0	667.1	663.8	640.8	645.6	615.8	582.1									
	MAX.W /FT	72.0	73.1	74.0	84.4	93.8	94.3	107.8	101.9	123.3	142.5									
	MIN.W /FT	61.8	62.6	63.5	71.2	78.0	78.3	87.7	85.3	99.0	112.3									
850	PIPE TEMP	749.4	747.3	741.1	724.5	706.4	703.0	678.3	683.6	651.7	615.7									
	MAX.W /FT	79.2	80.3	81.1	92.3	102.4	102.9	117.5	110.7	134.1	154.8									
	MIN.W /FT	67.6	68.4	69.2	77.5	84.8	85.0	95.1	92.4	107.1	121.3									
900	PIPE TEMP	791.4	789.3	782.8	765.1	745.7	742.1	715.8	721.5	687.6	649.3									
	MAX.W /FT	87.0	88.1	88.6	100.7	111.6	112.0	127.8	120.0	145.4	167.7									
	MIN.W /FT	73.8	74.5	75.3	84.1	91.9	92.1	102.8	99.7	115.5	130.6									
950	PIPE TEMP	833.5	831.3	824.4	805.5	784.9	781.3	753.3	759.4	723.6	682.8									
	MAX.W /FT	95.4	96.5	96.7	109.8	121.4	121.8	138.9	129.8	157.5	181.3									
	MIN.W /FT	80.5	81.2	81.7	91.2	99.6	99.5	111.0	107.3	124.3	140.4									

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-39

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

1-1/2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 0 F (-17.8 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
60	PIPE TEMP	57.0	56.8	56.3	55.7	55.2	54.9	53.6	53.3	51.9	50.2	47.1	44.2	41.6	39.1	38.0	36.3	34.9	33.4	31.0
	MAX.W /FT	2.1	2.2	2.5	2.8	3.0	3.1	3.8	3.9	4.7	5.5	6.8	7.9	8.7	9.8	10.3	11.2	11.9	12.6	13.8
	MIN.W /FT	2.0	2.1	2.4	2.6	2.8	2.9	3.5	3.7	4.3	5.0	6.2	7.3	8.3	9.3	9.8	10.6	11.3	11.9	13.0
80	PIPE TEMP	75.9	75.6	74.9	74.1	73.4	73.0	71.3	70.9	69.1	66.7	62.5	58.7	55.3	51.9	50.5	48.1	46.2	44.3	41.1
	MAX.W /FT	2.8	3.0	3.4	3.8	4.1	4.2	5.2	5.4	6.4	7.4	9.2	10.6	11.7	13.2	13.9	15.1	16.1	16.9	18.5
	MIN.W /FT	2.7	2.9	3.2	3.6	3.8	3.9	4.7	5.0	5.8	6.7	8.3	9.8	11.2	12.6	13.2	14.3	15.2	16.0	17.5
100	PIPE TEMP	94.8	94.4	93.5	92.5	91.6	91.1	88.9	88.4	86.1	83.1	77.9	73.1	68.8	64.5	62.8	59.9	57.5	55.1	51.1
	MAX.W /FT	3.7	3.9	4.4	4.9	5.2	5.4	6.6	6.8	8.1	9.5	11.7	13.4	14.8	16.7	17.5	19.0	20.2	21.3	23.2
	MIN.W /FT	3.5	3.6	4.1	4.6	4.8	5.0	6.0	6.3	7.3	8.5	10.5	12.4	14.1	15.9	16.6	18.0	19.2	20.1	22.0
120	PIPE TEMP	113.6	113.2	112.0	110.8	109.7	109.1	106.4	105.9	103.1	99.5	93.1	87.4	82.2	77.0	75.0	71.5	68.7	65.7	61.0
	MAX.W /FT	4.5	4.7	5.3	6.0	6.4	6.6	8.1	8.3	9.9	11.6	14.2	16.3	17.9	20.3	21.1	23.0	24.5	25.7	28.0
	MIN.W /FT	4.2	4.5	5.C	5.6	5.9	6.1	7.4	7.7	8.9	10.4	12.8	15.1	17.1	19.2	20.1	21.8	23.2	24.3	26.5
140	PIPE TEMP	132.3	131.8	130.5	129.0	127.8	127.1	123.8	123.3	120.0	115.7	108.3	101.6	95.5	89.4	87.1	83.0	79.7	76.3	70.8
	MAX.W /FT	5.4	5.6	6.4	7.2	7.6	7.8	9.6	9.9	11.7	13.7	16.8	19.2	21.1	23.9	24.9	27.0	28.7	30.2	32.9
	MIN.W /FT	5.1	5.3	6.C	6.7	7.1	7.3	8.8	9.1	10.6	12.3	15.1	17.8	20.1	22.6	23.6	25.6	27.2	28.6	31.1
160	PIPE TEMP	151.0	150.5	148.9	147.1	145.7	145.0	141.2	140.6	136.8	131.8	123.3	115.6	108.7	101.7	99.2	94.4	90.7	86.8	80.6
	MAX.W /FT	6.3	6.6	7.4	8.4	8.8	9.1	11.2	11.5	13.6	15.9	19.4	22.2	24.4	27.5	28.6	31.1	33.1	34.7	37.8
	MIN.W /FT	5.9	6.2	6.9	7.8	8.2	8.5	10.2	10.6	12.3	14.2	17.5	20.5	23.2	26.1	27.2	29.5	31.3	32.8	35.8
180	PIPE TEMP	169.6	169.0	167.2	165.2	163.6	162.8	158.4	157.8	153.5	147.9	138.3	129.6	121.8	113.8	111.1	105.7	101.5	97.2	90.2
	MAX.W /FT	7.2	7.6	8.6	9.7	10.1	10.4	12.8	13.2	15.6	18.2	22.1	25.3	27.7	31.3	32.5	35.3	37.5	39.3	42.8
	MIN.W /FT	6.8	7.1	8.C	8.9	9.4	9.7	11.7	12.1	14.0	16.2	19.9	23.3	26.3	29.6	30.8	33.4	35.5	37.2	40.4
200	PIPE TEMP	188.2	187.6	185.5	183.2	181.5	180.6	175.7	175.0	170.1	163.9	153.1	143.5	134.8	125.9	122.9	117.0	112.3	107.5	99.7
	MAX.W /FT	8.2	8.6	9.7	11.0	11.5	11.8	14.5	14.9	17.6	20.5	24.9	28.4	31.1	35.1	36.4	39.5	41.9	44.0	47.8
	MIN.W /FT	7.7	8.C	9.C	10.1	10.7	10.9	13.2	13.6	15.8	18.3	22.4	26.1	29.5	33.2	34.4	37.3	39.6	41.5	45.2
220	PIPE TEMP	206.7	206.1	203.7	201.2	199.3	198.3	192.8	192.0	186.7	179.7	167.9	157.2	147.6	137.8	134.6	128.1	123.0	117.7	109.2
	MAX.W /FT	9.3	9.6	10.9	12.3	12.9	13.2	16.2	16.7	19.6	22.9	27.7	31.6	34.5	38.9	40.3	43.8	46.5	48.7	52.7
	MIN.W /FT	8.7	9.0	10.1	11.4	11.9	12.2	14.7	15.2	17.6	20.4	24.9	29.0	32.7	36.8	38.1	41.3	43.9	45.9	49.9
240	PIPE TEMP	225.2	224.5	221.9	219.1	217.0	216.0	209.8	209.1	203.1	195.5	182.6	170.9	160.4	149.6	146.3	139.1	133.6	127.8	118.6
	MAX.W /FT	10.3	10.7	12.1	13.7	14.3	14.6	18.0	18.5	21.7	25.3	30.6	34.8	38.0	42.8	44.3	48.1	51.0	53.4	58.0
	MIN.W /FT	9.7	10.C	11.2	12.6	13.2	13.5	16.3	16.8	19.4	22.5	27.4	31.9	36.0	40.5	41.9	45.4	48.1	50.4	54.7
260	PIPE TEMP	243.6	242.9	240.1	237.0	234.7	233.6	226.8	226.0	219.6	211.2	197.1	184.5	173.1	161.4	157.8	150.0	144.1	137.9	127.9
	MAX.W /FT	11.4	11.8	13.4	15.1	15.8	16.1	19.8	20.3	23.9	27.8	33.6	38.1	41.5	46.8	48.3	52.5	55.6	58.2	63.2
	MIN.W /FT	10.7	11.1	12.4	13.9	14.6	14.9	17.9	18.5	21.3	24.7	30.0	34.9	39.3	44.2	45.7	49.5	52.5	54.9	59.6
280	PIPE TEMP	262.0	261.2	258.1	254.8	252.3	251.1	243.7	242.9	235.9	226.9	211.6	198.0	185.7	173.0	169.3	160.9	154.5	147.8	137.1
	MAX.W /FT	12.5	13.0	14.7	16.6	17.3	17.6	21.7	22.2	26.1	30.4	36.6	41.5	45.0	50.8	52.4	56.9	60.3	63.1	68.4
	MIN.W /FT	11.7	12.1	13.6	15.2	15.9	16.2	19.6	20.2	23.3	26.9	32.6	37.9	42.7	48.0	49.5	53.6	56.8	59.4	64.5
300	PIPE TEMP	280.3	279.5	276.2	272.5	269.8	268.6	260.6	259.7	252.2	242.4	226.1	211.6	198.3	184.6	180.6	171.7	164.8	157.7	146.3
	MAX.W /FT	13.7	14.2	16.C	18.1	18.8	19.2	23.7	24.2	28.4	33.0	39.6	44.9	48.7	54.9	56.4	61.3	65.0	67.9	73.7
	MIN.W /FT	12.8	13.2	14.8	16.6	17.3	17.6	21.3	21.9	25.2	29.2	35.3	41.0	46.1	51.8	53.4	57.8	61.2	64.0	69.4
350	PIPE TEMP	326.0	325.0	321.C	316.6	313.5	312.1	302.4	301.5	292.5	281.0	261.7	244.6	229.2	213.1	208.7	198.2	190.2	182.1	168.9
	MAX.W /FT	16.8	17.3	19.5	22.0	22.9	23.2	28.7	29.2	34.2	39.8	47.5	53.6	57.9	65.3	67.1	72.7	77.0	80.4	87.0
	MIN.W /FT	15.6	16.1	17.9	20.1	21.0	21.3	25.7	26.4	30.3	35.0	42.2	48.8	54.8	61.5	63.3	68.4	72.4	75.6	81.8
400	PIPE TEMP	371.3	370.3	365.6	360.3	356.8	355.3	343.9	343.0	332.5	319.1	297.0	277.2	259.6	241.0	236.3	224.2	215.2	205.9	191.0
	MAX.W /FT	20.1	20.6	23.2	26.2	27.1	27.5	34.0	34.5	40.4	46.8	55.7	62.6	67.5	76.0	78.0	84.4	89.2	93.1	100.6
	MIN.W /FT	18.6	19.1	21.3	23.9	24.8	25.1	30.3	31.0	35.6	41.0	49.2	56.9	63.7	71.4	73.4	79.3	83.8	87.5	94.5
450	PIPE TEMP	416.4	415.3	409.9	403.8	399.8	398.2	385.0	384.1	372.1	356.8	331.8	309.4	289.5	268.5	263.4	249.8	239.8	229.4	212.8
	MAX.W /FT	23.6	24.1	27.2	30.7	31.6	32.0	39.5	40.0	46.8	54.2	64.2	71.9	77.3	86.9	89.1	96.4	101.8	106.1	114.4
	MIN.W /FT	21.6	22.3	24.6	27.8	28.8	29.1	35.1	35.9	41.1	47.2	56.5	65.2	72.9	81.6	83.7	90.4	95.5	99.5	107.4
500	PIPE TEMP	461.2	460.1	453.9	447.0	442.5	440.8	425.8	424.9	411.4	394.2	366.2	341.2	319.0	295.5	290.0	275.0	263.9	252.4	234.1
	MAX.W /FT	27.3	27.8	31.3	35.3	36.3	36.7	45.3	45.8	53.5	61.9	73.0	81.5	87.4	98.2	100.4	108.6	114.5	119.3	128.5
	MIN.W /FT	25.1	25.6	28.5	31.9	33.0	33.3	40.1	40.9	46.8	53.7	64.0	73.7	82.2	92.0	94.2	101.7	107.3	111.8	120.5
550	PIPE TEMP	505.8	504.6	497.7	489.9	485.0	483.2	466.3	465.4	450.4	431.2	400.2	372.5	348.1	322.1	316.3	299.7	287.6	275.1	255.1
	MAX.W /FT	31.1	31.7	35.6	40.2	41.2	41.5	51.3	51.7	60.4	69.8	82.0	91.4	97.7	109.7	112.0	121.0	127.6	132.7	142.9
	MIN.W /FT	28.6	29.1	32.3	36.1	37.3	37.6	45.2	46.1	52.7	60.3	71.7	82.4	91.8	102.6	105.0	113.2	119.3	124.2	133.7
600	PIPE TEMP	550.2	549.0	541.3	532.6	527.3	525.3	506.6	505.7	489.1	467.9	433.9	403.5	376.8	348.3	342.2	324.1	310.9	297.4	275.8
	MAX.W /FT	35.2	35.7	40.1	45.2	46.3	46.6	57.6	57.9	67.6	77.9	91.3	101.5	108.2	121.4	123.8	133.7	140.8	146.4	157.4
	MIN.W /FT	32.2	32.7	36.3	40.5	41.8	42.0	50.5	51.4	58.7	67.1	79.6	91.3	101.6	113.4	115.9	124.9	131.5	136.8	147.1
650	PIPE TEMP	594.4	593.2	584.7	575.1	569.3	567.3	546.6	545.7	527.5	504.4	467.3	434.2	405.1	374.1	367.7	348.1	333.9	319.4	296.1
	MAX.W /FT	39.4	39.9	44.8	50.5	51.5	51.8	64.0	64.3	75.0	86.3	100.9	111.8	119.0	133.3	135.9	146.6	154.3	160.3	172.1
	MIN.W /FT	35.9	36.4	40.4	45.1	46.4	46.6	56.0	56.9	64.8	74.0	87.6	100.3	111.5	124.4	127.0	136.7	143.9	149.6	160.7
700	PIPE TEMP	638.5	637.2	627.9	617.5	611.2	609.0	586.4	585.6	565.8	540.6	500.4	464.5	433.1	399.6	392.9	371.8	356.7	341.1	316.2
	MAX.W /FT	43.7	44.3	49.7	55.9	56.9	57.2	70.6	70.8	82.6	94.9	110.6	122.4	130.0	145.5	148.2	159.7	168.0	174.4	187.1
	MIN.W /FT	39.8	40.3	44.6	49.7	51.1	51.3	61.5	62.5	71.1	81.1	95.8	109.6	121.6	135.6	138.3	148.8	156.5	162.6	174.4
750	PIPE TEMP	682.5	681.2	671.C	659.7	653.0	650.7	626.1	625.3	603.9	576.7	533.3	494.7	460.8	424.8	417.8	395.2	379.0	362.4	335.9
	MAX.W /FT	48.2	48.8	54.7	61.5	62.5	62.7	77.5	77.6	90.4	103.8	120.6	133.2	141.2	158.0	160.7	173.1	181.9	188.8	202.1
	MIN.W /FT	43.6	44.1	49.0	54.6	55.9	56.1	67.3	68.3	77.6	88.3	104.1	119.0	131.9	147.0	149.7	161.0	169.3	175.7	188.4
800	PIPE TEMP	726.4	725.0	714.1	701.8	694.6	692.2	665.7	664.9	641.9	612.6	566.1	524.6	488.3	449.8	442.5	418.4	401.2	383.5	355.4
	MAX.W /FT	52.9	53.5	60.C	67.3	68.2	68.5	84.5	84.5	98.4	112.9	130.6	144.2	152.6	170.6	173.4	186.7	196.1	203.4	217.7
	MIN.W /FT	47.9	48.4	53.5	59.5	60.9	61.1	73.2	74.1	84.2	95.7	112.6	128.6	142.4	158.5	161.4	173.4	182.2	189.1	202.5
850	PIPE TEMP	770.2	768.8	757.C	743.8	736.2	733.8	705.1	704.4	679.7	648.4	598.7	554.3	515.5	474.5	466.9	441.3	423.1	404.5	374.8
	MAX.W /FT	57.8	58.4	65.4	73.3	74.2	74.4	91.9	91.7	106.7	122.3	141.4	155.6	164.2	183.5	186.4	200.5	210.5	218.2	233.3
	MIN.W /FT	52.2	52.7	58.2	64.6	66.0	66.2	79.2	80.2	91.0	103.3	121.3	138.3	153.1	170.3	173.2	186.0	195.4	202.6	216.8
900	PIPE TEMP	813.9	812.5	799.9	785.8	777.7	775.0	744.5	743.8	717.5	686.1	631.2	583.9	542.6	499.0	491.1	464.1	446.8	425.2	393.9
	MAX.W /FT	63.0	63.6	71.1	79.6	80.4	80.6	99.5	99.1	115.4	132.0	152.2	167.2	176.2	196.7	199.6	214.6	225.2	233.3	249.1
	MIN.W /FT	56.7	57.2	63.1	70.0	71.4	71.5	85.5	86.4	98.0	111.2	130.3	148.3	164.0	182.2	185.3	198.9	208.7	216.3	231.3
950	PIPE TEMP	857.6	856.1	842.7	827.7	819.1	816.3	783.8	783.1	755.2	719.7	663.5	613.3	569.5	523.6	515.2	486.6	466.6	445.2	412.4
	MAX.W /FT	68.4	69.0	77.2	86.3	86.9	87.0	107.5	106.9	124.4	142.2	163.5	179.1	188.4	210.2	213.1	229.1	240.2	248.6	265.4
	MIN.W /FT	61.4	61.9	68.2	75.6	76.9	77.0	92.1	92.9	105.3	119.3	139.5	156.6	175.2	194.5	197.6	212.0	222.6	230.3	246.1

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-40

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 0 F (-17.8 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
60	PIPE TEMP	57.2	56.9	56.7	56.1	55.5	55.3	54.2	53.9	52.7	51.2	48.3	46.0	43.6	41.3	40.3	38.7	37.4	35.9	33.6
	WATTS/FT	2.0	2.1	2.1	2.5	2.7	2.8	3.4	3.5	4.1	4.8	5.9	6.7	7.7	8.7	9.1	9.9	10.6	11.2	12.3
	AMPS/FT	1.9	2.0	2.0	2.4	2.6	2.7	3.2	3.3	3.8	4.5	5.5	6.4	7.4	8.3	8.7	9.5	10.2	10.7	11.8
80	PIPE TEMP	76.1	75.8	75.5	74.6	73.9	73.6	72.1	71.7	70.1	68.1	64.2	61.1	57.9	54.8	53.5	51.4	49.6	47.7	44.6
	WATTS/FT	2.7	2.8	2.9	3.4	3.7	3.8	4.6	4.8	5.6	6.5	8.0	9.0	10.3	11.7	12.2	13.3	14.2	15.0	16.5
	AMPS/FT	2.6	2.7	2.8	3.2	3.5	3.6	4.3	4.5	5.2	6.0	7.5	8.7	10.0	11.2	11.7	12.8	13.7	14.4	15.8
100	PIPE TEMP	95.0	94.7	94.3	93.1	92.2	91.8	89.9	89.4	87.5	84.9	80.1	76.2	72.1	68.2	66.7	64.0	61.7	59.4	55.5
	WATTS/FT	3.5	3.6	3.7	4.4	4.7	4.9	5.8	6.1	7.1	8.3	10.1	11.4	13.1	14.7	15.4	16.8	17.9	18.9	20.8
	AMPS/FT	3.3	3.5	3.5	4.1	4.5	4.6	5.4	5.7	6.6	7.6	9.5	11.0	12.6	14.1	14.8	16.1	17.2	18.1	19.9
120	PIPE TEMP	113.9	113.5	113.0	111.6	110.5	110.0	107.7	107.1	104.8	101.6	95.8	91.1	86.2	81.5	79.7	76.5	73.8	71.0	66.4
	WATTS/FT	4.2	4.5	4.5	5.4	5.8	5.9	7.1	7.5	8.6	10.1	12.3	13.8	15.8	17.8	18.6	20.3	21.7	22.8	25.1
	AMPS/FT	4.0	4.2	4.3	5.1	5.4	5.6	6.6	7.0	8.0	9.3	11.5	13.3	15.2	17.1	17.9	19.5	20.8	21.9	24.0
140	PIPE TEMP	132.6	132.2	131.7	130.0	128.7	128.1	125.4	124.7	122.0	118.2	111.5	106.0	100.2	94.7	92.7	88.9	85.7	82.5	77.1
	WATTS/FT	5.1	5.3	5.4	6.4	6.8	7.1	8.5	8.8	10.2	11.9	14.6	16.2	18.6	21.0	21.9	23.9	25.5	26.8	29.4
	AMPS/FT	4.8	5.0	5.1	6.0	6.5	6.7	7.9	8.3	9.5	11.0	13.6	15.4	17.9	20.2	21.0	22.9	24.4	25.7	28.1
160	PIPE TEMP	151.4	150.9	150.3	148.3	146.9	146.2	143.0	142.3	139.1	134.8	127.0	120.7	114.1	107.8	105.5	101.2	97.6	93.9	87.8
	WATTS/FT	5.9	6.2	6.3	7.4	8.0	8.2	9.8	10.3	11.9	13.8	16.8	18.7	21.5	24.2	25.2	27.5	29.3	30.8	33.8
	AMPS/FT	5.6	5.9	6.0	7.0	7.5	7.7	9.1	9.6	11.0	12.7	15.7	18.1	20.6	23.2	24.2	26.3	28.0	29.5	32.3
180	PIPE TEMP	170.1	169.6	168.9	166.6	165.0	164.3	160.6	159.8	156.2	151.3	142.5	135.4	128.0	120.8	118.3	113.6	109.4	105.2	98.4
	WATTS/FT	6.8	7.1	7.2	8.5	9.1	9.4	11.3	11.7	13.6	15.8	19.2	21.3	24.4	27.5	28.6	31.1	33.2	34.9	38.2
	AMPS/FT	6.5	6.7	6.8	8.0	8.6	8.8	10.5	11.0	12.5	14.5	17.8	20.5	23.4	26.4	27.4	29.8	31.7	33.4	36.6
200	PIPE TEMP	188.7	188.2	187.4	184.9	183.0	182.2	178.1	177.2	173.2	167.7	157.9	150.0	141.7	133.7	131.0	125.5	121.1	116.4	108.9
	WATTS/FT	7.8	8.1	8.1	9.7	10.3	10.6	12.7	13.2	15.3	17.7	21.5	23.9	27.3	30.8	32.0	34.8	37.1	39.0	42.7
	AMPS/FT	7.3	7.6	7.7	9.1	9.7	10.0	11.8	12.3	14.1	16.3	20.0	23.0	26.2	29.5	30.7	33.3	35.5	37.3	40.8
220	PIPE TEMP	207.4	206.7	205.9	203.0	201.0	200.2	195.5	194.6	190.1	184.0	173.2	164.5	155.6	146.5	143.6	137.5	132.7	127.6	119.3
	WATTS/FT	8.7	9.0	9.1	10.8	11.6	11.8	14.2	14.8	17.1	19.8	24.0	26.5	30.3	34.2	35.5	38.6	41.1	43.2	47.2
	AMPS/FT	8.2	8.5	8.7	10.2	10.9	11.1	13.2	13.8	15.7	18.1	22.2	25.5	29.1	32.7	34.0	36.9	39.3	41.3	45.1
240	PIPE TEMP	225.9	225.2	224.4	221.2	218.9	218.0	212.9	211.9	207.0	200.3	188.5	179.0	169.0	159.2	156.1	149.5	144.2	138.7	129.6
	WATTS/FT	9.7	10.1	10.1	12.0	12.8	13.1	15.8	16.4	18.9	21.9	26.4	29.2	33.6	37.6	39.0	42.4	45.1	47.4	51.8
	AMPS/FT	9.2	9.5	9.6	11.3	12.1	12.3	14.6	15.2	17.3	20.0	24.5	28.1	32.0	36.0	37.3	40.5	43.1	45.3	49.5
260	PIPE TEMP	244.4	243.7	242.8	239.3	236.8	235.9	230.2	229.2	223.8	216.5	203.7	193.3	182.5	171.9	168.6	161.4	155.6	149.7	139.9
	WATTS/FT	10.7	11.1	11.2	13.3	14.1	14.4	17.3	18.0	20.7	24.0	29.0	31.9	36.4	41.1	42.5	46.2	49.2	51.7	56.4
	AMPS/FT	10.1	10.4	10.6	12.4	13.3	13.5	16.0	16.7	19.0	21.9	26.8	30.7	34.9	39.3	40.7	44.2	47.0	49.3	53.9
280	PIPE TEMP	262.9	262.2	261.1	257.3	254.6	253.6	247.5	246.4	240.6	232.6	218.8	207.6	195.9	184.4	180.9	173.2	167.0	160.6	150.1
	WATTS/FT	11.8	12.2	12.2	14.5	15.5	15.8	19.0	19.6	22.6	26.2	31.5	34.7	39.6	44.6	46.1	50.1	53.3	56.0	61.1
	AMPS/FT	11.1	11.4	11.6	13.6	14.5	14.8	17.5	18.2	20.7	23.9	29.1	33.3	37.9	42.6	44.1	47.9	50.9	53.4	58.5
300	PIPE TEMP	281.3	280.5	279.5	275.3	272.4	271.4	264.7	263.5	257.3	248.7	233.8	221.8	209.2	196.9	193.2	186.9	178.3	171.4	160.2
	WATTS/FT	12.9	13.3	13.3	15.8	16.8	17.1	20.6	21.3	24.5	28.4	34.1	37.5	42.7	48.1	49.7	54.0	57.4	60.3	65.8
	AMPS/FT	12.1	12.5	12.6	14.8	15.8	16.0	19.0	19.8	22.5	25.9	31.5	36.0	40.9	46.0	47.5	51.6	54.8	57.5	62.7
350	PIPE TEMP	327.2	326.3	325.1	320.0	316.7	315.5	307.4	306.2	298.7	288.5	271.0	257.0	242.2	227.7	223.5	213.8	206.2	198.2	185.2
	WATTS/FT	15.7	16.2	16.1	19.2	20.4	20.7	24.9	25.7	29.5	34.1	40.8	44.7	50.8	57.2	59.0	64.1	68.0	71.3	77.7
	AMPS/FT	14.8	15.1	15.2	17.9	19.1	19.3	22.9	23.8	26.9	31.0	37.6	42.9	48.6	54.6	56.3	61.1	64.8	68.0	74.0
400	PIPE TEMP	372.8	371.9	370.5	364.5	360.6	359.3	349.9	348.5	339.9	328.0	307.6	291.7	276.8	258.0	253.5	242.3	233.6	224.5	209.8
	WATTS/FT	18.8	19.2	19.2	22.8	24.2	24.5	29.4	30.3	34.8	40.1	47.8	52.1	59.2	66.6	68.5	74.3	78.8	82.6	89.8
	AMPS/FT	17.6	18.0	18.0	21.2	22.5	22.8	26.9	28.0	31.6	36.3	43.9	50.0	56.6	63.5	65.3	70.8	75.1	78.6	85.5
450	PIPE TEMP	418.1	417.2	415.7	408.8	404.3	402.9	392.0	390.5	380.7	367.1	344.2	325.9	306.9	287.8	282.9	270.3	260.6	250.4	234.0
	WATTS/FT	22.0	22.5	22.3	26.6	28.1	28.4	34.2	35.1	40.2	46.3	55.0	59.8	67.7	76.1	78.2	84.6	89.9	94.1	102.2
	AMPS/FT	20.5	21.0	20.9	24.6	26.1	26.4	31.2	32.3	36.5	41.8	50.4	57.2	64.7	72.5	74.5	80.7	85.5	89.5	97.1
500	PIPE TEMP	463.3	462.3	460.7	452.7	447.7	446.2	433.8	432.2	421.2	405.9	380.3	359.8	338.5	317.3	312.0	297.9	287.1	275.9	257.8
	WATTS/FT	25.4	25.9	25.6	30.6	32.2	32.5	39.1	40.1	45.9	52.7	62.6	67.7	76.5	86.0	88.2	95.5	101.2	105.8	114.7
	AMPS/FT	23.7	24.1	24.0	28.2	29.9	30.1	35.6	36.8	41.5	47.5	57.0	64.7	73.0	81.8	83.9	90.8	96.1	100.5	109.0
550	PIPE TEMP	508.2	507.2	505.5	496.5	491.0	489.3	475.4	473.7	461.6	444.4	416.0	393.3	369.8	346.3	340.6	325.1	313.3	301.1	281.2
	WATTS/FT	29.0	29.5	29.1	34.7	36.5	36.8	44.2	45.3	51.7	59.4	70.1	75.8	85.5	96.0	98.4	106.5	112.7	117.7	127.5
	AMPS/FT	26.9	27.3	27.2	32.0	33.8	34.0	40.1	41.4	46.7	53.4	63.9	72.4	81.5	91.2	93.5	101.1	107.0	111.7	121.0
600	PIPE TEMP	553.0	551.9	550.1	540.1	534.0	532.2	516.8	515.0	501.3	482.6	451.4	426.4	400.7	374.9	368.9	352.0	339.2	325.9	304.3
	WATTS/FT	32.7	33.2	32.7	39.0	40.9	41.2	49.5	50.6	57.8	66.2	77.9	84.1	94.8	106.2	108.8	117.6	124.4	129.9	140.5
	AMPS/FT	30.3	30.7	30.5	35.8	37.8	38.0	44.8	46.2	52.0	59.4	70.9	80.2	90.2	100.8	103.3	111.5	117.9	123.1	133.2
650	PIPE TEMP	597.6	596.4	594.6	583.5	576.8	575.0	557.9	556.0	541.1	520.5	486.4	459.2	431.3	403.2	396.8	378.5	364.7	350.3	327.1
	WATTS/FT	36.6	37.1	36.4	43.4	45.5	45.8	55.0	56.1	64.0	71.3	86.0	92.6	104.2	116.7	119.4	129.0	136.3	142.2	153.7
	AMPS/FT	33.8	34.2	33.5	39.8	41.9	42.1	49.6	51.1	57.4	65.5	78.1	88.2	99.1	110.6	113.2	122.2	129.1	134.7	145.6
700	PIPE TEMP	642.0	640.8	638.9	626.7	619.5	617.5	598.9	596.9	580.6	558.3	521.3	491.7	461.6	431.2	424.4	404.7	389.8	374.6	349.8
	WATTS/FT	40.6	41.1	40.3	48.0	50.3	50.5	60.6	61.8	70.4	80.5	96.2	101.3	113.8	127.3	130.1	140.5	148.4	154.7	167.1
	AMPS/FT	37.4	37.8	37.4	43.9	46.1	46.3	54.5	56.1	63.0	71.8	85.4	96.4	108.1	120.6	123.3	133.0	140.5	146.4	158.1
750	PIPE TEMP	686.4	685.1	683.1	669.9	662.0	659.9	639.7	637.6	620.0	595.8	555.9	524.0	491.6	458.9	451.8	430.6	414.8	398.3	371.8
	WATTS/FT	44.8	45.3	44.3	52.7	55.1	55.3	66.4	67.6	77.0	87.9	102.7	110.1	123.6	138.2	141.1	152.3	160.7	167.5	180.6
	AMPS/FT	41.1	41.5	41.0	48.1	50.5	50.6	59.6	61.3	68.7	78.2	92.6	104.7	117.3	130.7	133.6	144.0	152.0	158.2	170.8
800	PIPE TEMP	730.6	729.3	727.2	712.9	704.4	702.2	680.4	678.2	659.3	633.2	590.4	556.0	521.4	486.4	478.9	456.3	439.6	421.9	393.7
	WATTS/FT	49.1	49.6	48.4	57.6	60.1	60.3	72.3	73.6	83.8	95.5	111.3	119.1	133.6	149.2	152.3	164.2	173.2	180.6	194.4
	AMPS/FT	44.9	45.4	44.7	52.4	55.0	55.1	64.8	66.6	74.6	84.7	100.5	113.2	126.6	141.0	144.0	155.1	163.6	170.4	183.7
850	PIPE TEMP	774.8	773.5	771.3	755.8	746.8	744.4	721.0	718.6	698.4	670.5	624.6	587.9	550.9	513.6	505.8	481.7	463.8	445.3	415.5
	WATTS/FT	53.5	54.1	52.6	62.7	65.3	65.4	78.5	79.7	90.7	103.4	120.1	128.3	143.7	160.4	163.6	176.4	185.9	193.5	208.3
	AMPS/FT	48.9	49.4	48.6	56.9	59.6	59.7	70.1	72.0	80.6	91.5	108.2	121.8	136.1	151.5	154.6	166.5	175.3	182.6	196.7
900	PIPE TEMP	818.9	817.5	815.2	798.6	789.0	786.6	761.5	759.0	737.4	707.7	658.8	619.5	580.3	540.7	532.5	507.0	488.1	468.5	437.0
	WATTS/FT	58.2	58.7	57.1	67.9	70.6	70.8	84.8	86.1	97.9	111.4	129.2	137.8	154.1	171.9	175.2	188.8	198.9	206.9	222.5
	AMPS/FT	53.1	53.5	52.5	61.5	64.3	64.4	75.6	77.5	86.7	98.4	116.2	130.7	145.8	162.1	165.4	178.0	187.5	195.1	209.1
950	PIPE TEMP	862.9	861.6	859.2	841.4	831.2	828.6	801.9	799.3	776.4	744.7	692.8	651.0	609.5	567.6	559.0	532.1	512.2	491.5	458.6
	WATTS/FT	63.1	63.6	61.7	73.4	76.2	76.3	91.5	92.7	105.4	119.8	138.6	147.4	164.7	183.6	187.0	201.4	212.0	220.4	236.9
	AMPS/FT	57.4	57.8	56.7	66.3	69.2	69.3	81.3	83.3	93.1	105.5	124.3	139.7	155.7	173.8	176.4	189.7	199.7	207.7	223.3

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-41

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

2-1/2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 0 F (-17.8 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
60	PIPE TEMP	57.3	57.1	56.9	56.3	55.8	55.6	54.6	54.3	53.3	52.0	49.3	47.2	45.0	43.0	42.1	40.6	39.3	38.0	35.6
	MAX.W /FT	1.8	1.9	2.C	2.3	2.5	2.6	3.1	3.2	3.7	4.3	5.3	6.0	6.9	7.8	8.2	8.9	9.6	10.1	11.2
	MIN.W /FT	1.8	1.8	1.9	2.2	2.4	2.5	2.9	3.1	3.5	4.0	5.1	5.9	6.7	7.6	7.9	8.6	9.3	9.8	10.8
80	PIPE TEMP	76.4	76.1	75.8	75.0	74.3	74.0	72.7	72.3	70.9	69.2	65.6	62.8	59.9	57.1	55.9	53.9	52.3	50.5	47.5
	MAX.W /FT	2.5	2.6	2.7	3.2	3.4	3.5	4.2	4.4	5.0	5.8	7.2	8.1	9.3	10.5	11.0	12.0	12.9	13.6	15.0
	MIN.W /FT	2.4	2.5	2.6	3.0	3.3	3.4	3.9	4.2	4.8	5.4	6.8	7.9	9.0	10.2	10.7	11.6	12.4	13.1	14.5
100	PIPE TEMP	95.3	95.0	94.6	93.6	92.7	92.3	90.7	90.2	88.5	86.3	81.7	78.3	74.6	71.1	69.7	67.2	65.1	62.9	59.2
	MAX.W /FT	3.2	3.3	3.5	4.0	4.3	4.5	5.3	5.6	6.4	7.3	9.1	10.2	11.8	13.3	13.9	15.1	16.2	17.1	18.9
	MIN.W /FT	3.0	3.2	3.3	3.8	4.2	4.3	5.0	5.3	6.0	6.9	8.6	9.9	11.4	12.8	13.4	14.6	15.6	16.5	18.2
120	PIPE TEMP	114.3	113.8	113.4	112.1	111.1	110.7	108.6	108.0	106.0	103.3	97.9	93.7	89.3	85.0	83.4	80.4	77.8	75.2	70.7
	MAX.W /FT	3.9	4.1	4.2	4.9	5.3	5.5	6.5	6.8	7.8	8.9	11.0	12.4	14.2	16.1	16.8	18.3	19.6	20.7	22.8
	MIN.W /FT	3.7	3.9	4.1	4.7	5.1	5.2	6.1	6.5	7.3	8.4	10.5	12.0	13.8	15.5	16.2	17.7	18.9	19.9	22.0
140	PIPE TEMP	133.1	132.8	132.1	130.7	129.4	128.9	126.5	125.8	123.5	120.3	113.9	109.1	103.9	98.8	97.0	93.4	90.5	87.4	82.3
	MAX.W /FT	4.6	4.9	5.C	5.9	6.3	6.5	7.7	8.1	9.2	10.5	13.0	14.6	16.8	18.9	19.7	21.5	23.0	24.3	26.7
	MIN.W /FT	4.5	4.6	4.8	5.6	6.0	6.2	7.2	7.7	8.7	9.9	12.4	14.2	16.2	18.3	19.0	20.7	22.2	23.4	25.8
160	PIPE TEMP	152.0	151.6	150.9	149.1	147.7	147.1	144.3	143.6	140.8	137.2	129.9	124.3	118.4	112.6	110.5	106.5	103.1	99.5	93.7
	MAX.W /FT	5.4	5.7	5.8	6.8	7.4	7.5	8.9	9.4	10.7	12.2	15.0	16.9	19.3	21.8	22.7	24.7	26.4	27.9	30.7
	MIN.W /FT	5.2	5.4	5.6	6.5	7.0	7.2	8.4	8.9	10.0	11.5	14.3	16.4	18.7	21.0	21.9	23.9	25.5	26.9	29.6
180	PIPE TEMP	170.8	170.3	169.5	167.5	165.9	165.3	162.1	161.3	158.2	154.0	145.8	139.5	132.8	126.2	123.9	119.4	115.6	111.6	105.0
	MAX.W /FT	6.2	6.5	6.7	7.8	8.4	8.6	10.2	10.7	12.2	13.9	17.1	19.2	21.9	24.7	25.7	28.0	29.9	31.6	34.7
	MIN.W /FT	6.0	6.2	6.4	7.4	8.0	8.2	9.6	10.1	11.4	13.0	16.2	18.6	21.2	23.9	24.8	27.0	28.9	30.4	33.5
200	PIPE TEMP	189.5	189.0	188.2	185.9	184.1	183.4	179.8	178.9	175.4	170.8	161.6	154.6	147.1	139.8	137.3	132.2	128.0	123.6	116.3
	MAX.W /FT	7.1	7.3	7.6	8.8	9.5	9.7	11.5	12.0	13.7	15.6	19.2	21.5	24.6	27.7	28.8	31.3	33.5	35.3	38.8
	MIN.W /FT	6.8	7.0	7.2	8.4	9.1	9.2	10.3	11.4	12.9	14.7	18.2	20.8	23.8	26.7	27.8	30.2	32.3	34.0	37.4
220	PIPE TEMP	208.3	207.7	206.8	204.2	202.3	201.5	197.5	196.5	192.7	187.5	177.3	169.7	161.4	153.3	150.6	145.0	140.4	135.5	127.5
	MAX.W /FT	7.9	8.2	8.4	9.9	10.6	10.9	12.8	13.4	15.3	17.4	21.3	23.8	27.2	30.7	31.9	34.7	37.0	39.0	42.9
	MIN.W /FT	7.6	7.8	8.1	9.4	10.1	10.3	12.1	12.7	14.3	16.3	20.2	23.1	26.3	29.6	30.8	33.5	35.7	37.6	41.3
240	PIPE TEMP	226.9	226.4	225.3	222.5	220.4	219.6	215.1	214.1	209.8	204.2	193.0	184.6	175.6	166.7	163.8	157.7	152.7	147.4	138.6
	MAX.W /FT	8.8	9.1	9.4	11.0	11.8	12.0	14.2	14.9	16.9	19.2	23.5	26.2	30.0	33.8	35.0	38.1	40.7	42.8	47.0
	MIN.W /FT	8.4	8.7	9.0	10.4	11.2	11.4	13.3	14.0	15.8	18.0	22.3	25.4	29.0	32.6	33.8	36.7	39.2	41.3	45.1
260	PIPE TEMP	245.6	245.0	243.8	240.8	238.6	237.6	232.6	231.5	226.9	220.8	208.6	199.5	189.7	180.0	176.9	170.3	164.9	159.1	149.7
	MAX.W /FT	9.8	10.1	10.3	12.1	13.0	13.2	15.6	16.3	18.5	21.0	25.7	28.7	32.7	36.9	38.2	41.6	44.3	46.7	51.2
	MIN.W /FT	9.3	9.6	9.9	11.5	12.3	12.5	14.7	15.4	17.3	19.7	24.4	27.8	31.6	35.5	36.8	40.0	42.7	44.9	49.3
280	PIPE TEMP	264.2	263.5	262.3	259.0	256.4	255.5	250.1	249.0	244.0	237.3	224.2	214.3	203.7	193.3	190.0	182.8	177.0	170.8	160.7
	MAX.W /FT	10.7	11.0	11.3	13.2	14.2	14.4	17.1	17.8	20.2	22.9	28.0	31.2	35.5	40.0	41.4	45.0	48.0	50.6	55.4
	MIN.W /FT	10.2	10.5	10.8	12.5	13.5	13.7	16.0	16.8	18.9	21.5	26.5	30.2	34.3	38.6	39.9	43.4	46.2	48.7	53.3
300	PIPE TEMP	282.7	282.1	280.8	277.1	274.3	273.4	267.6	266.3	261.0	253.8	239.6	229.1	217.7	206.4	203.0	195.2	189.0	182.4	171.6
	MAX.W /FT	11.7	12.0	12.3	14.4	15.4	15.7	18.5	19.3	21.9	24.8	30.2	33.7	38.3	43.2	44.7	48.6	51.8	54.5	59.7
	MIN.W /FT	11.1	11.4	11.7	13.6	14.6	14.8	17.4	18.2	20.5	23.2	28.6	32.6	37.0	41.6	43.0	46.8	49.8	52.4	57.6
350	PIPE TEMP	328.9	328.2	326.7	322.3	319.0	318.0	311.0	309.6	303.2	294.7	278.0	265.7	252.3	239.0	235.2	226.1	218.8	211.1	198.5
	MAX.W /FT	14.2	14.6	14.9	17.5	18.7	18.9	22.3	23.2	26.3	29.8	36.1	40.1	45.6	51.3	53.0	57.6	61.3	64.4	70.5
	MIN.W /FT	13.5	13.8	14.2	16.5	17.7	17.9	20.9	21.9	24.5	27.8	34.2	38.8	44.0	49.4	51.0	55.4	58.9	61.9	67.8
400	PIPE TEMP	376.9	376.2	372.5	367.3	363.4	362.3	354.1	352.5	345.2	335.3	316.0	301.8	286.5	271.2	266.9	256.5	248.2	239.4	225.1
	MAX.W /FT	17.0	17.3	17.6	20.7	22.1	22.3	26.4	27.4	30.9	34.9	42.2	46.8	53.0	59.6	61.5	66.8	71.0	74.6	81.5
	MIN.W /FT	16.1	16.4	16.8	19.5	20.8	21.0	24.6	25.7	28.8	32.6	39.9	45.2	51.1	57.4	59.1	64.2	68.2	71.7	78.3
450	PIPE TEMP	420.7	419.9	418.0	412.0	407.6	406.4	397.0	395.2	386.8	375.5	353.7	337.6	320.2	302.9	298.2	286.4	277.1	267.3	251.3
	MAX.W /FT	19.8	20.2	20.5	24.1	25.6	25.9	30.5	31.7	35.7	40.3	48.6	53.6	60.7	68.2	70.2	76.2	81.0	85.0	92.7
	MIN.W /FT	18.7	19.1	19.5	22.8	24.1	24.3	28.4	29.7	33.2	37.5	45.8	51.7	58.5	65.5	67.5	73.2	77.7	81.6	89.0
500	PIPE TEMP	466.3	465.4	463.4	456.5	451.6	450.2	439.5	437.6	428.2	415.4	390.9	372.9	353.5	334.2	329.0	316.0	305.7	294.8	277.1
	MAX.W /FT	22.9	23.3	23.5	27.8	29.3	29.6	34.9	36.1	40.7	45.9	55.1	60.7	68.6	77.0	79.2	85.8	91.2	95.6	104.2
	MIN.W /FT	21.6	21.9	22.3	25.9	27.6	27.8	32.4	33.8	37.7	42.6	51.8	58.5	66.0	73.9	76.0	82.4	87.4	91.7	99.9
550	PIPE TEMP	511.7	510.8	508.5	500.8	495.3	493.8	481.9	479.8	469.3	455.1	427.9	407.9	386.5	365.1	359.4	345.1	333.8	322.0	302.5
	MAX.W /FT	26.0	26.4	26.7	31.3	33.2	33.4	39.4	40.8	45.9	51.6	61.8	67.9	76.7	86.0	88.3	95.7	101.5	106.4	115.8
	MIN.W /FT	24.5	24.8	25.2	29.3	31.2	31.4	36.5	38.0	42.4	47.8	58.1	65.4	73.7	82.5	84.7	91.7	97.3	101.9	111.0
600	PIPE TEMP	556.9	556.0	553.5	544.9	538.9	537.3	524.0	521.8	510.1	494.5	464.5	442.6	419.1	395.6	389.7	373.9	361.7	348.7	327.6
	MAX.W /FT	29.3	29.7	30.C	35.1	37.2	37.4	44.1	45.5	51.2	57.5	68.7	75.4	85.0	95.2	97.6	105.7	112.1	117.4	127.6
	MIN.W /FT	27.5	27.9	28.3	32.8	34.9	35.0	40.8	42.4	47.2	53.2	64.5	72.6	81.6	91.2	93.6	101.3	107.3	112.4	122.7
650	PIPE TEMP	602.0	601.0	598.4	588.8	582.2	580.6	565.9	563.5	550.8	533.6	500.9	477.0	451.5	425.8	419.5	402.6	389.1	375.1	352.4
	MAX.W /FT	32.7	33.1	33.3	39.1	41.3	41.5	48.9	50.4	56.7	63.6	75.8	83.0	93.4	104.5	107.2	116.0	122.9	128.6	139.6
	MIN.W /FT	30.7	31.0	31.4	36.4	38.7	38.8	45.1	46.9	52.2	58.7	71.0	79.8	89.7	100.1	102.7	111.0	117.6	123.0	133.6
700	PIPE TEMP	647.0	646.0	643.2	632.6	625.5	623.7	607.7	605.1	591.2	572.6	537.0	511.1	483.5	455.8	449.1	430.6	416.3	401.3	376.9
	MAX.W /FT	36.3	36.7	36.9	43.2	45.6	45.7	53.9	55.5	62.3	69.8	83.0	90.7	102.0	114.1	116.8	126.4	133.8	139.9	151.4
	MIN.W /FT	33.9	34.3	34.7	40.2	42.6	42.7	49.8	51.5	57.2	64.3	77.7	87.2	97.8	109.1	111.9	120.9	127.9	133.8	145.1
750	PIPE TEMP	691.9	690.8	687.8	676.3	668.6	666.7	649.3	646.6	631.5	611.4	572.9	544.9	515.2	485.4	478.3	458.5	443.2	427.2	401.1
	MAX.W /FT	39.9	40.3	40.5	47.4	49.9	50.1	59.0	60.7	68.1	76.2	90.4	98.7	110.8	123.8	126.7	137.0	144.9	151.5	164.2
	MIN.W /FT	37.3	37.6	38.0	44.0	46.6	46.7	54.2	56.2	62.4	70.1	84.5	94.7	106.2	118.3	121.2	130.9	138.5	144.7	156.9
800	PIPE TEMP	736.6	735.5	732.3	719.9	711.6	709.5	690.8	687.9	671.7	650.0	608.6	578.6	546.8	514.8	507.3	486.2	469.9	452.8	425.0
	MAX.W /FT	43.7	44.1	44.2	51.7	54.4	54.6	64.2	66.0	74.0	82.7	97.9	106.7	119.7	133.6	136.8	147.7	156.2	163.2	176.7
	MIN.W /FT	40.7	41.1	41.4	47.9	50.7	50.8	58.9	61.1	67.7	76.0	91.4	102.4	114.7	127.7	130.7	141.0	149.1	155.8	168.7
850	PIPE TEMP	781.3	780.2	776.8	763.4	754.4	752.3	732.1	729.1	711.7	688.4	644.1	612.0	578.1	544.0	536.2	513.6	496.3	478.2	448.8
	MAX.W /FT	47.6	48.0	48.C	56.2	59.1	59.2	69.6	71.5	80.1	89.4	105.7	115.0	128.8	143.7	146.9	158.6	167.7	175.1	189.4
	MIN.W /FT	44.3	44.6	45.C	52.0	54.9	55.0	63.7	66.0	73.2	82.0	98.5	110.3	123.3	137.2	140.4	151.4	160.0	167.U	180.7
900	PIPE TEMP	825.9	824.8	821.1	806.8	797.2	795.0	773.4	770.2	751.7	726.8	679.5	645.2	609.2	573.0	564.8	540.9	522.6	503.6	472.1
	MAX.W /FT	51.7	52.1	52.C	60.8	63.8	63.9	75.2	77.1	86.4	96.3	113.6	123.4	138.1	153.9	157.4	169.8	179.3	187.1	202.1
	MIN.W /FT	48.0	48.3	48.6	56.2	59.2	59.3	68.7	71.1	78.8	88.1	105.8	118.3	132.1	146.8	150.2	161.9	171.0	178.4	192.9
950	PIPE TEMP	870.5	869.3	865.4	850.2	840.0	837.6	814.6	811.2	791.5	765.0	714.8	678.3	640.2	601.9	593.2	568.0	548.6	528.6	495.7
	MAX.W /FT	55.9	56.3	56.1	65.6	68.8	68.9	80.9	82.9	92.9	103.4	121.7	132.0	147.6	164.4	168.0	181.1	191.2	199.6	215.6
	MIN.W /FT	51.8	52.2	52.4	60.5	63.7	63.8	73.8	76.3	84.5	94.5	113.2	126.4	141.1	156.7	160.2	172.5	182.2	190.3	205.2

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-42

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 0 F (-17.8 C)

CABLE TEMP DEG F		PIPE SIZE 1/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
60	PIPE TEMP	57.5	57.3	57.0	56.5	56.0	55.8	54.9	54.7	53.8	52.5	50.2	48.2	46.2	44.3	43.5	42.1	40.9	39.6	37.5
	MAX.W /FT	1.7	1.8	1.9	2.2	2.4	2.4	2.8	3.0	3.4	3.9	4.8	5.5	6.3	7.1	7.5	8.2	8.8	9.3	10.3
	MIN.W /FT	1.7	1.7	1.8	2.1	2.3	2.4	2.7	2.9	3.2	3.8	4.6	5.4	6.2	6.9	7.3	7.9	8.5	9.0	10.0
80	PIPE TEMP	76.5	76.3	76.0	75.2	74.6	74.3	73.1	72.8	71.6	69.9	66.7	64.1	61.4	58.9	57.8	56.0	54.4	52.7	49.9
	MAX.W /FT	2.3	2.4	2.6	3.0	3.2	3.3	3.9	4.1	4.6	5.3	6.4	7.4	8.5	9.6	10.1	11.0	11.8	12.5	13.8
	MIN.W /FT	2.3	2.4	2.5	2.8	3.1	3.2	3.7	3.9	4.4	5.1	6.3	7.3	8.3	9.3	9.8	10.7	11.4	12.1	13.4
100	PIPE TEMP	95.6	95.3	94.8	93.9	93.1	92.8	91.2	90.9	89.4	87.2	83.3	80.0	76.6	73.4	72.1	69.8	67.8	65.7	62.2
	MAX.W /FT	3.0	3.1	3.3	3.8	4.1	4.2	4.9	5.1	5.8	6.7	8.1	9.4	10.8	12.1	12.7	13.8	14.8	15.7	17.4
	MIN.W /FT	2.9	3.0	3.2	3.6	3.9	4.0	4.7	4.9	5.6	6.4	7.9	9.2	10.5	11.8	12.3	13.4	14.4	15.2	16.8
120	PIPE TEMP	114.5	114.2	113.7	112.6	111.6	111.2	109.3	108.9	107.1	104.5	99.7	95.8	91.7	87.8	86.3	83.5	81.1	78.6	74.4
	MAX.W /FT	3.7	3.8	4.0	4.6	5.0	5.1	6.0	6.3	7.1	8.1	9.8	11.4	13.0	14.7	15.3	16.7	17.9	18.9	20.9
	MIN.W /FT	3.5	3.7	3.8	4.4	4.8	4.9	5.7	6.0	6.8	7.8	9.6	11.1	12.7	14.3	14.9	16.2	17.4	18.4	20.3
140	PIPE TEMP	133.5	133.1	132.5	131.2	130.0	129.5	127.3	126.8	124.7	121.6	116.1	111.5	106.7	102.2	100.4	97.1	94.4	91.4	86.5
	MAX.W /FT	4.4	4.5	4.7	5.5	5.9	6.1	7.1	7.4	8.4	9.6	11.6	13.4	15.3	17.2	18.0	19.6	21.0	22.2	24.6
	MIN.W /FT	4.2	4.4	4.6	5.3	5.7	5.8	6.8	7.1	8.0	9.2	11.3	13.0	14.9	16.8	17.5	19.2	20.4	21.6	23.8
160	PIPE TEMP	152.4	152.0	151.3	149.7	148.4	147.9	145.3	144.7	142.3	138.8	132.4	127.2	121.7	116.4	114.5	110.7	107.6	104.2	98.5
	MAX.W /FT	5.1	5.3	5.5	6.4	6.9	7.0	8.2	8.6	9.7	11.1	13.4	15.4	17.6	19.9	20.7	22.6	24.2	25.6	28.2
	MIN.W /FT	4.9	5.1	5.3	6.1	6.6	6.8	7.8	8.2	9.2	10.6	13.0	15.0	17.2	19.3	20.1	21.9	23.4	24.8	27.4
180	PIPE TEMP	171.3	170.8	170.0	168.3	166.7	166.1	163.3	162.6	159.9	155.9	148.7	142.7	136.6	130.6	128.5	124.2	120.7	116.9	110.5
	MAX.W /FT	5.8	6.1	6.3	7.3	7.9	8.0	9.4	9.8	11.0	12.7	15.2	17.5	20.0	22.5	23.5	25.6	27.4	28.9	31.9
	MIN.W /FT	5.6	5.8	6.1	7.0	7.6	7.7	8.9	9.4	10.5	12.1	14.8	17.1	19.5	21.9	22.8	24.8	26.5	28.0	30.9
200	PIPE TEMP	190.1	189.6	188.8	186.7	185.0	184.4	181.1	180.4	177.4	172.9	164.9	158.3	151.4	144.7	142.4	137.6	133.7	129.5	122.5
	MAX.W /FT	6.6	6.8	7.1	8.2	8.9	9.1	10.6	11.0	12.4	14.2	17.0	19.6	22.4	25.2	26.2	28.6	30.6	32.3	35.6
	MIN.W /FT	6.4	6.6	6.8	7.9	8.5	8.7	10.1	10.6	11.8	13.6	16.6	19.1	21.8	24.5	25.5	27.7	29.7	31.3	34.5
220	PIPE TEMP	208.9	208.4	207.4	205.2	203.3	202.6	199.0	198.2	194.8	189.8	181.0	173.7	166.1	158.7	156.2	151.0	146.6	142.0	134.3
	MAX.W /FT	7.4	7.7	7.9	9.2	9.9	10.1	11.8	12.3	13.8	15.8	18.9	21.8	24.9	28.0	29.1	31.7	33.9	35.8	39.4
	MIN.W /FT	7.1	7.4	7.6	8.8	9.5	9.7	11.2	11.8	13.2	15.1	18.5	21.2	24.2	27.2	28.2	30.7	32.8	34.6	38.2
240	PIPE TEMP	227.6	227.1	226.1	223.6	221.5	220.7	216.7	215.9	212.2	206.7	197.0	189.1	180.8	172.7	170.0	164.2	159.5	154.5	146.1
	MAX.W /FT	8.2	8.5	8.8	10.2	11.0	11.2	13.1	13.6	15.2	17.5	20.8	24.0	27.3	30.8	31.9	34.8	37.2	39.2	43.2
	MIN.W /FT	7.9	8.2	8.5	9.8	10.5	10.7	12.4	13.0	14.5	16.7	20.3	23.3	26.6	29.9	31.0	33.7	36.0	38.0	41.8
260	PIPE TEMP	246.4	245.8	244.7	241.9	239.6	238.9	234.5	233.6	229.6	223.6	213.0	204.6	195.4	186.5	183.7	177.4	172.3	166.8	157.8
	MAX.W /FT	9.1	9.4	9.7	11.2	12.1	12.3	14.3	14.9	16.7	19.2	22.8	26.2	29.8	33.6	34.8	37.9	40.5	42.7	47.1
	MIN.W /FT	8.7	9.0	9.3	10.7	11.6	11.8	13.6	14.3	15.9	18.3	22.2	25.5	29.0	32.6	33.8	36.8	39.2	41.4	45.6
280	PIPE TEMP	265.0	264.5	263.2	260.2	257.7	256.9	252.2	251.2	246.9	240.4	229.0	219.6	209.9	200.3	197.3	190.6	185.1	179.2	169.4
	MAX.W /FT	10.0	10.3	10.6	12.3	13.2	13.4	15.6	16.2	18.2	20.9	24.8	28.4	32.4	36.4	37.8	41.1	43.9	46.3	50.9
	MIN.W /FT	9.6	9.8	10.2	11.7	12.7	12.8	14.9	15.5	17.3	19.9	24.1	27.7	31.5	35.3	36.6	39.8	42.5	44.8	49.3
300	PIPE TEMP	283.7	283.1	281.8	278.5	275.8	275.0	269.8	268.6	264.1	257.1	244.9	236.8	224.6	214.1	210.8	203.6	197.7	191.4	181.0
	MAX.W /FT	10.9	11.2	11.5	13.4	14.3	14.6	17.0	17.6	19.7	22.6	26.8	30.7	35.0	39.3	40.7	44.3	47.3	49.9	54.8
	MIN.W /FT	10.4	10.7	11.1	12.8	13.7	13.9	16.1	16.8	18.8	21.5	26.1	29.9	34.0	38.1	39.5	42.9	45.8	48.3	53.1
350	PIPE TEMP	336.2	329.5	328.0	324.0	320.8	319.9	313.7	312.4	307.0	298.7	284.3	272.5	260.2	248.1	244.4	236.0	229.1	221.7	209.6
	MAX.W /FT	13.2	13.5	13.9	16.2	17.3	17.5	20.5	21.2	23.7	27.1	32.0	36.6	41.5	46.7	48.3	52.5	56.0	59.0	64.8
	MIN.W /FT	12.7	13.0	13.4	15.4	16.6	16.8	19.4	20.2	22.5	25.7	31.1	35.6	40.3	45.2	46.8	50.8	54.2	57.1	62.6
400	PIPE TEMP	376.4	375.7	374.0	369.3	365.6	364.6	357.3	356.1	349.7	340.0	323.4	309.8	295.7	281.7	277.6	267.9	260.0	251.7	237.8
	MAX.W /FT	15.7	16.1	16.5	19.1	20.5	20.7	24.1	24.9	27.8	31.7	37.3	42.6	48.3	54.3	56.0	60.9	64.9	68.3	74.9
	MIN.W /FT	15.0	15.3	15.8	18.2	19.5	19.7	22.8	23.7	26.3	30.1	36.3	41.4	46.9	52.6	54.3	58.9	62.7	66.0	72.4
450	PIPE TEMP	422.5	421.3	419.0	414.4	410.2	409.0	400.7	399.3	392.0	381.0	362.1	346.7	330.7	314.8	310.3	299.4	290.6	281.2	265.7
	MAX.W /FT	18.4	18.7	19.1	22.2	23.7	23.9	27.9	28.8	32.1	36.8	42.9	48.9	55.3	62.1	64.0	69.5	74.0	77.8	85.2
	MIN.W /FT	17.5	17.8	18.3	21.1	22.6	22.8	26.3	27.4	30.3	34.7	41.7	47.5	53.6	60.1	61.9	67.2	71.5	75.2	82.3
500	PIPE TEMP	468.3	467.4	465.4	459.3	454.5	453.3	443.8	442.3	434.1	421.7	400.4	383.2	365.4	347.6	342.7	330.5	320.7	310.3	293.1
	MAX.W /FT	21.2	21.5	21.9	25.5	27.2	27.3	31.9	32.8	36.5	41.6	48.6	55.3	62.5	70.1	72.2	78.3	83.3	87.6	95.8
	MIN.W /FT	20.2	20.5	21.0	24.2	25.9	26.0	30.0	31.2	34.5	39.4	47.2	53.7	60.5	67.7	69.8	75.7	80.5	84.5	92.4
550	PIPE TEMP	514.0	513.2	510.8	503.9	498.7	497.3	486.7	485.1	475.9	462.1	438.5	419.4	399.7	380.0	374.7	361.3	350.5	339.0	320.2
	MAX.W /FT	24.1	24.4	24.9	28.8	30.7	30.9	36.0	37.0	41.1	46.8	54.5	61.9	69.9	78.3	80.5	87.3	92.8	97.5	106.5
	MIN.W /FT	22.9	23.2	23.7	27.3	29.2	29.4	33.8	35.1	38.8	44.2	52.9	60.0	67.6	75.6	77.8	84.3	89.6	94.0	102.7
600	PIPE TEMP	559.6	558.8	556.2	548.4	542.6	541.2	529.4	527.6	517.5	502.3	476.2	455.3	433.7	412.1	406.4	391.7	379.9	367.4	347.0
	MAX.W /FT	27.1	27.4	27.9	32.3	34.4	34.6	40.2	41.3	45.9	52.1	60.6	68.7	77.4	86.6	89.1	96.5	102.5	107.6	117.4
	MIN.W /FT	25.7	26.0	26.4	30.6	32.6	32.8	37.8	39.1	43.2	49.2	58.8	66.6	74.9	83.6	86.0	93.1	98.9	103.7	113.2
650	PIPE TEMP	605.0	604.1	601.3	592.8	586.4	584.9	571.9	570.0	559.0	542.2	513.7	490.9	467.4	443.9	437.7	421.7	409.0	395.5	373.4
	MAX.W /FT	30.2	30.6	31.0	36.0	38.2	38.3	44.6	45.7	50.8	57.6	66.8	75.6	85.1	95.2	97.8	105.9	112.4	117.8	128.5
	MIN.W /FT	28.6	28.9	29.4	34.0	36.2	36.3	41.8	43.3	47.7	54.3	64.7	73.2	82.3	91.8	94.3	102.1	108.3	113.6	123.8
700	PIPE TEMP	650.3	649.4	646.4	637.0	630.1	628.4	614.3	612.2	600.2	581.9	550.9	526.2	500.8	475.3	468.8	451.5	437.8	423.3	399.3
	MAX.W /FT	33.4	33.8	34.3	39.7	42.1	42.2	49.1	50.3	55.9	63.2	73.2	82.7	93.0	103.9	106.6	115.4	122.4	128.3	139.7
	MIN.W /FT	31.6	32.0	32.6	37.4	39.8	40.0	46.0	47.6	52.4	59.5	70.9	80.0	89.8	100.1	102.8	111.2	117.9	123.5	134.5
750	PIPE TEMP	695.5	694.6	691.3	681.1	673.6	671.8	656.5	654.3	641.3	621.5	587.9	561.3	534.0	506.5	499.6	481.0	466.4	450.8	425.4
	MAX.W /FT	38.8	37.1	37.6	43.5	46.1	46.2	53.7	55.0	60.9	68.9	79.6	90.0	101.0	112.7	115.6	125.1	132.6	138.9	151.1
	MIN.W /FT	34.7	35.1	35.7	41.0	43.6	43.7	50.2	51.9	57.1	64.8	77.1	87.0	97.5	108.6	111.4	120.4	127.6	133.7	145.4
800	PIPE TEMP	740.6	739.7	736.1	725.1	717.0	715.1	698.5	696.2	682.2	660.9	624.8	596.2	566.9	537.5	530.2	510.3	494.7	478.1	451.0
	MAX.W /FT	40.2	40.6	41.0	47.5	50.2	50.3	58.4	59.8	66.2	74.8	86.3	97.3	109.1	121.7	124.8	134.9	143.0	149.7	162.7
	MIN.W /FT	37.9	38.3	38.9	44.8	47.4	47.5	54.5	56.4	62.0	70.3	83.5	94.0	105.3	117.2	120.2	129.8	137.5	144.0	156.5
850	PIPE TEMP	785.7	784.7	780.9	769.1	760.3	758.3	740.5	738.0	723.0	700.2	661.4	630.9	599.6	568.3	560.5	539.4	522.8	505.2	476.4
	MAX.W /FT	43.8	44.1	44.6	51.5	54.5	54.6	63.3	64.7	71.6	80.8	93.1	104.8	117.5	130.9	134.1	144.9	153.5	160.6	174.5
	MIN.W /FT	41.2	41.6	42.2	48.4	51.4	51.4	59.0	60.9	67.0	75.8	90.0	101.3	113.2	125.9	129.1	139.3	147.5	154.4	167.7
900	PIPE TEMP	830.6	829.6	825.6	812.9	803.5	801.5	782.4	779.8	763.7	739.3	697.9	665.4	632.2	598.8	590.6	568.2	550.6	532.0	501.7
	MAX.W /FT	47.4	47.8	48.2	55.7	58.8	58.9	68.3	69.7	77.2	87.0	100.0	112.5	125.9	140.2	143.6	155.1	164.2	171.7	186.4
	MIN.W /FT	44.6	44.9	45.6	52.2	55.4	55.5	63.6	65.6	72.1	81.5	96.6	108.6	121.3	134.8	138.2	149.0	157.7	165.0	179.0
950	PIPE TEMP	875.5	874.5	870.2	856.7	846.7	844.5	824.2	821.4	804.3	779.3	734.3	699.8	664.5	629.2	620.6	596.9	578.3	558.7	526.7
	MAX.W /FT	51.2	51.6	52.0	60.1	63.3	63.4	73.4	74.9	82.9	93.4	107.1	120.4	134.6	149.8	153.3	165.5	175.1	183.0	198.5
	MIN.W /FT	48.1	48.5	49.1	56.2	59.5	59.6	68.3	70.4	77.3	87.4	103.4	116.1	129.6	143.9	147.4	158.9	168.1	175.7	190.5

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-43

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3-1/2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 0 F (-17.8 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
40	PIPE TEMP	57.6	57.4	57.1	56.7	56.2	56.0	55.2	54.9	54.1	52.9	50.8	49.0	47.2	45.4	44.6	43.4	42.2	41.0	39.0
	MAX.W /FT	1.6	1.7	1.8	2.1	2.2	2.3	2.6	2.8	3.2	3.6	4.4	5.1	5.9	6.6	6.9	7.6	8.1	8.6	9.6
	MIN.W /FT	1.6	1.7	1.7	2.0	2.2	2.2	2.6	2.7	3.1	3.5	4.3	5.0	5.7	6.5	6.8	7.4	7.9	8.4	9.3
80	PIPE TEMP	76.7	76.5	76.1	75.5	74.9	74.6	73.5	73.1	72.1	70.5	67.6	65.2	62.7	60.4	59.4	57.7	56.2	54.6	51.9
	MAX.W /FT	2.2	2.3	2.4	2.8	3.0	3.1	3.6	3.8	4.3	4.9	6.0	6.9	7.9	8.9	9.3	10.2	10.9	11.6	12.8
	MIN.W /FT	2.2	2.3	2.4	2.7	2.9	3.0	3.5	3.7	4.1	4.8	5.8	6.8	7.7	8.7	9.1	9.9	10.6	11.3	12.5
100	PIPE TEMP	95.7	95.5	95.1	94.2	93.5	93.1	91.8	91.3	90.0	88.0	84.6	81.6	78.3	75.3	74.1	71.9	70.1	68.0	64.7
	MAX.W /FT	2.8	3.0	3.1	3.6	3.8	3.9	4.5	4.8	5.4	6.2	7.5	8.7	10.0	11.2	11.7	12.8	13.7	14.5	16.1
	MIN.W /FT	2.8	2.9	3.0	3.4	3.7	3.8	4.4	4.7	5.2	6.0	7.4	8.5	9.7	10.9	11.4	12.5	13.4	14.2	15.7
120	PIPE TEMP	114.8	114.5	114.0	112.9	112.0	111.6	110.0	109.4	107.8	105.4	101.1	97.5	93.7	90.1	88.7	86.1	83.8	81.4	77.4
	MAX.W /FT	3.5	3.6	3.8	4.3	4.7	4.8	5.5	5.9	6.6	7.5	9.1	10.5	12.0	13.5	14.2	15.4	16.5	17.5	19.4
	MIN.W /FT	3.4	3.5	3.7	4.2	4.5	4.7	5.4	5.7	6.4	7.3	8.9	10.3	11.8	13.2	13.8	15.1	16.1	17.1	18.9
140	PIPE TEMP	133.8	133.4	132.8	131.6	130.5	130.1	128.1	127.5	125.6	122.7	117.7	113.5	109.1	104.8	103.2	100.2	97.6	94.8	90.1
	MAX.W /FT	4.1	4.3	4.5	5.2	5.5	5.7	6.6	7.0	7.8	8.9	10.7	12.4	14.2	15.9	16.6	18.1	19.4	20.6	22.8
	MIN.W /FT	4.0	4.2	4.4	5.0	5.4	5.5	6.3	6.7	7.5	8.6	10.5	12.1	13.8	15.5	16.2	17.7	18.9	20.0	22.2
160	PIPE TEMP	152.7	152.4	151.7	150.2	149.0	148.5	146.2	145.5	143.3	140.1	134.3	129.4	124.4	119.5	117.7	114.2	111.2	108.0	102.6
	MAX.W /FT	4.8	5.0	5.2	6.0	6.4	6.6	7.6	8.1	9.0	10.3	12.4	14.3	16.3	18.3	19.1	20.9	22.3	23.6	26.2
	MIN.W /FT	4.7	4.8	5.1	5.8	6.3	6.4	7.3	7.8	8.7	10.0	12.1	14.0	15.9	17.9	18.7	20.3	21.8	23.0	25.5
180	PIPE TEMP	171.6	171.2	170.5	168.8	167.4	166.9	164.3	163.5	161.0	157.3	150.8	145.3	139.7	134.1	132.1	128.2	124.8	121.2	115.2
	MAX.W /FT	5.5	5.7	6.0	6.9	7.4	7.5	8.7	9.2	10.2	11.7	14.1	16.2	18.5	20.8	21.7	23.6	25.3	26.8	29.6
	MIN.W /FT	5.4	5.5	5.8	6.6	7.1	7.3	8.4	8.9	9.9	11.3	13.8	15.9	18.1	20.3	21.1	23.0	24.6	26.1	28.8
200	PIPE TEMP	190.5	190.1	189.2	187.4	185.8	185.2	182.3	181.4	178.7	174.5	167.3	161.2	154.8	148.7	146.5	142.1	138.4	134.3	127.6
	MAX.W /FT	6.3	6.5	6.7	7.7	8.3	8.5	9.8	10.3	11.5	13.2	15.8	18.2	20.7	23.3	24.2	26.4	28.3	29.9	33.1
	MIN.W /FT	6.1	6.3	6.5	7.5	8.1	8.2	9.4	10.0	11.1	12.7	15.4	17.8	20.2	22.7	23.6	25.7	27.5	29.1	32.2
220	PIPE TEMP	209.4	208.9	208.0	205.9	204.2	203.5	200.3	199.3	196.3	191.7	183.7	177.0	170.0	163.1	160.8	155.9	151.8	147.4	140.0
	MAX.W /FT	7.0	7.2	7.5	8.7	9.3	9.4	10.9	11.5	12.8	14.6	17.5	20.2	23.0	25.8	26.8	29.2	31.3	33.1	36.6
	MIN.W /FT	6.8	7.0	7.3	8.4	9.0	9.1	10.5	11.1	12.4	14.2	17.1	19.7	22.4	25.2	26.2	28.5	30.5	32.2	35.6
240	PIPE TEMP	228.2	227.7	226.7	224.4	222.5	221.8	218.2	217.2	213.9	208.8	200.0	192.7	185.0	177.5	175.0	169.7	165.2	160.4	152.3
	MAX.W /FT	7.8	8.0	8.3	9.6	10.3	10.4	12.1	12.7	14.2	16.2	19.3	22.2	25.2	28.4	29.5	32.1	34.3	36.3	40.1
	MIN.W /FT	7.5	7.8	8.1	9.3	9.9	10.1	11.6	12.3	13.6	15.6	18.9	21.7	24.6	27.7	28.7	31.3	33.4	35.3	39.0
260	PIPE TEMP	247.0	246.5	245.3	242.8	240.7	240.0	236.1	235.0	231.4	225.9	216.3	208.3	200.0	191.8	189.1	183.3	178.5	173.3	164.6
	MAX.W /FT	8.6	8.8	9.2	10.5	11.3	11.5	13.2	13.9	15.5	17.7	21.1	24.2	27.5	31.0	32.1	36.0	37.4	39.5	43.6
	MIN.W /FT	8.3	8.5	8.9	10.2	10.9	11.1	12.7	13.5	14.9	17.1	20.6	23.7	26.9	30.2	31.3	34.1	36.4	38.5	42.4
280	PIPE TEMP	265.7	265.2	264.0	261.2	259.0	258.2	254.0	252.8	248.8	242.9	232.6	223.9	214.9	206.1	203.2	197.0	191.7	186.1	176.8
	MAX.W /FT	9.4	9.7	10.0	11.5	12.3	12.5	14.4	15.2	16.9	19.3	22.9	26.3	29.9	33.6	34.8	37.9	40.5	42.8	47.2
	MIN.W /FT	9.1	9.3	9.7	11.1	11.9	12.1	13.9	14.7	16.3	18.6	22.4	25.7	29.2	32.7	33.9	36.9	39.4	41.6	45.9
300	PIPE TEMP	284.4	283.9	282.6	279.6	277.2	276.4	271.8	270.5	266.3	259.8	248.7	239.4	229.8	220.3	217.2	210.5	204.9	198.9	188.9
	MAX.W /FT	10.3	10.5	10.9	12.5	13.4	13.6	15.7	16.5	18.3	20.8	24.8	28.4	32.3	36.3	37.6	40.9	43.7	46.1	50.9
	MIN.W /FT	9.9	10.1	10.5	12.1	12.9	13.1	15.1	15.9	17.6	20.1	24.2	27.7	31.5	35.3	36.6	39.8	42.5	44.9	49.4
350	PIPE TEMP	331.1	330.5	329.0	325.4	322.5	321.6	316.1	314.6	309.6	302.0	288.9	278.0	266.7	255.5	252.0	244.1	237.6	230.6	218.9
	MAX.W /FT	12.5	12.7	13.2	15.2	16.1	16.3	18.8	19.8	21.9	24.9	29.5	33.8	38.3	43.0	44.5	48.4	51.7	54.6	60.1
	MIN.W /FT	12.0	12.3	12.7	14.6	15.6	15.8	18.1	19.1	21.1	24.1	28.4	33.0	37.4	41.9	43.3	47.1	50.3	53.0	58.4
400	PIPE TEMP	377.5	376.9	375.2	370.9	367.6	366.6	360.1	358.5	352.7	343.8	328.8	316.2	303.2	290.2	286.6	277.3	269.8	261.8	248.5
	MAX.W /FT	14.8	15.1	15.6	17.9	19.3	19.2	22.2	23.2	25.7	29.2	34.5	39.4	44.6	50.0	51.7	56.2	59.9	63.2	69.3
	MIN.W /FT	14.3	14.5	15.0	17.2	18.4	18.5	21.2	22.4	24.7	28.2	33.7	38.4	43.4	48.7	50.3	54.6	58.2	61.4	67.5
450	PIPE TEMP	423.8	423.1	421.2	416.3	412.5	411.4	404.0	402.1	395.5	385.4	368.3	354.0	339.3	324.6	320.3	310.1	301.7	292.7	277.8
	MAX.W /FT	17.3	17.6	18.1	20.8	22.1	22.3	25.6	26.8	29.7	33.7	39.6	45.2	51.1	57.2	59.0	64.1	68.4	72.0	79.1
	MIN.W /FT	16.6	16.9	17.4	20.0	21.3	21.4	24.5	25.8	28.5	32.4	38.7	44.0	49.7	55.6	57.4	62.3	66.4	69.9	76.8
500	PIPE TEMP	469.9	469.2	467.0	461.4	457.1	456.0	447.6	445.5	438.1	426.7	407.5	391.5	375.0	358.6	353.9	342.5	333.2	323.2	306.6
	MAX.W /FT	19.9	20.2	20.7	23.8	25.2	25.4	29.2	30.6	33.8	38.3	44.9	51.1	57.7	64.6	66.6	72.3	77.0	81.0	88.9
	MIN.W /FT	19.1	19.4	20.0	22.8	24.3	24.5	28.0	29.4	32.4	36.8	43.8	49.8	56.1	62.7	64.7	70.2	74.7	78.6	86.2
550	PIPE TEMP	515.9	515.1	512.7	506.4	501.6	500.4	490.9	488.6	480.4	467.7	446.4	428.7	410.4	392.2	387.1	374.6	364.3	353.3	335.1
	MAX.W /FT	22.6	22.9	23.4	27.0	28.5	28.7	33.0	34.4	38.0	43.0	50.4	57.2	64.5	72.1	74.3	80.6	85.8	90.2	98.9
	MIN.W /FT	21.6	21.9	22.4	25.8	27.4	27.6	31.5	33.1	36.4	41.3	49.1	55.7	62.7	70.0	72.2	78.2	83.2	87.5	95.8
600	PIPE TEMP	561.7	560.9	558.2	551.2	545.9	544.6	534.1	531.6	522.6	508.5	485.0	465.5	445.5	425.5	420.0	406.2	395.0	383.1	363.3
	MAX.W /FT	25.4	25.7	26.3	30.2	31.9	32.1	36.9	38.5	42.4	47.9	56.0	63.5	71.4	79.9	82.2	89.1	94.8	99.6	109.0
	MIN.W /FT	24.3	24.6	25.3	28.9	30.7	30.8	35.2	36.9	40.5	46.0	54.5	61.8	69.4	77.3	79.8	86.4	91.9	96.6	105.6
650	PIPE TEMP	607.3	606.5	603.6	595.9	590.1	588.7	577.1	574.4	564.5	549.0	523.3	502.1	480.3	458.5	452.6	437.6	425.5	412.5	391.1
	MAX.W /FT	28.3	28.6	29.2	33.6	35.4	35.6	40.8	42.6	46.9	52.9	61.7	69.9	78.6	87.7	90.2	97.8	103.9	109.2	119.4
	MIN.W /FT	27.1	27.3	28.1	32.0	34.0	34.1	38.9	40.8	44.8	50.7	60.1	68.0	76.3	85.1	87.5	94.7	100.7	105.7	115.6
700	PIPE TEMP	652.9	652.0	648.9	640.5	634.1	632.6	620.0	617.1	606.2	589.6	561.4	538.6	514.9	491.3	485.0	468.7	455.7	441.7	418.7
	MAX.W /FT	31.3	31.6	32.3	37.0	39.0	39.2	44.9	46.8	51.5	58.1	67.6	76.4	85.8	95.8	98.4	106.6	113.2	118.9	129.8
	MIN.W /FT	29.9	30.2	31.0	35.3	37.4	37.5	42.8	44.9	49.1	55.6	65.8	74.3	83.3	92.8	95.4	103.2	109.6	115.1	125.7
750	PIPE TEMP	698.4	697.5	694.1	684.9	678.0	676.4	662.7	659.5	647.8	629.6	599.4	574.6	549.2	523.7	517.0	499.6	485.6	470.6	446.0
	MAX.W /FT	34.4	34.7	35.4	40.6	42.7	42.9	49.1	51.1	56.3	63.3	73.6	83.1	93.2	104.0	106.8	115.6	122.7	128.7	140.5
	MIN.W /FT	32.8	33.1	33.9	38.6	40.9	41.0	46.7	49.0	53.6	60.6	71.6	80.7	90.5	100.7	103.5	111.9	118.7	124.6	135.9
800	PIPE TEMP	743.7	742.8	739.2	729.2	721.8	720.1	705.3	701.9	689.3	669.6	637.1	610.5	583.2	556.0	548.8	530.2	515.3	499.3	473.0
	MAX.W /FT	37.6	37.9	38.6	44.2	46.5	46.6	53.5	55.6	61.1	68.7	79.7	89.9	100.8	112.3	115.3	124.7	132.3	138.7	151.3
	MIN.W /FT	35.8	36.1	37.0	42.1	44.5	44.6	50.8	53.2	58.2	65.7	77.5	87.3	97.7	108.7	111.6	120.6	128.0	134.2	146.3
850	PIPE TEMP	789.0	788.1	784.2	773.5	765.5	763.7	747.8	744.2	730.6	709.5	674.6	646.2	617.1	588.0	580.5	560.6	544.7	527.7	499.8
	MAX.W /FT	40.9	41.2	41.9	48.0	50.4	50.5	57.9	60.1	66.1	74.2	85.9	96.9	108.5	120.7	123.9	133.9	142.1	148.9	162.2
	MIN.W /FT	38.9	39.2	40.1	45.6	48.2	48.3	54.9	57.5	62.8	71.0	83.5	94.0	105.1	116.8	119.9	129.5	137.3	143.9	156.8
900	PIPE TEMP	834.2	833.3	829.1	817.6	809.1	807.2	790.2	786.3	771.9	749.3	712.0	681.7	650.8	619.9	611.9	590.8	573.9	555.9	526.4
	MAX.W /FT	44.3	44.6	45.3	51.9	54.4	54.5	62.4	64.8	71.2	79.9	92.3	104.0	116.3	129.4	132.7	143.4	152.0	159.2	173.3
	MIN.W /FT	42.1	42.4	43.3	49.2	52.0	52.1	59.2	61.7	67.6	76.3	89.7	100.9	112.7	125.1	128.4	138.6	146.9	153.8	167.4
950	PIPE TEMP	879.4	878.4	874.0	861.7	852.7	850.6	832.5	828.4	813.0	788.9	749.3	717.2	684.3	651.5	643.1	620.8	603.0	584.0	552.9
	MAX.W /FT	47.8	48.1	48.8	55.8	58.6	58.6	67.1	69.6	76.4	85.7	98.9	111.2	124.3	138.2	141.7	153.0	162.1	169.7	184.6
	MIN.W /FT	45.4	45.7	46.6	52.9	55.9	55.9	63.5	66.4	72.5	81.8	96.0	107.8	120.4	133.5	137.0	147.8	156.5	163.9	178.3

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-44

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

4" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 0 F (-17.8 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
60	PIPE TEMP	57.6	57.5	57.2	56.8	56.2	56.0	55.4	55.1	54.4	53.6	51.4	49.7	47.9	46.3	45.6	44.4	43.4	42.2	40.3
	PAR.in /FT	1.6	1.6	1.7	1.9	2.2	2.3	2.5	2.7	3.0	3.4	4.1	4.8	5.5	6.2	6.5	7.1	7.6	8.0	8.9
	PIA.in /FT	1.5	1.6	1.7	1.9	2.2	2.2	2.4	2.6	2.9	3.3	4.1	4.7	5.4	6.0	6.3	6.9	7.4	7.9	8.7
80	PIPE TEMP	76.8	76.6	76.3	75.6	74.9	74.6	73.8	73.4	72.5	71.0	68.4	66.1	63.8	61.6	60.7	59.1	57.7	56.2	53.6
	PAR.in /FT	2.1	2.2	2.3	2.6	3.0	3.1	3.4	3.6	4.0	4.5	5.6	6.5	7.4	8.3	8.7	9.5	10.2	10.8	12.0
	PIA.in /FT	2.1	2.2	2.3	2.6	2.9	3.0	3.3	3.5	3.9	4.5	5.5	6.3	7.2	8.1	8.5	9.3	9.9	10.5	11.7
100	PIPE TEMP	95.9	95.7	95.2	94.5	93.5	93.1	92.1	91.7	90.4	88.7	85.3	82.5	79.6	76.8	75.7	73.7	71.9	70.0	66.8
	PAR.in /FT	2.7	2.8	3.0	3.4	3.8	3.9	4.3	4.6	5.1	5.7	7.0	8.1	9.3	10.4	10.9	11.9	12.8	13.6	15.1
	PIA.in /FT	2.6	2.8	2.9	3.3	3.7	3.8	4.2	4.5	5.0	5.7	6.9	8.0	9.1	10.2	10.7	11.7	12.5	13.3	14.7
120	PIPE TEMP	114.9	114.7	114.2	113.2	112.0	111.6	110.4	109.9	108.4	106.3	102.2	98.8	95.3	92.0	90.7	88.3	86.1	83.8	80.0
	PAR.in /FT	3.3	3.5	3.6	4.1	4.7	4.8	5.2	5.6	6.2	7.0	8.5	9.9	11.2	12.6	13.2	14.4	15.4	16.4	18.2
	PIA.in /FT	3.2	3.4	3.5	4.0	4.5	4.7	5.1	5.4	6.0	6.9	8.4	9.7	11.0	12.4	12.9	14.1	15.1	16.0	17.7
140	PIPE TEMP	134.0	133.7	133.1	132.0	130.5	130.1	128.7	128.0	126.3	123.8	119.1	115.1	111.0	107.1	105.6	102.7	100.3	97.6	93.1
	PAR.in /FT	3.9	4.1	4.3	4.9	5.5	5.7	6.2	6.6	7.3	8.2	10.1	11.6	13.2	14.8	15.5	16.9	18.1	19.2	21.3
	PIA.in /FT	3.9	4.0	4.2	4.8	5.4	5.5	6.0	6.4	7.1	8.1	9.9	11.4	13.0	14.5	15.2	16.5	17.7	18.8	20.8
160	PIPE TEMP	153.0	152.6	152.0	150.7	149.0	148.5	146.9	146.2	144.2	141.3	135.9	131.3	126.7	122.1	120.4	117.2	114.3	111.3	106.1
	PAR.in /FT	4.6	4.8	5.C	5.7	6.4	6.6	7.2	7.6	8.5	9.5	11.6	13.4	15.2	17.1	17.8	19.4	20.8	22.1	24.5
	PIA.in /FT	4.5	4.6	4.8	5.5	6.3	6.4	7.0	7.4	8.2	9.4	11.4	13.1	14.9	16.7	17.4	19.0	20.4	21.6	23.9
180	PIPE TEMP	171.9	171.6	170.8	169.3	167.4	166.9	165.0	164.2	162.0	158.7	152.6	147.5	142.2	137.1	135.2	131.5	128.3	124.9	119.1
	PAR.in /FT	5.3	5.5	5.7	6.5	7.4	7.5	8.2	8.7	9.6	10.8	13.2	15.1	17.2	19.4	20.2	22.0	23.6	25.0	27.7
	PIA.in /FT	5.1	5.3	5.5	6.3	7.1	7.3	8.0	8.5	9.4	10.6	12.9	14.9	16.9	19.0	19.7	21.5	23.0	24.4	27.0
200	PIPE TEMP	190.9	190.5	189.7	188.0	185.8	185.2	183.1	182.3	179.8	176.1	169.3	163.6	157.7	152.0	149.9	145.8	142.3	138.4	132.0
	PAR.in /FT	6.0	6.2	6.4	7.3	8.3	8.5	9.2	9.8	10.8	12.1	14.8	17.0	19.3	21.7	22.6	24.6	26.3	27.9	30.9
	PIA.in /FT	5.8	6.0	6.2	7.1	8.1	8.2	9.0	9.5	10.5	11.9	14.5	16.6	18.9	21.2	22.1	24.0	25.7	27.2	30.2
220	PIPE TEMP	209.8	209.4	208.5	206.6	204.2	203.5	201.2	200.3	197.5	193.5	185.9	179.6	173.1	166.8	164.6	160.0	156.1	151.9	144.9
	PAR.in /FT	6.7	6.9	7.1	8.2	9.3	9.4	10.3	10.9	12.0	13.5	16.4	18.8	21.4	24.0	25.0	27.2	29.2	30.9	34.2
	PIA.in /FT	6.5	6.7	7.C	7.9	9.0	9.1	10.0	10.6	11.7	13.3	16.1	18.5	21.0	23.5	24.4	26.6	28.5	30.1	33.3
240	PIPE TEMP	228.6	228.2	227.2	225.1	222.5	221.8	219.3	218.2	215.2	210.8	202.5	195.6	188.5	181.6	179.2	174.2	170.0	165.4	157.7
	PAR.in /FT	7.4	7.6	7.9	9.0	10.3	10.4	11.4	12.0	13.3	14.9	18.0	20.7	23.5	26.4	27.4	29.9	32.0	33.9	37.5
	PIA.in /FT	7.2	7.4	7.7	8.8	9.9	10.1	11.0	11.7	12.9	14.6	17.7	20.3	23.0	25.8	26.8	29.2	31.2	33.1	36.6
260	PIPE TEMP	247.5	247.0	246.C	243.6	240.7	240.0	237.3	236.2	232.9	228.0	219.0	211.6	203.8	196.3	193.7	188.3	183.7	178.7	170.4
	PAR.in /FT	8.2	8.4	8.7	9.9	11.3	11.5	12.5	13.1	14.5	16.3	19.7	22.6	25.7	28.8	29.9	32.6	34.9	36.9	40.8
	PIA.in /FT	8.0	8.2	8.5	9.7	10.9	11.1	12.1	12.8	14.1	16.0	19.3	22.2	25.1	28.2	29.2	31.8	34.0	36.0	39.8
280	PIPE TEMP	266.3	265.8	264.7	262.1	259.0	258.2	255.2	254.0	250.5	245.2	235.5	227.4	219.1	210.9	208.2	202.3	197.4	192.0	183.0
	PAR.in /FT	9.0	9.2	9.5	10.9	12.3	12.5	13.6	14.3	15.8	17.7	21.4	24.5	27.9	31.3	32.4	35.3	37.8	39.9	44.1
	PIA.in /FT	8.7	8.9	9.3	10.6	11.9	12.1	13.2	14.0	15.4	17.4	21.0	24.0	27.3	30.6	31.7	34.5	36.9	39.0	43.1
300	PIPE TEMP	285.1	284.5	283.3	280.6	277.2	276.4	273.1	271.9	268.0	262.3	251.9	243.2	234.3	225.5	222.6	216.3	211.0	205.2	195.6
	PAR.in /FT	9.8	10.C	10.3	11.8	13.4	13.6	14.7	15.5	17.1	19.2	23.2	26.5	30.1	33.7	35.0	38.1	40.7	43.0	47.5
	PIA.in /FT	9.5	9.7	10.1	11.5	12.9	13.1	14.3	15.1	16.7	18.8	22.7	26.0	29.4	33.0	34.2	37.2	39.7	42.0	46.4
350	PIPE TEMP	331.9	331.3	329.9	326.6	322.5	321.6	317.7	316.3	311.8	305.0	292.7	282.5	272.0	261.6	258.3	250.9	244.7	238.0	226.9
	PAR.in /FT	11.9	12.1	12.5	14.2	16.1	16.3	17.7	18.6	20.5	22.9	27.6	31.5	35.7	40.1	41.5	45.1	48.2	50.9	56.1
	PIA.in /FT	11.5	11.7	12.1	13.8	15.6	15.8	17.2	18.2	19.9	22.5	27.1	30.9	34.9	39.1	40.5	44.0	47.0	49.6	54.7
400	PIPE TEMP	378.5	377.9	376.2	372.4	367.6	366.6	362.1	360.5	355.2	347.4	333.2	321.5	309.4	297.3	293.7	285.2	278.1	270.4	257.7
	PAR.in /FT	14.1	14.3	14.7	16.8	19.0	19.2	20.8	21.9	24.1	26.8	32.2	36.7	41.6	46.6	48.1	52.3	55.9	59.0	65.0
	PIA.in /FT	13.6	13.9	14.3	16.3	18.4	18.5	20.2	21.3	23.4	26.3	31.6	36.0	40.6	45.4	47.0	51.0	54.5	57.5	63.3
450	PIPE TEMP	424.9	424.3	422.4	418.0	412.5	411.4	406.3	404.4	398.4	389.5	373.4	360.1	346.4	332.7	328.6	319.0	311.1	302.4	288.1
	PAR.in /FT	16.4	16.7	17.1	19.5	22.1	22.3	24.1	25.2	27.8	30.9	37.0	42.1	47.6	53.2	55.0	59.7	63.7	67.2	74.0
	PIA.in /FT	15.9	16.1	16.6	18.9	21.3	21.4	23.3	24.6	26.9	30.3	36.2	41.2	46.5	52.0	53.6	58.2	62.1	65.5	72.0
500	PIPE TEMP	471.2	470.5	468.5	463.4	457.1	456.0	450.2	448.1	441.4	431.3	413.3	398.3	383.0	367.7	363.2	352.5	343.7	334.1	318.7
	PAR.in /FT	18.8	19.1	19.6	22.3	25.2	25.4	27.5	28.8	31.6	35.1	41.9	47.7	53.7	60.1	62.0	67.3	71.8	75.6	83.1
	PIA.in /FT	18.2	18.5	19.C	21.6	24.3	24.5	26.5	28.0	30.6	34.4	41.0	46.6	52.5	58.6	60.5	65.6	69.9	73.7	80.9
550	PIPE TEMP	517.3	516.6	514.3	508.6	501.6	500.4	493.9	491.6	484.1	472.9	452.8	436.3	419.3	402.4	397.5	385.6	375.9	365.4	347.9
	PAR.in /FT	21.4	21.7	22.2	25.3	28.5	28.7	31.0	32.4	35.5	39.4	47.0	53.4	60.1	67.1	69.2	75.1	80.0	84.2	92.5
	PIA.in /FT	20.7	20.9	21.5	24.4	27.4	27.6	29.9	31.5	34.4	38.6	46.0	52.1	58.7	65.4	67.5	73.1	77.9	82.0	90.0
600	PIPE TEMP	563.3	562.6	560.1	553.7	545.9	544.6	537.4	534.9	526.7	514.3	492.1	474.0	455.3	436.7	431.4	418.5	407.8	396.3	377.2
	PAR.in /FT	24.0	24.3	24.8	28.3	31.9	32.1	34.6	36.1	39.6	43.9	52.2	59.2	66.6	74.3	76.6	83.0	88.4	93.0	102.0
	PIA.in /FT	23.2	23.5	24.1	27.3	30.7	30.8	33.4	35.1	38.3	43.0	51.1	57.8	65.0	72.4	74.6	80.8	86.0	90.5	99.2
650	PIPE TEMP	609.2	608.4	605.7	598.7	590.1	588.7	580.8	578.1	569.0	555.4	531.2	511.4	491.0	470.8	465.1	451.0	439.4	426.9	406.3
	PAR.in /FT	26.8	27.1	27.6	31.4	35.4	35.6	38.3	40.0	43.8	48.5	57.6	65.2	73.2	81.7	84.1	91.1	96.9	102.0	111.7
	PIA.in /FT	25.8	26.1	26.7	30.3	34.0	34.1	36.9	38.8	42.4	47.5	56.3	63.6	71.4	79.5	81.9	88.7	94.3	99.2	108.6
700	PIPE TEMP	654.9	654.1	651.2	643.5	634.1	632.6	624.0	621.0	611.2	596.3	570.0	548.5	526.5	504.5	498.4	483.2	470.7	457.3	435.0
	PAR.in /FT	29.6	29.9	30.4	34.6	39.0	39.2	42.1	44.0	48.1	53.2	63.1	71.3	80.0	89.2	91.8	99.4	105.7	111.1	121.6
	PIA.in /FT	28.5	28.8	29.5	33.4	37.4	37.5	40.6	42.6	46.5	52.1	61.6	69.6	78.0	86.8	89.3	96.6	102.7	108.0	118.2
750	PIPE TEMP	700.6	699.8	696.6	688.3	678.0	676.4	667.1	663.9	653.2	637.1	608.7	585.5	561.7	538.1	531.6	515.1	501.8	487.3	463.5
	PAR.in /FT	32.5	32.8	33.4	38.0	42.7	42.9	46.1	48.0	52.5	58.0	68.7	77.5	86.9	96.8	99.5	107.7	114.5	120.3	131.6
	PIA.in /FT	31.3	31.6	32.3	36.5	40.9	41.0	44.3	46.5	50.7	56.8	67.0	75.6	84.7	94.2	96.8	104.7	111.3	116.9	127.8
800	PIPE TEMP	746.2	745.3	741.9	732.9	721.8	720.1	710.0	706.6	695.1	677.7	647.1	622.2	596.8	571.4	564.5	546.9	532.6	517.2	491.8
	PAR.in /FT	35.5	35.8	36.4	41.4	46.5	46.6	50.1	52.2	57.0	62.9	74.4	83.9	94.0	104.6	107.5	116.3	123.5	129.7	141.7
	PIA.in /FT	34.1	34.4	35.2	39.8	44.5	44.6	48.2	50.5	55.0	61.5	72.6	81.8	91.5	101.7	104.5	113.0	120.0	125.9	137.6
850	PIPE TEMP	791.7	790.8	787.2	777.4	765.5	763.7	752.8	749.2	736.8	718.2	685.4	658.8	631.6	604.5	597.1	578.4	563.2	546.8	519.8
	PAR.in /FT	38.6	38.9	39.5	44.8	50.4	50.5	54.2	56.5	61.7	68.0	80.2	90.4	101.1	112.5	115.6	124.9	132.6	139.2	152.0
	PIA.in /FT	37.1	37.3	38.1	43.1	48.2	48.3	52.1	54.6	59.4	66.4	78.2	88.1	98.4	109.3	112.3	121.3	128.8	135.1	147.5
900	PIPE TEMP	837.1	836.2	832.3	821.9	809.1	807.2	795.6	791.7	778.5	758.5	723.6	695.2	666.2	637.4	629.6	609.7	593.6	576.2	547.6
	PAR.in /FT	41.8	42.1	42.6	48.4	54.4	54.5	58.5	60.8	66.4	73.1	86.2	97.0	108.5	120.5	123.8	133.7	141.9	148.9	162.5
	PIA.in /FT	40.1	40.3	41.2	46.5	52.0	52.1	56.1	58.8	64.0	71.4	84.0	94.5	105.5	117.1	120.3	129.8	137.8	144.5	157.6
950	PIPE TEMP	882.5	881.5	877.4	866.3	852.7	850.6	838.2	834.1	820.1	798.8	761.6	731.4	700.7	670.1	661.9	640.9	623.8	605.5	575.3
	PAR.in /FT	45.0	45.3	45.9	52.1	58.6	58.6	62.8	65.3	71.2	78.4	92.3	103.8	115.9	128.7	132.2	142.7	151.4	158.7	173.1
	PIA.in /FT	43.2	43.5	44.3	50.0	55.9	55.9	60.2	63.1	68.6	76.6	89.9	101.0	112.7	125.0	128.3	138.5	146.9	154.0	167.8

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-45

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

1" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 30.0 F (-1.1 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
60	PIPE TEMP	58.2	58.1	57.9	57.5	57.1	56.9	56.3	56.2	55.3	54.3									
	MAX.W /FT	1.3	1.4	1.5	1.7	1.9	2.0	2.3	2.3	2.8	3.3									
	MIN.W /FT	1.2	1.3	1.4	1.5	1.7	1.8	2.0	2.1	2.5	2.9									
80	PIPE TEMP	77.0	76.7	76.4	75.8	75.0	74.7	73.6	73.6	72.1	70.4									
	MAX.W /FT	2.2	2.4	2.5	2.9	3.2	3.4	3.9	3.9	4.8	5.7									
	MIN.W /FT	2.1	2.2	2.3	2.6	2.9	3.1	3.5	3.5	4.2	4.9									
100	PIPE TEMP	95.6	95.3	94.8	93.9	92.9	92.4	90.9	90.8	88.8	86.3									
	MAX.W /FT	3.2	3.4	3.6	4.1	4.6	4.9	5.6	5.6	6.8	8.1									
	MIN.W /FT	3.0	3.2	3.3	3.7	4.2	4.4	5.0	5.0	6.0	7.0									
120	PIPE TEMP	114.2	113.8	113.1	112.0	110.6	110.0	108.1	108.0	105.3	102.1									
	MAX.W /FT	4.2	4.5	4.7	5.4	6.1	6.4	7.4	7.3	9.0	10.6									
	MIN.W /FT	3.9	4.1	4.4	4.9	5.5	5.7	6.5	6.6	7.8	9.1									
140	PIPE TEMP	132.8	132.2	131.4	130.0	128.2	127.5	125.1	125.1	121.7	117.8									
	MAX.W /FT	5.3	5.6	5.9	6.8	7.7	8.0	9.2	9.2	11.2	13.2									
	MIN.W /FT	4.9	5.2	5.4	6.1	6.9	7.1	8.1	8.2	9.7	11.3									
160	PIPE TEMP	151.2	150.6	149.6	147.9	145.8	144.9	142.1	142.0	138.1	133.4									
	MAX.W /FT	6.5	6.8	7.2	8.2	9.3	9.6	11.1	11.0	13.4	15.9									
	MIN.W /FT	6.0	6.3	6.6	7.4	8.3	8.6	9.8	9.8	11.7	13.6									
180	PIPE TEMP	169.6	168.9	167.8	165.7	163.2	162.3	158.9	158.9	154.3	148.8									
	MAX.W /FT	7.7	8.1	8.5	9.7	11.0	11.4	13.1	13.0	15.8	18.6									
	MIN.W /FT	7.0	7.4	7.7	8.8	9.8	10.1	11.5	11.5	13.7	15.9									
200	PIPE TEMP	187.9	187.1	185.8	183.5	180.6	179.6	175.7	175.7	170.4	164.2									
	MAX.W /FT	8.9	9.4	9.8	11.2	12.7	13.1	15.2	15.0	18.2	21.5									
	MIN.W /FT	8.2	8.5	8.9	10.1	11.3	11.7	13.3	13.3	15.7	18.3									
220	PIPE TEMP	206.1	205.3	203.8	201.1	197.9	196.8	192.4	192.4	186.5	179.4									
	MAX.W /FT	10.2	10.7	11.2	12.8	14.5	15.0	17.3	17.0	20.7	24.4									
	MIN.W /FT	9.3	9.8	10.2	11.5	12.9	13.3	15.1	15.1	17.8	20.7									
240	PIPE TEMP	224.3	223.4	221.8	218.7	215.1	213.9	208.9	209.1	202.4	194.6									
	MAX.W /FT	11.6	12.1	12.7	14.5	16.4	16.9	19.5	19.2	23.3	27.4									
	MIN.W /FT	10.6	11.0	11.5	13.0	14.5	14.9	17.0	16.9	20.0	23.2									
260	PIPE TEMP	242.4	241.4	239.6	236.2	232.2	230.9	225.4	225.6	218.3	209.6									
	MAX.W /FT	13.0	13.6	14.2	16.2	18.3	18.8	21.7	21.3	25.9	30.5									
	MIN.W /FT	11.8	12.3	12.8	14.5	16.2	16.6	18.9	18.8	22.2	25.7									
280	PIPE TEMP	260.4	259.4	257.4	253.7	249.3	247.8	241.8	242.1	234.0	224.6									
	MAX.W /FT	14.5	15.1	15.7	18.0	20.3	20.9	24.1	23.6	28.7	33.6									
	MIN.W /FT	13.1	13.6	14.2	16.1	17.9	18.3	20.8	20.7	24.4	28.3									
300	PIPE TEMP	278.4	277.3	275.2	271.0	266.2	264.7	258.1	258.5	249.7	239.4									
	MAX.W /FT	16.0	16.6	17.2	19.9	22.4	22.9	26.5	25.9	31.4	36.9									
	MIN.W /FT	14.5	15.0	15.6	17.7	19.7	20.1	22.9	22.7	26.7	30.9									
350	PIPE TEMP	323.0	321.7	319.3	314.2	308.3	306.5	298.5	299.2	288.5	276.2									
	MAX.W /FT	20.3	20.7	21.5	24.7	27.8	28.4	32.7	31.9	38.7	45.3									
	MIN.W /FT	18.0	18.6	19.3	21.8	24.3	24.8	28.1	27.8	32.7	37.7									
400	PIPE TEMP	367.2	365.8	363.0	356.9	349.9	348.0	338.5	339.5	326.9	312.6									
	MAX.W /FT	24.4	25.2	26.0	29.9	33.6	34.2	39.4	38.2	46.3	54.1									
	MIN.W /FT	21.8	22.4	23.2	26.3	29.2	29.8	33.5	33.1	38.9	44.7									
450	PIPE TEMP	411.0	409.5	406.3	399.2	391.1	389.0	378.0	379.4	364.9	348.2									
	MAX.W /FT	29.0	29.9	30.8	35.3	39.7	40.3	46.4	44.8	54.3	63.4									
	MIN.W /FT	25.8	26.5	27.3	30.9	34.3	34.7	39.3	38.7	45.3	52.0									
500	PIPE TEMP	454.6	453.0	449.4	441.2	431.9	429.7	417.1	418.9	402.4	383.5									
	MAX.W /FT	34.0	34.9	35.9	41.1	46.1	46.7	53.7	51.7	62.6	73.0									
	MIN.W /FT	30.1	30.8	31.6	35.8	39.6	40.0	45.2	44.4	51.9	59.5									
550	PIPE TEMP	497.8	496.1	492.1	482.9	472.5	470.1	455.9	458.2	439.6	418.5									
	MAX.W /FT	39.2	40.2	41.2	47.2	52.8	53.4	61.4	58.8	71.3	83.0									
	MIN.W /FT	34.5	35.2	36.2	40.8	45.1	45.5	51.3	50.3	58.8	67.2									
600	PIPE TEMP	540.7	538.9	534.7	524.3	512.7	510.2	496.4	497.1	476.6	453.2									
	MAX.W /FT	44.7	45.7	46.7	53.5	59.8	60.4	69.3	66.2	80.3	93.3									
	MIN.W /FT	39.2	39.9	40.8	46.0	50.8	51.2	57.6	56.4	65.8	75.1									
650	PIPE TEMP	583.4	581.6	577.0	565.5	552.7	550.0	532.7	535.9	513.2	487.6									
	MAX.W /FT	50.5	51.5	52.6	60.1	67.1	67.7	77.6	73.9	89.5	103.9									
	MIN.W /FT	44.0	44.7	45.7	51.4	56.6	57.0	64.1	62.7	73.0	83.2									
700	PIPE TEMP	625.9	624.1	619.1	606.5	592.5	589.7	570.7	574.4	549.7	521.7									
	MAX.W /FT	56.6	57.6	58.6	67.0	74.6	75.2	86.1	81.8	99.1	114.9									
	MIN.W /FT	49.0	49.8	50.7	57.0	62.7	63.0	70.8	69.1	80.3	91.4									
750	PIPE TEMP	668.3	666.4	661.1	647.3	632.2	629.2	608.6	612.8	586.0	555.7									
	MAX.W /FT	63.0	64.0	64.9	74.1	82.5	83.0	95.0	90.0	109.0	126.3									
	MIN.W /FT	54.3	55.0	55.9	62.8	68.9	69.2	77.6	75.7	87.9	99.9									
800	PIPE TEMP	710.5	708.6	703.0	688.1	671.7	668.6	646.3	651.0	622.1	589.5									
	MAX.W /FT	69.7	70.7	71.6	81.6	90.7	91.1	104.3	98.4	119.3	138.0									
	MIN.W /FT	59.7	60.5	61.4	68.8	75.4	75.7	84.7	82.4	95.7	108.6									
850	PIPE TEMP	752.7	750.8	744.8	728.7	711.2	707.9	684.0	689.1	658.2	623.3									
	MAX.W /FT	76.8	77.9	78.8	89.5	99.3	99.7	114.0	107.2	130.0	150.2									
	MIN.W /FT	65.5	66.2	67.0	75.1	82.1	82.3	92.1	89.4	103.7	117.5									
900	PIPE TEMP	794.9	792.9	786.5	769.3	750.5	747.1	721.6	727.2	694.2	656.9									
	MAX.W /FT	84.6	85.6	86.1	97.9	108.4	108.8	124.2	116.5	141.3	161.1									
	MIN.W /FT	71.7	72.4	73.1	81.7	89.2	89.4	99.8	96.7	112.1	126.8									
950	PIPE TEMP	837.0	834.9	828.2	809.9	789.8	786.3	759.1	765.1	730.1	690.5									
	MAX.W /FT	91.0	94.1	94.2	106.9	118.3	118.6	135.3	126.3	153.4	176.7									
	MIN.W /FT	78.3	79.1	79.5	88.7	96.7	96.6	108.5	104.3	120.9	136.6									

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-46

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

1-1/2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 30.0 F (-1.1 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
40	PIPE TEMP	58.5	58.4	58.1	57.8	57.6	57.4	56.7	56.6	55.9	55.0	53.5	52.0	50.7	49.4	48.9	48.0	47.3	46.5	45.3
	PAR.M /FT	1.1	1.1	1.3	1.4	1.5	1.6	1.9	2.0	2.4	2.8	3.4	4.0	4.4	5.0	5.2	5.7	6.1	6.4	7.0
	PIN.M /FT	1.0	1.1	1.2	1.3	1.4	1.5	1.8	1.8	2.2	2.5	3.1	3.7	4.2	4.7	5.0	5.4	5.7	6.0	6.6
80	PIPE TEMP	77.4	77.2	76.8	76.3	75.8	75.6	74.5	74.3	73.1	71.6	68.9	66.6	64.4	62.2	61.3	59.8	58.7	57.4	55.4
	PAR.M /FT	1.8	1.9	2.2	2.4	2.6	2.7	3.3	3.4	4.0	4.7	5.8	6.7	7.4	8.4	8.8	9.5	10.2	10.7	11.7
	PIN.M /FT	1.7	1.8	2.0	2.3	2.4	2.5	3.0	3.1	3.6	4.2	5.3	6.2	7.1	8.0	8.3	9.0	9.6	10.1	11.1
100	PIPE TEMP	96.3	96.1	95.4	94.7	94.1	93.7	92.1	91.8	90.2	88.1	84.3	81.0	77.9	74.8	73.7	71.6	69.9	68.2	65.4
	PAR.M /FT	2.6	2.7	3.1	3.5	3.7	3.8	4.7	4.8	5.7	6.7	8.3	9.5	10.5	11.9	12.4	13.5	14.3	15.1	16.5
	PIN.M /FT	2.5	2.6	2.9	3.2	3.4	3.5	4.3	4.5	5.2	6.0	7.5	8.8	10.0	11.3	11.7	12.8	13.6	14.3	15.6
120	PIPE TEMP	115.1	114.8	113.9	113.0	112.2	111.8	109.7	109.3	107.2	104.4	99.6	95.3	91.3	87.4	85.9	83.2	81.1	78.9	75.3
	PAR.M /FT	3.4	3.6	4.1	4.6	4.8	5.0	6.1	6.3	7.5	8.8	10.8	12.4	13.6	15.4	16.0	17.4	18.6	19.5	21.3
	PIN.M /FT	3.2	3.4	3.8	4.3	4.5	4.6	5.6	5.8	6.8	7.9	9.7	11.4	13.0	14.6	15.2	16.5	17.6	18.5	20.1
140	PIPE TEMP	133.9	133.5	132.4	131.2	130.3	129.8	127.1	126.7	124.1	120.7	114.8	109.5	104.6	99.7	98.0	94.7	92.1	89.4	85.1
	PAR.M /FT	4.3	4.5	5.1	5.7	6.0	6.2	7.6	7.9	9.3	10.9	13.3	15.3	16.8	19.0	19.8	21.5	22.9	24.0	26.2
	PIN.M /FT	4.0	4.2	4.7	5.3	5.6	5.8	7.0	7.2	8.4	9.8	12.0	14.1	16.0	18.0	18.7	20.3	21.6	22.7	24.7
160	PIPE TEMP	152.6	152.2	150.9	149.4	148.3	147.7	144.5	144.1	140.9	136.9	129.9	123.6	117.8	112.0	110.0	106.1	103.1	99.9	94.6
	PAR.M /FT	5.2	5.4	6.1	6.9	7.3	7.5	9.2	9.5	11.2	13.1	16.0	18.3	20.0	22.7	23.5	25.6	27.2	28.5	31.1
	PIN.M /FT	4.9	5.1	5.7	6.4	6.7	6.9	8.4	8.7	10.1	11.7	14.4	16.8	19.1	21.5	22.3	24.2	25.7	27.0	29.4
180	PIPE TEMP	171.3	170.8	169.2	167.6	166.2	165.6	161.9	161.3	157.7	153.0	144.9	137.6	131.0	124.2	122.0	117.4	113.9	110.3	104.4
	PAR.M /FT	6.1	6.4	7.2	8.1	8.5	8.8	10.8	11.1	13.1	15.3	18.7	21.3	23.4	26.4	27.4	29.8	31.6	33.1	36.1
	PIN.M /FT	5.7	6.0	6.7	7.5	7.9	8.1	9.8	10.2	11.8	13.7	16.8	19.6	22.2	25.0	25.9	28.1	29.9	31.3	34.1
200	PIPE TEMP	189.9	189.3	187.6	185.8	184.1	183.4	179.1	178.5	174.3	169.0	159.7	151.5	144.0	136.2	133.8	128.6	124.7	120.6	113.9
	PAR.M /FT	7.1	7.4	8.3	9.4	9.9	10.1	12.5	12.8	15.1	17.6	21.4	24.4	26.7	30.2	31.3	34.0	36.1	37.8	41.1
	PIN.M /FT	6.6	6.9	7.7	8.7	9.1	9.4	11.3	11.7	13.5	15.7	19.2	22.4	25.4	28.6	29.6	32.1	34.1	35.7	38.8
220	PIPE TEMP	208.4	207.8	205.8	203.6	201.9	201.1	196.3	195.6	190.9	184.9	174.5	165.2	156.9	148.2	145.5	139.8	135.3	130.7	123.4
	PAR.M /FT	8.1	8.4	9.5	10.7	11.2	11.5	14.2	14.5	17.1	20.0	24.2	27.6	30.1	34.0	35.2	38.2	40.6	42.5	46.2
	PIN.M /FT	7.6	7.9	8.8	9.9	10.4	10.6	12.8	13.3	15.3	17.8	21.7	25.3	28.6	32.2	33.3	36.1	38.3	40.1	43.6
240	PIPE TEMP	226.9	226.3	224.1	221.6	219.7	218.8	213.4	212.7	207.5	200.7	189.2	178.9	169.7	160.0	157.1	150.8	145.9	140.8	132.7
	PAR.M /FT	9.1	9.5	10.7	12.1	12.6	12.9	15.9	16.3	19.2	22.4	27.1	30.8	33.6	37.9	39.2	42.6	45.2	47.3	51.3
	PIN.M /FT	8.5	8.8	9.9	11.1	11.7	11.9	14.4	14.9	17.2	19.9	24.2	28.2	31.8	35.8	37.0	40.1	42.6	44.8	48.4
260	PIPE TEMP	245.4	244.7	242.2	239.4	237.4	236.5	230.4	229.7	223.9	216.5	203.9	192.6	182.4	171.8	168.7	161.7	156.4	150.9	142.0
	PAR.M /FT	10.2	10.6	11.9	13.5	14.1	14.4	17.7	18.1	21.3	24.9	30.0	34.1	37.1	41.9	43.2	46.9	49.8	52.1	56.5
	PIN.M /FT	9.5	9.9	11.0	12.4	13.0	13.2	16.0	16.5	19.0	22.0	26.8	31.2	35.1	39.5	40.8	44.2	46.9	49.1	53.2
280	PIPE TEMP	263.8	263.1	260.3	257.3	255.1	254.0	247.4	246.6	240.3	232.1	218.4	206.1	195.0	183.4	180.1	172.6	166.8	160.8	151.2
	PAR.M /FT	11.3	11.7	13.2	14.9	15.6	15.9	19.6	20.0	23.5	27.4	33.0	37.4	40.7	45.9	47.3	51.4	54.4	56.9	61.6
	PIN.M /FT	10.6	10.9	12.2	13.7	14.3	14.6	17.6	18.2	21.0	24.2	29.4	34.2	38.5	43.3	44.7	48.4	51.3	53.6	58.1
300	PIPE TEMP	282.2	281.4	278.4	275.0	272.6	271.6	264.2	263.5	256.6	247.7	232.8	219.5	207.5	195.0	191.5	183.3	177.1	170.7	160.3
	PAR.M /FT	12.5	12.9	14.5	16.4	17.1	17.4	21.5	21.9	25.8	30.0	36.0	40.8	44.3	50.0	51.5	55.8	59.2	61.8	67.0
	PIN.M /FT	11.6	12.0	13.4	15.1	15.7	16.0	19.3	19.9	22.9	26.5	32.1	37.3	41.9	47.1	48.5	52.6	55.7	58.2	63.1
350	PIPE TEMP	327.9	327.0	323.3	319.2	316.4	315.1	306.2	305.4	297.1	286.4	268.6	252.7	238.5	223.5	219.6	209.8	202.3	195.0	182.8
	PAR.M /FT	15.5	15.9	18.0	20.3	21.1	21.4	26.5	26.9	31.6	36.7	43.9	49.5	53.5	60.4	62.0	67.2	71.2	74.3	80.4
	PIN.M /FT	14.4	14.8	16.5	18.5	19.3	19.6	23.7	24.3	28.0	32.2	38.9	45.1	50.6	56.8	58.4	63.2	66.9	69.8	75.5
400	PIPE TEMP	373.3	372.4	368.0	363.1	359.8	358.4	347.7	346.9	337.1	324.6	303.9	285.4	268.9	251.5	247.1	235.9	227.5	218.8	204.9
	PAR.M /FT	18.7	19.2	21.6	24.5	25.3	25.6	31.7	32.1	37.7	43.7	52.0	58.5	63.1	71.0	72.9	78.9	83.4	87.0	94.0
	PIN.M /FT	17.4	17.8	19.8	22.2	23.1	23.4	28.2	28.9	33.2	38.2	45.9	53.1	59.5	66.7	68.5	74.1	78.3	81.7	88.2
450	PIPE TEMP	418.4	417.4	412.4	406.6	402.9	401.6	389.0	388.1	376.9	362.4	338.8	317.7	298.9	279.0	274.3	261.5	252.0	242.3	226.6
	PAR.M /FT	22.1	22.6	25.5	28.8	29.7	30.0	37.2	37.6	44.0	51.0	60.4	67.8	72.8	82.0	84.0	90.9	96.0	100.0	107.9
	PIN.M /FT	20.5	20.9	23.3	26.1	27.1	27.3	33.0	33.7	38.6	44.4	53.2	61.3	68.6	76.9	78.8	85.1	89.9	93.7	101.1
500	PIPE TEMP	463.3	462.3	456.5	449.9	445.7	444.1	429.9	429.0	416.3	399.9	373.3	349.5	328.5	306.1	301.0	286.6	276.1	265.3	247.9
	PAR.M /FT	25.8	26.3	29.6	33.4	34.3	34.7	42.9	43.3	50.6	58.6	69.1	77.3	82.9	93.2	95.3	103.0	108.7	113.2	122.0
	PIN.M /FT	23.7	24.2	26.9	30.1	31.2	31.4	37.9	38.7	44.3	50.8	60.6	69.8	77.9	87.3	89.3	96.4	101.7	106.0	114.2
550	PIPE TEMP	508.0	506.9	500.3	492.9	488.3	486.6	470.5	469.7	455.3	437.0	407.5	381.0	357.6	332.7	327.3	311.4	299.8	287.9	268.9
	PAR.M /FT	29.6	30.1	33.8	38.2	39.1	39.5	48.8	49.2	57.5	66.4	78.1	87.1	93.1	104.7	106.9	115.5	121.8	126.7	136.3
	PIN.M /FT	27.2	27.6	30.7	34.3	35.4	35.7	43.0	43.8	50.1	57.3	68.2	78.5	87.5	97.9	100.0	107.9	113.8	118.4	127.5
600	PIPE TEMP	552.5	551.4	544.6	535.8	530.7	528.8	510.9	510.1	494.2	473.9	441.3	412.1	386.4	359.0	353.2	335.8	323.2	310.3	289.5
	PAR.M /FT	33.5	34.1	38.3	43.2	44.1	44.6	55.0	55.3	64.6	74.5	87.3	97.1	103.6	116.3	118.7	128.1	135.0	140.4	150.3
	PIN.M /FT	30.7	31.2	34.6	38.7	39.8	40.1	48.2	49.1	56.0	64.0	76.0	87.3	97.2	108.6	110.9	119.6	126.0	131.3	140.9
650	PIPE TEMP	596.9	595.7	587.5	578.4	572.8	570.9	551.0	550.2	532.8	510.5	474.8	442.9	414.8	384.9	378.8	359.9	346.3	332.3	309.3
	PAR.M /FT	37.7	38.2	42.9	48.3	49.3	49.8	61.3	61.8	71.8	82.8	96.8	107.4	114.3	128.3	130.7	141.0	148.4	154.3	165.6
	PIN.M /FT	34.4	34.9	38.7	43.1	44.4	44.8	53.6	54.5	62.1	70.9	84.0	96.3	107.1	119.6	122.0	131.4	138.3	143.8	154.5
700	PIPE TEMP	641.0	639.8	630.9	620.8	614.8	612.7	591.0	590.2	571.2	546.9	508.1	473.4	442.9	410.5	404.1	383.7	369.0	354.0	330.0
	PAR.M /FT	42.0	42.5	47.7	53.7	54.7	54.9	67.9	68.0	79.4	91.3	108.5	117.9	125.3	140.4	142.9	154.1	162.1	168.4	180.6
	PIN.M /FT	38.2	38.7	42.8	47.8	49.0	49.2	59.1	60.0	68.3	77.9	92.1	105.5	117.2	130.7	133.2	143.4	150.9	156.7	168.2
750	PIPE TEMP	685.1	683.8	674.1	663.1	656.7	654.5	630.8	630.0	609.4	583.1	541.2	503.7	470.8	435.8	429.1	407.2	391.4	375.4	349.8
	PAR.M /FT	46.5	47.0	52.7	59.2	60.2	60.4	74.7	74.7	87.1	100.1	116.4	128.7	136.4	152.8	155.4	167.5	176.3	182.7	195.7
	PIN.M /FT	42.2	42.6	47.2	52.5	53.8	54.0	64.8	65.7	74.7	85.1	100.4	114.8	127.4	142.0	144.7	155.6	163.6	169.9	182.1
800	PIPE TEMP	729.0	727.7	717.2	705.4	698.4	696.1	670.5	669.7	647.4	619.1	574.0	533.7	498.3	460.9	455.8	430.4	413.7	396.6	369.3
	PAR.M /FT	51.1	51.7	57.9	65.0	65.9	66.1	81.7	81.6	95.1	109.1	126.6	139.6	147.8	165.4	168.1	181.0	190.2	197.3	211.2
	PIN.M /FT	46.3	46.7	51.7	57.4	58.8	58.9	70.6	71.6	81.3	92.5	108.9	124.3	137.9	153.5	156.3	166.0	176.6	183.2	198.2
850	PIPE TEMP	772.9	771.6	760.2	747.5	740.1	737.6	710.0	709.3	685.4	655.0	606.8	563.6	525.7	485.7	478.4	453.4	435.7	417.5	388.7
	PAR.M /FT	56.0	56.5	63.3	71.0	71.8	72.0	88.9	88.7	103.3	118.5	137.1	150.9	159.4	178.3	181.0	194.8	204.6	212.1	226.8
	PIN.M /FT	50.5	51.0	56.3	62.5	63.9	64.0	76.7	77.6	88.1	100.0	117.5	134.1	148.5	165.2	168.1	180.6	189.7	196.7	210.5
900	PIPE TEMP	816.7	815.3	803.2	789.5	781.6	779.0	749.5	748.8	723.3	690.8	639.4	593.2	552.9	510.3	502.7	476.3	457.5	438.3	407.8
	PAR.M /FT	61.1	61.7	69.0	77.3	78.0	78.1	96.6	96.1	112.0	128.2	147.9	162.5	171.3	191.9	194.2	208.9	219.2	227.1	242.7
	PIN.M /FT	55.0	55.4	61.2	67.8	69.2	69.3	82.9	83.8	95.1	107.8	126.4	144.0	159.4	177.2	180.1	193.4	203.3	210.4	225.0
950	PIPE TEMP	860.5	859.1	846.1	831.5	823.1	820.4	788.8	788.1	761.0	726.5	671.6	622.8	579.9	534.8	526.9	498.9	479.1	458.9	426.9
	PAR.M /FT	66.5	67.1	75.1	83.9	84.6	84.6	104.6	103.9	121.0	138.3	159.1	174.4	183.5	204.9	207.7	223.3	234.2	242.5	258.9
	PIN.M /FT	59.7	60.1	66.1	73.4	74.7	74.8	89.5	90.3	102.6	115.9	135.6	154.3	170.5	189.4	192.4	206.5	216.6	224.4	239.4

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-47

ELECTRIC HEAT TRACING
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 30.0 F (-1.1 C)

CABLE TEMP DEG F		PIPE SIZE																		
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
60	PIPE TEMP	58.6	58.5	58.3	58.0	57.7	57.6	57.0	56.9	56.3	55.5	54.1	52.9	51.7	50.5	50.1	49.2	48.6	47.9	46.7
	PARAL /FT	1.0	1.1	1.1	1.3	1.4	1.4	1.7	1.8	2.1	2.4	3.0	3.4	3.9	4.4	4.6	5.0	5.4	5.7	6.2
	PIPE /FT	1.0	1.0	1.0	1.2	1.3	1.3	1.6	1.7	1.9	2.2	2.8	3.2	3.7	4.2	4.4	4.8	5.1	5.4	6.0
80	PIPE TEMP	77.5	77.4	77.2	76.6	76.2	75.9	75.0	74.8	73.8	72.5	70.1	68.1	66.0	64.1	63.3	61.9	60.8	59.6	57.7
	PARAL /FT	1.7	1.8	1.8	2.2	2.3	2.4	2.9	3.0	3.5	4.1	5.1	5.7	6.5	7.4	7.7	8.4	9.0	9.5	10.4
	PIPE /FT	1.6	1.7	1.8	2.0	2.2	2.3	2.7	2.8	3.3	3.8	4.7	5.5	6.3	7.1	7.4	8.1	8.6	9.1	10.0
100	PIPE TEMP	96.5	96.2	96.0	95.1	94.5	94.2	92.9	92.5	91.2	89.3	85.9	83.2	80.3	77.5	76.5	74.5	73.0	71.3	68.6
	PARAL /FT	2.4	2.6	2.6	3.1	3.3	3.4	4.1	4.3	5.0	5.8	7.2	8.0	9.2	10.4	10.9	11.9	12.7	13.4	14.7
	PIPE /FT	2.3	2.4	2.5	2.9	3.1	3.2	3.8	4.0	4.6	5.4	6.7	7.7	8.9	10.0	10.4	11.4	12.1	12.8	14.1
120	PIPE TEMP	115.3	115.0	114.7	113.6	112.8	112.4	110.7	110.3	108.5	106.1	101.7	98.1	94.4	90.8	89.5	87.0	85.0	82.9	79.6
	PARAL /FT	3.2	3.4	3.4	4.1	4.4	4.5	5.4	5.6	6.5	7.6	9.3	10.4	12.0	13.5	14.1	15.4	16.4	17.3	19.0
	PIPE /FT	3.1	3.2	3.3	3.8	4.1	4.2	5.0	5.3	6.1	7.0	8.7	10.0	11.5	13.0	13.5	14.7	15.7	16.6	18.2
140	PIPE TEMP	134.2	133.8	133.4	132.1	131.1	130.6	128.6	127.9	125.7	122.7	117.6	113.0	108.6	104.0	102.5	99.6	97.0	94.6	90.1
	PARAL /FT	4.0	4.2	4.3	5.1	5.4	5.6	6.7	7.0	8.1	9.5	11.6	12.9	14.8	16.7	17.4	18.9	20.2	21.3	23.3
	PIPE /FT	3.8	4.0	4.1	4.8	5.1	5.3	6.2	6.6	7.5	8.7	10.7	12.4	14.2	16.0	16.7	18.1	19.3	20.4	22.3
160	PIPE TEMP	152.9	152.5	152.0	150.4	149.2	148.7	146.1	145.5	142.9	139.3	133.0	127.8	122.4	117.2	115.3	111.7	108.8	105.8	100.6
	PARAL /FT	4.9	5.1	5.1	6.1	6.5	6.7	8.1	8.4	9.7	11.3	13.8	15.4	17.6	19.9	20.7	22.5	24.0	25.3	27.7
	PIPE /FT	4.6	4.8	4.9	5.7	6.2	6.3	7.5	7.9	9.0	10.4	12.8	14.8	16.9	19.1	19.8	21.6	23.0	24.2	26.5
180	PIPE TEMP	171.7	171.2	170.7	168.8	167.4	166.8	163.7	163.0	160.0	155.8	148.5	142.5	136.3	130.2	128.1	124.0	120.6	117.1	111.4
	PARAL /FT	5.7	6.0	6.0	7.2	7.7	7.9	9.5	9.9	11.4	13.3	16.1	17.9	20.5	23.2	24.1	26.2	27.9	29.4	32.2
	PIPE /FT	5.4	5.7	5.7	6.8	7.2	7.4	8.8	9.2	10.5	12.2	15.0	17.2	19.7	22.2	23.1	25.1	26.7	28.1	30.8
200	PIPE TEMP	190.3	189.9	189.2	187.0	185.4	184.8	181.2	180.5	177.0	172.3	163.9	157.1	150.0	143.1	140.8	136.1	132.3	128.3	121.8
	PARAL /FT	6.7	6.9	7.0	8.3	8.9	9.1	10.9	11.4	13.1	15.2	18.5	20.5	23.5	26.5	27.5	29.9	31.9	33.5	36.7
	PIPE /FT	6.3	6.5	6.6	7.8	8.3	8.5	10.1	10.6	12.1	14.0	17.1	19.7	22.5	25.4	26.3	28.6	30.5	32.0	35.0
220	PIPE TEMP	209.0	208.4	207.7	205.2	203.5	202.7	198.7	197.9	194.0	188.6	179.3	171.7	163.7	155.9	153.4	148.1	143.9	139.5	132.2
	PARAL /FT	7.6	7.9	7.9	9.4	10.1	10.3	12.4	12.9	14.9	17.2	20.9	23.1	26.4	29.9	30.9	33.7	35.8	37.7	41.2
	PIPE /FT	7.2	7.4	7.5	8.9	9.5	9.7	11.5	12.0	13.7	15.8	19.4	22.2	25.4	28.6	29.6	32.2	34.2	36.0	39.3
240	PIPE TEMP	227.6	227.0	226.2	223.6	221.4	220.7	216.1	215.3	210.9	204.9	194.5	186.1	177.3	168.6	165.9	160.1	155.4	150.5	142.6
	PARAL /FT	8.6	8.9	8.9	10.6	11.3	11.6	13.9	14.4	16.7	19.3	23.4	25.8	29.5	33.3	34.4	37.5	39.9	41.9	45.8
	PIPE /FT	8.1	8.4	8.5	9.9	10.6	10.8	12.9	13.4	15.3	17.7	21.6	24.8	28.3	31.8	32.9	35.8	38.1	40.0	43.7
260	PIPE TEMP	246.1	245.5	244.7	241.5	239.3	238.5	233.4	232.5	227.8	221.2	209.7	200.5	190.8	181.3	178.6	171.9	166.8	161.5	152.8
	PARAL /FT	9.6	9.9	9.9	11.8	12.6	12.8	15.5	16.0	18.5	21.4	25.9	28.5	32.5	36.7	38.0	41.3	43.9	46.2	50.4
	PIPE /FT	9.0	9.3	9.4	11.1	11.8	12.0	14.3	14.9	16.9	19.6	23.9	27.4	31.2	35.1	36.3	39.4	41.9	44.0	48.1
280	PIPE TEMP	264.6	264.0	263.1	259.6	257.2	256.3	250.7	249.8	244.5	237.3	224.9	214.8	204.3	193.8	190.7	183.7	178.2	172.4	163.0
	PARAL /FT	10.6	10.9	11.0	13.1	13.9	14.2	17.1	17.7	20.4	23.6	28.6	31.3	35.7	40.2	41.6	45.2	48.1	50.5	55.1
	PIPE /FT	10.0	10.3	10.4	12.2	13.0	13.3	15.7	16.4	18.6	21.5	26.2	30.0	34.2	38.4	39.7	43.1	45.8	48.1	52.5
300	PIPE TEMP	283.1	282.4	281.4	277.6	275.0	274.1	268.0	267.0	261.3	253.4	239.9	229.0	217.6	206.3	203.0	195.4	189.5	183.2	173.1
	PARAL /FT	11.7	12.0	12.1	14.4	15.3	15.5	18.7	19.3	22.3	25.8	31.0	34.1	38.8	43.8	45.2	49.1	52.2	54.8	59.8
	PIPE /FT	11.0	11.3	11.4	13.4	14.3	14.5	17.2	17.9	20.4	23.5	28.6	32.7	37.2	41.8	43.2	46.9	49.8	52.2	57.0
350	PIPE TEMP	329.0	328.2	327.1	322.4	319.3	318.3	310.8	309.7	302.8	293.4	277.2	264.2	250.6	237.1	233.4	224.4	217.3	210.0	198.0
	PARAL /FT	14.5	14.9	14.8	17.7	18.8	19.1	23.0	23.7	27.2	31.4	37.6	41.2	46.9	52.8	54.4	59.1	62.8	65.8	71.7
	PIPE /FT	13.6	13.9	14.0	16.5	17.5	17.8	21.1	21.9	24.8	28.6	34.6	39.5	44.9	50.4	51.9	56.3	59.8	62.7	68.3
400	PIPE TEMP	374.7	373.8	372.6	367.0	363.4	362.2	353.4	352.1	344.0	333.0	314.1	299.0	283.2	267.5	263.3	252.8	244.7	236.3	222.6
	PARAL /FT	17.5	17.9	17.8	21.2	22.5	22.8	27.4	28.2	32.4	37.4	44.5	48.6	55.2	62.2	63.9	69.4	73.6	77.1	83.9
	PIPE /FT	16.4	16.7	16.7	19.7	20.9	21.2	25.1	26.0	29.4	33.8	40.9	46.6	52.7	59.2	60.9	66.0	70.0	73.4	79.8
450	PIPE TEMP	420.1	419.2	417.9	411.3	407.2	405.9	395.6	394.2	384.9	372.2	350.6	333.4	315.4	297.4	292.8	280.9	271.8	262.2	246.8
	PARAL /FT	20.7	21.1	20.9	25.0	26.6	26.6	32.1	33.0	37.8	43.5	51.7	56.3	63.7	71.7	73.6	79.9	84.7	88.6	96.2
	PIPE /FT	19.3	19.7	19.8	23.1	24.5	24.7	29.3	30.3	34.2	39.3	47.3	53.8	60.8	68.2	70.1	75.9	80.5	84.2	91.4
500	PIPE TEMP	465.3	464.4	463.0	455.4	450.7	449.3	437.5	436.0	425.5	411.1	386.8	367.3	347.1	326.9	321.9	308.6	298.4	287.7	270.5
	PARAL /FT	24.0	24.5	24.2	28.9	30.4	30.7	37.0	37.9	43.4	49.9	59.1	64.1	72.5	81.5	83.6	90.6	95.9	100.3	108.8
	PIPE /FT	22.3	22.7	22.6	26.7	28.2	28.4	33.6	34.7	39.2	44.9	54.0	61.3	69.1	77.5	79.5	86.0	91.1	95.2	103.3
550	PIPE TEMP	510.4	509.4	507.8	499.3	494.0	492.5	479.2	477.6	465.8	449.7	422.6	400.9	378.5	356.0	350.6	335.8	324.6	312.9	294.0
	PARAL /FT	27.5	28.0	27.6	32.9	34.7	34.9	42.0	43.0	49.2	56.5	66.7	72.1	81.5	91.5	93.7	101.5	107.4	112.2	121.6
	PIPE /FT	25.5	25.9	25.8	30.3	32.0	32.2	38.1	39.3	44.3	50.7	60.8	68.9	77.6	86.9	89.0	96.3	101.9	106.4	115.3
600	PIPE TEMP	555.2	554.1	552.5	542.9	537.1	535.4	520.7	519.0	505.9	488.0	458.1	434.1	409.5	384.7	379.0	362.7	350.5	337.7	317.1
	PARAL /FT	31.2	31.7	31.2	37.2	39.0	39.3	47.2	48.3	55.2	63.2	74.4	80.4	90.6	101.7	104.3	112.6	119.1	124.3	134.6
	PIPE /FT	28.9	29.3	29.2	34.1	36.0	36.2	42.7	44.1	49.6	56.6	67.7	76.7	86.2	96.4	98.8	106.7	112.8	117.8	127.5
650	PIPE TEMP	599.9	598.8	597.1	586.4	580.0	578.3	561.9	560.1	545.8	526.1	493.3	467.1	440.2	413.1	407.0	389.4	376.0	362.2	339.9
	PARAL /FT	35.0	35.5	34.9	41.5	43.6	43.8	52.6	53.7	61.3	70.2	82.6	88.8	100.0	112.1	114.6	123.9	131.0	136.6	147.7
	PIPE /FT	32.3	32.7	32.4	38.1	40.1	40.2	47.5	48.9	55.0	62.7	74.8	84.6	95.1	106.2	108.7	117.3	124.0	129.4	139.8
700	PIPE TEMP	644.4	643.3	641.5	629.7	622.8	620.9	603.0	601.1	585.4	563.9	528.3	499.7	470.6	441.2	434.7	415.6	401.3	386.4	362.9
	PARAL /FT	39.0	39.5	38.7	46.1	48.2	48.4	58.2	59.3	67.7	77.4	90.6	97.4	109.6	122.7	125.4	135.5	143.1	149.2	161.1
	PIPE /FT	35.9	36.3	35.9	42.1	44.3	44.4	52.3	53.9	60.5	68.9	82.1	92.7	104.0	116.1	118.7	128.1	135.3	141.1	152.4
750	PIPE TEMP	688.8	687.6	685.7	672.9	665.4	663.4	643.9	641.9	624.9	601.6	563.0	532.1	500.7	469.0	462.2	441.6	426.3	410.3	384.6
	PARAL /FT	43.1	43.6	42.6	50.8	53.0	53.2	63.9	65.1	74.2	84.7	99.0	106.2	119.3	133.5	136.3	147.2	155.3	161.9	174.6
	PIPE /FT	39.6	40.0	39.5	46.3	48.6	48.7	57.3	59.0	66.2	75.3	89.5	101.0	113.2	126.2	129.0	139.1	146.8	153.0	165.0
800	PIPE TEMP	733.1	731.9	729.9	716.0	707.9	705.8	684.7	682.6	664.3	639.1	597.6	564.2	530.6	496.6	489.4	467.4	451.0	434.0	406.7
	PARAL /FT	47.3	47.8	46.7	55.6	58.0	58.2	69.8	71.0	80.9	92.3	107.6	115.2	129.2	144.5	147.4	159.1	167.8	174.8	188.4
	PIPE /FT	43.4	43.8	43.1	50.6	53.0	53.1	62.5	64.2	72.0	81.8	97.0	109.4	122.5	136.4	139.4	150.2	158.4	165.0	177.9
850	PIPE TEMP	777.3	776.1	774.0	759.0	750.3	748.1	725.4	723.1	703.5	676.5	632.0	596.2	560.2	523.9	516.4	492.9	475.5	457.5	428.5
	PARAL /FT	51.8	52.3	50.9	60.6	63.1	63.3	75.9	77.1	87.8	100.1	116.6	124.4	139.6	155.7	158.7	171.2	180.5	187.9	202.3
	PIPE /FT	47.3	47.7	47.0	55.0	57.6	57.7	67.8	69.6	77.9	88.5	104.8	118.0	131.9	146.9	149.9	161.5	170.2	177.2	190.9
900	PIPE TEMP	821.5	820.3	818.0	802.0	792.6	790.3	765.9	763.6	742.6	713.8	666.2	627.9	589.7	551.1	543.1	518.3	499.8	480.8	450.1
	PARAL /FT	56.4	56.9	55.1	65.8	68.4	68.6	82.3	83.4	95.0	108.1	125.4	133.8	149.7	167.1	170.3	183.5	193.4	201.2	216.5
	PIPE /FT	51.4	51.8	50.9	59.6	62.3	62.4	73.3	75.1	84.1	95.4	112.7	126.8	141.6	157.5	160.7	172.9	182.2	189.6	204.0
950	PIPE TEMP	865.6	864.3	862.0	844.8	834.8	832.4	806.4	803.9	781.6	750.9	700.3	659.5	619.1	578.1	569.8	543.5	524.0	503.9	471.5
	PARAL /FT	61.3	61.8	59.9	71.1	74.0	74.1	88.9	90.0	102.4	116.4	134.7	143.4	160.3	178.8	182.1	196.1	206.5	214.7	230.9
	PIPE /FT	55.8	56.2	55.0	64.4	67.2	67.3	78.9	80.9	90.4	102.5	120.8	135.8	151.5	168.3	171.6	184.6	194.4	202.2	217.4

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-48

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

2-1/2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 30.0 F (-1.1 C)

CABLE TEMP DEG F		PIPE SIZE																		
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
60	PIPE TEMP	58.6	58.6	58.4	58.1	57.9	57.8	57.3	57.1	56.6	56.0	54.6	53.6	52.5	51.4	51.0	50.2	49.6	48.9	47.4
	MAX.W /FT	0.9	1.0	1.0	1.2	1.3	1.3	1.5	1.6	1.9	2.1	2.7	3.0	3.5	3.9	4.1	4.5	4.8	5.1	5.6
	MIN.W /FT	0.9	0.9	1.0	1.1	1.2	1.3	1.5	1.6	1.8	2.0	2.6	2.9	3.4	3.8	4.0	4.4	4.7	4.9	5.4
80	PIPE TEMP	77.7	77.5	77.3	76.8	76.4	76.2	75.4	75.1	74.3	73.2	70.9	69.2	67.3	65.5	64.8	63.6	62.5	61.4	59.5
	MAX.W /FT	1.6	1.6	1.7	2.0	2.2	2.2	2.6	2.8	3.2	3.6	4.5	5.1	5.9	6.6	6.9	7.6	8.1	8.6	9.5
	MIN.W /FT	1.5	1.6	1.6	1.9	2.1	2.1	2.5	2.6	3.0	3.4	4.3	5.0	5.7	6.4	6.7	7.3	7.8	8.3	9.1
100	PIPE TEMP	96.7	96.5	96.2	95.5	94.9	94.6	93.4	93.1	91.9	90.3	87.1	84.7	82.1	79.6	78.6	76.8	75.4	73.8	71.2
	MAX.W /FT	2.2	2.4	2.4	2.8	3.1	3.2	3.7	3.9	4.5	5.2	6.4	7.2	8.3	9.4	9.8	10.7	11.4	12.1	13.3
	MIN.W /FT	2.2	2.3	2.3	2.7	2.9	3.0	3.5	3.7	4.3	4.9	6.1	7.0	8.0	9.1	9.5	10.3	11.0	11.7	12.9
120	PIPE TEMP	115.7	115.4	115.0	114.1	113.3	112.9	111.4	111.0	109.4	107.4	103.3	100.1	96.8	93.5	92.3	90.0	88.1	86.1	82.8
	MAX.W /FT	2.9	3.1	3.2	3.7	4.0	4.1	4.9	5.1	5.9	6.7	8.3	9.4	10.8	12.2	12.7	13.8	14.8	15.6	17.2
	MIN.W /FT	2.8	3.0	3.1	3.6	3.8	3.9	4.6	4.9	5.5	6.3	7.9	9.1	10.4	11.7	12.3	13.4	14.3	15.1	16.6
140	PIPE TEMP	134.6	134.3	133.8	132.6	131.6	131.2	129.3	128.8	126.9	124.6	119.3	115.5	111.4	107.4	105.9	103.1	100.8	98.3	94.3
	MAX.W /FT	3.7	3.8	4.0	4.6	5.0	5.1	6.1	6.4	7.3	8.3	10.3	11.6	13.3	15.0	15.6	17.0	18.2	19.2	21.2
	MIN.W /FT	3.5	3.7	3.8	4.4	4.8	4.9	5.7	6.1	6.9	7.8	9.8	11.2	12.9	14.5	15.1	16.4	17.6	18.5	20.4
160	PIPE TEMP	153.4	153.1	152.5	151.1	149.9	149.5	147.2	146.6	144.3	141.3	135.3	130.8	125.9	121.1	119.5	116.1	113.4	110.5	105.7
	MAX.W /FT	4.4	4.6	4.8	5.6	6.0	6.2	7.3	7.7	8.7	10.0	12.3	13.8	15.8	17.9	18.6	20.3	21.7	22.9	25.2
	MIN.W /FT	4.3	4.4	4.6	5.3	5.7	5.9	6.9	7.3	8.2	9.4	11.7	13.4	15.3	17.3	18.0	19.6	20.9	22.0	24.2
180	PIPE TEMP	172.3	171.9	171.2	169.5	168.2	167.7	165.0	164.3	161.7	158.2	151.2	146.0	140.3	134.8	132.9	129.0	125.9	122.5	117.0
	MAX.W /FT	5.2	5.4	5.6	6.6	7.1	7.2	8.6	9.0	10.2	11.7	14.3	16.1	18.4	20.8	21.6	23.6	25.2	26.5	29.2
	MIN.W /FT	5.0	5.2	5.4	6.2	6.7	6.9	8.1	8.5	9.6	11.0	13.6	15.6	17.8	20.1	20.9	22.7	24.3	25.6	28.1
200	PIPE TEMP	191.0	190.6	189.9	187.9	186.4	185.8	182.7	182.0	179.0	175.0	167.1	161.1	154.7	148.4	146.3	141.9	138.3	134.5	128.3
	MAX.W /FT	6.1	6.3	6.5	7.6	8.1	8.3	9.8	10.3	11.7	13.4	16.4	18.4	21.1	23.8	24.7	26.9	28.7	30.3	33.3
	MIN.W /FT	5.8	6.0	6.2	7.2	7.8	7.9	9.3	9.8	11.0	12.6	15.6	17.8	20.4	22.9	23.8	25.9	27.7	29.2	32.0
220	PIPE TEMP	209.8	209.3	208.5	206.3	204.6	203.9	200.4	199.6	196.2	191.7	182.9	176.2	169.0	161.9	159.6	154.7	150.7	146.4	139.5
	MAX.W /FT	6.9	7.1	7.3	8.6	9.2	9.4	11.2	11.7	13.3	15.1	18.6	20.8	23.7	26.8	27.8	30.2	32.3	34.0	37.4
	MIN.W /FT	6.6	6.8	7.0	8.2	8.8	9.0	10.5	11.0	12.5	14.2	17.6	20.1	22.9	25.8	26.8	29.1	31.1	32.8	36.0
240	PIPE TEMP	228.5	228.0	227.1	224.6	222.7	222.0	218.0	217.1	213.4	208.4	198.6	191.2	183.2	175.3	172.8	167.3	162.9	158.3	150.6
	MAX.W /FT	7.8	8.0	8.2	9.7	10.4	10.6	12.5	13.1	14.9	16.9	20.7	23.2	26.4	29.8	30.9	33.7	35.9	37.8	41.5
	MIN.W /FT	7.4	7.7	7.9	9.2	9.9	10.0	11.8	12.4	13.9	15.9	19.6	22.4	25.5	28.7	29.8	32.4	34.6	36.4	40.0
260	PIPE TEMP	247.2	246.6	245.6	242.9	240.8	240.0	235.6	234.7	230.5	225.0	214.2	206.1	197.3	188.6	185.9	180.0	175.1	170.0	161.6
	MAX.W /FT	8.7	9.0	9.2	10.8	11.6	11.8	13.9	14.5	16.5	18.8	22.9	25.6	29.2	32.9	34.1	37.1	39.6	41.7	45.7
	MIN.W /FT	8.3	8.5	8.8	10.2	11.0	11.1	13.1	13.7	15.4	17.6	21.7	24.8	28.2	31.7	32.9	35.7	38.1	40.1	44.0
280	PIPE TEMP	265.8	265.2	264.1	261.1	258.8	258.0	253.2	252.1	247.6	241.6	229.8	220.9	211.3	201.9	199.0	192.5	187.2	181.7	172.6
	MAX.W /FT	9.6	9.9	10.1	11.9	12.7	13.0	15.3	16.0	18.2	20.6	25.2	28.1	32.0	36.0	37.3	40.6	43.3	45.5	49.9
	MIN.W /FT	9.2	9.4	9.7	11.3	12.1	12.3	14.4	15.1	17.0	19.3	23.8	27.1	30.9	34.7	35.9	39.1	41.6	43.8	48.0
300	PIPE TEMP	284.4	283.8	282.6	279.3	276.8	275.9	270.6	269.5	264.7	258.1	245.3	235.7	225.3	215.1	212.0	204.9	199.3	193.3	183.5
	MAX.W /FT	10.6	10.9	11.1	13.1	14.0	14.2	16.8	17.5	19.9	22.5	27.4	30.6	34.8	39.2	40.5	44.1	47.0	49.5	54.2
	MIN.W /FT	10.1	10.3	10.6	12.3	13.2	13.4	15.7	16.5	18.5	21.1	26.0	29.6	33.6	37.8	39.1	42.4	45.2	47.6	52.1
350	PIPE TEMP	330.7	330.0	328.6	324.6	321.5	320.6	314.1	312.9	307.0	299.1	283.7	272.3	260.0	247.7	244.1	235.8	229.1	222.0	210.4
	MAX.W /FT	13.1	13.4	13.7	16.1	17.2	17.4	20.6	21.4	24.2	27.4	33.3	37.0	42.0	47.3	48.8	53.1	56.5	59.4	65.0
	MIN.W /FT	12.4	12.7	13.0	15.2	16.2	16.4	19.2	20.1	22.6	25.6	31.5	35.7	40.5	45.5	47.0	51.0	54.3	57.1	62.5
400	PIPE TEMP	376.7	376.0	374.5	369.6	366.0	365.0	357.3	355.9	349.0	339.8	321.8	308.5	296.2	279.9	275.9	266.2	258.5	250.3	237.0
	MAX.W /FT	15.8	16.1	16.4	19.2	20.5	20.7	24.5	25.5	28.8	32.5	39.3	43.6	49.4	55.6	57.3	62.3	66.2	69.6	76.0
	MIN.W /FT	14.9	15.2	15.6	18.1	19.4	19.5	22.9	23.9	26.7	30.3	37.1	42.1	47.7	53.5	55.1	59.8	63.6	66.8	73.0
450	PIPE TEMP	422.6	421.8	420.1	414.4	410.3	409.1	400.3	398.6	390.7	380.1	359.5	344.4	328.0	311.6	307.2	296.2	287.4	278.2	263.1
	MAX.W /FT	18.6	18.9	19.2	22.6	24.0	24.2	28.7	29.7	33.5	37.8	45.6	50.4	57.1	64.2	66.0	71.7	76.2	80.0	87.3
	MIN.W /FT	17.6	17.9	18.2	21.2	22.6	22.8	26.6	27.8	31.1	35.2	43.0	48.6	55.0	61.6	63.5	68.8	73.1	76.7	83.7
500	PIPE TEMP	468.2	467.4	465.5	458.9	454.3	453.0	442.9	441.2	432.2	420.1	396.9	379.8	361.4	343.0	338.2	325.8	316.0	305.7	288.9
	MAX.W /FT	21.6	21.9	22.2	26.1	27.7	27.9	33.0	34.1	38.5	43.3	52.1	57.4	64.9	72.9	75.0	81.3	86.4	90.6	98.7
	MIN.W /FT	20.3	20.7	21.0	24.4	26.0	26.2	30.6	31.9	35.6	40.2	49.0	55.3	62.5	70.0	72.0	78.0	82.8	86.8	94.6
550	PIPE TEMP	513.7	512.8	510.7	503.3	498.1	496.8	485.4	483.4	473.4	459.9	433.9	414.9	394.5	374.0	368.8	355.0	344.2	332.9	314.4
	MAX.W /FT	24.7	25.1	25.3	29.7	31.5	31.7	37.4	38.7	43.6	49.0	58.7	64.6	73.0	81.9	84.1	91.1	96.7	101.3	110.4
	MIN.W /FT	23.2	23.6	23.9	27.8	29.6	29.7	34.7	36.1	40.2	45.4	55.2	62.2	70.1	78.5	80.6	87.3	92.6	97.1	105.7
600	PIPE TEMP	559.0	558.1	555.8	547.5	541.8	540.3	527.6	525.5	514.3	499.4	470.7	449.7	427.2	404.6	399.0	383.9	372.1	359.7	339.9
	MAX.W /FT	27.9	28.3	28.5	33.5	35.4	35.6	42.0	43.4	48.8	54.9	65.6	72.0	81.2	91.0	93.4	101.1	107.2	112.3	122.1
	MIN.W /FT	26.2	26.6	26.9	31.3	33.2	33.4	38.9	40.4	45.0	50.7	61.5	69.3	78.0	87.2	89.5	96.8	102.6	107.5	116.9
650	PIPE TEMP	604.2	603.2	600.7	591.5	585.2	583.6	569.6	567.3	555.1	538.6	507.2	484.2	459.6	434.9	428.9	412.4	399.6	386.2	364.4
	MAX.W /FT	31.3	31.7	31.9	37.4	39.5	39.7	46.8	48.3	54.3	60.9	72.6	79.5	89.6	100.3	102.8	111.3	118.0	123.5	134.1
	MIN.W /FT	29.3	29.7	30.0	34.8	37.0	37.1	43.2	44.9	49.9	56.2	68.0	76.5	86.0	96.0	98.5	106.5	112.8	118.1	128.2
700	PIPE TEMP	649.2	648.2	645.5	635.4	628.5	626.8	611.5	609.0	595.7	577.7	543.4	518.4	491.8	465.0	458.6	440.7	426.9	412.4	388.9
	MAX.W /FT	34.8	35.2	35.3	41.4	43.7	43.9	51.7	53.3	59.8	67.0	79.8	87.3	98.1	109.8	112.5	121.7	128.9	134.8	146.1
	MIN.W /FT	32.5	32.9	33.2	38.5	40.8	41.0	47.6	49.4	54.9	61.8	74.6	83.8	94.1	105.0	107.7	116.3	123.2	128.8	139.8
750	PIPE TEMP	694.1	693.1	690.2	679.2	671.7	669.9	653.2	650.5	636.1	616.6	579.4	552.3	523.6	494.7	487.9	468.7	453.9	438.4	413.1
	MAX.W /FT	38.4	38.8	38.9	45.6	48.1	48.2	56.8	58.4	65.6	73.4	87.1	95.1	106.9	119.5	122.3	132.2	139.9	146.3	158.6
	MIN.W /FT	35.9	36.2	36.5	42.3	44.8	44.9	52.1	54.1	60.1	67.5	81.4	91.3	102.4	114.2	117.0	126.3	133.7	139.7	151.5
800	PIPE TEMP	738.9	737.9	734.8	722.8	714.8	712.9	696.7	691.9	676.3	655.3	615.3	586.1	555.3	524.3	517.0	496.5	480.7	464.1	437.1
	MAX.W /FT	42.1	42.5	42.6	49.9	52.5	52.6	62.0	63.7	71.4	79.9	94.6	103.2	115.8	129.3	132.3	142.9	151.2	158.0	171.1
	MIN.W /FT	39.3	39.6	39.9	46.2	48.9	49.0	56.8	58.9	65.3	73.3	88.3	99.0	110.8	123.5	126.4	136.9	144.3	150.7	163.1
850	PIPE TEMP	783.7	782.6	779.3	766.4	757.7	755.7	736.2	733.2	716.4	693.9	650.9	619.6	586.7	553.6	545.9	524.0	507.2	489.6	461.0
	MAX.W /FT	46.0	46.4	46.4	54.3	57.1	57.2	67.3	69.1	77.5	86.5	102.3	111.4	124.6	139.3	142.5	153.8	162.6	169.8	183.6
	MIN.W /FT	42.8	43.2	43.4	50.3	53.1	53.1	61.6	63.6	70.6	79.3	95.3	106.8	119.4	132.9	136.0	146.7	155.1	161.9	175.3
900	PIPE TEMP	828.4	827.3	823.7	809.9	800.6	798.5	777.5	774.4	756.4	732.3	686.4	653.0	618.0	582.7	574.7	551.4	533.5	514.8	484.6
	MAX.W /FT	50.1	50.5	50.3	58.9	61.8	61.9	72.8	74.7	83.7	93.4	110.2	119.8	134.1	149.5	152.8	164.9	174.3	181.9	196.7
	MIN.W /FT	46.5	46.8	47.1	54.4	57.4	57.4	66.5	68.9	76.3	85.4	102.5	114.7	128.2	142.6	145.8	157.2	166.1	173.3	187.4
950	PIPE TEMP	873.0	871.8	868.1	853.3	843.4	841.1	818.8	815.4	796.6	770.6	721.7	686.2	649.1	611.6	603.2	578.6	559.7	540.0	508.3
	MAX.W /FT	54.3	54.7	54.4	63.7	66.8	66.8	78.6	80.5	90.2	100.5	118.3	128.3	143.5	159.9	163.4	176.2	186.1	194.1	209.8
	MIN.W /FT	50.3	50.6	50.8	58.7	61.8	61.9	71.7	74.1	82.1	91.8	109.9	122.9	137.1	152.4	155.8	167.8	177.2	184.9	199.4

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-49

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 30.0 F (-1.1 C)

CABLE TEMP DEG F		PIPE SIZE																	
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
60	PIPE TEMP	58.7	58.6	58.5	58.2	58.0	57.9	57.4	57.3	56.9	56.2	55.0	54.1	53.1	52.1	51.7	51.0	50.4	49.8	48.7
	PAR.W /FT	0.9	0.9	0.9	1.1	1.2	1.2	1.4	1.5	1.7	2.0	2.4	2.8	3.2	3.6	3.8	4.1	4.4	4.7	5.2
	PIN.W /FT	0.8	0.9	0.9	1.1	1.2	1.4	1.5	1.6	1.9	2.3	2.7	3.1	3.5	3.7	4.0	4.3	4.5	5.0	
80	PIPE TEMP	77.8	77.7	77.5	77.0	76.6	76.4	75.7	75.5	74.7	73.6	71.7	70.0	68.3	66.7	66.0	64.9	63.9	62.8	61.0
	PAR.W /FT	1.5	1.5	1.6	1.9	2.0	2.1	2.4	2.6	2.9	3.3	4.0	4.7	5.4	6.1	6.3	6.9	7.4	7.9	8.7
	PIN.W /FT	1.4	1.5	1.6	1.8	1.9	2.0	2.3	2.5	2.8	3.2	3.9	4.6	5.2	5.9	6.2	6.7	7.2	7.6	8.4
100	PIPE TEMP	96.9	96.7	96.4	95.7	95.1	94.9	93.8	93.5	92.5	91.0	88.2	85.9	83.5	81.2	80.3	78.7	77.3	75.8	73.3
	PAR.W /FT	2.1	2.2	2.3	2.7	2.9	3.0	3.5	3.6	4.1	4.7	5.7	6.6	7.6	8.5	8.9	9.8	10.5	11.1	12.2
	PIN.W /FT	2.0	2.1	2.2	2.6	2.8	2.8	3.3	3.5	3.9	4.5	5.6	6.5	7.4	8.3	8.7	9.5	10.1	10.7	11.9
120	PIPE TEMP	115.9	115.6	115.2	114.4	113.6	113.3	111.9	111.6	110.2	108.3	104.7	101.7	98.6	95.7	94.5	92.4	90.6	88.7	85.5
	PAR.W /FT	2.8	2.9	3.0	3.5	3.8	3.9	4.5	4.7	5.3	6.1	7.4	8.6	9.8	11.1	11.6	12.6	13.5	14.3	15.8
	PIN.W /FT	2.7	2.8	2.9	3.3	3.6	3.7	4.3	4.5	5.1	5.9	7.2	8.4	9.6	10.8	11.2	12.3	13.1	13.9	15.3
140	PIPE TEMP	134.8	134.6	134.1	133.0	132.1	131.7	130.0	129.6	127.9	125.5	121.1	117.4	113.7	110.0	108.7	106.1	103.9	101.5	97.6
	PAR.W /FT	3.5	3.6	3.7	4.3	4.7	4.8	5.6	5.9	6.6	7.6	9.2	10.6	12.1	13.7	14.3	15.5	16.6	17.6	19.5
	PIN.W /FT	3.3	3.5	3.6	4.2	4.5	4.6	5.4	5.6	6.3	7.3	8.9	10.3	11.8	13.3	13.8	15.1	16.1	17.1	18.9
160	PIPE TEMP	153.8	153.5	152.9	151.6	150.5	150.1	148.0	147.5	145.5	142.6	137.4	133.1	128.6	124.3	122.7	119.6	117.1	114.3	109.7
	PAR.W /FT	4.2	4.3	4.5	5.2	5.6	5.8	6.7	7.0	7.9	9.1	10.9	12.6	14.4	16.3	17.0	18.5	19.8	20.9	23.1
	PIN.W /FT	4.0	4.2	4.3	5.0	5.4	5.5	6.4	6.7	7.6	8.7	10.7	12.3	14.1	15.8	16.5	17.9	19.2	20.3	22.4
180	PIPE TEMP	172.7	172.3	171.7	170.2	168.9	168.4	166.0	165.4	163.1	159.7	153.7	148.7	143.5	138.5	136.7	133.1	130.2	127.0	121.7
	PAR.W /FT	4.9	5.1	5.3	6.1	6.6	6.7	7.9	8.2	9.2	10.6	12.7	14.7	16.8	18.9	19.7	21.5	23.0	24.3	26.8
	PIN.W /FT	4.7	4.9	5.1	5.9	6.3	6.5	7.5	7.9	8.8	10.2	12.4	14.3	16.3	18.4	19.1	20.8	22.3	23.5	26.0
200	PIPE TEMP	191.5	191.1	190.4	188.7	187.2	186.7	183.9	183.2	180.7	176.8	169.9	164.3	158.4	152.6	150.6	146.6	143.2	139.6	133.6
	PAR.W /FT	5.7	5.9	6.1	7.0	7.6	7.7	9.1	9.4	10.6	12.2	14.6	16.8	19.2	21.6	22.5	24.5	26.2	27.7	30.5
	PIN.W /FT	5.5	5.6	5.8	6.7	7.3	7.4	8.6	9.0	10.1	11.6	14.2	16.4	18.7	21.0	21.8	23.8	25.4	26.8	29.6
220	PIPE TEMP	210.3	209.9	209.1	207.1	205.5	204.9	201.7	201.0	198.1	193.8	186.1	179.7	173.1	166.6	164.5	159.9	156.1	152.1	145.4
	PAR.W /FT	6.4	6.7	6.9	8.0	8.6	8.8	10.3	10.7	12.0	13.8	16.5	19.0	21.6	24.4	25.3	27.6	29.5	31.1	34.3
	PIN.W /FT	6.2	6.4	6.6	7.7	8.3	8.4	9.8	10.2	11.4	13.2	16.0	18.5	21.0	23.7	24.6	26.7	28.6	30.2	33.2
240	PIPE TEMP	229.1	228.7	227.8	225.5	223.7	223.1	219.5	218.8	215.6	210.7	202.2	195.1	187.8	180.6	178.2	173.2	169.0	164.6	157.2
	PAR.W /FT	7.3	7.5	7.7	9.0	9.7	9.8	11.5	12.0	13.4	15.4	18.4	21.1	24.1	27.1	28.2	30.7	32.8	34.6	38.1
	PIN.W /FT	7.0	7.2	7.4	8.6	9.3	9.4	10.9	11.4	12.8	14.7	17.9	20.6	23.4	26.3	27.3	29.7	31.8	33.5	36.9
260	PIPE TEMP	247.9	247.4	246.4	243.9	241.9	241.2	237.3	236.5	232.9	227.6	218.2	210.4	202.4	194.5	191.9	186.4	181.8	176.9	168.9
	PAR.W /FT	8.1	8.3	8.6	10.0	10.7	10.9	12.8	13.3	14.9	17.1	20.3	23.3	26.6	30.0	31.1	33.8	36.1	38.1	42.0
	PIN.W /FT	7.8	8.0	8.3	9.6	10.3	10.5	12.1	12.7	14.2	16.3	19.8	22.7	25.8	29.1	30.1	32.8	35.0	36.9	40.6
280	PIPE TEMP	266.6	266.1	265.0	262.3	260.0	259.3	255.0	254.1	250.3	244.4	234.1	225.7	217.0	208.3	205.6	199.5	194.6	189.3	180.5
	PAR.W /FT	9.0	9.2	9.5	11.0	11.9	12.0	14.1	14.6	16.4	18.8	22.3	25.6	29.1	32.8	34.0	37.0	39.5	41.7	45.9
	PIN.W /FT	8.6	8.8	9.1	10.5	11.4	11.5	13.4	14.0	15.6	17.9	21.7	24.9	28.3	31.8	32.9	35.8	38.3	40.3	44.4
300	PIPE TEMP	285.2	284.7	283.5	280.6	278.1	277.4	272.7	271.8	267.5	261.2	250.0	240.9	231.4	222.0	219.1	212.6	207.2	201.5	192.0
	PAR.W /FT	9.8	10.1	10.4	12.1	13.0	13.2	15.6	15.9	17.9	20.5	24.3	27.9	31.7	35.7	36.9	40.2	42.9	45.3	49.8
	PIN.W /FT	9.4	9.7	10.0	11.5	12.4	12.6	14.8	15.2	17.0	19.5	23.0	27.1	30.8	34.6	35.8	38.9	41.5	43.8	48.1
350	PIPE TEMP	331.8	331.2	329.8	326.1	323.2	322.4	316.7	315.6	310.5	302.9	289.5	278.7	267.3	256.1	252.7	244.9	238.6	231.8	220.6
	PAR.W /FT	12.2	12.4	12.8	14.8	15.9	16.1	18.8	19.5	21.8	24.9	29.4	33.7	38.3	43.1	44.5	48.4	51.6	54.4	59.7
	PIN.W /FT	11.6	11.9	12.3	14.2	15.2	15.4	17.8	18.6	20.7	23.7	28.6	32.7	37.1	41.7	43.1	46.8	49.9	52.6	57.7
400	PIPE TEMP	378.1	377.5	375.9	371.5	368.1	367.1	360.4	359.2	353.2	344.2	328.7	316.0	302.8	289.7	286.0	276.9	269.6	261.8	248.9
	PAR.W /FT	14.6	14.9	15.3	17.8	19.0	19.2	22.4	23.1	25.8	29.5	34.8	39.7	45.0	50.6	52.2	56.8	60.5	63.7	69.8
	PIN.W /FT	14.0	14.2	14.7	16.9	18.1	18.3	21.2	22.1	24.5	28.3	33.8	38.6	43.7	49.0	50.5	54.9	58.5	61.5	67.5
450	PIPE TEMP	424.2	423.5	421.7	416.6	412.7	411.6	403.8	402.5	395.6	385.3	367.5	353.0	338.0	323.0	318.8	308.4	300.1	291.3	276.7
	PAR.W /FT	17.2	17.5	17.9	20.8	22.2	22.4	26.2	27.0	30.1	34.3	40.3	45.9	52.0	58.4	60.2	65.4	69.6	73.2	80.2
	PIN.W /FT	16.4	16.7	17.2	19.8	21.2	21.4	24.7	25.7	28.5	32.5	39.1	44.6	50.4	56.5	58.2	63.2	67.2	70.7	77.4
500	PIPE TEMP	470.2	469.4	467.4	461.6	457.1	455.9	447.0	445.6	437.8	426.1	405.9	389.6	372.7	355.8	351.2	339.6	330.3	320.6	304.2
	PAR.W /FT	20.0	20.3	20.7	24.0	25.6	25.8	30.1	31.0	34.5	39.3	46.0	52.3	59.1	66.3	68.3	74.1	78.9	82.9	90.7
	PIN.W /FT	19.0	19.3	19.8	22.8	24.4	24.5	28.3	29.4	32.6	37.2	44.8	50.7	57.3	64.1	66.0	71.6	76.1	80.0	87.5
550	PIPE TEMP	515.9	515.2	512.5	506.3	501.3	500.1	490.0	488.4	479.7	468.6	444.1	425.9	407.1	388.3	383.3	370.4	360.2	349.3	331.3
	PAR.W /FT	22.8	23.1	23.6	27.4	29.1	29.3	34.1	35.1	39.0	44.4	51.8	58.9	66.5	74.5	76.6	83.1	88.3	92.8	101.4
	PIN.W /FT	21.7	22.0	22.5	25.9	27.7	27.8	32.1	33.3	36.8	41.9	50.3	57.1	64.3	71.9	74.0	80.2	85.2	89.5	97.6
600	PIPE TEMP	561.6	560.7	558.2	550.9	545.4	544.0	532.8	531.1	521.4	506.8	481.9	461.9	441.2	420.5	415.1	400.9	389.7	377.7	358.1
	PAR.W /FT	25.8	26.1	26.6	30.8	32.8	32.9	38.3	39.3	43.7	49.7	57.8	65.6	74.0	82.8	85.1	92.2	98.0	102.9	112.3
	PIN.W /FT	24.5	24.8	25.3	29.1	31.1	31.2	36.0	37.3	41.2	46.9	56.1	63.5	71.5	79.9	82.1	89.0	94.5	99.1	108.2
650	PIPE TEMP	607.0	606.2	603.5	595.4	589.2	587.8	575.4	573.5	562.9	546.9	519.5	497.6	475.0	452.3	446.5	431.1	418.8	405.9	384.6
	PAR.W /FT	28.9	29.2	29.7	34.4	36.5	36.7	42.6	43.7	48.6	55.1	64.0	72.5	81.6	91.3	93.8	101.6	107.8	113.1	123.3
	PIN.W /FT	27.4	27.7	28.2	32.5	34.6	34.7	40.0	41.4	45.7	51.9	62.0	70.2	78.9	88.0	90.4	97.9	103.9	108.9	118.6
700	PIPE TEMP	652.4	651.5	648.6	639.7	633.0	631.4	617.8	615.8	604.3	586.7	556.8	533.0	508.5	483.9	477.6	461.0	447.8	433.7	410.8
	PAR.W /FT	32.1	32.4	32.9	38.1	40.4	40.5	47.1	48.2	53.5	60.6	70.3	79.5	89.4	99.9	102.6	111.0	117.8	123.5	134.6
	PIN.W /FT	30.3	30.7	31.2	35.9	38.2	38.3	44.1	45.6	50.3	57.1	68.1	76.9	86.3	96.3	98.9	106.9	113.6	118.9	129.5
750	PIPE TEMP	697.7	696.7	693.6	683.8	676.6	674.9	660.1	658.0	645.6	626.4	594.0	568.2	541.8	515.2	508.5	490.6	476.4	461.3	436.8
	PAR.W /FT	35.6	35.7	36.2	41.9	44.3	44.5	51.6	52.9	58.6	66.4	76.7	86.7	97.4	108.7	111.5	120.7	128.0	134.1	145.9
	PIN.W /FT	33.4	33.7	34.3	39.4	41.9	42.0	48.3	49.9	55.0	62.4	74.3	83.8	94.0	104.7	107.5	116.2	123.1	129.0	140.4
800	PIPE TEMP	742.8	741.9	738.5	727.9	720.3	718.2	702.2	700.0	686.5	665.9	630.9	603.2	574.8	546.3	539.2	520.0	504.8	488.7	462.5
	PAR.W /FT	38.8	39.1	39.6	45.8	48.4	48.5	56.3	57.6	63.9	72.2	83.3	94.0	105.5	117.7	120.7	130.5	138.3	144.8	157.5
	PIN.W /FT	36.6	36.9	37.5	43.0	45.7	45.8	52.6	54.4	59.8	67.6	80.6	90.8	101.7	113.3	116.2	125.5	133.0	139.2	151.4
850	PIPE TEMP	787.9	786.9	783.3	771.9	763.9	761.5	744.3	741.9	727.3	705.2	667.6	638.0	607.7	577.2	569.7	549.1	532.9	515.8	487.9
	PAR.W /FT	42.1	42.6	43.1	49.8	52.6	52.7	61.2	62.5	69.3	78.2	90.0	101.5	113.8	126.8	130.0	140.5	148.8	155.7	169.2
	PIN.W /FT	39.9	40.2	40.8	46.6	49.6	49.7	57.0	58.9	64.8	73.3	87.0	98.0	109.6	122.0	125.1	135.0	143.0	149.6	162.9
900	PIPE TEMP	832.9	831.9	828.1	815.8	806.7	804.7	786.2	783.7	768.1	744.9	706.2	672.7	640.3	607.8	599.9	578.1	560.9	542.8	513.2
	PAR.W /FT	45.5	46.3	46.7	54.0	57.0	57.0	66.1	67.5	74.8	84.3	96.9	109.1	122.2	136.1	139.4	150.6	159.4	166.8	181.1
	PIN.W /FT	43.2	43.5	44.2	50.6	53.6	53.7	61.6	63.6	69.8	79.0	93.7	105.3	117.7	130.8	134.1	144.7	153.1	160.2	173.9
950	PIPE TEMP	877.9	876.8	872.7	859.6	849.7	847.6	829.0	825.4	808.6	783.5	740.7	707.1	672.8	638.3	630.0	606.9	588.7	569.6	538.3
	PAR.W /FT	49.7	50.1	50.6	58.3	61.6	61.5	71.3	72.7	80.5	90.7	104.0	117.0	130.8	145.6	149.1	160.9	170.3	178.0	193.1
	PIN.W /FT	46.7	47.0	47.7	54.6	57.8	57.8	66.3	68.4	75.1	84.8	100.4	112.8	125.9	139.9	143.3	154.5	163.5	170.9	185.4

INSULATION THICKNESS REQUIREMENTS

Service Designation T-50

ELECTRIC HEAT TRACING
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT
PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3-1/2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 30.0 F (-1.1 C)

CABLE TEMP DEG F		PIPE SIZE																	
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
60	PIPE TEMP	58.8	58.7	58.6	58.3	58.1	58.0	57.6	57.4	57.0	56.4	55.4	54.5	53.5	52.6	52.3	51.6	51.1	50.5	49.4
	MAX.W /FT	0.8	0.9	0.9	1.0	1.1	1.2	1.3	1.4	1.6	1.8	2.2	2.6	3.0	3.3	3.5	3.8	4.1	4.3	4.8
	MIN.W /FT	0.8	0.8	0.9	1.0	1.1	1.1	1.3	1.4	1.5	1.8	2.2	2.5	2.9	3.2	3.4	3.7	4.0	4.2	4.7
80	PIPE TEMP	77.9	77.8	77.6	77.1	76.8	76.6	75.9	75.7	75.0	74.0	72.2	70.7	69.1	67.6	67.0	66.0	65.0	64.0	62.3
	MAX.W /FT	1.4	1.5	1.5	1.8	1.9	2.0	2.3	2.4	2.7	3.1	3.7	4.3	5.0	5.6	5.9	6.4	6.9	7.3	8.1
	MIN.W /FT	1.4	1.4	1.5	1.7	1.8	1.9	2.2	2.3	2.6	3.0	3.7	4.2	4.9	5.5	5.7	6.2	6.7	7.1	7.9
100	PIPE TEMP	97.0	96.8	96.5	95.9	95.4	95.2	94.2	93.9	92.9	91.5	89.0	86.9	84.7	82.6	81.7	80.2	78.9	77.5	75.1
	MAX.W /FT	2.0	2.1	2.2	2.5	2.7	2.8	3.2	3.4	3.8	4.4	5.3	6.1	7.0	7.9	8.3	9.0	9.7	10.2	11.4
	MIN.W /FT	1.9	2.0	2.1	2.4	2.6	2.7	3.1	3.3	3.7	4.2	5.2	6.0	6.9	7.7	8.1	8.8	9.4	10.0	11.1
120	PIPE TEMP	116.0	115.8	115.4	114.7	114.0	113.7	112.4	112.0	110.8	109.0	105.7	103.0	100.1	97.4	96.4	94.4	92.7	90.9	87.9
	MAX.W /FT	2.6	2.7	2.9	3.3	3.5	3.6	4.2	4.4	5.0	5.7	6.9	8.0	9.1	10.2	10.7	11.7	12.5	13.2	14.7
	MIN.W /FT	2.5	2.6	2.8	3.2	3.4	3.5	4.0	4.3	4.8	5.5	6.7	7.8	8.9	10.0	10.4	11.4	12.2	12.9	14.3
140	PIPE TEMP	135.1	134.8	134.3	133.4	132.5	132.2	130.6	130.1	128.6	126.4	122.4	119.0	115.5	112.2	110.9	108.5	106.4	104.2	100.5
	MAX.W /FT	3.3	3.4	3.5	4.1	4.4	4.5	5.2	5.5	6.2	7.0	8.5	9.8	11.2	12.6	13.2	14.3	15.4	16.3	18.0
	MIN.W /FT	3.2	3.3	3.4	3.9	4.3	4.4	5.0	5.3	5.9	6.8	8.3	9.6	10.9	12.3	12.8	14.0	15.0	15.9	17.6
160	PIPE TEMP	154.0	153.8	153.2	152.0	151.0	150.6	148.7	148.2	146.4	143.7	139.0	135.0	130.9	126.9	125.4	122.5	120.1	117.5	113.1
	MAX.W /FT	3.9	4.1	4.3	4.9	5.3	5.4	6.2	6.6	7.4	8.4	10.1	11.7	13.3	15.0	15.7	17.1	18.3	19.4	21.4
	MIN.W /FT	3.8	4.0	4.1	4.7	5.1	5.2	6.0	6.4	7.1	8.2	9.9	11.4	13.0	14.7	15.3	16.6	17.8	18.9	20.9
180	PIPE TEMP	173.0	172.7	172.0	170.6	169.5	169.0	166.8	166.2	164.1	161.0	155.5	150.9	146.1	141.5	139.8	136.5	133.7	130.6	125.6
	MAX.W /FT	4.6	4.8	5.0	5.7	6.2	6.3	7.3	7.7	8.6	9.8	11.8	13.6	15.5	17.5	18.2	19.8	21.2	22.5	24.9
	MIN.W /FT	4.5	4.6	4.8	5.6	6.0	6.1	7.0	7.5	8.3	9.5	11.6	13.3	15.2	17.0	17.7	19.3	20.7	21.9	24.2
200	PIPE TEMP	191.9	191.5	190.8	189.2	187.9	187.4	184.9	184.1	181.8	178.2	172.0	166.8	161.3	156.0	154.2	150.4	147.2	143.8	138.0
	MAX.W /FT	5.4	5.5	5.7	6.6	7.1	7.2	8.4	8.8	9.9	11.3	13.5	15.6	17.7	20.0	20.7	22.6	24.2	25.6	28.3
	MIN.W /FT	5.2	5.3	5.6	6.4	6.9	7.0	8.1	8.5	9.5	10.9	13.2	15.2	17.3	19.5	20.2	22.0	23.6	24.9	27.5
220	PIPE TEMP	210.8	210.4	209.6	207.8	206.2	205.7	202.9	202.1	199.4	195.4	188.4	182.6	176.5	170.5	168.5	164.2	160.7	156.8	150.4
	MAX.W /FT	6.1	6.3	6.5	7.5	8.1	8.2	9.5	10.0	11.1	12.7	15.2	17.5	20.0	22.5	23.3	25.4	27.2	28.8	31.8
	MIN.W /FT	5.9	6.1	6.3	7.3	7.8	7.9	9.1	9.7	10.7	12.3	14.9	17.1	19.5	21.9	22.7	24.8	26.5	28.0	30.9
240	PIPE TEMP	229.6	229.2	228.3	226.3	224.6	224.0	220.8	219.9	217.0	212.5	204.8	198.3	191.6	184.9	182.7	178.0	174.0	169.8	162.7
	MAX.W /FT	6.9	7.0	7.3	8.4	9.0	9.2	10.6	11.2	12.5	14.2	17.0	19.5	22.2	25.0	26.0	28.3	30.3	32.0	35.3
	MIN.W /FT	6.6	6.8	7.1	8.1	8.7	8.9	10.2	10.8	12.0	13.8	16.6	19.1	21.7	24.4	25.3	27.6	29.5	31.1	34.4
260	PIPE TEMP	248.4	248.0	247.0	244.7	242.9	242.3	238.8	237.8	234.5	229.6	221.1	214.0	206.6	199.3	196.9	191.7	187.4	182.7	175.0
	MAX.W /FT	7.6	7.8	8.1	9.4	10.0	10.2	11.8	12.4	13.8	15.8	18.8	21.6	24.5	27.6	28.6	31.2	33.4	35.3	38.9
	MIN.W /FT	7.4	7.6	7.9	9.0	9.7	9.9	11.3	12.0	13.3	15.2	18.4	21.1	23.9	26.9	27.9	30.4	32.5	34.3	37.8
280	PIPE TEMP	267.2	266.7	265.6	263.2	261.1	260.5	256.6	255.6	252.0	246.6	237.4	229.6	221.5	213.5	211.0	205.3	200.6	195.6	187.1
	MAX.W /FT	8.4	8.7	9.0	10.3	11.1	11.2	13.0	13.6	15.2	17.3	20.6	23.6	26.9	30.2	31.3	34.1	36.5	38.5	42.5
	MIN.W /FT	8.2	8.4	8.7	10.0	10.7	10.8	12.5	13.2	14.6	16.7	20.1	23.1	26.2	29.4	30.5	33.2	35.5	37.5	41.3
300	PIPE TEMP	285.9	285.5	284.3	281.6	279.4	278.7	274.5	273.3	269.5	263.6	253.6	245.1	236.6	227.7	225.0	218.9	213.8	208.3	199.3
	MAX.W /FT	9.3	9.5	9.8	11.3	12.1	12.3	14.2	14.9	16.6	18.9	22.4	25.7	29.3	32.9	34.1	37.1	39.6	41.8	46.1
	MIN.W /FT	9.0	9.2	9.5	10.9	11.7	11.9	13.6	14.4	15.9	18.2	21.9	25.1	28.5	32.0	33.2	36.1	38.5	40.7	44.8
350	PIPE TEMP	332.7	332.1	330.7	327.4	324.7	323.9	318.9	317.5	312.9	305.9	293.8	283.8	273.3	262.9	259.8	252.5	246.5	240.0	229.3
	MAX.W /FT	11.4	11.7	12.1	13.9	14.8	15.0	17.3	18.2	20.2	22.9	27.2	31.1	35.3	39.6	41.0	44.6	47.7	50.3	55.4
	MIN.W /FT	11.0	11.3	11.7	13.4	14.3	14.5	16.6	17.5	19.4	22.1	26.6	30.4	34.4	38.6	39.9	43.4	46.3	48.8	53.8
400	PIPE TEMP	379.2	378.6	377.0	373.0	369.9	369.0	363.0	361.4	356.1	347.8	333.8	322.0	309.9	297.8	294.2	285.7	278.8	271.3	258.9
	MAX.W /FT	13.7	14.0	14.4	16.6	17.7	17.8	20.6	21.6	23.9	27.2	32.1	36.7	41.5	46.6	48.2	52.4	55.9	58.9	64.8
	MIN.W /FT	13.2	13.5	13.9	16.0	17.1	17.2	19.7	20.8	22.9	26.2	31.3	35.6	40.4	45.3	46.8	50.9	54.3	57.2	62.9
450	PIPE TEMP	425.5	424.9	423.6	418.4	414.9	413.9	406.9	405.1	399.0	389.4	373.3	359.9	346.0	332.2	328.2	318.5	310.6	302.2	288.1
	MAX.W /FT	16.2	16.4	16.9	19.5	20.7	20.8	24.0	25.1	27.8	31.0	37.2	42.4	47.9	53.8	55.5	60.3	64.3	67.7	74.4
	MIN.W /FT	15.6	15.8	16.3	18.7	19.9	20.1	23.0	24.2	26.7	30.4	36.3	41.3	46.7	52.3	53.9	58.5	62.4	65.7	72.1
500	PIPE TEMP	471.7	471.0	468.9	463.7	459.6	458.5	450.6	448.6	441.6	430.8	412.6	397.5	381.9	366.3	361.9	351.0	342.2	332.7	317.0
	MAX.W /FT	18.7	19.0	19.5	22.5	23.8	24.0	27.6	28.8	31.9	36.1	42.4	48.3	54.5	61.1	63.0	68.4	72.9	76.7	84.1
	MIN.W /FT	18.0	18.2	18.8	21.5	22.9	23.1	26.4	27.7	30.5	34.7	41.4	47.0	53.1	59.3	61.2	66.4	70.7	74.4	81.6
550	PIPE TEMP	517.7	517.0	514.7	508.7	504.2	503.0	494.0	491.8	484.0	471.9	451.6	434.8	417.4	400.0	395.2	383.1	373.4	362.9	345.6
	MAX.W /FT	21.4	21.7	22.2	25.5	27.0	27.2	31.3	32.7	36.1	40.8	47.8	54.3	61.3	68.6	70.7	76.7	81.6	85.9	94.1
	MIN.W /FT	20.5	20.8	21.4	24.4	26.0	26.1	29.9	31.4	34.5	39.2	46.6	52.9	59.6	66.6	68.6	74.4	79.1	83.2	91.2
600	PIPE TEMP	563.5	562.8	560.2	553.6	548.6	547.3	537.3	534.9	526.2	512.8	490.3	471.7	452.6	433.6	428.2	416.9	406.2	397.7	373.8
	MAX.W /FT	24.2	24.5	25.0	28.8	30.4	30.5	35.1	36.6	40.4	45.7	53.6	60.6	68.2	76.3	78.5	85.1	90.6	95.2	104.2
	MIN.W /FT	23.1	23.4	24.1	27.5	29.2	29.3	33.5	35.2	38.6	43.8	52.0	58.9	66.3	74.0	76.2	82.5	87.8	92.2	100.9
650	PIPE TEMP	609.2	608.5	605.7	598.3	592.8	591.4	580.4	577.8	568.3	553.4	528.8	508.4	487.5	466.5	460.8	446.4	434.7	422.1	401.7
	MAX.W /FT	27.0	27.3	27.9	32.1	33.9	34.0	39.1	40.7	44.9	50.6	59.1	66.9	75.3	84.1	86.5	93.8	99.7	104.7	114.5
	MIN.W /FT	25.9	26.1	26.8	30.6	32.5	32.6	37.2	39.0	42.8	48.5	57.5	65.1	73.1	81.6	83.9	90.8	96.5	101.4	110.9
700	PIPE TEMP	654.9	654.1	651.0	642.9	636.9	635.4	623.3	620.5	610.1	593.9	567.0	544.8	522.1	499.3	493.3	477.6	465.0	451.5	429.3
	MAX.W /FT	30.0	30.3	30.9	35.5	37.4	37.6	43.1	44.9	49.4	55.7	64.9	73.4	82.5	92.1	94.7	102.5	108.9	114.4	125.0
	MIN.W /FT	28.7	28.9	29.7	33.8	35.9	36.0	41.0	43.0	47.1	53.4	63.1	71.4	80.1	89.2	91.8	99.3	105.5	110.7	120.9
750	PIPE TEMP	700.4	699.5	696.3	687.4	680.8	679.3	666.1	663.0	651.8	634.2	605.0	581.0	556.5	531.9	525.4	508.6	495.0	480.5	456.7
	MAX.W /FT	33.1	33.4	34.0	39.0	41.1	41.2	47.3	49.2	54.1	61.0	70.8	80.1	89.9	100.2	103.0	111.5	118.4	124.2	135.6
	MIN.W /FT	31.6	31.8	32.6	37.2	39.4	39.5	44.9	47.1	51.6	58.3	68.9	77.8	87.2	97.1	99.7	107.9	114.5	120.2	131.1
800	PIPE TEMP	745.8	744.9	741.4	731.8	724.7	723.0	708.7	705.5	693.3	674.3	642.8	617.1	590.7	564.3	557.3	539.3	524.8	509.3	483.4
	MAX.W /FT	36.2	36.5	37.2	42.6	44.9	45.0	51.6	53.6	58.9	66.3	76.9	86.8	97.4	108.5	111.4	120.5	127.9	134.2	146.3
	MIN.W /FT	34.5	34.8	35.6	40.6	42.9	43.0	49.0	51.3	56.1	63.4	74.8	84.3	94.4	105.0	107.9	116.6	123.7	129.7	141.3
850	PIPE TEMP	791.1	790.2	786.5	776.1	768.5	766.7	751.3	747.8	734.7	714.2	680.4	652.9	624.6	596.4	589.1	569.8	554.3	537.8	510.7
	MAX.W /FT	39.5	39.8	40.5	46.4	48.7	48.8	55.9	58.1	63.9	71.8	83.1	93.7	105.0	116.9	120.0	129.8	137.6	144.3	157.3
	MIN.W /FT	37.6	37.9	38.7	44.1	46.6	46.7	53.1	55.5	60.7	68.6	80.8	91.0	101.8	113.1	116.1	125.5	133.0	139.5	151.9
900	PIPE TEMP	836.4	835.5	831.5	820.3	812.1	810.2	793.7	790.0	776.0	754.1	717.9	688.5	658.6	628.6	620.6	600.1	583.7	566.1	537.4
	MAX.W /FT	42.7	43.2	43.8	50.2	52.7	52.8	60.5	62.8	68.9	77.4	89.5	100.6	112.8	125.5	128.8	139.1	147.5	154.6	168.3
	MIN.W /FT	40.8	41.0	41.9	47.7	50.3	50.4	57.3	59.9	65.5	73.9	86.9	97.4	109.3	121.4	124.6	134.5	142.5	149.3	162.6
950	PIPE TEMP	881.6	880.7	876.4	864.5	855.7	853.7	836.1	832.1	817.2	793.8	755.3	724.0	692.1	660.1	651.9	630.2	612.8	594.3	563.9
	MAX.W /FT	46.4	46.7	47.3	54.2	56.8	56.9	65.1	67.5	74.2	83.2	96.0	108.0	120.8	134.3	137.7	148.7	157.6	165.1	179.8
	MIN.W /FT	44.0	44.3	45.2	51.4	54.2	54.3	61.6	64.4	70.4	79.4	93.2	104.7	116.9	129.8	133.1	143.6	152.2	159.4	173.1

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-51

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

4" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 30.0 F (-1.1 C)

CABLE TEMP DEG F		PIPE SIZE																		
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
60	PIPE TEMP	58.8	58.7	58.6	58.4	58.1	58.0	57.7	57.6	57.2	56.7	55.7	54.8	53.9	53.1	52.8	52.2	51.6	51.1	50.1
	MAX.W /FT	0.8	0.8	0.9	1.0	1.1	1.2	1.3	1.3	1.5	1.7	2.1	2.4	2.8	3.1	3.3	3.5	3.8	4.0	4.5
	MIN.W /FT	0.8	0.8	0.8	1.0	1.1	1.1	1.2	1.3	1.5	1.7	2.0	2.4	2.7	3.0	3.2	3.5	3.7	4.0	4.4
80	PIPE TEMP	78.0	77.9	77.6	77.3	76.8	76.6	76.1	75.9	75.3	74.4	72.7	71.3	69.8	68.4	67.9	66.9	66.0	65.0	63.4
	MAX.W /FT	1.3	1.4	1.5	1.7	1.9	2.0	2.1	2.3	2.5	2.9	3.5	4.1	4.6	5.2	5.5	6.0	6.4	6.8	7.5
	MIN.W /FT	1.3	1.4	1.4	1.6	1.8	1.9	2.1	2.2	2.5	2.8	3.4	4.0	4.5	5.1	5.3	5.8	6.3	6.6	7.4
100	PIPE TEMP	97.1	96.9	96.6	96.1	95.4	95.2	94.5	94.1	93.3	92.0	89.7	87.7	85.6	83.7	82.9	81.5	80.2	78.9	76.6
	MAX.W /FT	1.9	2.0	2.1	2.4	2.7	2.8	3.0	3.2	3.6	4.0	5.0	5.7	6.5	7.4	7.7	8.4	9.0	9.6	10.6
	MIN.W /FT	1.9	1.9	2.0	2.3	2.6	2.7	3.0	3.2	3.5	4.0	4.9	5.6	6.4	7.2	7.5	8.2	8.8	9.3	10.4
120	PIPE TEMP	116.2	116.0	115.6	114.9	114.0	113.7	112.8	112.4	111.3	109.6	106.6	104.0	101.4	98.9	97.9	96.0	94.6	92.7	89.8
	MAX.W /FT	2.5	2.6	2.7	3.1	3.5	3.6	4.0	4.2	4.7	5.3	6.4	7.4	8.5	9.5	10.0	10.9	11.6	12.4	13.7
	MIN.W /FT	2.4	2.5	2.7	3.0	3.4	3.5	3.8	4.1	4.6	5.2	6.3	7.3	8.3	9.3	9.7	10.6	11.4	12.1	13.4
140	PIPE TEMP	135.2	135.0	134.6	133.7	132.5	132.2	131.0	130.6	129.2	127.2	123.4	120.3	117.1	114.0	112.8	110.5	108.6	106.5	102.9
	MAX.W /FT	3.1	3.2	3.4	3.9	4.4	4.5	4.9	5.2	5.8	6.5	7.9	9.2	10.5	11.7	12.3	13.4	14.3	15.2	16.9
	MIN.W /FT	3.0	3.2	3.3	3.8	4.3	4.4	4.8	5.1	5.6	6.4	7.8	9.0	10.2	11.5	12.0	13.1	14.0	14.8	16.5
160	PIPE TEMP	154.3	154.0	153.5	152.4	151.0	150.6	149.3	148.7	147.1	144.7	140.3	136.6	132.7	129.0	127.6	125.0	122.6	120.1	115.9
	MAX.W /FT	3.8	3.9	4.0	4.6	5.3	5.4	5.9	6.2	6.9	7.8	9.5	10.9	12.4	14.0	14.6	15.9	17.0	18.1	20.0
	MIN.W /FT	3.7	3.8	4.0	4.5	5.1	5.2	5.7	6.1	6.7	7.6	9.3	10.7	12.2	13.7	14.3	15.5	16.7	17.6	19.6
180	PIPE TEMP	173.3	173.0	172.3	171.1	169.5	169.0	167.5	166.8	164.9	162.2	157.0	152.7	148.3	144.0	142.4	139.3	136.7	133.8	128.9
	MAX.W /FT	4.4	4.6	4.7	5.4	6.2	6.3	6.9	7.3	8.1	9.1	11.0	12.7	14.5	16.3	16.9	18.5	19.8	21.0	23.2
	MIN.W /FT	4.3	4.4	4.6	5.3	6.0	6.1	6.7	7.1	7.9	8.9	10.8	12.5	14.2	15.9	16.6	18.0	19.3	20.5	22.7
200	PIPE TEMP	192.2	191.9	191.2	189.7	187.9	187.4	185.6	184.9	182.7	179.6	173.7	168.9	163.8	158.9	157.2	153.6	150.6	147.3	141.8
	MAX.W /FT	5.1	5.3	5.5	6.2	7.1	7.2	7.9	8.3	9.2	10.4	12.6	14.5	16.5	18.6	19.3	21.1	22.6	23.9	26.5
	MIN.W /FT	5.0	5.1	5.3	6.1	6.9	7.0	7.7	8.1	9.0	10.2	12.4	14.2	16.2	18.2	18.9	20.6	22.0	23.3	25.8
220	PIPE TEMP	211.1	210.8	210.0	208.3	206.2	205.7	203.7	202.9	200.5	197.0	190.4	184.9	179.3	173.7	171.8	167.8	164.5	160.8	154.7
	MAX.W /FT	5.8	6.0	6.2	7.1	8.1	8.2	8.9	9.4	10.4	11.7	14.2	16.4	18.6	20.9	21.7	23.7	25.4	26.8	29.7
	MIN.W /FT	5.7	5.8	6.0	6.9	7.8	7.9	8.7	9.2	10.2	11.5	14.0	16.0	18.2	20.5	21.3	23.1	24.8	26.2	29.0
240	PIPE TEMP	230.0	229.6	228.8	226.9	224.6	224.0	221.8	220.9	218.2	214.3	207.0	200.9	194.7	188.5	186.4	182.0	178.3	174.2	167.4
	MAX.W /FT	6.5	6.7	6.9	7.9	9.0	9.2	10.0	10.5	11.7	13.1	15.9	18.2	20.7	23.3	24.2	26.3	28.2	29.8	33.0
	MIN.W /FT	6.4	6.5	6.8	7.7	8.7	8.9	9.7	10.3	11.4	12.9	15.6	17.9	20.3	22.8	23.6	25.7	27.5	29.1	32.2
260	PIPE TEMP	248.9	248.5	247.5	245.5	242.9	242.3	239.8	238.8	235.9	231.5	223.5	216.9	210.0	203.2	201.0	196.1	192.0	187.6	180.2
	MAX.W /FT	7.3	7.5	7.7	8.8	10.0	10.2	11.1	11.7	12.9	14.5	17.5	20.1	22.9	25.7	26.7	29.0	31.1	32.9	36.4
	MIN.W /FT	7.1	7.3	7.5	8.6	9.7	9.9	10.8	11.4	12.6	14.2	17.2	19.7	22.4	25.1	26.1	28.4	30.3	32.1	35.5
280	PIPE TEMP	267.7	267.3	266.3	264.0	261.1	260.5	257.8	256.7	253.5	248.8	240.0	232.8	225.3	217.9	215.4	210.1	205.7	200.9	192.8
	MAX.W /FT	8.0	8.2	8.5	9.7	11.1	11.2	12.2	12.8	14.2	15.9	19.2	22.1	25.0	28.1	29.2	31.8	34.0	35.9	39.7
	MIN.W /FT	7.8	8.0	8.3	9.5	10.7	10.8	11.8	12.5	13.8	15.6	18.9	21.6	24.5	27.5	28.5	31.0	33.2	35.1	38.7
300	PIPE TEMP	286.5	286.1	285.0	282.5	279.4	278.7	275.7	274.6	271.1	265.9	256.5	248.6	240.5	232.4	229.8	224.1	219.3	214.1	205.4
	MAX.W /FT	8.8	9.0	9.3	10.7	12.1	12.3	13.3	14.0	15.5	17.3	21.0	24.0	27.2	30.4	31.7	34.5	36.9	39.0	43.1
	MIN.W /FT	8.6	8.8	9.1	10.4	11.7	11.9	12.9	13.7	15.1	17.0	20.6	23.5	26.7	29.9	31.0	33.7	36.0	38.1	42.0
350	PIPE TEMP	333.4	332.9	331.6	328.5	324.7	323.9	320.4	319.1	314.9	308.7	297.4	288.0	278.2	268.6	265.6	258.8	253.1	246.9	236.6
	MAX.W /FT	10.9	11.1	11.4	13.1	14.8	15.0	16.3	17.1	18.9	21.1	25.4	29.0	32.9	36.9	38.2	41.5	44.4	46.9	51.7
	MIN.W /FT	10.6	10.8	11.1	12.7	14.3	14.5	15.8	16.7	18.3	20.7	24.9	28.4	32.1	36.0	37.3	40.5	43.3	45.7	50.4
400	PIPE TEMP	360.0	379.5	378.0	374.4	369.9	369.0	364.8	363.3	358.4	351.1	337.9	327.0	315.7	304.4	301.0	293.1	286.5	279.3	267.4
	MAX.W /FT	13.0	13.3	13.7	15.6	17.7	17.8	19.3	20.3	22.4	24.9	30.0	34.2	38.7	43.4	44.8	48.7	52.0	54.9	60.5
	MIN.W /FT	12.6	12.9	13.3	15.1	17.1	17.2	18.7	19.8	21.7	24.5	29.3	33.5	37.8	42.3	43.7	47.5	50.7	53.5	59.0
450	PIPE TEMP	426.5	425.9	424.2	420.0	414.9	413.9	409.0	407.3	401.7	393.3	378.2	365.6	352.7	339.9	336.0	327.0	319.5	311.4	297.9
	MAX.W /FT	15.3	15.6	16.0	18.3	20.7	20.8	22.6	23.6	26.0	29.0	34.7	39.5	44.7	50.0	51.6	56.1	59.9	63.1	69.5
	MIN.W /FT	14.9	15.1	15.4	17.7	19.9	20.1	21.8	23.0	25.2	28.4	34.0	38.7	43.6	48.8	50.4	54.7	58.3	61.5	67.7
500	PIPE TEMP	472.9	472.2	470.3	465.5	459.6	458.5	453.0	451.1	444.7	435.2	418.1	404.0	389.4	375.0	370.7	360.5	352.1	343.1	328.0
	MAX.W /FT	17.7	18.0	18.4	21.0	23.8	24.0	25.9	27.1	29.8	33.1	39.6	45.0	50.8	56.8	58.6	63.7	67.9	71.6	78.7
	MIN.W /FT	17.2	17.4	17.9	20.4	22.9	23.1	25.0	26.4	28.9	32.5	38.7	44.0	49.6	55.4	57.2	62.0	66.1	69.7	76.6
550	PIPE TEMP	519.0	518.4	516.2	510.8	504.2	503.0	496.8	494.7	487.5	476.9	457.8	442.0	425.9	409.7	405.1	393.8	384.5	374.4	357.7
	MAX.W /FT	20.3	20.5	21.0	23.9	27.0	27.2	29.4	30.7	33.7	37.4	44.6	50.7	57.1	63.8	65.8	71.4	76.1	80.1	88.0
	MIN.W /FT	19.6	19.8	20.4	23.1	26.0	26.1	28.3	29.8	32.6	36.7	43.7	49.5	55.7	62.2	64.1	69.5	74.1	78.0	85.6
600	PIPE TEMP	565.1	564.4	562.0	556.0	548.6	547.3	540.4	538.0	530.2	518.3	497.2	479.8	461.9	444.1	439.1	426.6	416.4	405.4	387.1
	MAX.W /FT	22.9	23.1	23.6	26.9	30.4	30.5	32.9	34.4	37.7	41.8	49.8	56.5	63.5	71.0	73.1	79.3	84.4	88.9	97.5
	MIN.W /FT	22.1	22.3	22.9	26.0	29.2	29.3	31.8	33.4	36.5	41.0	48.7	55.2	62.0	69.1	71.2	77.2	82.2	86.5	94.8
650	PIPE TEMP	611.0	610.3	607.7	601.0	592.8	591.4	583.9	581.3	572.6	559.5	536.3	517.3	497.8	478.3	472.8	459.2	448.1	436.1	416.3
	MAX.W /FT	25.6	25.9	26.4	30.0	33.9	34.0	36.6	38.2	41.9	46.4	55.1	62.4	70.1	78.3	80.6	87.3	92.9	97.8	107.2
	MIN.W /FT	24.7	24.9	25.5	29.0	32.5	32.6	35.3	37.1	40.5	45.4	53.9	60.9	68.4	76.2	78.5	85.0	90.4	95.1	104.2
700	PIPE TEMP	656.8	656.1	653.3	645.9	636.9	635.4	627.1	624.3	614.3	600.5	575.3	554.5	533.3	512.2	506.3	491.6	479.5	466.6	445.1
	MAX.W /FT	28.4	28.7	29.2	33.2	37.4	37.6	40.4	42.2	46.1	51.1	60.5	68.5	76.9	85.7	88.2	95.5	101.6	106.8	117.0
	MIN.W /FT	27.3	27.6	28.3	32.0	35.9	36.0	38.9	40.9	44.6	50.0	59.1	66.8	74.9	83.4	85.8	92.9	98.8	103.8	113.7
750	PIPE TEMP	702.5	701.8	698.7	690.7	680.8	679.3	670.3	667.2	656.9	641.4	614.0	591.6	568.7	545.8	539.5	523.6	510.7	498.7	473.7
	MAX.W /FT	31.3	31.5	32.1	36.5	41.1	41.2	44.3	46.2	50.5	55.8	66.1	74.7	83.7	93.3	96.0	103.9	110.4	116.0	126.9
	MIN.W /FT	30.1	30.3	31.0	35.1	39.4	39.5	42.6	44.8	48.8	54.6	64.5	72.8	81.6	90.8	93.3	101.0	107.3	112.7	123.3
800	PIPE TEMP	748.2	747.4	744.1	735.4	724.7	723.0	713.3	710.0	698.9	682.1	652.5	628.4	603.8	579.2	572.5	555.5	541.6	526.7	502.0
	MAX.W /FT	34.2	34.5	35.1	39.9	44.9	45.0	48.3	50.3	55.0	60.7	71.8	81.0	90.7	101.0	103.9	112.4	119.4	125.6	137.1
	MIN.W /FT	32.9	33.2	33.9	38.4	42.9	43.0	46.4	48.7	53.1	59.4	70.0	79.0	88.4	98.2	101.0	109.2	115.9	121.7	133.0
850	PIPE TEMP	793.7	792.9	789.4	779.9	768.5	766.7	756.2	752.7	740.7	722.6	690.9	665.1	638.7	612.4	605.3	587.1	572.3	556.6	530.2
	MAX.W /FT	37.3	37.6	38.1	43.3	48.7	48.8	52.4	54.6	59.6	65.7	77.6	87.4	97.9	108.9	111.9	121.0	128.5	134.9	147.3
	MIN.W /FT	35.8	36.1	36.8	41.6	46.6	46.7	50.3	52.8	57.5	64.2	75.7	85.2	95.3	105.8	108.7	117.5	124.7	130.9	142.9
900	PIPE TEMP	839.2	838.3	834.6	824.5	812.1	810.2	799.0	795.2	782.4	763.0	729.2	701.6	673.5	645.4	637.9	618.5	602.8	585.9	558.1
	MAX.W /FT	40.4	40.7	41.3	46.9	52.7	52.8	56.6	58.9	64.3	70.8	83.5	94.0	105.2	116.9	120.1	129.8	137.7	144.5	157.7
	MIN.W /FT	38.8	39.1	39.9	45.0	50.3	50.4	54.3	57.0	61.9	69.2	81.4	91.6	102.3	113.5	116.6	126.0	133.6	140.2	153.0
950	PIPE TEMP	884.6	883.7	879.7	868.9	855.7	853.7	841.7	837.7	824.1	803.3	767.3	737.9	708.0	678.2	670.3	649.8	633.1	615.3	585.8
	MAX.W /FT	43.7	44.0	44.8	50.6	56.8	56.9	60.9	63.4	69.1	76.1	89.6	100.8	112.6	125.1	128.4	138.7	147.1	154.3	168.3
	MIN.W /FT	41.9	42.2	43.0	48.5	54.2	54.3	58.4	61.2	66.6	74.3	87.3	98.1	109.5	121.4	124.7	134.8	142.7	149.6	163.2

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-52

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

1" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 60.0 F (15.6 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
80	PIPE TEMP	78.8	78.7	78.5	78.3	78.0	77.8	77.4	77.4	76.8	76.1									
	MAX.W /FT	0.9	1.0	1.0	1.2	1.3	1.4	1.6	1.6	1.9	2.3									
	MIN.W /FT	0.8	0.9	0.9	1.1	1.2	1.2	1.4	1.4	1.7	2.0									
100	PIPE TEMP	97.5	97.3	97.0	96.5	95.8	95.6	94.7	94.7	93.5	92.1									
	MAX.W /FT	1.9	2.0	2.1	2.4	2.7	2.8	3.3	3.2	4.0	4.7									
	MIN.W /FT	1.7	1.8	1.9	2.2	2.4	2.5	2.9	2.9	3.5	4.0									
120	PIPE TEMP	116.1	115.8	115.4	114.8	113.8	113.2	111.9	111.9	110.1	107.9									
	MAX.W /FT	2.9	3.1	3.2	3.7	4.1	4.3	5.0	5.0	6.1	7.2									
	MIN.W /FT	2.7	2.8	2.9	3.3	3.7	3.9	4.4	4.4	5.3	6.2									
140	PIPE TEMP	134.6	134.3	133.7	132.8	131.3	130.8	129.0	129.0	126.5	123.6									
	MAX.W /FT	3.9	4.2	4.4	5.0	5.7	5.9	6.8	6.8	8.2	9.7									
	MIN.W /FT	3.6	3.8	4.0	4.5	5.1	5.3	6.0	6.0	7.2	8.3									
160	PIPE TEMP	153.1	152.7	151.9	150.6	148.9	148.3	146.0	146.0	142.9	139.3									
	MAX.W /FT	5.1	5.3	5.6	6.4	7.2	7.5	8.7	8.6	10.5	12.4									
	MIN.W /FT	4.7	4.9	5.1	5.8	6.5	6.7	7.6	7.7	9.1	10.6									
180	PIPE TEMP	171.5	171.0	170.1	168.4	166.4	165.7	162.9	162.9	159.2	154.8									
	MAX.W /FT	6.2	6.6	6.9	7.9	8.9	9.2	10.6	10.5	12.8	15.1									
	MIN.W /FT	5.7	6.0	6.3	7.1	7.9	8.2	9.3	9.3	11.1	12.9									
200	PIPE TEMP	189.9	189.3	188.2	186.2	183.8	183.0	179.7	179.8	175.3	170.1									
	MAX.W /FT	7.5	7.8	8.2	9.4	10.6	11.0	12.7	12.5	15.2	17.9									
	MIN.W /FT	6.8	7.1	7.5	8.4	9.5	9.7	11.1	11.1	13.1	15.2									
220	PIPE TEMP	208.2	207.4	206.2	203.9	201.2	200.2	196.4	196.5	191.4	185.4									
	MAX.W /FT	8.7	9.2	9.6	11.0	12.4	12.8	14.8	14.5	17.7	20.8									
	MIN.W /FT	8.0	8.3	8.7	9.8	11.0	11.3	12.9	12.9	15.2	17.6									
240	PIPE TEMP	226.4	225.6	224.2	221.5	218.4	217.3	213.0	213.2	207.4	200.6									
	MAX.W /FT	10.1	10.5	11.0	12.6	14.2	14.7	16.9	16.6	20.2	23.8									
	MIN.W /FT	9.2	9.5	10.0	11.3	12.6	12.9	14.7	14.7	17.3	20.1									
260	PIPE TEMP	244.5	243.6	242.1	239.1	235.6	234.4	229.6	229.8	223.3	215.7									
	MAX.W /FT	11.5	12.0	12.5	14.3	16.1	16.6	19.2	18.6	22.9	26.9									
	MIN.W /FT	10.4	10.8	11.3	12.8	14.3	14.6	16.6	16.5	19.5	22.6									
280	PIPE TEMP	262.6	261.6	259.9	256.6	252.6	251.4	246.0	246.3	239.1	230.7									
	MAX.W /FT	12.9	13.4	14.0	16.1	18.1	18.6	21.5	21.0	25.5	30.0									
	MIN.W /FT	11.7	12.1	12.6	14.3	16.0	16.3	18.5	18.4	21.7	25.2									
300	PIPE TEMP	280.6	279.6	277.7	274.0	269.6	268.3	262.4	262.8	254.8	245.6									
	MAX.W /FT	14.4	15.0	15.6	17.9	20.1	20.6	23.8	23.3	28.3	33.2									
	MIN.W /FT	13.0	13.5	14.0	15.9	17.7	18.1	20.5	20.4	24.0	27.8									
350	PIPE TEMP	325.3	324.1	321.9	317.2	311.8	310.3	302.9	303.6	293.8	282.4									
	MAX.W /FT	18.3	19.0	19.7	22.6	25.5	26.0	30.0	29.2	35.5	41.6									
	MIN.W /FT	16.5	17.0	17.6	20.0	22.2	22.6	25.7	25.6	29.9	34.5									
400	PIPE TEMP	369.6	368.3	365.7	360.0	353.5	351.8	343.0	344.0	332.3	318.8									
	MAX.W /FT	22.6	23.4	24.1	27.7	31.1	31.7	36.6	35.4	43.0	50.3									
	MIN.W /FT	20.2	20.8	21.5	24.3	27.0	27.4	31.1	30.7	36.0	41.5									
450	PIPE TEMP	413.5	412.2	409.2	402.5	394.9	393.0	382.6	384.0	370.6	354.7									
	MAX.W /FT	27.2	28.0	28.9	33.1	37.2	37.8	43.5	41.9	50.9	59.5									
	MIN.W /FT	24.2	24.8	25.6	28.9	32.1	32.5	36.7	36.2	42.4	48.7									
500	PIPE TEMP	457.2	455.7	452.2	444.6	435.9	433.8	421.9	423.7	408.0	390.2									
	MAX.W /FT	32.1	32.9	33.8	38.8	43.5	44.1	50.7	48.7	59.1	69.0									
	MIN.W /FT	28.4	29.0	29.8	33.7	37.3	37.7	42.6	41.8	48.9	56.1									
550	PIPE TEMP	500.5	498.9	495.2	486.4	476.5	474.3	460.8	463.0	445.6	425.3									
	MAX.W /FT	37.2	38.1	39.1	44.8	50.1	50.7	58.3	55.8	67.7	78.9									
	MIN.W /FT	32.7	33.4	34.3	38.7	42.7	43.1	48.6	47.7	55.7	63.7									
600	PIPE TEMP	543.5	541.9	537.8	527.9	516.9	514.5	499.5	502.1	482.5	460.1									
	MAX.W /FT	42.7	43.6	44.5	51.0	57.0	57.6	66.1	63.1	76.6	89.1									
	MIN.W /FT	37.3	38.0	38.9	43.8	48.3	48.7	54.9	53.7	62.6	71.6									
650	PIPE TEMP	586.4	584.7	580.3	569.3	557.0	554.5	537.9	541.0	519.3	496.6									
	MAX.W /FT	48.4	49.3	50.3	57.5	64.2	64.7	74.3	70.7	85.7	99.6									
	MIN.W /FT	42.1	42.8	43.7	49.2	54.1	54.5	61.3	59.9	69.8	79.6									
700	PIPE TEMP	629.0	627.2	622.5	610.4	597.0	594.3	576.0	579.7	555.9	529.0									
	MAX.W /FT	54.3	55.3	56.2	64.3	71.6	72.2	82.7	78.9	95.2	110.5									
	MIN.W /FT	47.0	47.7	48.6	54.7	60.1	60.5	67.9	66.2	77.1	87.8									
750	PIPE TEMP	671.5	669.7	664.6	651.4	636.8	633.9	614.0	618.1	592.3	563.1									
	MAX.W /FT	60.6	61.6	62.5	71.3	79.4	79.9	91.5	86.6	105.0	121.7									
	MIN.W /FT	52.2	52.9	53.8	60.4	66.3	66.6	74.7	72.7	84.6	96.2									
800	PIPE TEMP	713.8	712.0	706.6	692.2	676.4	673.4	651.9	656.5	628.6	597.0									
	MAX.W /FT	67.3	68.3	69.1	78.8	87.5	88.0	100.7	95.0	115.2	133.4									
	MIN.W /FT	57.7	58.4	59.2	66.4	72.7	73.0	81.7	79.5	92.3	104.8									
850	PIPE TEMP	756.1	754.2	748.5	733.0	716.0	712.8	689.7	694.7	664.7	630.9									
	MAX.W /FT	74.4	75.4	76.0	86.6	96.1	96.5	110.4	103.8	125.9	145.6									
	MIN.W /FT	63.4	64.1	64.8	72.6	79.4	79.6	89.1	86.4	100.3	113.7									
900	PIPE TEMP	798.3	796.4	790.3	773.6	755.4	752.1	727.3	732.8	700.8	664.7									
	MAX.W /FT	82.1	83.1	83.5	95.0	105.2	105.6	120.6	113.0	137.2	158.4									
	MIN.W /FT	69.5	70.2	70.8	79.2	86.5	86.6	96.8	93.7	108.7	121.0									
950	PIPE TEMP	840.5	838.5	832.1	814.2	794.8	791.3	764.9	770.8	736.7	698.3									
	MAX.W /FT	90.6	91.6	91.7	104.1	115.1	115.4	131.7	122.8	149.3	172.1									
	MIN.W /FT	76.2	76.9	77.3	86.2	94.0	94.1	104.9	101.3	117.5	132.8									

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-53

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

1-1/2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 60.0 F (15.6 C)

CABLE TEMP DEG F		PIPE SIZE																	
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
80	PIPE TEMP	79.0	78.9	78.7	78.5	78.3	78.2	77.8	77.7	77.2	76.6	75.5	74.6	73.7	72.8	72.4	71.8	71.4	70.9	70.0
	MAX.W /FT	0.7	0.8	0.9	1.0	1.0	1.1	1.3	1.4	1.6	1.9	2.4	2.7	3.0	3.4	3.6	3.9	4.1	4.3	4.7
	MIN.W /FT	0.7	0.7	0.8	0.9	1.0	1.0	1.2	1.3	1.5	1.7	2.1	2.5	2.9	3.2	3.4	3.7	3.9	4.1	4.5
100	PIPE TEMP	97.9	97.7	97.3	96.9	96.6	96.4	95.4	95.3	94.3	93.1	90.9	89.0	87.2	85.4	84.8	83.6	82.6	81.6	80.0
	MAX.W /FT	1.5	1.6	1.8	2.0	2.1	2.2	2.7	2.8	3.3	3.9	4.8	5.5	6.1	6.9	7.2	7.8	8.3	8.7	9.5
	MIN.W /FT	1.4	1.5	1.7	1.9	2.0	2.0	2.5	2.6	3.0	3.5	4.3	5.1	5.8	6.5	6.8	7.4	7.9	8.3	9.0
120	PIPE TEMP	116.7	116.5	115.9	115.3	114.7	114.5	113.0	112.8	111.4	109.5	106.3	103.3	100.6	97.9	97.0	95.2	93.7	92.2	89.8
	MAX.W /FT	2.3	2.4	2.7	3.1	3.3	3.4	4.1	4.3	5.1	5.9	7.3	8.4	9.2	10.4	10.8	11.8	12.5	13.2	14.4
	MIN.W /FT	2.2	2.3	2.6	2.9	3.0	3.1	3.8	3.9	4.6	5.3	6.6	7.7	8.7	9.9	10.3	11.2	11.9	12.5	13.6
140	PIPE TEMP	135.5	135.2	134.4	133.6	132.9	132.5	130.5	130.2	128.3	125.8	121.5	117.5	114.0	110.3	109.1	106.7	104.8	102.8	99.6
	MAX.W /FT	3.1	3.3	3.7	4.2	4.4	4.6	5.6	5.8	6.8	8.0	9.8	11.3	12.4	14.0	14.6	15.8	16.8	17.7	19.3
	MIN.W /FT	3.0	3.1	3.5	3.9	4.1	4.2	5.1	5.3	6.2	7.2	8.8	10.4	11.8	13.3	13.8	15.0	15.9	16.7	18.2
160	PIPE TEMP	154.2	153.9	152.9	151.8	150.9	150.4	148.0	147.6	145.2	142.0	136.6	131.7	127.2	122.6	121.1	118.1	115.7	113.2	109.2
	MAX.W /FT	4.0	4.2	4.8	5.4	5.6	5.8	7.1	7.4	8.7	10.2	12.6	14.2	15.6	17.7	18.3	20.0	21.2	22.2	24.2
	MIN.W /FT	3.8	4.0	4.4	5.0	5.2	5.4	6.5	6.7	7.8	9.1	11.2	13.1	14.8	16.7	17.4	18.8	20.0	21.0	22.9
180	PIPE TEMP	172.9	172.5	171.3	169.9	168.9	168.3	165.3	164.9	162.0	158.1	151.6	145.7	140.3	134.8	133.0	129.4	126.5	123.6	118.8
	MAX.W /FT	4.9	5.1	5.8	6.6	6.9	7.1	8.7	9.0	10.6	12.4	15.1	17.3	18.9	21.4	22.2	24.1	25.6	26.9	29.2
	MIN.W /FT	4.6	4.8	5.4	6.1	6.4	6.6	7.9	8.2	9.5	11.1	13.6	15.9	18.0	20.2	21.0	22.8	24.2	25.3	27.6
200	PIPE TEMP	191.6	191.1	189.7	188.0	186.8	186.2	182.6	182.1	178.7	174.2	166.5	159.6	153.3	146.8	144.8	140.6	137.2	133.8	128.1
	MAX.W /FT	5.9	6.1	6.9	7.8	8.2	8.4	10.4	10.7	12.6	14.7	17.9	20.4	22.3	25.2	26.1	28.3	30.1	31.5	34.1
	MIN.W /FT	5.5	5.7	6.4	7.2	7.6	7.8	9.4	9.7	11.3	13.1	16.0	18.7	21.1	23.8	24.6	26.7	28.4	29.7	32.3
220	PIPE TEMP	210.2	209.7	208.0	206.1	204.6	204.0	199.8	199.3	195.3	190.1	181.3	173.4	166.2	158.8	156.6	151.7	147.9	144.0	137.7
	MAX.W /FT	6.9	7.1	8.1	9.1	9.5	9.8	12.1	12.4	14.6	17.0	20.7	23.5	25.7	29.0	30.0	32.6	34.6	36.3	39.4
	MIN.W /FT	6.4	6.7	7.5	8.4	8.8	9.0	10.9	11.3	13.0	15.1	18.5	21.6	24.3	27.4	28.3	30.7	32.6	34.2	37.1
240	PIPE TEMP	228.7	228.2	226.2	224.0	222.4	221.7	216.9	216.4	211.8	206.0	196.0	187.1	179.0	170.6	168.2	162.7	158.4	154.1	147.1
	MAX.W /FT	7.9	8.2	9.3	10.5	10.9	11.2	13.8	14.1	16.6	19.4	23.5	26.7	29.1	32.9	34.0	36.9	39.2	41.0	44.5
	MIN.W /FT	7.4	7.6	8.6	9.6	10.1	10.3	12.5	12.9	14.9	17.2	21.0	24.5	27.6	31.1	32.1	34.8	36.9	38.6	41.9
260	PIPE TEMP	247.2	246.6	244.4	242.0	240.2	239.4	234.0	233.4	228.3	221.8	210.7	200.7	191.8	182.6	179.7	173.6	168.9	164.1	156.3
	MAX.W /FT	9.0	9.3	10.5	11.9	12.4	12.6	15.6	15.9	18.8	21.9	26.4	30.0	32.6	36.9	38.1	41.3	43.8	45.8	49.7
	MIN.W /FT	8.4	8.6	9.7	10.9	11.4	11.6	14.0	14.5	16.7	19.4	23.5	27.4	30.9	34.8	35.9	38.9	41.2	43.1	46.8
280	PIPE TEMP	265.6	265.0	262.5	259.8	257.9	257.0	251.0	250.4	244.7	237.5	225.3	214.3	204.4	194.0	191.2	184.4	179.3	174.0	165.5
	MAX.W /FT	10.0	10.4	11.7	13.3	13.8	14.1	17.4	17.8	20.9	24.4	29.4	33.3	36.2	40.9	42.2	45.8	48.5	50.7	55.0
	MIN.W /FT	9.4	9.7	10.8	12.2	12.7	13.0	15.7	16.1	18.6	21.5	26.1	30.4	34.2	38.5	39.7	43.0	45.6	47.7	51.7
300	PIPE TEMP	284.0	283.4	280.6	277.6	275.5	274.5	267.9	267.3	261.1	253.1	239.7	227.7	216.9	205.6	202.6	195.2	189.6	183.8	174.6
	MAX.W /FT	11.2	11.5	13.0	14.7	15.3	15.6	19.3	19.7	23.1	27.0	32.4	36.7	39.8	45.0	46.3	50.2	53.2	55.6	60.3
	MIN.W /FT	10.4	10.7	12.0	13.5	14.1	14.3	17.3	17.8	20.5	23.7	28.8	33.5	37.6	42.3	43.6	47.2	50.0	52.3	56.6
350	PIPE TEMP	329.8	329.0	325.7	321.9	319.3	318.2	310.0	309.3	301.7	291.9	275.6	261.0	247.9	234.1	230.6	221.7	215.0	208.1	197.0
	MAX.W /FT	14.1	14.5	16.4	18.6	19.2	19.5	24.2	24.6	28.9	33.6	40.2	45.3	49.0	55.3	56.8	61.6	65.2	68.1	73.7
	MIN.W /FT	13.2	13.5	15.1	16.9	17.6	17.9	21.6	22.2	25.5	29.5	35.5	41.2	46.3	52.0	53.5	57.9	61.2	63.9	69.1
400	PIPE TEMP	375.3	374.6	370.6	365.8	362.8	361.6	351.7	350.9	341.8	330.2	311.0	293.8	278.4	262.2	258.2	247.7	239.9	231.9	219.0
	MAX.W /FT	17.3	17.7	20.0	22.6	23.4	23.7	29.3	29.8	34.9	40.5	48.3	54.3	58.5	66.0	67.7	73.3	77.5	80.9	87.4
	MIN.W /FT	16.1	16.4	18.3	20.6	21.4	21.6	26.1	26.7	30.7	35.4	42.5	49.2	55.2	61.9	63.5	68.7	72.6	75.8	81.9
450	PIPE TEMP	420.5	419.8	414.9	409.5	406.0	404.6	393.0	392.2	381.7	368.1	346.0	326.1	308.5	289.7	285.3	273.3	264.5	255.3	240.7
	MAX.W /FT	20.7	21.1	23.8	26.9	27.7	28.1	34.7	35.1	41.2	47.8	56.6	63.5	68.3	76.9	78.8	85.2	90.0	93.8	101.2
	MIN.W /FT	19.1	19.5	21.7	24.4	25.3	25.5	30.8	31.5	36.1	41.5	49.7	57.4	64.2	72.1	73.9	79.8	84.3	87.8	94.9
500	PIPE TEMP	465.5	464.6	459.1	452.9	449.0	447.4	434.0	433.2	421.2	405.7	380.6	358.1	338.1	316.8	312.1	298.5	288.6	278.6	262.0
	MAX.W /FT	24.2	24.7	27.8	31.4	32.3	32.6	40.4	40.8	47.7	55.2	65.3	73.0	78.3	88.1	90.1	97.4	102.8	107.1	115.4
	MIN.W /FT	22.3	22.7	25.3	28.4	29.3	29.6	35.7	36.4	41.7	47.8	57.1	65.8	73.5	82.4	84.3	91.1	96.1	100.1	107.8
550	PIPE TEMP	510.3	509.3	503.C	496.0	491.6	490.0	474.8	474.0	460.4	443.0	414.9	389.7	367.4	343.5	338.5	323.4	312.3	301.0	283.0
	MAX.W /FT	28.0	28.5	32.C	36.2	37.1	37.3	46.2	46.6	54.5	63.0	74.1	82.7	88.5	99.5	101.6	109.8	115.8	120.5	129.7
	MIN.W /FT	25.7	26.1	29.C	32.5	33.5	33.8	40.7	41.4	47.5	54.3	64.7	74.4	83.0	93.0	95.0	102.5	108.1	112.5	121.1
600	PIPE TEMP	554.9	553.8	546.8	538.9	534.1	532.4	515.2	514.5	499.3	480.0	448.8	420.9	396.2	369.9	364.5	347.8	335.7	323.4	303.6
	MAX.W /FT	31.9	32.4	36.4	41.1	42.0	42.3	52.3	52.6	61.5	71.0	83.3	92.7	98.9	111.2	113.4	122.5	129.0	134.2	144.2
	MIN.W /FT	29.2	29.6	32.9	36.8	37.9	38.1	45.9	46.7	53.3	61.0	72.4	83.2	92.7	103.7	105.9	114.1	120.3	125.1	136.5
650	PIPE TEMP	599.3	598.2	590.4	581.7	576.4	574.5	555.5	554.8	538.1	516.7	482.5	451.8	424.8	395.9	390.2	372.0	358.8	345.4	324.0
	MAX.W /FT	36.0	36.5	41.C	46.2	47.1	47.4	58.6	59.8	68.7	79.2	92.6	102.9	109.6	123.1	125.3	135.3	142.5	148.1	159.0
	MIN.W /FT	32.8	33.3	36.9	41.2	42.4	42.5	51.2	52.0	59.3	67.8	80.3	92.2	102.6	114.6	116.9	126.0	132.6	137.9	148.1
700	PIPE TEMP	643.6	642.4	633.8	624.2	618.5	616.5	595.6	594.9	576.6	553.2	515.9	482.4	453.0	421.6	415.5	395.8	381.7	367.2	344.0
	MAX.W /FT	40.2	40.8	45.7	51.4	52.4	52.6	65.1	65.2	76.1	87.6	102.3	113.3	120.5	135.2	137.5	148.4	156.1	162.1	173.9
	MIN.W /FT	36.6	37.C	41.C	45.8	47.0	47.1	58.6	59.5	65.5	74.7	88.4	101.3	112.6	125.7	128.1	137.9	145.1	150.8	161.6
750	PIPE TEMP	687.7	686.5	677.1	666.6	660.5	658.3	635.5	634.8	614.9	589.5	549.1	512.8	480.9	447.0	440.6	419.6	404.2	388.7	363.9
	MAX.W /FT	44.7	45.2	50.7	56.9	57.8	58.0	71.8	71.8	83.8	96.3	112.1	124.0	131.6	147.5	150.0	161.6	170.0	176.4	189.1
	MIN.W /FT	40.5	40.9	45.3	50.5	51.7	51.9	62.3	63.1	71.9	81.9	96.6	110.6	122.8	137.0	139.5	150.1	157.8	163.9	175.7
800	PIPE TEMP	731.7	730.5	720.3	708.9	702.3	700.0	675.3	674.6	653.1	625.7	582.1	543.0	508.6	472.2	465.5	442.7	426.5	409.9	383.5
	MAX.W /FT	49.3	49.8	55.8	62.6	63.5	63.7	78.7	78.6	91.7	105.3	122.2	135.0	142.9	160.1	162.6	175.2	184.1	191.0	204.5
	MIN.W /FT	44.6	45.C	49.8	55.3	56.6	56.8	68.1	69.0	78.4	89.2	105.0	120.1	133.2	148.5	151.1	162.5	170.8	177.2	189.6
850	PIPE TEMP	775.7	774.4	763.4	751.1	744.0	741.6	714.9	714.2	691.1	661.7	615.0	573.0	536.1	497.1	490.1	465.8	448.5	430.9	402.4
	MAX.W /FT	54.1	54.6	61.2	68.6	69.4	69.5	86.0	85.7	99.9	114.6	132.7	146.2	154.5	172.9	175.5	189.0	199.5	205.8	220.1
	MIN.W /FT	48.8	49.2	54.4	60.4	61.7	61.8	74.1	74.9	85.1	96.7	113.7	129.8	143.8	160.1	162.9	175.0	183.9	190.7	204.1
900	PIPE TEMP	819.6	818.2	806.4	793.2	785.6	783.1	754.5	753.8	729.1	697.6	647.7	602.8	563.4	521.9	514.6	488.7	470.4	451.8	422.1
	MAX.W /FT	59.2	59.7	66.9	74.9	75.5	75.7	93.6	93.1	108.5	124.3	143.4	157.7	166.3	186.0	188.7	203.0	213.1	220.8	236.0
	MIN.W /FT	53.2	53.7	59.3	65.7	67.0	67.1	80.3	81.1	92.1	104.5	122.5	139.7	154.7	172.0	174.9	187.8	197.2	204.4	218.6
950	PIPE TEMP	863.4	862.0	849.4	835.2	827.1	824.5	793.9	793.2	766.9	733.3	680.2	632.5	590.6	546.5	538.8	511.5	492.2	472.5	441.2
	MAX.W /FT	64.6	65.2	72.5	81.5	82.0	82.1	101.6	100.9	117.6	134.4	154.7	169.6	178.5	199.4	202.2	217.4	228.1	236.2	252.2
	MIN.W /FT	57.9	58.4	64.4	71.3	72.5	72.5	86.9	87.6	99.4	112.6	131.7	149.9	165.6	184.2	187.2	200.9	210.8	218.4	233.3

INSULATION THICKNESS REQUIREMENTS .

Service Designation T-5

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 60 0 F (15.6 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
80	PIPE TEMP	79.0	78.9	78.9	78.6	78.4	78.4	78.0	77.9	77.5	77.0	76.0	75.2	74.3	73.6	73.2	72.7	72.2	71.8	71.0
	WATTS /FT	0.7	0.7	0.7	0.9	0.9	1.0	1.2	1.2	1.4	1.7	2.0	2.3	2.6	3.0	3.1	3.4	3.6	3.8	4.2
	AMPS /FT	0.7	0.7	0.7	0.8	0.9	0.9	1.1	1.2	1.3	1.5	1.9	2.2	2.5	2.9	3.0	3.3	3.5	3.7	4.0
100	PIPE TEMP	97.9	97.8	97.7	97.2	96.8	96.7	95.9	95.7	94.9	93.8	91.9	90.3	88.6	87.0	86.4	85.3	84.4	83.6	81.9
	WATTS /FT	1.4	1.5	1.5	1.8	1.9	2.0	2.4	2.5	2.9	3.4	4.1	4.6	5.3	6.0	6.3	6.9	7.3	7.7	8.5
	AMPS /FT	1.3	1.4	1.4	1.7	1.8	1.9	2.2	2.3	2.7	3.1	3.9	4.5	5.1	5.8	6.0	6.6	7.0	7.4	8.1
120	PIPE TEMP	116.9	116.7	116.4	115.7	115.2	114.9	113.7	113.6	112.2	110.6	107.7	105.3	102.8	100.3	99.5	97.8	96.4	95.0	92.7
	WATTS /FT	2.2	2.3	2.3	2.7	2.9	3.0	3.6	3.8	4.4	5.1	6.3	7.0	8.1	9.1	9.5	10.4	11.1	11.7	12.8
	AMPS /FT	2.1	2.2	2.2	2.6	2.8	2.9	3.4	3.6	4.1	4.7	5.9	6.8	7.8	8.8	9.1	9.9	10.6	11.2	12.2
140	PIPE TEMP	135.7	135.5	135.1	134.2	133.6	133.1	131.5	131.1	129.5	127.3	123.4	120.2	116.8	113.5	112.6	110.2	108.6	106.5	103.6
	WATTS /FT	3.0	3.1	3.1	3.7	4.0	4.1	4.9	5.2	6.0	7.0	8.5	9.5	10.9	12.3	12.8	13.9	14.9	15.7	17.2
	AMPS /FT	2.8	2.9	3.0	3.5	3.8	3.9	4.6	4.8	5.5	6.4	7.9	9.1	10.4	11.8	12.2	13.3	14.2	15.0	16.4
160	PIPE TEMP	154.5	154.2	153.8	152.6	151.6	151.2	149.2	148.7	146.7	143.9	139.0	135.0	130.8	126.7	125.3	122.5	120.2	117.8	114.0
	WATTS /FT	3.8	4.0	4.0	4.7	5.1	5.2	6.3	6.5	7.6	8.8	10.7	12.0	13.7	15.5	16.1	17.5	18.7	19.7	21.6
	AMPS /FT	3.6	3.7	3.8	4.5	4.8	4.9	5.8	6.1	7.0	8.1	10.0	11.5	13.2	14.8	15.4	16.8	17.9	18.8	20.6
180	PIPE TEMP	173.3	172.9	172.5	170.9	169.8	169.3	166.8	166.3	163.6	160.5	154.5	149.7	144.6	139.7	138.1	134.7	132.0	129.1	124.5
	WATTS /FT	4.6	4.8	4.9	5.8	6.2	6.4	7.7	8.0	9.2	10.7	13.1	14.5	16.6	18.8	19.5	21.2	22.6	23.8	26.0
	AMPS /FT	4.4	4.6	4.6	5.5	5.8	6.0	7.1	7.4	8.5	9.8	12.1	13.9	15.9	18.0	18.6	20.3	21.6	22.7	24.9
200	PIPE TEMP	192.0	191.6	191.0	189.2	187.9	187.4	184.6	183.8	180.9	177.0	170.0	164.4	158.4	152.6	150.8	146.8	143.7	140.4	135.0
	WATTS /FT	5.5	5.8	5.8	6.9	7.4	7.5	9.1	9.4	10.9	12.7	15.4	17.1	19.5	22.1	22.9	24.9	26.5	27.9	30.5
	AMPS /FT	5.2	5.4	5.5	6.5	6.9	7.1	8.4	8.8	10.0	11.6	14.3	16.4	18.7	21.1	21.9	23.8	25.3	26.6	29.1
220	PIPE TEMP	210.6	210.2	209.6	207.5	205.9	205.4	201.9	201.2	197.9	193.4	185.4	178.9	172.1	165.4	163.6	158.8	155.2	151.5	145.4
	WATTS /FT	6.5	6.7	6.7	8.0	8.6	8.7	10.5	10.9	12.6	14.7	17.8	19.7	22.5	25.4	26.3	28.7	30.5	32.1	35.1
	AMPS /FT	6.1	6.3	6.4	7.5	8.0	8.2	9.7	10.2	11.6	13.4	16.5	18.9	21.6	24.3	25.2	27.4	29.1	30.6	33.5
240	PIPE TEMP	229.2	228.8	228.1	225.7	223.9	223.3	219.3	218.6	214.9	209.7	200.7	193.4	185.7	178.2	175.9	170.8	166.8	162.5	155.7
	WATTS /FT	7.6	7.7	7.7	9.2	9.8	10.0	12.0	12.5	14.4	16.7	20.2	22.3	25.5	28.8	29.8	32.5	34.6	36.3	39.7
	AMPS /FT	7.0	7.2	7.3	8.6	9.2	9.4	11.1	11.6	13.2	15.3	18.7	21.5	24.5	27.6	28.5	31.0	33.0	34.6	37.8
260	PIPE TEMP	247.8	247.3	246.6	243.8	241.9	241.2	236.7	235.9	231.7	225.9	215.9	207.8	199.3	190.8	188.3	182.7	178.2	173.5	165.9
	WATTS /FT	8.6	8.7	8.7	10.4	11.1	11.3	13.6	14.1	16.2	18.8	22.7	25.0	28.6	32.3	33.4	36.3	38.6	40.6	44.3
	AMPS /FT	7.9	8.2	8.2	9.7	10.4	10.5	12.5	13.1	14.9	17.2	21.0	24.0	27.4	30.8	31.9	34.6	36.8	38.7	42.7
280	PIPE TEMP	266.3	265.8	265.0	261.9	259.8	259.0	254.0	253.2	248.6	242.1	231.1	222.1	212.7	203.4	200.7	194.6	189.5	184.4	176.1
	WATTS /FT	9.4	9.7	9.7	11.6	12.4	12.6	15.2	15.7	18.1	20.9	25.2	27.8	31.7	35.8	37.0	40.2	42.7	44.9	49.0
	AMPS /FT	8.9	9.1	9.2	10.8	11.6	11.8	14.0	14.5	16.5	19.1	23.3	26.7	30.4	34.2	35.3	38.3	40.7	42.8	46.6
300	PIPE TEMP	284.8	284.2	283.4	280.0	277.6	276.8	271.3	270.6	265.3	258.3	246.1	236.3	226.1	215.9	213.0	206.2	200.8	195.2	186.1
	WATTS /FT	10.5	10.8	10.8	12.9	13.7	13.9	16.8	17.3	20.0	23.1	27.8	30.6	34.8	39.3	40.6	44.1	46.9	49.2	53.7
	AMPS /FT	9.8	10.1	10.2	12.0	12.8	13.0	15.6	16.1	18.2	21.0	25.6	29.3	33.4	37.5	38.7	42.1	44.7	46.9	51.1
350	PIPE TEMP	336.8	336.2	329.2	324.9	322.0	321.1	314.3	313.2	307.0	298.3	283.5	271.6	259.2	246.7	243.4	235.1	228.7	222.0	211.1
	WATTS /FT	13.2	13.6	13.5	16.2	17.1	17.4	21.0	21.6	24.9	28.7	34.6	37.7	42.9	48.4	49.8	54.1	57.5	60.3	65.6
	AMPS /FT	12.4	12.7	12.7	15.0	16.0	16.2	19.2	20.0	22.6	26.1	31.6	36.1	41.0	46.1	47.5	51.5	54.7	57.3	62.4
400	PIPE TEMP	376.6	375.8	374.7	369.5	366.2	365.1	356.9	355.7	348.3	338.0	320.5	306.5	291.8	277.1	273.3	263.6	256.1	248.3	235.6
	WATTS /FT	16.2	16.6	16.4	19.6	20.8	21.0	25.4	26.1	30.0	34.6	41.3	45.1	51.2	57.7	59.3	64.6	68.3	71.5	77.8
	AMPS /FT	15.1	15.4	15.5	18.2	19.3	19.6	23.2	24.0	27.2	31.3	37.8	43.1	48.9	54.9	56.5	61.2	64.9	68.0	73.9
450	PIPE TEMP	422.1	421.3	420.1	413.9	410.0	408.8	399.2	397.9	389.3	377.3	357.1	340.9	324.0	307.1	302.9	291.7	283.1	274.2	259.7
	WATTS /FT	19.3	19.7	19.5	23.3	24.6	24.9	30.0	30.8	35.3	40.7	48.4	52.6	59.7	67.2	69.0	74.8	79.3	83.0	90.2
	AMPS /FT	18.0	18.3	18.3	21.6	22.9	23.1	27.3	28.3	32.0	36.7	44.2	50.3	56.9	63.9	65.6	71.1	75.3	78.8	85.6
500	PIPE TEMP	467.4	466.5	465.2	458.1	453.7	452.3	441.2	439.9	430.0	416.3	393.6	375.0	355.9	336.7	332.0	319.6	309.8	299.7	283.5
	WATTS /FT	22.6	23.0	22.7	27.2	28.6	28.9	34.8	35.6	40.8	47.0	55.7	60.4	68.4	76.9	78.9	85.5	90.4	94.7	102.7
	AMPS /FT	21.0	21.4	21.3	25.1	26.5	26.7	31.6	32.7	36.9	42.3	50.8	57.7	65.2	73.1	75.0	81.1	85.9	89.9	97.5
550	PIPE TEMP	512.5	511.6	510.2	502.0	497.1	495.6	483.0	481.5	470.4	455.0	429.3	408.7	387.3	365.8	360.8	346.7	336.0	324.3	306.9
	WATTS /FT	26.0	26.5	26.1	31.2	32.8	33.3	39.8	40.7	46.6	53.5	63.2	68.4	77.3	86.9	89.0	96.4	102.0	106.6	115.5
	AMPS /FT	24.1	24.5	24.4	28.7	30.3	30.5	36.0	37.2	41.9	48.0	57.6	65.3	73.6	82.4	84.5	91.4	96.7	101.1	109.5
600	PIPE TEMP	557.4	556.5	554.6	545.8	540.2	538.7	524.6	523.0	510.6	493.5	466.9	442.0	418.5	396.7	389.2	373.7	362.0	349.8	330.1
	WATTS /FT	29.7	30.1	29.6	35.3	37.1	37.3	44.9	45.9	52.5	60.2	70.9	76.6	86.6	97.0	99.3	107.5	113.7	118.7	128.5
	AMPS /FT	27.6	27.8	27.6	32.4	34.2	34.4	40.6	41.9	47.1	53.9	64.5	73.0	82.2	92.0	94.2	101.8	107.7	112.6	121.7
650	PIPE TEMP	602.2	601.2	599.5	589.6	583.3	581.6	566.0	564.2	550.5	531.7	500.3	475.0	449.3	423.2	417.4	400.6	387.6	374.3	352.9
	WATTS /FT	33.4	33.9	33.2	39.6	41.6	41.8	50.2	51.3	58.6	67.1	78.8	85.0	95.7	107.4	109.8	118.8	125.5	131.0	141.6
	AMPS /FT	30.8	31.2	30.9	36.3	38.2	38.4	45.3	46.7	52.5	59.9	71.5	80.9	91.0	101.7	104.0	112.4	118.8	123.9	134.0
700	PIPE TEMP	646.8	645.7	644.0	632.8	626.1	624.3	607.1	605.3	590.3	569.6	535.6	507.8	479.7	451.6	445.2	426.8	413.0	398.6	375.5
	WATTS /FT	37.3	37.8	37.0	44.1	46.2	46.6	55.7	56.8	64.8	74.2	87.0	93.6	105.3	118.0	120.5	130.2	137.6	143.5	155.0
	AMPS /FT	34.3	34.7	34.3	40.3	42.4	42.5	50.1	51.6	57.9	66.1	78.7	89.0	99.9	111.6	114.1	123.1	130.0	135.6	146.5
750	PIPE TEMP	691.3	690.2	688.4	676.1	668.8	666.9	648.2	646.2	629.9	607.6	570.2	540.3	510.0	479.3	472.7	452.9	438.0	422.6	397.9
	WATTS /FT	41.6	41.9	40.9	48.7	50.9	51.1	61.4	62.5	71.3	81.5	95.3	102.3	115.9	128.7	131.4	141.9	149.8	156.1	168.5
	AMPS /FT	38.0	38.4	37.9	44.6	46.7	46.8	55.1	56.7	63.6	72.4	86.1	97.2	109.0	121.6	124.3	134.0	141.5	147.5	159.1
800	PIPE TEMP	735.7	734.3	732.6	719.2	711.4	709.4	689.0	687.0	669.4	645.1	606.9	572.6	540.0	507.0	500.0	478.7	462.8	446.4	419.9
	WATTS /FT	45.6	46.1	44.9	53.5	55.9	56.0	67.3	68.4	77.9	89.0	103.8	111.2	124.8	139.6	142.4	153.8	162.2	169.0	182.2
	AMPS /FT	41.8	42.2	41.5	48.7	51.1	51.2	60.2	61.9	69.3	78.8	93.6	105.6	118.2	131.8	134.6	145.1	153.1	159.5	171.4
850	PIPE TEMP	780.0	778.8	776.8	762.3	753.9	751.8	729.8	727.6	708.7	682.5	638.4	604.6	569.8	534.5	527.1	504.4	487.4	469.9	441.7
	WATTS /FT	50.0	50.5	49.1	58.5	61.0	61.1	73.3	74.5	84.8	96.7	112.5	120.3	134.9	150.8	153.7	165.8	174.9	182.1	196.1
	AMPS /FT	45.7	46.1	45.3	53.1	55.6	55.7	65.5	67.2	75.3	85.5	101.3	114.2	127.7	142.2	145.1	156.3	164.8	171.6	184.3
900	PIPE TEMP	824.2	823.0	820.9	805.3	796.3	794.0	770.6	768.1	747.8	719.9	673.8	636.5	599.6	561.7	554.0	529.8	511.9	493.3	463.6
	WATTS /FT	54.6	55.1	53.5	63.7	66.2	66.4	79.7	80.8	92.0	104.7	121.5	129.7	145.2	162.2	165.2	178.2	187.7	195.4	210.3
	AMPS /FT	49.8	50.2	49.3	57.7	60.3	60.4	70.9	72.7	81.4	92.3	109.2	122.9	137.3	152.8	155.9	167.8	176.8	184.0	198.1
950	PIPE TEMP	868.4	867.1	864.5	848.2	838.5	836.2	810.9	808.5	786.9	757.0	707.9	668.2	628.8	588.9	580.8	555.1	536.1	516.3	484.4
	WATTS /FT	59.5	60.0	58.1	69.2	71.8	71.9	86.3	87.4	99.6	113.0	130.8	139.3	155.8	175.8	177.0	190.7	200.9	208.9	224.6
	AMPS /FT	54.1	54.5	53.4	62.6	65.2	65.2	76.6	78.5	87.8	99.4	117.3	131.9	147.1	163.6	166.8	179.5	189.0	196.6	211.6

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-55

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

2-1/2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 600 F (156 C)

CABLE TEMP DEG F		PIPE SIZE																	
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
80	PIPE TEMP	79.1	79.0	78.9	78.7	78.5	78.5	78.1	78.0	77.7	77.2	76.3	75.6	74.9	74.2	73.9	73.4	72.9	72.5	71.7
	MAX.W /FT	0.6	0.7	0.7	0.8	0.9	0.9	1.1	1.1	1.3	1.5	1.8	2.1	2.4	2.7	2.8	3.1	3.3	3.5	3.8
	MIN.W /FT	0.6	0.6	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.4	1.7	2.0	2.3	2.6	2.7	3.0	3.2	3.3	3.7
100	PIPE TEMP	98.1	98.0	97.8	97.4	97.0	96.9	96.2	96.0	95.3	94.4	92.6	91.2	89.7	88.2	87.7	86.6	85.8	84.9	83.4
	MAX.W /FT	1.3	1.4	1.4	1.6	1.8	1.8	2.2	2.3	2.6	3.0	3.7	4.2	4.8	5.4	5.7	6.2	6.6	7.0	7.7
	MIN.W /FT	1.2	1.3	1.4	1.6	1.7	1.7	2.0	2.2	2.5	2.8	3.5	4.1	4.6	5.2	5.5	6.0	6.4	6.7	7.4
120	PIPE TEMP	117.1	116.9	116.6	116.0	115.5	115.3	114.2	113.9	112.9	111.5	108.7	106.6	104.4	102.2	101.4	99.8	98.5	97.2	96.2
	MAX.W /FT	2.0	2.1	2.1	2.5	2.7	2.8	3.3	3.5	4.0	4.5	5.6	6.3	7.3	8.2	8.5	9.3	10.0	10.5	11.6
	MIN.W /FT	1.9	2.0	2.1	2.4	2.6	2.7	3.1	3.3	3.7	4.3	5.3	6.1	7.0	7.9	8.3	9.0	9.6	10.2	11.2
140	PIPE TEMP	136.0	135.8	135.4	134.6	133.9	133.6	132.1	131.8	130.4	128.5	124.8	122.0	119.0	116.0	115.0	112.9	111.2	109.4	106.4
	MAX.W /FT	2.7	2.8	2.9	3.4	3.7	3.8	4.5	4.7	5.4	6.1	7.6	8.5	9.8	11.0	11.5	12.5	13.4	14.1	15.6
	MIN.W /FT	2.6	2.7	2.8	3.2	3.5	3.6	4.2	4.4	5.0	5.8	7.2	8.3	9.4	10.6	11.1	12.1	12.9	13.6	15.0
160	PIPE TEMP	156.9	156.6	156.2	155.1	152.2	151.8	150.0	149.6	147.8	145.5	140.8	137.3	133.5	129.8	128.5	125.9	123.8	121.5	117.6
	MAX.W /FT	3.5	3.6	3.7	4.3	4.7	4.8	5.7	6.0	6.8	7.7	9.6	10.7	12.3	13.9	14.4	15.8	16.8	17.8	19.6
	MIN.W /FT	3.3	3.4	3.6	4.1	4.5	4.6	5.3	5.6	6.4	7.3	9.1	10.4	11.9	13.4	13.9	15.2	16.2	17.1	18.8
180	PIPE TEMP	173.7	173.4	172.9	171.6	170.5	170.1	167.9	167.3	165.2	162.4	156.8	152.5	148.0	143.5	142.0	138.8	136.3	133.6	129.1
	MAX.W /FT	4.2	4.4	4.5	5.3	5.7	5.8	6.9	7.2	8.3	9.4	11.6	13.0	14.9	16.8	17.5	19.0	20.3	21.5	23.6
	MIN.W /FT	4.0	4.2	4.3	5.0	5.4	5.5	6.5	6.9	7.7	8.8	11.0	12.6	14.4	16.2	16.9	18.4	19.6	20.7	22.7
200	PIPE TEMP	192.6	192.2	191.6	190.0	188.7	188.2	185.6	185.0	182.5	179.2	172.6	167.7	162.3	157.1	155.3	151.7	148.7	145.6	140.4
	MAX.W /FT	5.0	5.2	5.4	6.3	6.8	6.9	8.2	8.6	9.8	11.1	13.7	15.3	17.5	19.8	20.5	22.4	23.9	25.2	27.7
	MIN.W /FT	4.8	5.0	5.1	6.0	6.4	6.6	7.7	8.1	9.1	10.6	13.0	14.8	16.9	19.1	19.8	21.5	23.0	24.2	26.6
220	PIPE TEMP	211.3	210.9	210.3	208.4	206.9	206.4	203.4	202.7	199.8	196.0	188.4	182.8	176.6	170.6	168.6	164.5	161.1	157.5	151.5
	MAX.W /FT	5.9	6.1	6.2	7.3	7.9	8.0	9.5	9.9	11.3	12.9	15.8	17.7	20.2	22.8	23.6	25.7	27.5	28.9	31.8
	MIN.W /FT	5.6	5.8	6.0	6.9	7.5	7.6	8.9	9.4	10.6	12.1	15.0	17.1	19.5	22.0	22.8	24.8	26.4	27.9	30.6
240	PIPE TEMP	230.1	229.6	228.9	226.7	225.1	224.5	221.0	220.3	217.0	212.7	204.2	197.8	190.8	184.0	181.9	177.1	173.3	169.3	162.6
	MAX.W /FT	6.7	6.9	7.1	8.4	9.0	9.1	10.8	11.3	12.9	14.6	17.9	20.0	22.9	25.8	26.7	29.1	31.1	32.7	35.9
	MIN.W /FT	6.4	6.6	6.8	7.9	8.5	8.7	10.2	10.7	12.0	13.7	17.0	19.4	22.1	24.9	25.8	28.0	29.9	31.5	34.6
260	PIPE TEMP	248.7	248.3	247.6	245.0	243.2	242.5	238.7	237.8	234.2	229.6	219.8	212.7	205.0	197.4	195.0	189.7	185.5	181.0	173.7
	MAX.W /FT	7.6	7.8	8.0	9.6	10.1	10.3	12.2	12.7	14.5	16.6	20.1	22.5	25.6	28.9	29.9	32.6	34.7	36.6	40.1
	MIN.W /FT	7.3	7.5	7.7	8.9	9.6	9.8	11.4	12.0	13.5	15.4	19.0	21.7	24.7	27.8	28.8	31.4	33.4	35.2	38.6
280	PIPE TEMP	267.4	266.9	266.0	263.3	261.2	260.5	256.2	255.3	251.3	245.9	235.6	227.6	219.1	210.6	208.1	202.3	197.6	192.7	184.6
	MAX.W /FT	8.5	8.8	9.0	10.5	11.3	11.5	13.6	14.2	16.1	18.3	22.3	24.9	28.6	32.0	33.1	36.1	38.4	40.5	44.6
	MIN.W /FT	8.1	8.3	8.6	10.0	10.7	10.9	12.7	13.4	15.0	17.1	21.1	24.1	27.4	30.8	31.9	34.7	37.0	38.9	42.6
300	PIPE TEMP	286.0	285.5	284.5	281.5	279.2	278.5	273.7	272.7	268.4	262.5	251.0	242.4	233.1	223.8	221.1	214.7	209.7	204.3	195.5
	MAX.W /FT	9.5	9.7	9.9	11.7	12.5	12.7	15.0	15.7	17.8	20.2	24.6	27.4	31.2	35.2	36.4	39.6	42.2	44.6	48.6
	MIN.W /FT	9.0	9.2	9.5	11.0	11.8	12.0	14.1	14.8	16.6	18.9	23.3	26.5	30.1	33.9	35.0	38.1	40.6	42.7	46.7
350	PIPE TEMP	332.4	331.8	330.6	326.8	324.1	323.2	317.3	316.1	310.8	303.6	289.5	279.1	267.7	256.5	253.3	245.6	239.5	233.0	222.4
	MAX.W /FT	11.9	12.2	12.4	14.6	15.6	15.8	18.8	19.5	22.1	25.0	30.4	33.8	38.4	43.3	44.6	48.6	51.7	54.3	59.5
	MIN.W /FT	11.3	11.6	11.8	13.8	14.8	15.0	17.5	18.3	20.6	23.4	28.7	32.6	37.0	41.8	42.9	46.7	49.7	52.2	57.1
400	PIPE TEMP	378.5	377.9	376.4	371.9	368.6	367.7	360.6	359.3	352.9	344.3	327.7	315.6	302.0	288.7	285.1	276.0	268.9	261.3	249.0
	MAX.W /FT	14.6	14.9	15.1	17.8	18.9	19.1	22.7	23.5	26.6	30.1	36.4	40.3	45.8	51.6	53.1	57.7	61.4	64.5	70.5
	MIN.W /FT	13.8	14.1	14.4	16.7	17.9	18.0	21.1	22.1	24.7	28.0	34.3	38.9	44.1	49.6	51.1	55.4	58.9	61.9	67.6
450	PIPE TEMP	426.4	425.7	424.1	418.8	415.0	414.0	405.6	404.1	396.7	386.8	365.5	351.3	335.9	320.6	316.5	306.1	297.9	289.3	275.1
	MAX.W /FT	17.3	17.7	17.9	21.1	22.4	22.6	26.7	27.7	31.3	35.3	42.6	47.1	53.4	60.1	61.4	67.1	71.3	74.9	81.7
	MIN.W /FT	16.4	16.7	17.0	19.8	21.1	21.3	24.9	25.9	29.0	32.8	40.2	45.4	51.4	57.7	59.4	64.4	68.4	71.8	78.3
500	PIPE TEMP	476.2	475.4	473.8	468.1	464.1	463.0	454.1	452.6	444.7	436.3	424.9	403.0	386.8	369.4	352.0	347.5	335.7	326.5	310.8
	MAX.W /FT	20.3	20.6	20.8	24.5	26.0	26.2	31.0	32.1	36.2	40.8	49.1	54.1	61.2	68.8	70.7	76.7	81.5	85.4	93.1
	MIN.W /FT	19.1	19.4	19.7	23.0	24.5	24.6	28.8	30.0	33.5	37.8	46.1	52.1	58.9	66.0	67.8	73.5	78.1	81.9	89.2
550	PIPE TEMP	515.7	514.9	512.9	505.9	501.0	499.7	488.9	487.1	477.6	466.7	440.1	422.0	402.6	383.1	378.2	365.0	356.8	344.5	326.4
	MAX.W /FT	23.3	23.7	23.9	28.1	29.8	30.0	35.4	36.6	41.2	46.4	55.7	61.2	69.2	77.7	79.8	86.5	91.8	96.2	104.6
	MIN.W /FT	22.0	22.3	22.6	26.3	27.9	28.1	32.8	34.1	38.1	43.0	52.3	59.0	66.5	74.5	76.5	82.8	87.9	92.1	100.1
600	PIPE TEMP	561.1	560.2	558.0	550.2	544.7	543.3	531.2	529.2	518.6	504.4	477.0	456.9	435.4	413.8	408.5	394.0	382.7	370.9	351.6
	MAX.W /FT	26.5	26.5	27.1	31.8	33.7	33.8	40.0	41.2	46.4	52.2	62.4	68.6	77.4	86.8	89.0	96.4	102.3	107.5	116.5
	MIN.W /FT	24.9	25.2	25.6	29.7	31.5	31.7	36.9	38.4	42.8	48.2	58.5	66.0	74.3	83.1	85.3	92.3	97.9	102.5	111.5
650	PIPE TEMP	606.3	605.4	603.0	594.3	588.3	586.8	573.3	571.2	559.5	543.7	513.6	491.5	468.0	444.3	438.5	422.7	410.4	397.5	376.5
	MAX.W /FT	29.8	30.2	30.4	35.7	37.7	37.9	44.7	46.1	51.8	58.1	69.4	76.1	85.7	96.0	98.4	106.6	113.0	118.2	128.2
	MIN.W /FT	28.0	28.3	28.6	33.2	35.2	35.4	41.2	42.8	47.6	53.6	65.0	73.1	82.2	91.9	94.2	101.9	108.0	113.0	122.6
700	PIPE TEMP	651.6	650.5	647.5	638.2	631.7	630.0	615.3	612.9	600.1	582.9	549.9	525.8	500.2	474.6	468.2	451.0	437.7	423.8	401.1
	MAX.W /FT	33.3	33.7	33.8	39.7	41.8	42.0	49.5	51.0	57.3	64.2	76.5	83.7	94.2	105.5	108.0	116.9	123.8	129.5	140.8
	MIN.W /FT	31.1	31.5	31.8	36.9	39.1	39.2	45.6	47.3	52.6	59.2	71.5	80.4	90.3	100.8	103.4	111.7	118.3	123.7	134.1
750	PIPE TEMP	696.6	695.6	692.7	682.1	674.9	673.2	657.1	654.6	640.6	621.9	586.1	559.9	532.2	504.3	497.7	479.1	466.6	449.6	425.6
	MAX.W /FT	38.9	37.3	37.5	43.8	46.1	46.3	54.5	56.1	63.0	70.5	83.8	91.5	102.9	115.1	117.8	127.4	135.0	141.2	153.4
	MIN.W /FT	36.4	36.8	35.1	40.6	43.0	43.1	50.1	52.0	57.7	64.8	78.2	87.9	98.6	109.9	112.6	121.6	128.7	134.6	146.0
800	PIPE TEMP	741.3	740.3	737.3	725.8	718.0	716.2	699.7	696.0	681.0	660.7	622.0	593.8	564.0	533.9	526.9	507.0	491.7	475.6	449.5
	MAX.W /FT	43.6	41.0	41.2	48.0	50.5	50.7	59.7	61.3	68.8	76.9	91.2	99.5	111.7	124.9	127.7	138.1	146.1	152.8	165.6
	MIN.W /FT	37.8	38.1	38.4	44.5	47.0	47.1	56.7	58.7	62.9	70.6	85.1	95.5	107.0	119.2	122.0	131.7	139.4	145.6	157.8
850	PIPE TEMP	786.1	785.1	781.9	769.4	761.1	759.1	740.3	737.4	721.2	699.3	657.7	627.6	595.5	563.3	555.9	534.7	518.3	501.2	473.4
	MAX.W /FT	46.6	46.8	46.8	52.6	55.1	55.2	65.0	66.7	74.6	83.6	98.9	107.7	120.7	134.8	137.9	148.9	157.5	164.5	178.1
	MIN.W /FT	41.3	41.7	41.9	48.5	51.2	51.3	59.5	61.6	68.3	76.6	92.1	103.2	115.5	128.6	131.6	142.0	150.1	156.8	169.7
900	PIPE TEMP	830.6	829.8	826.4	813.0	804.0	801.9	781.7	778.6	761.3	737.8	693.3	660.9	626.9	592.5	584.8	562.1	544.7	526.6	497.1
	MAX.W /FT	49.6	48.8	48.7	57.0	59.4	59.9	70.5	72.3	81.1	90.9	106.7	116.0	130.0	145.0	148.2	160.0	169.1	176.5	190.7
	MIN.W /FT	45.0	45.3	45.5	52.6	55.5	55.6	64.4	66.6	73.8	82.7	99.3	111.1	124.2	138.2	141.4	152.4	161.1	168.2	181.8
950	PIPE TEMP	875.5	874.6	870.8	856.6	846.8	844.6	823.0	819.7	801.2	776.2	728.8	694.2	658.0	621.6	613.4	589.4	571.0	551.6	520.6
	MAX.W /FT	52.6	51.0	52.0	61.8	64.7	64.8	76.2	78.1	87.5	97.5	114.8	125.6	139.4	155.4	158.7	171.3	180.9	188.7	204.0
	MIN.W /FT	48.8	49.1	49.2	56.9	60.0	60.0	69.5	71.9	79.6	89.0	106.7	119.3	133.2	148.0	151.3	163.1	172.2	179.6	194.2

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-56

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 600 F (156 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
80	PIPE TEMP	79.1	79.1	79.0	78.8	78.6	78.5	78.2	78.2	77.9	77.4	76.6	76.0	75.3	74.6	74.4	73.9	73.5	73.1	72.3
	PAR.h /FT	0.6	0.6	0.7	0.8	0.8	0.8	1.0	1.0	1.2	1.3	1.6	1.9	2.2	2.4	2.6	2.8	3.0	3.2	3.5
	PIN.h /FT	0.6	0.6	0.6	0.7	0.8	0.8	0.9	1.0	1.1	1.3	1.6	1.8	2.1	2.4	2.5	2.7	2.9	3.1	3.4
100	PIPE TEMP	98.2	98.1	97.9	97.5	97.2	97.1	96.6	96.3	95.7	94.8	93.2	91.9	90.5	89.2	88.7	87.7	86.9	86.0	84.6
	PAR.h /FT	1.2	1.3	1.3	1.5	1.7	1.7	2.0	2.1	2.4	2.7	3.3	3.8	4.4	4.9	5.2	5.6	6.0	6.4	7.1
	PIN.h /FT	1.2	1.2	1.3	1.5	1.6	1.6	1.9	2.0	2.3	2.6	3.2	3.7	4.3	4.8	5.0	5.5	5.9	6.2	6.8
120	PIPE TEMP	117.2	117.1	116.8	116.2	115.7	115.5	114.6	114.3	113.4	112.1	109.7	107.7	105.6	103.6	102.9	101.4	100.2	98.9	96.8
	PAR.h /FT	1.9	1.9	2.0	2.3	2.5	2.6	3.0	3.2	3.6	4.1	5.0	5.8	6.6	7.5	7.8	8.5	9.1	9.6	10.7
	PIN.h /FT	1.8	1.9	2.0	2.2	2.4	2.5	2.9	3.1	3.4	4.0	4.9	5.6	6.4	7.3	7.6	8.2	8.8	9.3	10.3
140	PIPE TEMP	136.2	136.0	135.7	134.9	134.2	133.9	132.7	132.4	131.1	129.3	126.1	123.5	120.7	118.0	117.0	115.1	113.5	111.8	108.9
	PAR.h /FT	2.5	2.6	2.7	3.2	3.4	3.5	4.1	4.3	4.8	5.6	6.7	7.8	8.9	10.0	10.5	11.4	12.2	12.9	14.3
	PIN.h /FT	2.4	2.5	2.6	3.0	3.3	3.4	3.9	4.1	4.6	5.3	6.6	7.6	8.7	9.7	10.2	11.1	11.8	12.5	13.8
160	PIPE TEMP	155.2	154.9	154.5	153.5	152.6	152.3	150.7	150.3	148.8	146.5	142.5	139.1	135.7	132.3	131.1	128.7	126.7	124.5	121.0
	PAR.h /FT	3.2	3.4	3.5	4.0	4.4	4.5	5.2	5.4	6.1	7.1	8.5	9.8	11.2	12.7	13.2	14.4	15.4	16.2	17.9
	PIN.h /FT	3.1	3.2	3.4	3.9	4.2	4.3	5.0	5.2	5.9	6.8	8.3	9.6	10.9	12.3	12.8	13.9	14.9	15.7	17.4
180	PIPE TEMP	174.1	173.8	173.3	172.1	171.0	170.6	168.7	168.2	166.4	163.7	158.8	154.8	150.6	146.5	145.1	142.2	139.8	137.2	132.9
	PAR.h /FT	4.0	4.1	4.2	4.9	5.3	5.4	6.4	6.6	7.5	8.6	10.3	11.9	13.6	15.3	15.9	17.4	18.6	19.6	21.7
	PIN.h /FT	3.8	3.9	4.1	4.7	5.1	5.2	6.1	6.4	7.1	8.2	10.0	11.6	13.2	14.9	15.4	16.8	18.0	19.0	21.0
200	PIPE TEMP	193.0	192.6	192.0	190.6	189.4	188.9	186.6	186.1	183.9	180.7	175.0	170.3	165.4	160.6	159.0	155.6	152.8	149.8	144.8
	PAR.h /FT	4.7	4.9	5.0	5.8	6.3	6.4	7.5	7.8	8.8	10.1	12.1	14.0	16.0	18.0	18.7	20.4	21.8	23.0	25.4
	PIN.h /FT	4.5	4.7	4.8	5.6	6.1	6.2	7.2	7.5	8.4	9.7	11.8	13.6	15.5	17.5	18.1	19.8	21.1	22.3	24.6
220	PIPE TEMP	211.8	211.5	210.8	209.1	207.7	207.2	204.5	203.9	201.4	197.7	191.2	185.8	180.2	174.6	172.8	168.9	165.7	162.3	156.6
	PAR.h /FT	5.5	5.6	5.9	6.8	7.3	7.4	8.7	9.1	10.2	11.7	14.0	16.1	18.4	20.7	21.5	23.4	25.1	26.5	29.2
	PIN.h /FT	5.3	5.4	5.6	6.5	7.0	7.1	8.3	8.7	9.7	11.2	13.4	15.7	17.9	20.1	20.9	22.7	24.3	25.6	28.2
240	PIPE TEMP	230.6	230.2	229.4	227.5	225.9	225.4	222.3	221.7	218.9	214.7	207.3	201.2	194.9	188.6	186.6	182.2	178.6	174.8	168.6
	PAR.h /FT	6.3	6.5	6.7	7.8	8.3	8.5	9.9	10.3	11.6	13.3	15.9	18.3	20.8	23.5	24.4	26.5	28.4	29.9	33.0
	PIN.h /FT	6.0	6.2	6.4	7.4	8.0	8.1	9.4	9.9	11.0	12.7	15.5	17.8	20.2	22.8	23.6	25.7	27.5	29.0	31.9
260	PIPE TEMP	249.4	249.0	248.1	245.9	244.1	243.6	240.1	239.6	236.3	231.6	223.6	216.6	209.5	202.5	200.3	195.6	191.4	187.1	180.1
	PAR.h /FT	7.1	7.3	7.5	8.7	9.4	9.6	11.2	11.6	13.0	15.0	17.8	20.5	23.3	26.3	27.2	29.7	31.7	33.5	36.8
	PIN.h /FT	6.8	7.0	7.2	8.4	9.0	9.2	10.6	11.1	12.4	14.2	17.3	19.9	22.7	25.5	26.4	28.7	30.7	32.4	35.6
280	PIPE TEMP	268.1	267.7	266.7	264.3	262.3	261.7	257.9	257.1	253.7	248.5	239.3	231.9	224.1	216.4	214.0	208.6	204.2	199.5	191.7
	PAR.h /FT	7.9	8.1	8.4	9.8	10.5	10.7	12.5	12.9	14.5	16.6	19.8	22.7	25.9	29.1	30.2	32.9	35.1	37.0	40.7
	PIN.h /FT	7.6	7.8	8.1	9.3	10.1	10.2	11.8	12.4	13.8	15.8	19.2	22.1	25.1	28.2	29.2	31.8	34.0	35.8	39.4
300	PIPE TEMP	286.8	286.3	285.3	282.6	280.5	279.8	275.6	274.8	271.0	265.3	255.3	247.1	238.6	230.1	227.5	221.6	216.8	211.7	203.2
	PAR.h /FT	8.8	9.0	9.3	10.8	11.6	11.8	13.8	14.3	16.0	18.3	21.8	25.0	28.4	32.0	33.1	36.1	38.5	40.6	44.6
	PIN.h /FT	8.4	8.6	8.9	10.3	11.1	11.3	13.1	13.6	15.2	17.4	21.2	24.3	27.6	31.0	32.1	34.9	37.2	39.3	43.2
350	PIPE TEMP	333.6	332.9	331.6	328.3	325.6	324.8	319.6	318.7	314.0	307.0	296.8	286.9	276.5	266.2	263.2	256.0	250.2	242.0	231.8
	PAR.h /FT	11.1	11.3	11.6	13.5	14.5	14.7	17.1	17.7	19.9	22.7	26.9	30.8	35.0	39.3	40.6	44.2	47.2	49.7	54.6
	PIN.h /FT	10.6	10.8	11.2	12.9	13.9	14.0	16.2	16.9	18.8	21.6	26.1	29.9	33.9	38.1	39.4	42.8	45.6	48.0	52.7
400	PIPE TEMP	379.8	379.2	377.7	373.7	370.5	369.7	363.4	362.3	356.8	348.5	334.1	322.3	310.1	297.9	294.4	286.0	279.2	272.0	260.0
	PAR.h /FT	13.5	13.8	14.1	16.4	17.5	17.7	20.7	21.4	23.9	27.3	32.1	36.7	41.7	46.9	48.5	52.6	56.1	59.0	64.7
	PIN.h /FT	12.9	13.1	13.5	15.6	16.7	16.9	19.6	20.4	22.6	25.9	31.2	35.7	40.4	45.3	46.8	50.8	54.2	57.0	62.5
450	PIPE TEMP	426.0	425.4	423.7	418.9	415.3	414.3	406.9	405.7	399.3	389.6	372.9	359.4	345.3	331.2	327.3	317.6	309.8	301.6	287.9
	PAR.h /FT	16.0	16.3	16.7	19.4	20.7	20.9	24.4	25.2	28.1	32.0	37.6	42.9	48.6	54.6	56.3	61.1	65.1	68.5	75.0
	PIN.h /FT	15.3	15.6	16.0	18.4	19.8	19.9	23.0	23.9	26.5	30.3	36.5	41.6	47.1	52.8	54.4	59.1	62.9	66.1	72.4
500	PIPE TEMP	472.0	471.3	469.4	463.9	459.7	458.6	450.2	448.9	441.6	430.5	411.5	396.1	380.1	364.2	359.8	348.9	340.1	330.8	315.6
	PAR.h /FT	18.7	19.0	19.4	22.6	24.1	24.2	28.3	29.1	32.4	36.9	43.2	49.3	55.7	62.5	64.5	69.9	74.4	78.2	85.5
	PIN.h /FT	17.8	18.1	18.6	21.4	22.9	23.0	26.6	27.6	30.6	34.9	42.0	47.8	53.9	60.4	62.2	67.5	71.8	75.4	82.5
550	PIPE TEMP	517.8	517.1	515.0	508.8	504.0	502.8	493.3	491.8	483.6	471.1	449.7	432.5	414.7	396.8	392.0	379.8	370.0	359.6	342.6
	PAR.h /FT	21.5	21.9	22.3	25.8	27.5	27.7	32.3	33.2	36.9	42.0	49.0	55.8	63.0	70.6	72.6	78.8	83.8	88.0	96.2
	PIN.h /FT	20.5	20.8	21.2	24.5	26.1	26.3	30.3	31.5	34.8	39.7	47.6	54.0	60.9	68.2	70.1	76.0	80.8	84.9	92.7
600	PIPE TEMP	563.5	562.8	560.4	553.4	548.1	546.8	536.2	534.5	525.4	511.5	487.7	468.4	448.9	429.0	423.9	410.3	399.6	388.2	369.5
	PAR.h /FT	24.5	24.8	25.2	29.3	31.1	31.2	36.4	37.4	41.6	47.2	55.0	62.4	70.4	78.9	81.1	87.9	93.4	98.1	107.1
	PIN.h /FT	23.2	23.5	24.0	27.7	29.5	29.6	34.2	35.4	39.1	44.5	53.3	60.5	68.1	76.1	78.2	84.8	90.0	94.5	103.1
650	PIPE TEMP	609.1	608.3	605.7	597.9	592.1	590.7	578.8	577.1	567.0	551.6	525.4	504.4	482.7	461.0	455.4	440.6	428.9	416.4	396.0
	PAR.h /FT	27.5	27.8	28.3	32.8	34.8	34.9	40.7	41.7	46.3	52.6	61.1	69.3	78.0	87.3	89.7	97.2	103.2	108.3	118.1
	PIN.h /FT	26.1	26.4	26.9	30.9	33.0	33.1	38.1	39.5	43.6	49.5	59.2	67.0	75.4	84.2	86.5	93.6	99.4	104.2	113.7
700	PIPE TEMP	656.5	655.7	652.9	644.3	638.9	637.4	623.4	621.6	610.5	593.6	562.8	540.0	516.6	492.7	486.7	470.6	457.9	444.4	422.3
	PAR.h /FT	30.7	31.0	31.4	36.4	38.6	38.8	45.0	46.2	51.3	58.1	67.4	76.2	85.8	95.9	98.5	106.6	113.2	118.6	129.5
	PIN.h /FT	29.0	29.3	29.9	34.3	36.6	36.7	42.2	43.7	48.1	54.7	65.2	73.7	82.8	92.4	94.9	102.7	108.9	114.2	124.4
750	PIPE TEMP	699.8	698.9	695.5	686.5	679.6	677.9	663.7	661.7	649.7	631.3	600.1	575.3	549.7	524.1	517.7	500.3	486.6	472.1	448.3
	PAR.h /FT	33.9	34.3	34.7	40.2	42.6	42.7	49.6	50.8	56.3	63.7	73.8	83.4	93.7	104.7	107.6	116.2	123.3	129.2	140.6
	PIN.h /FT	32.1	32.4	32.9	37.8	40.2	40.3	46.4	47.9	52.8	59.9	71.4	80.6	90.4	100.8	103.6	111.8	118.6	124.2	135.2
800	PIPE TEMP	745.0	744.1	740.9	730.7	723.1	721.4	706.0	703.8	690.8	670.9	637.1	610.4	582.9	555.3	548.4	529.8	515.1	499.5	474.1
	PAR.h /FT	37.1	37.7	38.1	44.1	46.6	46.7	54.2	55.5	61.5	69.5	80.3	90.7	101.8	113.6	116.5	126.0	133.5	139.8	152.1
	PIN.h /FT	35.2	35.5	36.1	41.4	44.0	44.1	50.6	52.3	57.6	65.3	77.7	87.6	98.1	109.3	112.1	121.1	128.4	134.4	146.2
850	PIPE TEMP	790.2	789.2	785.8	774.7	766.5	764.7	748.1	745.7	731.7	710.3	673.9	645.3	615.8	586.2	579.0	559.0	543.6	526.8	499.7
	PAR.h /FT	40.8	41.1	41.5	48.1	50.8	50.9	59.0	60.3	66.8	75.5	87.0	98.1	110.0	122.7	125.7	135.9	144.0	150.7	163.8
	PIN.h /FT	38.5	38.7	39.4	45.1	47.9	47.9	55.0	56.8	62.5	70.8	84.1	94.7	106.0	118.0	120.9	130.6	138.3	144.8	157.3
900	PIPE TEMP	835.2	834.3	830.5	818.7	809.9	807.9	790.1	787.6	772.6	749.6	710.6	680.0	648.6	617.0	609.3	588.1	571.6	553.6	525.0
	PAR.h /FT	44.4	44.8	45.1	52.2	55.1	55.2	64.0	65.3	72.4	81.8	93.9	105.7	118.4	131.9	135.1	146.0	154.8	161.7	175.7
	PIN.h /FT	41.8	42.1	42.7	48.9	51.9	51.9	59.6	61.5	67.6	76.6	90.7	102.0	114.0	126.8	129.9	140.2	148.5	155.3	168.6
950	PIPE TEMP	880.2	879.2	875.3	862.5	853.1	851.1	831.9	829.3	813.3	788.8	747.1	714.5	681.2	647.6	639.5	617.0	599.3	580.7	550.2
	PAR.h /FT	48.2	48.6	48.9	56.5	59.6	59.8	69.1	70.5	78.0	87.9	100.9	113.5	127.0	141.4	144.8	156.3	165.9	173.0	187.7
	PIN.h /FT	45.3	45.6	46.2	52.9	56.0	56.1	64.3	66.3	72.8	82.3	97.4	109.6	122.2	135.8	139.1	150.0	158.8	166.0	180.1

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-57

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3-1/2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 60.0 F (15.6 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
80	PIPE TEMP	79.1	79.1	79.0	78.8	78.7	78.6	78.3	78.3	78.0	77.6	76.9	76.3	75.6	75.0	74.8	74.3	74.0	73.5	72.9
	MAX.W /FT	0.6	0.6	0.6	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.5	1.8	2.0	2.3	2.4	2.6	2.8	2.9	3.1
	MIN.W /FT	0.6	0.6	0.6	0.7	0.7	0.8	0.9	0.9	1.1	1.2	1.5	1.7	2.0	2.2	2.3	2.5	2.7	2.9	3.1
100	PIPE TEMP	98.3	98.2	98.0	97.6	97.3	97.2	96.7	96.5	95.9	95.1	93.7	92.4	91.2	89.9	89.5	88.6	87.8	87.0	85.4
	MAX.W /FT	1.2	1.2	1.3	1.4	1.6	1.6	1.8	2.0	2.2	2.5	3.1	3.5	4.0	4.4	4.8	5.2	5.6	5.9	6.5
	MIN.W /FT	1.1	1.2	1.2	1.4	1.5	1.6	1.8	1.9	2.1	2.4	3.0	3.5	4.0	4.4	4.6	5.1	5.4	5.8	6.4
120	PIPE TEMP	117.3	117.2	116.9	116.4	115.9	115.8	114.9	114.6	113.8	112.6	110.6	108.6	106.6	104.8	104.1	102.8	101.6	100.4	98.4
	MAX.W /FT	1.8	1.8	1.9	2.2	2.4	2.6	2.8	3.0	3.3	3.8	4.6	5.3	6.1	6.9	7.2	7.8	8.4	8.9	9.7
	MIN.W /FT	1.7	1.8	1.9	2.1	2.3	2.4	2.7	2.9	3.2	3.7	4.5	5.2	6.0	6.7	7.0	7.6	8.2	8.7	9.6
140	PIPE TEMP	136.4	136.2	135.8	135.1	134.5	134.3	133.1	132.8	131.7	130.0	127.1	124.6	122.1	119.6	118.7	116.9	115.4	113.7	111.0
	MAX.W /FT	2.4	2.5	2.6	3.0	3.2	3.3	3.8	4.0	4.5	5.2	6.2	7.2	8.2	9.3	9.7	10.5	11.3	11.9	13.2
	MIN.W /FT	2.3	2.4	2.5	2.9	3.1	3.2	3.7	3.9	4.4	5.0	6.1	7.0	8.0	9.0	9.4	10.3	11.0	11.6	12.9
160	PIPE TEMP	155.4	155.2	154.7	153.8	153.0	152.7	151.3	150.8	149.4	147.6	143.7	140.6	137.6	134.3	133.2	130.9	129.0	127.0	123.6
	MAX.W /FT	3.1	3.2	3.3	3.8	4.1	4.2	4.8	5.1	5.7	6.5	7.9	9.1	10.4	11.7	12.1	13.3	14.2	15.0	16.6
	MIN.W /FT	3.0	3.1	3.2	3.7	4.0	4.0	4.7	4.9	5.5	6.3	7.7	8.9	10.1	11.4	11.8	12.9	13.8	14.6	16.2
180	PIPE TEMP	174.3	174.1	173.6	172.4	171.5	171.2	169.4	168.9	167.2	164.7	160.3	156.5	152.7	148.9	147.6	144.9	142.6	140.2	136.1
	MAX.W /FT	3.7	3.9	4.0	4.6	5.0	5.1	5.9	6.2	6.9	7.9	9.5	11.0	12.5	14.1	14.7	16.0	17.1	18.1	20.1
	MIN.W /FT	3.6	3.7	3.9	4.5	4.8	4.9	5.7	6.0	6.7	7.7	9.3	10.7	12.2	13.8	14.3	15.6	16.7	17.7	19.5
200	PIPE TEMP	193.3	193.0	192.4	191.1	189.9	189.5	187.5	186.8	184.9	181.9	176.8	172.4	167.9	163.5	162.0	158.8	156.2	153.3	148.5
	MAX.W /FT	4.4	4.6	4.8	5.5	5.9	6.0	6.9	7.3	8.2	9.4	11.2	12.9	14.7	16.6	17.2	18.8	20.1	21.3	23.5
	MIN.W /FT	4.3	4.4	4.6	5.3	5.7	5.8	6.7	7.1	7.9	9.0	11.0	12.6	14.4	16.2	16.8	18.3	19.6	20.7	22.9
220	PIPE TEMP	212.2	211.9	211.2	209.6	208.3	207.9	205.5	204.8	202.6	199.1	193.2	188.2	183.1	178.0	176.3	172.6	169.6	166.3	160.9
	MAX.W /FT	5.2	5.3	5.5	6.4	6.8	6.9	8.0	8.5	9.5	10.8	12.9	14.9	17.0	19.1	19.8	21.6	23.1	24.5	27.0
	MIN.W /FT	5.0	5.1	5.4	6.2	6.6	6.7	7.7	8.2	9.1	10.4	12.7	14.5	16.6	18.6	19.3	21.0	22.5	23.8	26.3
240	PIPE TEMP	231.0	230.7	229.9	228.2	226.7	226.2	223.5	222.7	220.2	216.3	209.6	204.0	198.1	192.4	190.5	186.4	183.0	179.3	173.7
	MAX.W /FT	5.9	6.1	6.3	7.3	7.8	7.9	9.2	9.6	10.8	12.3	14.7	16.9	19.2	21.6	22.5	24.5	26.2	27.7	30.6
	MIN.W /FT	5.7	5.9	6.1	7.0	7.5	7.7	8.8	9.3	10.4	11.9	14.4	16.5	18.8	21.1	21.9	23.8	25.5	26.9	29.7
260	PIPE TEMP	249.9	249.5	248.6	246.6	245.0	244.5	241.4	240.5	237.7	233.6	225.9	219.7	213.2	206.7	204.7	200.1	196.3	192.2	185.6
	MAX.W /FT	6.7	6.9	7.1	8.2	8.8	8.9	10.3	10.8	12.1	13.8	16.5	18.9	21.5	24.2	25.1	27.4	29.3	30.9	34.1
	MIN.W /FT	6.5	6.6	6.9	7.9	8.5	8.6	9.9	10.5	11.6	13.3	16.1	18.5	21.0	23.6	24.5	26.6	28.5	30.1	33.2
280	PIPE TEMP	268.7	268.3	267.3	265.1	263.3	262.7	259.3	258.4	255.2	250.5	242.2	235.3	228.1	221.0	218.8	213.7	209.6	205.1	197.6
	MAX.W /FT	7.5	7.7	7.9	9.2	9.8	9.9	11.5	12.1	13.4	15.3	18.3	21.0	23.8	26.8	27.8	30.3	32.4	34.2	37.7
	MIN.W /FT	7.2	7.4	7.7	8.8	9.5	9.6	11.0	11.7	12.9	14.8	17.9	20.5	23.3	26.1	27.1	29.5	31.5	33.2	36.7
300	PIPE TEMP	287.6	287.0	286.0	283.5	281.6	280.9	277.2	276.1	272.7	267.5	258.5	250.9	243.0	235.2	232.8	227.3	222.8	217.9	209.7
	MAX.W /FT	8.3	8.5	8.8	10.1	10.8	11.0	12.7	13.3	14.8	16.9	20.1	23.1	26.2	29.5	30.5	33.2	35.5	37.5	41.4
	MIN.W /FT	8.0	8.2	8.5	9.8	10.5	10.6	12.2	12.9	14.2	16.3	19.6	22.5	25.5	28.7	29.7	32.3	34.5	36.5	40.2
350	PIPE TEMP	334.2	333.7	332.5	329.4	327.0	326.3	321.6	320.4	316.2	309.8	298.8	289.6	280.0	270.5	267.6	261.0	255.5	249.5	239.7
	MAX.W /FT	10.4	10.6	11.0	12.7	13.5	13.6	15.8	16.5	18.4	20.9	24.8	28.4	32.2	36.2	37.5	40.8	43.5	45.9	50.6
	MIN.W /FT	10.0	10.2	10.6	12.2	13.0	13.2	15.1	16.0	17.6	20.2	24.2	27.7	31.4	35.2	36.4	39.6	42.3	44.6	49.1
400	PIPE TEMP	380.8	380.3	378.8	375.1	372.3	371.4	365.9	364.4	359.5	351.8	338.8	327.9	316.6	305.4	302.1	294.2	287.8	280.9	269.4
	MAX.W /FT	12.7	12.9	13.3	15.3	16.3	16.5	19.0	19.9	22.1	25.1	29.7	33.9	38.4	43.2	44.6	48.5	51.7	54.5	60.0
	MIN.W /FT	12.2	12.4	12.8	14.7	15.7	15.9	18.2	19.2	21.2	24.2	29.0	33.1	37.4	41.9	43.3	47.1	50.2	52.9	58.2
450	PIPE TEMP	427.2	426.6	424.9	420.6	417.3	416.4	409.8	408.2	402.4	393.5	378.5	365.9	352.9	339.9	336.2	327.1	319.7	311.8	299.7
	MAX.W /FT	15.1	15.3	15.7	18.1	19.3	19.4	22.4	23.4	25.9	29.5	34.7	39.6	44.8	50.3	51.9	56.4	60.1	63.3	69.4
	MIN.W /FT	14.5	14.7	15.2	17.4	18.6	18.7	21.4	22.6	24.9	28.3	33.9	38.6	43.6	48.8	50.4	54.7	58.3	61.4	67.2
500	PIPE TEMP	473.4	472.8	470.9	465.9	462.1	461.1	453.6	451.7	445.2	435.0	417.8	403.6	388.8	374.1	369.9	359.7	351.3	342.4	327.6
	MAX.W /FT	17.6	17.8	18.3	21.1	22.3	22.5	25.9	27.1	29.9	34.0	39.9	45.4	51.3	57.6	59.3	64.4	68.7	72.3	79.1
	MIN.W /FT	16.9	17.1	17.6	20.2	21.5	21.6	24.8	26.1	28.7	32.6	38.9	44.3	49.9	55.9	57.6	62.5	66.6	70.1	76.7
550	PIPE TEMP	519.5	518.8	516.7	511.0	506.7	505.6	497.1	495.1	487.7	476.2	456.9	440.9	424.6	407.9	403.3	391.9	382.6	372.6	356.2
	MAX.W /FT	20.2	20.5	21.0	24.1	25.5	25.7	29.6	30.9	34.1	38.6	45.3	51.5	58.1	65.0	67.0	72.7	77.4	81.6	89.1
	MIN.W /FT	19.4	19.6	20.2	23.1	24.6	24.7	28.2	29.7	32.6	37.1	44.1	50.1	56.4	63.1	65.0	70.5	75.0	78.9	86.3
600	PIPE TEMP	565.6	564.7	562.3	556.0	551.2	550.0	540.5	538.2	530.0	517.1	495.7	478.0	459.7	441.4	436.6	423.8	413.5	402.6	384.5
	MAX.W /FT	22.9	23.2	23.7	27.3	28.9	29.0	33.3	34.8	38.4	43.4	50.8	57.6	64.9	72.6	74.8	81.1	86.3	90.7	99.1
	MIN.W /FT	22.0	22.2	22.8	26.1	27.7	27.8	31.8	33.4	36.7	41.6	49.4	56.1	63.1	70.5	72.5	78.6	83.6	87.9	96.2
650	PIPE TEMP	611.2	610.5	607.8	600.8	595.5	594.2	583.6	581.2	572.1	557.9	536.3	516.8	496.7	476.6	469.2	455.3	444.1	432.2	412.5
	MAX.W /FT	25.6	26.0	26.6	30.6	32.3	32.4	37.2	38.8	42.8	48.3	56.4	63.9	71.9	80.4	82.7	89.7	95.4	100.2	109.4
	MIN.W /FT	24.6	24.9	25.6	29.2	31.0	31.1	35.5	37.2	40.8	46.3	54.9	62.2	69.9	78.0	80.2	86.9	92.3	97.0	106.1
700	PIPE TEMP	656.9	656.1	653.2	645.5	639.7	638.2	626.6	623.9	614.0	598.6	572.6	551.3	529.5	507.5	501.7	486.7	474.5	461.5	440.1
	MAX.W /FT	28.7	29.0	29.6	34.0	35.8	35.9	41.3	43.0	47.3	53.6	62.2	70.6	79.1	88.6	90.8	98.4	104.6	110.0	120.1
	MIN.W /FT	27.6	27.7	28.4	32.4	34.3	34.4	39.3	41.2	45.1	51.1	60.5	68.4	76.8	85.6	88.0	95.3	101.2	106.3	116.1
750	PIPE TEMP	702.4	701.6	698.5	690.0	683.7	682.2	669.5	666.6	655.7	638.8	610.7	587.6	564.0	540.2	534.0	517.7	504.6	490.6	467.4
	MAX.W /FT	31.7	32.0	32.6	37.4	39.4	39.5	45.4	47.2	52.0	58.5	68.1	77.0	86.4	96.4	99.1	107.3	113.9	119.6	130.6
	MIN.W /FT	30.5	30.5	31.3	35.7	37.8	37.9	43.1	45.2	49.5	56.0	66.2	74.8	83.8	93.4	96.0	103.8	110.2	115.7	126.3
800	PIPE TEMP	747.9	747.1	743.7	734.5	727.6	726.0	712.2	709.1	697.4	679.0	648.6	623.7	598.2	572.7	566.0	548.5	534.5	519.5	494.8
	MAX.W /FT	34.9	35.2	35.8	41.0	43.2	43.3	49.6	51.6	56.7	63.9	74.1	83.7	93.9	104.7	107.5	116.3	123.5	129.5	141.3
	MIN.W /FT	33.2	33.5	34.3	39.0	41.3	41.4	47.1	49.3	54.0	61.1	72.0	81.3	91.0	101.3	104.0	112.5	119.4	125.2	136.6
850	PIPE TEMP	793.3	792.4	788.8	778.8	771.4	769.7	754.9	751.5	738.8	719.0	686.3	659.7	632.3	604.9	597.8	579.1	564.1	548.1	521.8
	MAX.W /FT	38.1	38.4	39.0	44.7	47.0	47.1	54.0	56.1	61.6	69.3	80.3	90.6	101.5	113.1	116.0	125.5	133.1	139.6	152.2
	MIN.W /FT	36.3	36.5	37.3	42.5	44.9	45.0	51.2	53.6	58.6	66.2	78.0	87.9	98.3	109.4	112.3	121.3	128.7	134.9	147.0
900	PIPE TEMP	838.6	837.7	833.8	823.1	815.1	813.3	797.4	793.7	780.2	759.0	723.9	695.4	666.2	637.0	629.5	609.5	593.6	576.5	548.9
	MAX.W /FT	41.5	41.8	42.4	48.6	51.0	51.0	58.5	60.7	66.7	74.9	86.6	97.6	109.2	121.6	124.8	134.8	143.0	149.9	163.2
	MIN.W /FT	39.6	39.7	40.5	46.1	48.7	48.7	55.6	58.0	63.3	71.5	84.1	94.7	105.8	117.6	120.7	130.3	138.1	144.7	157.6
950	PIPE TEMP	883.9	882.9	878.8	867.3	858.8	856.8	839.8	835.9	821.4	798.7	761.3	731.0	699.9	668.8	660.9	639.7	622.8	604.6	575.7
	MAX.W /FT	44.9	45.2	45.9	52.5	55.1	55.1	63.1	65.5	71.9	80.7	93.1	104.8	117.2	130.3	133.7	144.4	153.0	160.3	174.3
	MIN.W /FT	42.7	42.9	43.8	49.8	52.5	52.6	59.7	62.5	68.2	76.9	90.4	101.6	113.4	126.0	129.2	139.4	147.7	154.7	168.4

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-58

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

4" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 60.0 F (15.6 C)

CABLE TEMP DEG F		PIPE SIZE																	
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
80	PIPE TEMP	79.2	79.1	79.0	78.9	78.7	78.6	78.4	78.3	78.1	77.7	77.0	76.5	75.9	75.3	75.1	74.7	74.3	74.0	73.3
	PAR.h /FT	0.5	0.6	0.6	0.7	0.8	0.8	0.9	0.9	1.0	1.2	1.4	1.6	1.9	2.1	2.2	2.4	2.6	2.7	3.0
	PIN.h /FT	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.4	1.6	1.8	2.1	2.2	2.4	2.5	2.7	3.1
100	PIPE TEMP	98.3	98.2	98.1	97.7	97.3	97.2	96.8	96.6	96.1	95.4	94.0	92.9	91.7	90.6	90.2	89.3	88.6	87.8	86.5
	PAR.h /FT	1.1	1.1	1.2	1.4	1.6	1.6	1.7	1.9	2.1	2.3	2.9	3.3	3.8	4.2	4.4	4.8	5.2	5.5	6.1
	PIN.h /FT	1.1	1.1	1.2	1.3	1.5	1.6	1.7	1.8	2.0	2.3	2.8	3.2	3.7	4.2	4.3	4.7	5.1	5.4	6.0
120	PIPE TEMP	117.4	117.3	117.1	116.6	115.9	115.8	115.1	114.9	114.1	113.0	111.0	109.3	107.5	105.8	105.1	103.9	102.8	101.7	99.7
	PAR.h /FT	1.7	1.6	1.8	2.1	2.4	2.4	2.7	2.8	3.1	3.5	4.3	5.0	5.7	6.4	6.7	7.3	7.8	8.3	9.2
	PIN.h /FT	1.6	1.7	1.8	2.0	2.3	2.4	2.6	2.8	3.1	3.5	4.3	4.9	5.6	6.3	6.6	7.1	7.7	8.1	9.0
140	PIPE TEMP	136.5	136.3	136.0	135.4	134.5	134.3	133.4	133.1	132.1	130.6	127.9	125.6	123.2	120.9	120.1	118.4	117.0	115.4	112.9
	PAR.h /FT	2.3	2.4	2.5	2.8	3.2	3.3	3.6	3.8	4.2	4.8	5.8	6.7	7.7	8.6	9.0	9.8	10.5	11.1	12.4
	PIN.h /FT	2.2	2.3	2.4	2.8	3.1	3.2	3.5	3.7	4.1	4.7	5.7	6.6	7.5	8.4	8.8	9.6	10.3	10.9	12.1
160	PIPE TEMP	155.6	155.3	154.9	154.1	153.0	152.7	151.7	151.2	150.0	148.1	144.7	141.8	138.8	136.0	136.9	132.8	131.0	129.1	125.6
	PAR.h /FT	2.9	3.0	3.1	3.6	4.1	4.2	4.6	4.8	5.4	6.0	7.4	8.5	9.7	10.9	11.3	12.3	13.2	14.0	15.5
	PIN.h /FT	2.8	2.9	3.1	3.5	4.0	4.0	4.4	4.7	5.2	5.9	7.2	8.3	9.5	10.6	11.1	12.1	12.9	13.7	15.2
180	PIPE TEMP	174.6	174.3	173.8	172.8	171.5	171.2	169.9	169.4	167.9	165.6	161.5	158.0	154.6	150.9	149.7	147.2	145.0	142.7	138.8
	PAR.h /FT	3.6	3.7	3.8	4.4	5.0	5.1	5.5	5.9	6.5	7.3	8.9	10.2	11.7	13.1	13.7	14.9	16.0	16.9	18.7
	PIN.h /FT	3.5	3.6	3.7	4.3	4.8	4.9	5.4	5.7	6.3	7.2	8.7	10.0	11.4	12.8	13.4	14.6	15.6	16.5	18.3
200	PIPE TEMP	193.5	193.3	192.7	191.5	189.9	189.5	188.1	187.5	185.7	183.1	178.2	174.2	170.0	165.9	164.4	161.5	159.0	156.3	151.7
	PAR.h /FT	4.2	4.4	4.5	5.2	5.9	6.0	6.5	6.9	7.7	8.6	10.5	12.1	13.7	15.4	16.0	17.5	18.7	19.8	22.0
	PIN.h /FT	4.1	4.2	4.4	5.0	5.7	5.8	6.4	6.7	7.5	8.5	10.3	11.8	13.4	15.1	15.7	17.1	18.3	19.4	21.4
220	PIPE TEMP	212.5	212.2	211.5	210.1	208.3	207.9	206.2	205.5	203.5	200.5	196.9	190.2	185.4	180.7	179.1	175.7	172.9	169.7	164.5
	PAR.h /FT	4.9	5.1	5.2	6.0	6.8	6.9	7.6	8.0	8.9	9.9	12.1	13.9	15.8	17.8	18.5	20.1	21.5	22.8	25.2
	PIN.h /FT	4.8	4.9	5.1	5.8	6.6	6.7	7.4	7.8	8.6	9.8	11.9	13.6	15.5	17.4	18.0	19.6	21.0	22.3	24.6
240	PIPE TEMP	231.4	231.1	230.3	228.7	226.7	226.2	224.3	223.5	221.2	217.8	211.5	206.3	200.8	195.5	193.7	189.9	186.7	183.2	177.1
	PAR.h /FT	5.6	5.8	6.0	6.8	7.8	7.9	8.6	9.1	10.1	11.3	13.7	15.7	17.9	20.1	20.9	22.8	24.4	25.8	28.5
	PIN.h /FT	5.5	5.6	5.8	6.7	7.5	7.7	8.4	8.9	9.8	11.1	13.4	15.4	17.5	19.7	20.4	22.2	23.8	25.2	27.8
260	PIPE TEMP	250.3	249.9	249.1	247.3	245.0	244.5	242.3	241.5	238.9	235.1	228.1	222.2	216.2	210.2	208.3	204.0	200.4	196.5	190.0
	PAR.h /FT	6.4	6.5	6.7	7.7	8.8	8.9	9.7	10.2	11.3	12.7	15.4	17.6	20.0	22.5	23.4	25.5	27.2	28.8	31.9
	PIN.h /FT	6.2	6.3	6.6	7.5	8.5	8.6	9.4	10.0	11.0	12.5	15.1	17.3	19.6	22.0	22.8	24.9	26.6	28.1	31.1
280	PIPE TEMP	269.1	268.8	267.9	265.8	263.3	262.7	260.3	259.4	256.6	252.3	244.6	238.1	231.5	224.9	222.7	218.1	214.1	209.8	202.7
	PAR.h /FT	7.1	7.3	7.5	8.6	9.8	9.9	10.8	11.4	12.6	14.1	17.0	19.6	22.2	25.0	25.9	28.2	30.1	31.9	35.2
	PIN.h /FT	6.9	7.1	7.3	8.4	9.5	9.6	10.5	11.1	12.2	13.8	16.7	19.2	21.7	24.4	25.3	27.5	29.4	31.1	34.4
300	PIPE TEMP	288.0	287.6	286.6	284.3	281.6	280.9	278.3	277.3	274.2	269.5	261.1	254.0	246.7	239.5	237.2	232.0	227.7	223.1	215.3
	PAR.h /FT	7.9	8.1	8.3	9.5	10.8	11.0	11.9	12.5	13.9	15.5	18.8	21.5	24.4	27.4	28.4	30.9	33.1	35.0	38.6
	PIN.h /FT	7.7	7.8	8.1	9.2	10.5	10.6	11.6	12.2	13.5	15.2	18.4	21.1	23.9	26.8	27.7	30.2	32.3	34.1	37.7
350	PIPE TEMP	334.9	334.4	333.2	330.5	327.0	326.3	323.0	321.8	318.0	312.4	302.0	293.4	284.5	275.7	273.0	266.7	261.5	255.9	246.5
	PAR.h /FT	9.9	10.1	10.4	11.9	13.5	13.6	14.8	15.6	17.2	19.2	23.1	26.5	30.0	33.7	34.8	37.9	40.5	42.8	47.2
	PIN.h /FT	9.6	9.8	10.1	11.5	13.0	13.2	14.4	15.2	16.7	18.8	22.7	25.9	29.3	32.9	34.0	37.0	39.5	41.7	46.0
400	PIPE TEMP	381.6	381.1	379.7	376.4	372.3	371.4	367.6	366.1	361.6	354.9	342.6	332.5	322.0	311.6	308.4	301.1	295.0	288.3	277.3
	PAR.h /FT	12.0	12.2	12.6	14.4	16.3	16.5	17.8	18.7	20.6	23.0	27.7	31.6	35.8	40.1	41.5	45.1	48.2	50.8	56.0
	PIN.h /FT	11.7	11.9	12.2	13.9	15.7	15.9	17.3	18.2	20.0	22.6	27.1	30.9	35.0	39.1	40.5	44.0	46.9	49.5	54.6
450	PIPE TEMP	428.2	427.6	426.0	422.1	417.3	416.4	411.8	410.2	405.0	397.1	383.0	371.3	359.2	347.1	343.5	335.1	328.0	320.4	307.8
	PAR.h /FT	14.3	14.5	14.9	17.0	19.3	19.4	21.0	22.0	24.2	27.0	32.4	36.9	41.7	46.7	48.3	52.5	56.0	59.0	65.0
	PIN.h /FT	13.8	14.0	14.3	16.5	18.6	18.7	20.3	21.4	23.5	26.5	31.7	36.1	40.7	45.6	47.1	51.1	54.5	57.5	63.3
500	PIPE TEMP	474.5	474.0	472.2	467.7	462.1	461.1	455.9	454.1	448.1	439.1	423.0	409.7	396.0	382.3	378.3	368.7	360.8	352.2	337.9
	PAR.h /FT	16.6	16.9	17.3	19.7	22.3	22.5	24.3	25.5	28.0	31.1	37.2	42.4	47.8	53.5	55.2	60.0	64.0	67.4	74.1
	PIN.h /FT	16.1	16.3	16.8	19.1	21.5	21.6	23.5	24.6	27.1	30.5	36.4	41.4	46.7	52.2	53.8	58.4	62.3	65.6	72.1
550	PIPE TEMP	520.8	520.2	518.2	513.0	506.7	505.6	499.8	497.7	491.0	480.9	462.8	447.8	432.5	417.1	412.7	402.0	393.2	383.6	367.4
	PAR.h /FT	19.1	19.4	19.8	22.6	25.5	25.7	27.7	29.0	31.8	35.4	42.2	48.0	54.1	60.5	62.3	67.7	72.1	76.0	83.4
	PIN.h /FT	18.5	18.7	19.2	21.8	24.6	24.7	26.8	28.2	30.8	34.7	41.3	46.9	52.7	58.9	60.7	65.9	70.2	73.9	81.2
600	PIPE TEMP	566.9	566.2	564.0	558.3	551.2	550.0	543.5	541.2	533.7	522.4	502.3	485.7	468.7	451.7	446.9	435.0	425.2	414.7	397.3
	PAR.h /FT	21.2	22.0	22.4	25.6	28.9	29.0	31.3	32.7	35.8	39.7	47.3	53.7	60.5	67.6	69.6	75.5	80.4	85.7	92.9
	PIN.h /FT	20.9	21.2	21.7	24.7	27.7	27.8	30.2	31.7	34.7	38.9	46.3	52.5	59.0	65.8	67.8	73.5	78.2	82.3	90.3
650	PIPE TEMP	612.9	612.2	609.7	603.3	595.5	594.2	587.0	584.5	576.2	563.7	541.5	523.3	506.6	485.9	480.7	467.7	457.0	445.5	426.5
	PAR.h /FT	24.4	24.8	25.1	28.6	32.3	32.4	34.9	36.5	39.9	44.3	52.6	59.6	67.0	74.8	77.0	83.5	88.9	93.5	102.5
	PIN.h /FT	23.5	23.7	24.3	27.6	31.0	31.1	33.6	35.4	38.6	43.3	51.4	58.2	65.3	72.8	75.0	81.2	86.4	90.9	99.6
700	PIPE TEMP	658.7	658.0	655.4	648.3	639.7	638.2	630.3	627.6	618.5	604.8	580.6	560.7	540.3	519.9	514.3	500.1	488.5	476.0	455.6
	PAR.h /FT	27.1	27.4	27.5	31.4	35.8	35.9	38.7	40.4	44.2	48.9	58.0	65.6	73.7	82.2	84.8	91.7	97.5	102.5	112.3
	PIN.h /FT	26.1	26.4	27.0	30.6	34.3	34.4	37.2	39.1	42.7	47.8	56.6	64.0	71.8	80.0	82.3	89.1	94.8	99.6	109.1
750	PIPE TEMP	704.5	703.8	700.9	693.1	683.7	682.2	673.5	670.6	660.7	645.8	619.6	597.8	575.7	553.6	547.6	532.3	519.8	506.3	484.1
	PAR.h /FT	30.0	30.3	30.8	35.0	39.6	39.5	42.5	44.3	48.5	53.6	63.5	71.8	80.5	89.8	92.3	99.9	106.3	111.7	122.2
	PIN.h /FT	28.9	29.1	29.8	33.7	37.8	37.9	40.9	43.0	46.8	52.4	62.0	70.0	78.4	87.3	89.8	97.1	103.2	108.5	118.7
800	PIPE TEMP	750.2	749.4	746.3	737.9	727.6	726.0	716.6	713.4	702.7	686.5	658.0	634.7	610.9	587.1	580.7	564.2	550.8	536.3	512.5
	PAR.h /FT	32.9	33.2	33.7	38.4	43.2	43.3	46.5	48.6	52.9	58.5	69.1	78.0	87.5	97.4	100.2	108.4	115.2	121.0	132.3
	PIN.h /FT	31.7	31.9	32.6	36.9	41.3	41.4	44.7	46.9	51.1	57.2	67.5	76.4	85.2	94.7	97.6	105.3	111.6	117.5	128.6
850	PIPE TEMP	795.8	795.0	791.6	782.5	771.4	769.7	759.6	756.2	744.6	727.1	696.5	671.5	646.0	620.4	613.6	595.9	581.6	566.2	540.7
	PAR.h /FT	36.0	36.2	36.8	41.8	47.0	47.1	50.6	52.6	57.5	63.6	74.9	84.5	94.6	105.2	108.1	117.3	124.2	130.4	142.5
	PIN.h /FT	34.5	34.8	35.5	40.2	44.9	45.0	48.6	50.9	55.4	62.0	73.1	82.3	92.0	102.3	105.1	113.6	120.6	126.6	138.3
900	PIPE TEMP	841.3	840.5	836.8	827.1	815.1	813.3	802.6	799.0	786.6	767.6	736.8	708.1	680.8	653.6	646.2	627.5	612.2	595.8	568.7
	PAR.h /FT	39.1	39.4	39.9	45.3	51.0	51.0	54.7	57.0	62.2	68.5	80.6	91.0	101.8	113.2	116.3	125.7	133.6	140.0	152.7
	PIN.h /FT	37.5	37.8	38.5	43.5	48.7	48.7	52.5	55.1	59.9	66.9	78.6	88.6	99.0	110.0	113.0	122.0	129.5	135.8	148.3
950	PIPE TEMP	886.8	885.9	882.0	871.5	858.8	856.8	845.2	841.3	828.1	808.0	775.0	744.5	715.4	686.5	678.7	658.8	642.6	625.2	596.6
	PAR.h /FT	42.4	42.8	43.2	49.0	55.1	55.1	59.1	61.4	67.3	73.8	86.6	97.7	109.2	121.4	124.6	134.6	142.8	149.8	163.4
	PIN.h /FT	40.6	40.9	41.6	47.0	52.5	52.6	56.6	59.3	64.5	72.0	84.6	95.1	106.2	117.8	121.0	130.6	138.5	145.3	158.9

INSULATION THICKNESS REQUIREMENTS

Service Designation T-59

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

1" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 90.0 F (32.2 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
100	PIPE TEMP	99.4	99.3	99.2	99.1	98.9	98.9	98.7	98.7	98.3	98.0									
	MAX.W /FT	0.5	0.5	0.5	0.6	0.7	0.7	0.8	0.8	1.0	1.2									
	MIN.W /FT	0.4	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.9	1.0									
120	PIPE TEMP	118.0	117.9	117.6	117.2	116.8	116.6	115.9	115.9	115.0	113.9									
	MAX.W /FT	1.5	1.6	1.8	1.9	2.1	2.2	2.5	2.5	3.1	3.7									
	MIN.W /FT	1.4	1.4	1.5	1.7	1.9	2.0	2.2	2.3	2.7	3.1									
140	PIPE TEMP	136.6	136.4	136.0	135.3	134.5	134.2	133.0	133.0	131.5	129.6									
	MAX.W /FT	2.5	2.7	2.8	3.2	3.6	3.7	4.3	4.3	5.2	6.2									
	MIN.W /FT	2.3	2.4	2.5	2.9	3.2	3.3	3.8	3.8	4.5	5.3									
160	PIPE TEMP	155.1	154.8	154.3	153.3	152.1	151.7	150.1	150.1	147.9	145.3									
	MAX.W /FT	3.6	3.8	4.0	4.4	5.2	5.3	6.2	6.1	7.5	8.8									
	MIN.W /FT	3.3	3.5	3.6	4.1	4.8	4.8	5.4	5.4	6.4	7.5									
180	PIPE TEMP	173.6	173.2	172.5	171.2	169.7	169.1	167.0	167.0	164.2	160.8									
	MAX.W /FT	4.8	5.0	5.2	6.0	6.8	7.0	8.1	8.0	9.8	11.5									
	MIN.W /FT	4.4	4.6	4.8	5.4	6.0	6.2	7.1	7.1	8.4	9.8									
200	PIPE TEMP	191.9	191.4	190.6	189.0	187.1	186.4	183.8	183.9	180.4	176.2									
	MAX.W /FT	6.0	6.2	6.5	7.5	8.5	8.7	10.1	10.0	12.1	14.3									
	MIN.W /FT	5.4	5.7	5.9	6.7	7.5	7.7	8.8	8.8	10.6	12.1									
220	PIPE TEMP	210.2	209.7	208.7	206.8	204.5	203.7	200.6	200.7	196.5	191.6									
	MAX.W /FT	7.2	7.5	7.9	9.0	10.2	10.5	12.2	12.0	14.6	17.2									
	MIN.W /FT	6.6	6.8	7.1	8.1	9.1	9.3	10.6	10.6	12.5	14.5									
240	PIPE TEMP	228.5	227.8	226.7	224.4	221.8	220.6	217.3	217.4	212.5	206.8									
	MAX.W /FT	8.5	8.9	9.3	10.7	12.0	12.4	14.3	14.0	17.1	20.2									
	MIN.W /FT	7.7	8.1	8.4	9.5	10.6	10.9	12.6	12.6	14.6	16.9									
260	PIPE TEMP	246.6	245.9	244.6	242.0	239.0	238.0	233.8	234.1	228.5	221.9									
	MAX.W /FT	9.9	10.3	10.7	12.3	13.9	14.3	16.5	16.2	19.7	23.2									
	MIN.W /FT	9.0	9.3	9.7	11.0	12.3	12.6	14.3	14.2	16.8	19.4									
280	PIPE TEMP	264.7	264.0	262.5	259.5	256.1	255.0	250.3	250.6	244.3	236.9									
	MAX.W /FT	11.3	11.8	12.2	14.0	15.8	16.3	18.8	18.3	22.3	26.3									
	MIN.W /FT	10.2	10.6	11.0	12.5	13.9	14.2	16.2	16.1	19.0	22.0									
300	PIPE TEMP	282.8	281.9	280.3	277.0	273.1	272.0	266.7	267.1	260.1	251.9									
	MAX.W /FT	12.8	13.3	13.8	15.8	17.8	18.3	21.1	20.6	25.1	29.5									
	MIN.W /FT	11.5	11.9	12.4	14.0	15.7	16.0	18.2	18.0	21.2	24.6									
350	PIPE TEMP	327.6	326.6	324.6	320.3	315.4	314.0	307.4	308.0	299.1	288.8									
	MAX.W /FT	16.4	17.2	17.9	20.5	23.1	23.6	27.2	26.6	32.1	37.7									
	MIN.W /FT	14.9	15.4	16.0	18.1	20.1	20.5	23.3	23.0	27.3	31.2									
400	PIPE TEMP	372.0	370.9	368.5	363.3	357.3	355.7	347.6	348.5	337.8	325.3									
	MAX.W /FT	20.8	21.5	22.2	25.5	28.7	29.2	33.7	32.5	39.6	46.4									
	MIN.W /FT	18.6	19.1	19.8	22.4	24.9	25.2	28.6	28.2	33.1	38.1									
450	PIPE TEMP	416.1	414.8	412.1	405.8	398.7	397.0	387.3	388.7	376.0	361.3									
	MAX.W /FT	25.3	26.1	26.8	30.8	34.6	35.1	40.5	39.0	47.4	55.5									
	MIN.W /FT	22.5	23.1	23.8	26.9	29.8	30.2	34.2	33.6	39.4	45.3									
500	PIPE TEMP	459.8	458.4	455.3	448.1	439.9	437.5	426.7	428.5	413.8	396.9									
	MAX.W /FT	30.1	30.9	31.7	36.4	40.8	41.4	47.7	45.7	55.6	64.9									
	MIN.W /FT	26.6	27.2	27.9	31.6	35.0	35.4	39.9	39.2	45.9	52.6									
550	PIPE TEMP	503.2	501.8	498.3	490.0	480.7	478.5	465.8	468.0	451.3	432.2									
	MAX.W /FT	35.2	36.0	36.9	42.3	47.3	47.6	55.1	52.7	64.0	74.7									
	MIN.W /FT	30.9	31.5	32.3	36.5	40.3	40.7	45.9	45.0	52.6	60.2									
600	PIPE TEMP	548.4	546.9	543.1	531.7	521.2	518.9	504.6	507.2	488.5	467.2									
	MAX.W /FT	40.5	41.4	42.3	48.4	54.1	54.7	62.9	59.9	72.8	84.8									
	MIN.W /FT	35.4	36.1	36.9	41.6	45.9	46.2	52.1	50.9	59.5	68.0									
650	PIPE TEMP	589.4	587.8	583.6	573.1	561.4	559.0	543.1	546.2	525.4	501.8									
	MAX.W /FT	46.1	47.0	47.9	54.8	61.2	61.7	70.9	67.4	81.8	95.2									
	MIN.W /FT	40.1	40.8	41.6	46.9	51.4	51.9	58.4	57.1	66.5	75.9									
700	PIPE TEMP	632.1	630.4	626.0	614.3	601.5	598.5	581.4	585.0	562.2	536.3									
	MAX.W /FT	52.1	53.0	53.8	61.5	68.6	69.1	79.3	75.1	91.2	106.0									
	MIN.W /FT	45.0	45.7	46.5	52.3	57.5	57.8	65.0	63.3	73.7	84.0									
750	PIPE TEMP	674.7	673.0	668.2	655.4	641.6	638.1	619.6	623.6	598.7	570.5									
	MAX.W /FT	58.3	59.2	60.0	68.5	76.3	76.8	88.0	83.2	101.0	117.1									
	MIN.W /FT	50.2	50.8	51.6	58.0	63.7	63.9	71.7	69.8	81.2	92.4									
800	PIPE TEMP	717.2	715.4	710.2	696.6	681.2	678.3	657.5	662.0	635.1	604.6									
	MAX.W /FT	64.9	65.8	66.5	75.9	84.4	84.8	97.1	91.5	111.1	128.8									
	MIN.W /FT	55.6	56.2	57.0	63.9	70.0	70.3	78.7	76.5	88.9	101.0									
850	PIPE TEMP	759.5	757.7	752.2	737.2	720.8	717.8	695.4	700.3	671.3	638.6									
	MAX.W /FT	72.0	72.9	73.5	83.7	92.9	93.3	106.7	100.2	121.8	140.9									
	MIN.W /FT	61.3	61.9	62.6	70.1	76.7	76.5	86.0	83.4	96.9	109.9									
900	PIPE TEMP	801.8	800.0	794.1	777.9	760.3	757.1	733.1	738.5	707.4	672.4									
	MAX.W /FT	79.7	80.6	81.0	92.1	102.0	102.4	117.0	109.4	133.0	153.7									
	MIN.W /FT	67.4	68.1	68.8	76.7	83.6	83.5	93.7	90.7	105.2	119.2									
950	PIPE TEMP	844.0	842.1	835.9	818.6	799.7	796.4	770.7	776.5	743.4	706.1									
	MAX.W /FT	88.2	89.1	89.1	101.2	111.9	112.2	128.1	119.3	145.2	167.4									
	MIN.W /FT	74.1	74.7	75.1	83.7	91.3	91.4	101.9	98.3	114.1	128.9									

INSULATION THICKNESS REQUIREMENTS .

Service Designation T-60

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

1-1/2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 90.0 F (32.2 C)

CABLE TEMP DEG F		PIPE SIZE																	
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
100	PIPE TEMP	99.5	99.4	99.3	99.2	99.1	99.1	98.8	98.8	98.6	98.3	97.7	97.2	96.8	96.3	96.1	95.8	95.6	95.3	94.9
	MAX.W /FT	0.4	0.4	0.5	0.5	0.5	0.6	0.7	0.7	0.8	1.0	1.2	1.4	1.5	1.7	1.8	2.0	2.1	2.2	2.4
	MIN.W /FT	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.7	0.8	0.9	1.1	1.3	1.5	1.7	1.7	1.9	2.0	2.1	2.3
120	PIPE TEMP	118.3	118.2	117.9	117.6	117.3	117.2	116.5	116.4	115.6	114.7	113.0	111.5	110.2	108.8	108.3	107.4	106.7	105.9	104.7
	MAX.W /FT	1.2	1.2	1.4	1.6	1.7	1.7	2.1	2.2	2.6	3.0	3.7	4.2	4.7	5.3	5.5	6.0	6.4	6.7	7.3
	MIN.W /FT	1.1	1.2	1.3	1.5	1.5	1.6	1.9	2.0	2.3	2.7	3.3	3.9	4.4	5.0	5.2	5.7	6.0	6.3	6.9
140	PIPE TEMP	137.1	137.0	136.5	135.9	135.5	135.2	134.0	133.8	132.6	131.0	128.3	125.8	123.5	121.2	120.4	118.9	117.7	116.6	114.4
	MAX.W /FT	2.0	2.1	2.4	2.7	2.8	2.9	3.6	3.7	4.3	5.1	6.2	7.1	7.8	8.9	9.2	10.0	10.7	11.2	12.2
	MIN.W /FT	1.9	2.0	2.2	2.5	2.6	2.7	3.2	3.4	3.9	4.5	5.6	6.6	7.4	8.4	8.7	9.5	10.1	10.6	11.5
160	PIPE TEMP	155.9	155.7	155.0	154.2	153.6	153.2	151.5	151.2	149.5	147.3	143.4	139.9	136.7	133.5	132.4	130.3	128.6	126.9	124.1
	MAX.W /FT	2.9	3.0	3.4	3.8	4.0	4.1	5.1	5.2	6.2	7.2	8.8	10.1	11.1	12.6	13.0	14.2	15.1	15.8	17.2
	MIN.W /FT	2.7	2.8	3.1	3.5	3.7	3.8	4.6	4.8	5.5	6.4	7.9	9.3	10.5	11.9	12.3	13.4	14.2	14.9	16.2
180	PIPE TEMP	174.6	174.3	173.4	172.4	171.6	171.2	168.9	168.6	166.3	163.4	158.4	153.9	149.9	145.6	144.4	141.6	139.4	137.2	133.6
	MAX.W /FT	3.7	3.9	4.4	5.0	5.2	5.4	6.6	6.8	8.1	9.4	11.5	13.1	14.4	16.3	16.9	18.3	19.5	20.4	22.2
	MIN.W /FT	3.5	3.7	4.1	4.6	4.9	5.0	6.0	6.2	7.2	8.4	10.3	12.0	13.6	15.4	15.9	17.3	18.4	19.2	20.9
200	PIPE TEMP	193.3	193.0	191.8	190.5	189.5	189.0	186.2	185.8	183.1	179.5	173.4	167.9	162.9	157.7	156.1	152.7	150.1	147.4	143.0
	MAX.W /FT	4.7	4.9	5.5	6.2	6.5	6.7	8.3	8.5	10.0	11.7	14.2	16.2	17.7	20.1	20.8	22.6	24.0	25.1	27.3
	MIN.W /FT	4.4	4.6	5.1	5.8	6.0	6.2	7.5	7.7	8.9	10.4	12.7	14.9	16.8	19.0	19.6	21.3	22.6	23.6	25.7
220	PIPE TEMP	211.9	211.5	210.1	208.6	207.4	206.8	203.4	203.0	199.7	195.5	188.2	181.7	175.8	169.6	167.9	163.8	160.7	157.5	152.9
	MAX.W /FT	5.3	5.9	6.6	7.5	7.8	8.0	9.9	10.2	12.0	14.0	17.0	19.6	21.1	23.9	24.7	26.9	28.5	29.8	32.4
	MIN.W /FT	5.3	5.5	6.1	6.9	7.3	7.4	9.0	9.3	10.7	12.4	15.2	17.7	20.0	22.6	23.3	25.3	26.8	28.1	30.5
240	PIPE TEMP	230.5	230.0	228.4	226.6	225.2	224.6	220.6	220.1	216.3	211.4	203.0	195.4	188.6	181.5	179.5	174.8	171.2	167.6	161.7
	MAX.W /FT	6.7	6.9	7.8	8.8	9.2	9.4	11.6	11.9	14.0	16.4	19.8	22.6	24.6	27.8	28.7	31.2	33.1	34.6	37.6
	MIN.W /FT	6.2	6.4	7.2	8.1	8.5	8.7	10.5	10.8	12.5	14.5	17.7	20.6	23.3	26.2	27.1	29.3	31.1	32.6	35.3
260	PIPE TEMP	248.0	248.5	246.6	244.5	243.0	242.3	237.7	237.2	232.8	227.2	217.7	209.1	201.3	193.2	191.0	185.7	181.7	177.6	170.9
	MAX.W /FT	7.7	8.0	9.0	10.2	10.6	10.8	13.4	13.7	16.1	18.8	22.7	25.8	28.1	31.6	32.7	35.6	37.7	39.5	42.8
	MIN.W /FT	7.2	7.4	8.3	9.3	9.8	10.0	12.1	12.4	14.3	16.6	20.2	23.6	26.6	29.9	30.8	33.4	35.5	37.1	40.2
280	PIPE TEMP	267.5	266.9	264.8	262.4	260.7	259.6	254.7	254.2	249.3	242.9	232.2	222.6	214.0	204.9	202.5	196.5	192.1	187.5	180.1
	MAX.W /FT	8.8	9.0	10.2	11.6	12.1	12.3	15.2	15.5	18.3	21.3	25.7	29.1	31.6	35.8	36.8	40.0	42.4	44.3	48.1
	MIN.W /FT	8.2	8.4	9.4	10.6	11.1	11.3	13.7	14.1	16.2	18.8	22.8	26.5	29.9	33.7	34.7	37.6	39.8	41.6	45.1
300	PIPE TEMP	285.9	285.3	282.9	280.2	278.4	277.5	271.7	271.1	265.7	258.6	246.8	236.1	226.6	216.5	213.8	207.3	202.3	197.3	189.1
	MAX.W /FT	9.9	10.2	11.5	13.0	13.5	13.8	17.1	17.4	20.5	23.9	28.7	32.5	35.2	39.9	41.0	44.5	47.1	49.3	53.4
	MIN.W /FT	9.2	9.5	10.6	11.9	12.4	12.6	15.3	15.7	18.1	21.0	25.4	29.6	33.3	37.5	38.6	41.8	44.2	46.2	50.1
350	PIPE TEMP	331.2	331.1	328.0	324.6	322.3	321.3	313.8	313.2	306.3	297.6	282.7	269.5	257.6	245.0	241.9	233.8	227.7	221.5	211.5
	MAX.W /FT	12.8	13.1	14.8	16.8	17.4	17.7	21.9	22.2	26.1	30.4	36.4	41.1	44.4	50.2	51.5	55.9	59.1	61.8	66.8
	MIN.W /FT	11.9	12.2	13.6	15.3	15.9	16.1	19.5	20.0	23.1	26.6	32.1	37.3	41.9	47.1	48.4	52.4	55.4	57.9	62.6
400	PIPE TEMP	377.3	376.6	372.8	368.7	365.9	364.8	355.6	355.0	346.6	335.9	318.2	302.3	288.2	273.1	269.5	259.8	252.7	245.3	233.5
	MAX.W /FT	15.9	16.3	18.4	20.8	21.5	21.8	27.0	27.3	32.1	37.3	44.4	50.0	53.9	60.9	62.3	67.6	71.4	74.5	80.5
	MIN.W /FT	14.7	15.1	16.8	18.9	19.6	19.8	24.0	24.5	28.2	32.5	39.1	45.3	50.8	57.0	58.5	63.3	66.9	69.8	75.3
450	PIPE TEMP	422.3	421.8	417.6	412.6	409.2	407.6	397.1	396.4	386.5	373.9	353.3	334.8	318.3	300.7	296.7	285.4	277.2	268.7	255.1
	MAX.W /FT	19.2	19.6	22.1	25.0	25.8	26.0	32.3	32.6	38.3	44.4	52.7	59.2	63.6	71.8	73.4	79.5	84.0	87.5	94.4
	MIN.W /FT	17.7	18.1	20.2	22.6	23.4	23.7	28.6	29.2	33.5	38.6	46.2	53.4	59.8	67.2	68.8	74.3	78.5	81.8	88.3
500	PIPE TEMP	467.2	466.6	461.7	455.9	452.2	450.8	438.2	437.5	426.2	411.6	388.0	366.8	348.0	327.8	323.5	310.7	301.3	291.7	276.4
	MAX.W /FT	22.3	23.2	26.1	29.5	30.3	30.5	37.9	38.2	44.7	51.8	61.3	68.6	73.6	82.9	84.7	91.6	96.7	100.7	108.6
	MIN.W /FT	20.5	21.3	23.7	26.5	27.4	27.7	33.4	34.1	39.0	44.8	53.6	61.8	69.1	77.5	79.2	85.6	90.3	94.0	101.3
550	PIPE TEMP	512.6	511.7	505.8	499.1	495.0	493.5	479.1	478.4	465.5	449.0	422.4	398.5	377.3	356.6	349.9	335.5	325.1	314.4	297.3
	MAX.W /FT	26.4	26.8	30.2	34.1	34.9	35.2	43.6	43.9	51.4	59.5	70.1	78.3	83.7	94.3	96.2	104.0	109.7	114.2	122.9
	MIN.W /FT	24.2	24.6	27.4	30.6	31.6	31.8	38.4	39.1	44.7	51.2	61.1	70.3	78.5	88.0	89.9	97.0	102.3	106.5	114.6
600	PIPE TEMP	557.3	556.3	549.6	542.2	537.6	536.0	519.7	519.0	504.6	486.2	456.5	429.8	406.3	381.1	376.0	360.1	348.6	336.6	318.0
	MAX.W /FT	30.2	30.7	34.5	38.9	39.8	40.1	49.6	49.9	58.3	67.4	79.1	88.2	94.1	105.9	107.9	116.0	122.9	127.8	137.4
	MIN.W /FT	27.7	28.1	31.2	34.8	35.9	36.1	43.5	44.2	50.5	57.8	68.8	79.1	88.2	98.7	100.7	108.6	114.4	119.0	128.0
650	PIPE TEMP	601.8	600.7	593.3	585.0	580.0	578.2	560.1	559.4	543.4	523.0	490.3	460.9	434.9	407.2	401.7	384.3	371.7	358.9	338.3
	MAX.W /FT	34.3	34.7	39.0	44.0	44.8	45.1	55.8	56.0	65.5	75.5	88.4	98.3	104.7	117.7	119.9	129.5	136.3	141.7	152.2
	MIN.W /FT	31.3	31.7	35.1	39.2	40.3	40.5	48.7	49.5	56.5	64.6	76.6	88.0	98.0	109.5	111.7	120.4	126.6	131.6	141.0
700	PIPE TEMP	646.1	645.0	636.8	627.6	622.2	620.3	600.3	599.6	582.0	559.7	523.8	491.6	463.2	433.0	427.2	408.2	394.6	380.7	358.4
	MAX.W /FT	38.4	38.9	43.7	49.2	50.0	50.3	62.3	62.5	72.8	83.9	98.0	108.7	115.6	129.8	132.0	142.5	149.9	155.8	167.1
	MIN.W /FT	35.0	35.4	39.2	43.7	44.9	45.0	54.2	55.0	62.6	71.5	84.6	97.0	107.9	120.6	122.9	132.3	139.1	144.7	155.3
750	PIPE TEMP	690.4	689.2	680.2	670.2	664.2	662.2	640.3	639.6	620.5	596.1	557.2	522.2	491.3	458.5	452.4	431.9	417.2	402.2	378.3
	MAX.W /FT	42.8	43.3	48.6	54.6	55.4	55.7	68.9	68.9	80.4	92.5	107.8	119.3	126.6	142.3	144.6	155.7	163.6	170.0	182.3
	MIN.W /FT	38.8	39.3	43.5	48.4	49.4	49.7	59.7	60.6	68.9	78.6	92.8	106.3	118.1	131.4	134.2	144.5	152.3	157.8	169.2
800	PIPE TEMP	734.5	733.3	723.5	712.5	706.1	704.0	680.1	679.5	658.8	632.4	590.3	552.6	519.1	483.6	477.3	455.3	439.6	423.5	398.0
	MAX.W /FT	47.4	47.9	53.7	60.3	61.1	61.2	75.8	75.7	89.3	101.4	117.8	130.2	137.9	154.6	157.0	169.2	177.9	184.5	197.6
	MIN.W /FT	42.9	43.3	47.9	53.2	54.4	54.6	65.5	66.3	75.4	85.8	101.2	115.7	128.5	143.3	145.8	156.8	164.8	171.0	183.3
850	PIPE TEMP	778.5	777.2	766.7	754.8	747.9	745.6	719.9	719.2	696.9	668.5	623.2	582.5	546.7	508.8	502.1	478.5	461.7	444.6	417.5
	MAX.W /FT	52.2	52.3	59.0	66.2	66.9	67.1	83.0	82.7	96.5	110.7	128.2	141.3	149.4	167.4	169.9	183.0	192.2	199.3	213.2
	MIN.W /FT	47.1	47.5	52.5	58.3	59.5	59.6	71.5	72.3	82.1	93.3	109.8	125.4	139.0	154.9	157.5	169.3	177.9	184.5	197.5
900	PIPE TEMP	822.4	821.1	809.7	796.9	789.6	787.2	759.4	758.8	734.9	704.4	656.0	612.5	574.2	533.7	526.6	501.5	483.7	465.6	436.7
	MAX.W /FT	57.1	57.8	64.7	72.4	73.0	73.2	90.6	90.1	105.1	120.4	139.0	152.8	161.2	180.4	183.0	197.0	206.6	214.4	229.2
	MIN.W /FT	51.5	51.9	57.3	63.6	64.7	64.8	77.7	78.5	89.1	101.1	118.6	135.3	149.9	166.8	169.5	182.1	191.2	198.2	212.0
950	PIPE TEMP	866.2	864.9	852.7	839.0	831.1	828.6	798.9	798.3	772.7	740.2	688.7	642.2	601.4	558.4	551.0	524.4	505.5	486.4	455.9
	MAX.W /FT	62.7	63.2	70.8	79.1	79.5	79.6	98.6	97.9	114.1	130.5	150.2	164.7	173.4	193.9	196.5	211.6	221.8	229.7	245.9
	MIN.W /FT	56.2	56.6	62.5	69.2	70.3	70.3	84.3	85.0	96.4	109.2	127.8	145.5	160.9	179.0	181.8	195.2	204.8	212.2	226.8

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-61

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 90.0 F (32.2 C)

CABLE TEMP DEG F		PIPE SIZE																	
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
100	PIPE TEMP	99.5	99.4	99.4	99.3	99.2	99.2	99.0	98.9	98.7	98.4	97.9	97.5	97.1	96.7	96.6	96.3	96.0	95.8	95.4
	MAX.W /FT	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.9	1.1	1.2	1.4	1.5	1.6	1.7	1.9	2.0	2.1
	MIN.W /FT	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8	1.0	1.1	1.3	1.5	1.5	1.7	1.8	1.9	2.1
120	PIPE TEMP	118.4	118.3	118.2	117.8	117.5	117.4	116.8	116.7	116.1	115.2	113.8	112.5	111.3	110.0	109.6	108.8	108.1	107.3	106.2
	MAX.W /FT	1.1	1.2	1.2	1.4	1.5	1.5	1.8	1.9	2.2	2.6	3.2	3.6	4.1	4.6	4.8	5.3	5.6	5.9	6.5
	MIN.W /FT	1.0	1.1	1.1	1.3	1.4	1.4	1.7	1.8	2.1	2.4	3.0	3.4	3.9	4.4	4.6	5.0	5.4	5.6	6.2
140	PIPE TEMP	137.3	137.1	136.9	136.3	135.8	135.6	134.6	134.4	133.4	132.0	129.5	127.5	125.3	123.3	122.6	121.1	120.0	118.8	116.8
	MAX.W /FT	1.9	2.0	2.0	2.4	2.5	2.6	3.1	3.3	3.8	4.6	5.4	6.0	6.9	7.6	8.1	8.8	9.4	9.9	10.9
	MIN.W /FT	1.8	1.9	1.9	2.2	2.4	2.4	2.9	3.0	3.5	4.0	5.0	5.8	6.6	7.5	7.7	8.4	9.0	9.5	10.4
160	PIPE TEMP	156.1	155.9	155.6	154.7	154.1	153.8	152.3	152.0	150.6	148.6	145.1	142.3	139.3	136.4	135.4	133.4	131.8	130.2	127.4
	MAX.W /FT	2.7	2.8	2.8	3.4	3.6	3.7	4.4	4.6	5.4	6.2	7.6	8.5	9.7	11.0	11.4	12.4	13.3	14.0	15.3
	MIN.W /FT	2.5	2.6	2.7	3.2	3.4	3.5	4.1	4.3	4.9	5.7	7.1	8.1	9.3	10.5	10.9	11.9	12.7	13.3	14.6
180	PIPE TEMP	174.9	174.6	174.3	173.1	172.3	171.9	170.0	169.6	167.8	165.2	160.7	157.0	153.2	149.4	148.2	145.6	143.6	141.5	138.0
	MAX.W /FT	3.5	3.7	3.7	4.4	4.7	4.8	5.8	6.0	7.0	8.1	9.9	11.0	12.6	14.2	14.8	16.1	17.2	18.0	19.6
	MIN.W /FT	3.3	3.5	3.5	4.1	4.4	4.5	5.4	5.6	6.4	7.5	9.2	10.6	12.1	13.6	14.1	15.4	16.4	17.2	18.8
200	PIPE TEMP	193.6	193.3	192.9	191.4	190.4	190.0	187.6	187.1	184.9	181.7	176.2	171.7	167.0	162.3	160.9	157.7	155.2	152.6	148.4
	MAX.W /FT	4.4	4.6	4.6	5.5	5.9	6.0	7.2	7.5	8.7	10.1	12.2	13.6	15.5	17.6	18.2	19.8	21.1	22.2	24.3
	MIN.W /FT	4.2	4.3	4.4	5.1	5.5	5.6	6.7	7.0	8.0	9.2	11.3	13.0	14.9	16.8	17.4	18.9	20.1	21.2	23.1
220	PIPE TEMP	212.3	211.9	211.5	209.7	208.5	208.0	205.1	204.6	201.9	198.1	191.6	186.3	180.7	175.2	173.5	169.8	166.8	163.7	158.7
	MAX.W /FT	5.3	5.5	5.5	6.6	7.0	7.2	8.7	9.0	10.4	12.1	14.6	16.2	18.5	20.9	21.6	23.6	25.1	26.4	28.8
	MIN.W /FT	5.0	5.2	5.2	6.2	6.6	6.7	8.0	8.3	9.5	11.0	13.5	15.5	17.7	20.0	20.7	22.5	23.9	25.1	27.5
240	PIPE TEMP	231.0	230.5	230.0	227.9	226.5	226.0	222.6	222.0	218.9	214.5	206.9	200.8	194.3	187.9	186.0	181.7	178.3	174.8	169.0
	MAX.W /FT	6.2	6.5	6.5	7.7	8.2	8.4	10.1	10.5	12.1	14.1	17.0	18.8	21.5	24.3	25.1	27.4	29.1	30.6	33.4
	MIN.W /FT	5.9	6.1	6.1	7.2	7.7	7.9	9.4	9.8	11.1	12.9	15.7	18.1	20.6	23.2	24.0	26.1	27.8	29.2	31.7
260	PIPE TEMP	249.5	249.1	248.5	246.1	244.5	243.9	240.0	239.4	235.8	230.8	222.2	215.2	207.8	200.6	198.5	193.6	189.7	185.7	179.2
	MAX.W /FT	7.2	7.4	7.5	8.9	9.5	9.7	11.7	12.1	13.9	16.2	19.5	21.5	24.6	27.8	28.7	31.2	33.2	34.9	38.1
	MIN.W /FT	6.8	7.0	7.1	8.3	8.9	9.0	10.7	11.2	12.7	14.7	18.0	20.6	23.5	26.5	27.4	29.7	31.6	33.2	36.2
280	PIPE TEMP	268.1	267.6	267.0	264.2	262.4	261.7	257.4	256.7	252.6	247.0	237.3	229.5	221.3	213.2	210.8	205.4	201.1	196.6	189.3
	MAX.W /FT	8.2	8.5	8.5	10.1	10.8	10.9	13.2	13.7	15.8	18.3	22.0	24.2	27.7	31.3	32.3	35.1	37.3	39.2	42.8
	MIN.W /FT	7.7	7.9	8.0	9.4	10.1	10.2	12.2	12.7	14.6	16.6	20.3	23.3	26.5	29.8	30.8	33.4	35.5	37.3	40.7
300	PIPE TEMP	286.6	286.1	285.4	282.3	280.3	279.6	274.7	273.9	269.4	263.2	252.5	243.8	234.7	225.7	223.1	217.1	212.4	207.4	199.4
	MAX.W /FT	9.2	9.5	9.5	11.4	12.1	12.3	14.8	15.3	17.6	20.4	24.6	27.0	30.8	34.8	35.9	39.0	41.5	43.5	47.5
	MIN.W /FT	8.7	8.9	9.0	10.6	11.3	11.4	13.6	14.2	16.1	18.6	22.6	25.9	29.5	33.2	34.2	37.2	39.5	41.4	45.1
350	PIPE TEMP	332.3	332.1	331.2	327.3	324.8	323.9	317.7	316.8	311.1	303.3	289.9	279.1	267.8	256.6	253.6	246.0	240.2	234.1	224.3
	MAX.W /FT	11.9	12.3	12.2	14.6	15.5	15.7	18.9	19.5	22.5	26.0	31.1	34.1	38.8	43.6	45.1	49.0	52.1	54.6	59.4
	MIN.W /FT	11.2	11.5	11.5	13.6	14.4	14.6	17.6	18.0	20.6	23.6	28.6	32.7	37.1	41.7	43.0	46.0	48.5	51.9	56.5
400	PIPE TEMP	378.5	377.6	376.9	372.1	369.0	368.0	360.5	359.4	352.5	343.1	327.0	314.1	300.5	287.0	283.5	274.5	267.6	260.4	248.8
	MAX.W /FT	14.8	15.2	15.1	18.0	19.1	19.3	23.3	23.9	27.5	31.8	37.9	41.4	47.1	53.1	54.6	59.2	62.9	65.8	71.6
	MIN.W /FT	13.9	14.2	14.2	16.7	17.7	17.9	21.3	22.0	25.0	28.7	34.8	39.6	44.9	50.5	51.9	56.3	59.7	62.5	68.0
450	PIPE TEMP	424.2	423.4	422.3	416.6	413.0	411.8	402.9	401.7	393.6	382.5	363.7	348.8	332.8	317.0	313.1	302.7	294.7	286.4	272.9
	MAX.W /FT	17.9	18.3	18.1	21.6	22.8	23.1	27.8	28.6	32.8	37.8	45.0	49.0	55.6	62.8	64.2	69.7	73.9	77.3	84.0
	MIN.W /FT	16.7	17.0	17.0	20.0	21.2	21.4	25.3	26.2	29.7	34.1	41.1	46.8	53.0	59.5	61.1	66.2	70.1	73.4	79.7
500	PIPE TEMP	465.5	464.7	463.5	460.8	458.7	458.4	448.0	447.3	438.4	427.6	408.1	392.7	376.8	360.8	356.7	342.3	330.4	321.4	312.0	296.7
	MAX.W /FT	21.1	21.5	21.3	25.4	26.8	27.0	32.6	33.4	38.2	44.0	52.2	56.7	64.2	72.3	74.1	80.3	85.1	89.0	96.6
	MIN.W /FT	19.4	20.0	19.9	23.4	24.8	25.0	29.6	30.6	34.5	39.8	47.6	54.1	61.2	68.6	70.4	76.2	80.7	84.4	91.5
550	PIPE TEMP	514.7	513.9	512.5	506.8	502.2	498.8	486.9	485.5	475.0	460.5	436.1	416.5	396.3	375.9	371.2	357.6	347.7	337.2	322.7
	MAX.W /FT	24.5	24.9	24.6	29.6	30.9	31.1	37.5	38.3	43.9	50.5	59.7	64.7	73.1	82.2	84.2	91.2	96.5	102.9	109.3
	MIN.W /FT	22.7	23.1	22.9	27.0	28.5	28.7	34.0	35.0	39.5	45.3	54.3	61.7	69.5	77.9	79.9	86.4	91.4	95.8	103.5
600	PIPE TEMP	555.7	554.6	553.4	548.7	543.4	542.0	528.6	527.1	515.3	499.0	471.9	450.0	427.6	404.8	399.7	384.4	373.7	362.1	346.3
	MAX.W /FT	28.1	28.5	28.0	33.5	35.1	35.3	42.6	43.5	49.7	57.1	67.3	72.8	82.2	92.3	94.6	102.2	108.2	113.0	122.3
	MIN.W /FT	26.0	26.3	26.1	30.7	32.4	32.5	38.5	39.7	44.7	51.1	61.2	69.4	78.1	87.4	89.5	96.8	102.4	106.9	115.7
650	PIPE TEMP	604.5	603.6	602.1	592.4	586.6	585.0	570.1	568.4	555.4	537.3	507.1	483.2	458.5	433.5	427.9	411.6	399.6	386.7	366.6
	MAX.W /FT	31.8	32.2	31.8	37.7	39.5	39.7	47.8	48.8	55.8	63.9	75.2	81.1	91.6	102.6	104.9	113.5	120.0	125.2	135.4
	MIN.W /FT	29.3	29.7	29.6	34.5	36.4	36.5	44.1	44.9	49.9	57.1	68.1	77.2	86.8	97.1	99.3	107.3	113.4	118.4	128.2
700	PIPE TEMP	645.2	644.2	642.6	635.9	629.5	627.8	611.3	609.6	595.2	575.6	542.5	516.0	489.1	461.4	455.4	438.1	426.0	411.1	388.6
	MAX.W /FT	35.2	36.1	35.3	42.1	44.1	44.3	53.3	54.3	62.0	71.0	83.2	89.6	100.6	113.1	115.5	124.9	132.3	137.7	149.2
	MIN.W /FT	32.8	33.2	32.8	38.5	40.5	40.6	47.9	49.3	55.4	63.2	75.3	85.2	95.7	106.9	109.3	118.0	124.7	130.0	140.9
750	PIPE TEMP	693.8	692.6	691.0	679.2	672.3	670.3	652.5	650.6	634.9	613.3	577.5	548.6	519.4	489.8	483.5	464.3	452.3	435.2	411....
	MAX.W /FT	39.2	40.1	39.2	46.7	48.9	49.2	58.9	59.9	68.4	78.2	91.5	98.3	110.5	123.6	126.4	136.5	144.4	150.1	162....
	MIN.W /FT	36.4	36.8	36.3	42.6	44.7	44.8	52.8	54.3	60.9	69.4	82.6	93.4	104.7	116.9	119.5	128.9	136.0	141.6	153.1
800	PIPE TEMP	738.3	737.2	735.4	722.5	715.0	713.0	693.4	691.5	674.5	651.1	612.3	581.0	549.5	517.6	510.9	490.1	476.4	459.0	433.7
	MAX.W /FT	43.6	44.3	43.2	51.5	53.7	53.8	64.7	65.8	75.0	85.6	99.9	107.1	120.1	134.7	137.6	148.6	156.8	163.1	177.1
	MIN.W /FT	40.2	40.5	39.9	46.8	48.1	48.2	57.9	59.5	66.7	75.9	90.1	101.7	113.9	127.1	129.8	139.9	147.8	153.8	167.6
850	PIPE TEMP	782.6	781.5	779.6	765.6	757.5	755.4	734.2	732.2	713.9	688.6	646.9	613.2	579.4	545.2	536.1	516.0	499.6	482.6	455.1
	MAX.W /FT	48.2	48.7	47.9	56.9	58.8	58.9	70.7	71.8	81.8	93.3	108.8	116.2	130.3	145.8	148.8	160.4	169.2	176.2	191.4
	MIN.W /FT	44.1	44.4	43.7	51.2	53.0	53.1	63.1	64.8	72.6	82.5	97.7	110.2	123.3	137.4	140.3	151.1	159.4	166.0	179.8
900	PIPE TEMP	826.5	825.4	823.7	808.6	799.9	797.7	774.9	772.7	753.1	726.0	681.3	645.2	609.1	572.8	563.1	541.8	524.1	506.1	477.1
	MAX.W /FT	52.5	53.1	51.7	61.6	64.0	64.1	77.0	78.1	89.0	101.3	117.6	125.5	140.8	157.4	160.6	172.7	182.6	189.9	206.7
	MIN.W /FT	48.1	48.5	47.6	55.7	58.3	58.3	68.6	70.3	78.7	89.3	105.8	119.0	132.9	148.0	150.9	162.5	171.1	178.3	192.6
950	PIPE TEMP	871.1	869.9	867.7	851.6	842.2	839.9	815.5	813.1	792.2	763.2	715.6	677.0	636.7	598.6	592.0	567.6	548.5	529.4	498.7
	MAX.W /FT	57.7	58.2	56.3	67.1	69.6	69.7	83.7	84.7	96.4	109.7	126.9	135.1	151.2	168.8	171.9	185.2	195.1	203.0	218.3
	MIN.W /FT	52.5	52.8	51.7	60.5	63.2	63.2	74.3	76.0	85.1	96.6	113.7	127.9	142.8	158.6	161.9	174.2	183.5	190.9	205.3

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-6

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

2-1/2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 90.0 F (32.2 C)

CABLE TEMP DEG F		PIPE SIZE																	
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
100	PIPE TEMP	99.5	99.5	99.4	99.3	99.2	99.2	99.0	99.0	98.8	98.6	98.1	97.8	97.4	97.0	96.9	96.6	96.4	96.2	95.8
	PAR.h /FT	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.1	1.2	1.4	1.4	1.6	1.7	1.8	1.9
	PIN.h /FT	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.9	1.0	1.2	1.3	1.4	1.5	1.6	1.7	1.9
120	PIPE TEMP	118.5	118.4	118.3	118.0	117.7	117.6	117.1	116.9	116.4	115.7	114.3	113.2	112.1	111.0	110.6	109.8	109.1	108.5	107.3
	PAR.h /FT	1.0	1.1	1.1	1.3	1.4	1.4	1.7	1.8	2.0	2.3	2.8	3.2	3.7	4.1	4.3	4.7	5.0	5.3	5.9
	PIN.h /FT	1.0	1.0	1.0	1.2	1.3	1.3	1.6	1.7	1.9	2.2	2.7	3.1	3.6	4.0	4.2	4.5	4.9	5.1	5.7
140	PIPE TEMP	137.5	137.3	137.1	136.6	136.1	135.9	135.0	134.8	133.9	132.8	130.4	128.6	126.7	124.8	124.2	122.9	121.8	120.7	118.8
	PAR.h /FT	1.7	1.8	1.8	2.2	2.3	2.4	2.8	3.0	3.4	3.9	4.8	5.4	6.2	7.0	7.3	7.9	8.5	8.9	9.8
	PIN.h /FT	1.6	1.7	1.8	2.1	2.2	2.3	2.7	2.8	3.2	3.6	4.5	5.2	6.0	6.7	7.0	7.6	8.2	8.6	9.5
160	PIPE TEMP	156.4	156.2	155.9	155.1	154.5	154.2	153.0	152.6	151.6	149.7	146.4	144.0	141.3	138.6	137.7	135.9	134.4	132.8	130.2
	PAR.h /FT	2.6	2.5	2.6	3.1	3.3	3.4	4.0	4.2	4.8	5.5	6.8	7.6	8.7	9.8	10.2	11.2	11.9	12.6	13.8
	PIN.h /FT	2.3	2.4	2.5	2.9	3.2	3.2	3.8	4.0	4.5	5.2	6.4	7.4	8.4	9.5	9.9	10.7	11.5	12.1	13.3
180	PIPE TEMP	175.3	175.0	174.6	173.6	172.8	172.5	170.8	170.4	168.8	166.7	162.4	159.2	155.7	152.3	151.2	148.8	146.9	144.8	141.5
	PAR.h /FT	3.2	3.3	3.4	4.0	4.3	4.4	5.2	5.5	6.3	7.1	8.8	9.9	11.3	12.6	13.2	14.4	15.4	16.3	17.9
	PIN.h /FT	3.1	3.2	3.3	3.8	4.1	4.2	4.9	5.2	5.9	6.7	8.3	9.5	10.9	12.3	12.8	13.9	14.8	15.7	17.2
200	PIPE TEMP	194.1	193.8	193.3	192.1	191.1	190.7	188.6	188.1	186.2	183.5	178.3	174.4	170.1	165.9	164.6	161.6	159.3	156.8	152.7
	PAR.h /FT	4.0	4.1	4.3	5.0	5.4	5.5	6.5	6.8	7.7	8.8	10.8	12.2	13.9	15.7	16.3	17.8	19.0	20.0	22.0
	PIN.h /FT	3.8	3.9	4.1	4.7	5.1	5.2	6.1	6.4	7.3	8.3	10.3	11.8	13.4	15.1	15.7	17.1	18.3	19.2	21.1
220	PIPE TEMP	212.9	212.6	212.0	210.5	209.3	208.8	206.4	205.8	203.5	200.3	194.1	189.5	184.4	179.4	177.9	174.4	171.6	168.7	163.8
	PAR.h /FT	4.8	5.0	5.1	6.0	6.4	6.6	7.8	8.1	9.3	10.6	12.9	14.5	16.6	18.7	19.4	21.1	22.6	23.8	26.1
	PIN.h /FT	4.6	4.7	4.9	5.7	6.1	6.2	7.3	7.7	8.7	9.9	12.3	14.0	16.0	18.0	18.7	20.3	21.7	22.9	25.1
240	PIPE TEMP	231.6	231.3	230.6	228.8	227.6	227.0	224.1	223.4	220.7	217.1	209.9	204.5	198.6	192.9	191.1	187.1	183.9	180.5	176.9
	PAR.h /FT	5.7	5.8	6.0	7.0	7.5	7.7	9.1	9.5	10.8	12.3	15.1	16.9	19.3	21.6	22.5	24.5	26.2	27.6	30.3
	PIN.h /FT	5.4	5.6	5.7	6.7	7.2	7.3	8.5	9.0	10.1	11.5	14.3	16.3	18.6	21.0	21.7	23.6	25.2	26.5	29.1
260	PIPE TEMP	250.4	250.0	249.2	247.2	245.6	245.0	241.7	241.0	237.9	233.7	225.6	219.4	212.8	206.2	204.2	199.7	196.1	192.2	185.9
	PAR.h /FT	6.5	6.7	6.9	8.1	8.7	8.8	10.5	10.9	12.4	14.1	17.3	19.3	22.0	24.8	25.7	28.0	29.8	31.4	34.5
	PIN.h /FT	6.2	6.4	6.6	7.7	8.2	8.4	9.8	10.3	11.6	13.2	16.3	18.6	21.2	23.9	24.7	26.9	28.7	30.2	33.1
280	PIPE TEMP	269.0	268.6	267.8	265.6	263.7	263.1	259.3	258.5	255.0	250.4	241.2	234.3	226.9	219.5	217.3	212.3	208.2	203.9	196.9
	PAR.h /FT	7.4	7.6	7.8	9.2	9.8	10.0	11.8	12.4	14.0	15.9	19.5	21.7	24.8	27.9	28.9	31.5	33.5	35.3	38.7
	PIN.h /FT	7.1	7.3	7.4	8.7	9.3	9.5	11.0	11.6	13.1	14.9	18.4	21.0	23.9	26.9	27.8	30.2	32.2	33.9	37.2
300	PIPE TEMP	287.7	287.2	286.3	283.7	281.7	281.1	276.9	276.0	272.1	266.9	256.7	249.1	240.9	232.7	230.3	224.7	220.2	215.5	207.7
	PAR.h /FT	8.3	8.6	8.7	10.3	11.0	11.2	13.3	13.8	15.7	17.8	21.7	24.2	27.6	31.1	32.1	35.0	37.3	39.2	43.0
	PIN.h /FT	7.9	8.1	8.3	9.7	10.4	10.6	12.4	13.0	14.6	16.6	20.5	23.4	26.6	29.9	30.9	33.6	35.9	37.7	41.3
320	PIPE TEMP	334.1	333.6	332.5	329.1	326.6	325.5	320.5	319.5	314.6	308.1	295.6	285.9	275.7	265.6	262.6	255.6	250.1	244.2	234.6
	PAR.h /FT	10.4	11.0	11.2	13.2	14.1	14.3	16.9	17.6	20.0	22.6	27.5	30.5	34.7	39.2	40.4	43.9	46.8	49.2	53.8
	PIN.h /FT	10.2	10.4	10.7	12.5	13.3	13.5	15.8	16.5	18.6	21.1	25.9	29.5	33.5	37.6	38.8	42.2	44.9	47.2	51.6
340	PIPE TEMP	380.3	379.7	378.4	374.3	371.3	370.4	363.9	362.7	356.8	348.9	333.6	322.3	310.0	297.7	294.4	286.1	279.5	272.5	261.2
	PAR.h /FT	13.3	13.6	13.8	16.3	17.4	17.5	20.8	21.6	24.6	27.6	33.5	37.1	42.1	47.4	48.8	53.1	56.5	59.3	64.9
	PIN.h /FT	12.8	12.9	13.1	15.3	16.4	16.5	19.4	20.2	22.7	25.7	31.5	35.8	40.5	45.5	46.9	50.9	54.2	56.9	62.2
360	PIPE TEMP	426.3	425.7	424.2	419.2	415.7	414.7	407.C	405.6	398.7	389.5	371.5	358.3	344.0	329.6	325.9	316.1	308.5	300.3	287.3
	PAR.h /FT	16.1	16.4	16.6	19.5	20.8	20.9	24.8	25.7	29.0	32.8	39.6	43.8	49.7	55.9	57.5	62.5	66.4	69.7	76.1
	PIN.h /FT	15.2	15.4	15.7	18.3	19.6	19.7	23.1	24.C	26.9	30.5	37.3	42.2	47.8	53.6	55.2	59.9	63.6	66.8	72.9
380	PIPE TEMP	472.1	471.4	469.7	464.C	459.9	458.8	449.9	448.3	440.4	429.7	409.1	393.9	377.6	361.2	357.0	345.9	337.2	328.1	313.2
	PAR.h /FT	18.5	19.3	19.5	22.9	24.3	24.5	29.0	30.C	33.9	38.2	46.0	50.7	57.4	64.6	66.3	72.C	76.5	80.2	87.5
	PIN.h /FT	17.5	18.1	18.4	21.5	22.9	23.C	26.9	28.0	31.3	35.4	43.2	48.9	55.2	61.9	63.6	69.0	73.3	76.8	83.7
400	PIPE TEMP	517.7	517.C	515.1	508.5	503.9	502.7	492.5	490.8	481.8	469.7	446.6	429.2	410.9	392.3	387.7	375.3	365.6	355.6	338.7
	PAR.h /FT	22.C	22.3	22.5	26.4	28.C	28.2	33.3	34.5	38.8	43.7	52.5	57.8	65.3	73.4	75.4	81.7	86.8	91.C	99.1
	PIN.h /FT	20.7	20.9	21.3	24.7	26.3	26.4	30.9	32.1	35.8	40.5	49.3	55.4	62.8	70.3	72.2	78.3	83.0	87.0	94.8
420	PIPE TEMP	563.2	562.4	560.3	552.6	547.7	546.4	536.9	535.0	525.9	509.6	483.6	464.3	443.8	423.2	418.1	404.3	393.6	382.3	363.9
	PAR.h /FT	25.1	25.4	25.6	30.1	31.9	32.C	37.8	39.1	44.3	49.5	59.2	65.1	73.5	82.4	84.6	91.7	97.2	101.9	111.6
	PIN.h /FT	23.6	23.9	24.2	28.1	29.8	30.C	35.0	36.4	40.5	45.7	55.5	62.0	70.5	78.9	81.0	87.7	93.3	97.9	106.9
440	PIPE TEMP	608.5	607.7	605.4	597.1	591.3	589.6	577.3	575.0	563.9	548.9	520.1	499.0	476.4	453.7	448.2	433.1	421.3	409.0	388.9
	PAR.h /FT	28.4	28.7	28.9	33.9	35.8	36.C	42.5	43.8	49.3	55.4	66.1	72.5	81.7	91.C	93.9	101.C	107.4	112.4	122.7
	PIN.h /FT	26.6	26.9	27.2	31.6	33.5	33.6	39.2	40.7	45.3	51.0	61.9	69.2	78.4	87.7	89.9	97.3	103.1	107.9	117.2
460	PIPE TEMP	653.2	652.0	650.3	641.1	634.8	633.3	619.1	616.5	604.7	588.2	556.5	533.4	508.6	484.0	478.1	461.6	448.6	435.6	413.5
	PAR.h /FT	31.8	32.1	32.3	37.9	40.C	40.1	47.3	48.7	54.8	61.6	73.2	80.1	90.2	101.C	104.3	112.C	118.7	123.2	134.8
	PIN.h /FT	29.7	30.C	30.3	35.2	37.3	37.4	43.5	45.2	50.2	56.5	68.4	76.9	86.5	96.6	99.0	107.0	113.3	118.6	128.7
480	PIPE TEMP	698.7	697.8	695.2	685.C	678.1	676.5	661.C	658.4	645.2	627.2	592.8	567.6	540.9	513.9	507.7	489.7	475.9	461.5	437.9
	PAR.h /FT	35.1	35.7	35.8	41.9	44.2	44.3	52.2	53.7	60.4	67.6	80.4	87.9	98.4	110.C	113.2	122.5	129.7	135.6	147.1
	PIN.h /FT	33.C	33.3	33.6	38.9	41.2	41.2	48.0	49.8	55.3	62.1	75.1	84.3	94.6	105.8	108.2	118.9	125.8	131.6	142.6
500	PIPE TEMP	743.7	742.7	739.9	728.8	721.3	719.6	702.8	700.2	685.7	666.1	628.8	601.6	572.6	543.7	537.0	517.7	502.9	487.3	462.1
	PAR.h /FT	39.C	39.4	39.6	46.2	48.6	48.3	57.4	58.9	66.2	74.0	87.8	95.8	107.8	120.3	123.1	133.1	140.9	147.2	159.6
	PIN.h /FT	36.3	36.6	36.9	42.8	45.2	45.3	52.6	54.3	60.5	67.9	81.9	91.9	103.0	114.8	117.6	127.0	134.3	140.4	152.1
520	PIPE TEMP	788.5	787.4	784.5	772.5	764.4	762.5	744.4	741.6	726.0	706.9	666.7	635.3	606.4	573.2	566.1	545.3	529.6	513.0	486.1
	PAR.h /FT	42.8	43.2	43.1	50.5	53.1	53.2	62.6	64.3	72.2	80.6	95.4	103.5	116.8	130.3	133.2	143.9	151.2	159.0	172.2
	PIN.h /FT	39.6	40.1	40.4	46.7	49.3	49.4	57.3	59.4	65.8	73.6	88.9	99.6	111.5	124.2	127.1	137.2	145.0	151.5	166.0
540	PIPE TEMP	833.3	832.3	829.0	816.1	807.4	805.4	785.8	782.9	766.1	745.8	730.3	666.9	635.9	602.5	595.0	573.0	556.2	538.5	509.9
	PAR.h /FT	46.8	47.2	47.C	55.1	57.8	57.5	68.1	69.9	78.4	87.4	103.2	112.3	125.8	140.4	143.5	154.9	163.4	171.3	185.3
	PIN.h /FT	43.5	43.8	44.0	50.8	53.4	53.7	62.2	64.4	71.4	79.9	96.0	107.5	120.2	133.8	136.8	147.6	156.0	162.8	178.1
560	PIPE TEMP	878.0	877.C	873.5	859.6	850.3	848.2	827.2	824.0	806.1	781.8	735.8	702.2	667.1	631.7	623.8	600.9	582.5	563.8	533.5
	PAR.h /FT	51.C	51.4	51.1	59.9	62.7	62.6	73.9	75.7	84.8	94.5	111.3	120.8	135.2	150.8	154.0	166.2	175.6	184.2	199.-
	PIN.h /FT	47.3	47.6	47.7	55.1	58.1	58.1	67.3	69.6	77.1	86.2	103.4	115.6	129.1	143.6	146.8	158.2	167.1	174.3	188.4

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-63

ELECTRIC HEAT TRACING - MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 90 0 F (32.2 C)

CABLE TEMP DEG F		PIPE SIZE																	
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
100	PIPE TEMP	99.5	99.5	99.5	99.4	99.3	99.3	99.1	99.1	98.9	98.7	98.3	97.9	97.6	97.3	97.1	96.9	96.7	96.5	96.1
	MAX.W /FT	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.8	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.8
	MIN.W /FT	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.1	1.2	1.3	1.4	1.5	1.6	1.7
120	PIPE TEMP	118.6	118.5	118.4	118.1	117.8	117.7	117.3	117.1	116.7	116.0	114.8	113.8	112.7	111.7	111.3	110.6	110.0	109.4	108.3
	MAX.W /FT	0.9	1.0	1.0	1.2	1.3	1.3	1.5	1.6	1.8	2.1	2.5	2.9	3.3	3.8	3.9	4.3	4.6	4.9	5.4
	MIN.W /FT	0.9	0.9	1.0	1.1	1.2	1.3	1.5	1.5	1.7	2.0	2.5	2.8	3.3	3.7	3.8	4.2	4.5	4.7	5.2
140	PIPE TEMP	137.4	137.3	137.3	136.8	136.3	136.2	135.4	135.2	134.4	133.3	131.2	129.6	127.8	126.1	125.5	124.3	123.3	122.2	120.4
	MAX.W /FT	1.6	1.7	1.7	2.0	2.2	2.2	2.6	2.7	3.1	3.5	4.2	4.9	5.6	6.3	6.6	7.2	7.7	8.2	9.0
	MIN.W /FT	1.5	1.6	1.7	1.9	2.1	2.1	2.5	2.6	2.9	3.4	4.1	4.8	5.5	6.2	6.4	7.0	7.5	7.9	8.7
160	PIPE TEMP	156.6	156.4	156.1	155.4	154.8	154.6	153.4	153.2	152.1	150.5	147.6	145.3	142.8	140.4	139.6	137.8	136.4	134.9	132.4
	MAX.W /FT	2.3	2.4	2.5	2.9	3.1	3.2	3.7	3.8	4.3	5.0	6.0	6.9	7.9	9.0	9.3	10.2	10.9	11.5	12.7
	MIN.W /FT	2.2	2.3	2.4	2.7	3.0	3.0	3.5	3.7	4.1	4.8	5.9	6.8	7.7	8.7	9.0	9.9	10.5	11.1	12.3
180	PIPE TEMP	175.5	175.3	174.9	174.0	173.2	172.9	171.4	171.1	169.7	167.6	163.9	160.9	157.7	154.6	153.6	151.4	149.5	147.6	144.4
	MAX.W /FT	3.0	3.1	3.2	3.7	4.0	4.1	4.8	5.0	5.6	6.5	7.8	9.0	10.3	11.6	12.1	13.2	14.1	14.9	16.4
	MIN.W /FT	2.9	3.0	3.1	3.6	3.9	3.9	4.6	4.8	5.4	6.2	7.6	8.8	10.0	11.3	11.7	12.7	13.6	14.4	15.9
200	PIPE TEMP	194.4	194.2	193.7	192.5	191.6	191.2	189.4	189.0	187.3	184.7	180.2	176.4	172.6	168.7	167.5	166.8	162.5	160.2	156.2
	MAX.W /FT	3.7	3.9	4.0	4.6	5.0	5.1	6.0	6.2	7.0	8.0	9.6	11.1	12.7	14.3	14.8	16.2	17.3	18.3	20.2
	MIN.W /FT	3.6	3.7	3.8	4.4	4.8	4.9	5.7	5.9	6.7	7.7	9.4	10.8	12.3	13.9	14.4	15.7	16.4	17.7	19.5
220	PIPE TEMP	213.3	213.0	212.4	211.0	209.9	209.5	207.5	206.8	204.8	201.8	196.4	191.9	187.3	182.8	181.3	178.1	175.5	172.7	168.0
	MAX.W /FT	4.5	4.6	4.8	5.6	6.0	6.1	7.1	7.4	8.4	9.6	11.5	13.2	15.1	17.0	17.7	19.2	20.6	21.7	23.9
	MIN.W /FT	4.3	4.4	4.6	5.3	5.7	5.8	6.8	7.1	7.9	9.1	11.2	12.9	14.7	16.5	17.1	18.6	19.9	21.0	23.2
240	PIPE TEMP	232.1	231.8	231.1	229.5	228.2	227.7	225.2	224.6	222.3	218.7	212.5	207.4	202.0	196.8	195.1	191.4	188.4	185.1	179.8
	MAX.W /FT	5.3	5.4	5.6	6.5	7.0	7.1	8.3	8.7	9.7	11.2	13.4	15.4	17.5	19.8	20.5	22.3	23.9	25.2	27.8
	MIN.W /FT	5.1	5.2	5.4	6.2	6.7	6.8	7.9	8.3	9.3	10.7	13.0	15.0	17.0	19.2	19.9	21.6	23.1	24.4	26.8
260	PIPE TEMP	250.9	250.6	249.8	248.0	246.6	245.9	243.0	242.4	235.7	235.7	228.6	222.8	216.7	210.7	208.8	204.6	201.2	197.5	191.4
	MAX.W /FT	6.1	6.2	6.4	7.5	8.1	8.2	9.6	9.9	11.2	12.8	15.3	17.6	20.0	22.6	23.4	25.5	27.2	28.7	31.6
	MIN.W /FT	5.8	6.0	6.2	7.2	7.7	7.8	9.1	9.5	10.6	12.2	14.9	17.1	19.4	21.9	22.7	24.7	26.3	27.8	30.6
280	PIPE TEMP	269.7	269.3	268.5	266.3	264.6	264.1	260.7	260.1	257.1	252.6	244.6	238.1	231.3	224.5	222.5	217.8	213.9	209.8	203.1
	MAX.W /FT	6.9	7.1	7.3	8.5	9.1	9.3	10.8	11.2	12.6	14.5	17.2	19.8	22.5	25.4	26.3	28.6	30.6	32.3	35.5
	MIN.W /FT	6.6	6.8	7.0	8.1	8.7	8.9	10.3	10.7	12.0	13.8	16.6	19.2	21.9	24.6	25.5	27.7	29.6	31.2	34.3
300	PIPE TEMP	288.4	288.0	287.1	284.7	282.8	282.2	278.5	277.8	274.4	269.4	260.6	253.3	245.8	238.3	236.1	230.8	226.6	222.1	214.6
	MAX.W /FT	7.6	7.9	8.2	9.5	10.2	10.4	12.1	12.6	14.1	16.2	19.2	22.0	25.1	28.3	29.2	31.8	34.0	35.8	39.4
	MIN.W /FT	7.4	7.6	7.9	9.1	9.8	9.9	11.5	12.0	13.4	15.4	18.7	21.4	24.3	27.4	28.3	30.8	32.9	34.7	38.1
350	PIPE TEMP	335.1	334.6	333.5	330.4	328.0	327.3	322.6	321.8	317.6	311.2	300.2	291.2	281.8	272.5	269.7	263.3	258.0	252.4	243.2
	MAX.W /FT	10.0	10.2	10.5	12.2	13.1	13.2	15.5	16.0	17.9	20.5	24.3	27.8	31.6	35.6	36.7	40.0	42.7	44.9	49.4
	MIN.W /FT	9.6	9.8	10.1	11.6	12.5	12.6	14.6	15.1	17.0	19.5	23.6	27.0	30.6	34.4	35.6	38.7	41.2	43.4	47.7
400	PIPE TEMP	381.5	381.0	379.6	375.9	373.0	372.2	366.5	365.5	360.4	352.8	339.5	328.7	317.5	306.2	303.0	295.3	289.0	282.4	271.-
	MAX.W /FT	12.6	12.8	12.9	15.0	16.1	16.2	19.0	19.6	21.9	25.0	29.5	33.7	38.3	43.1	44.4	48.3	51.5	54.2	59.5
	MIN.W /FT	11.8	12.0	12.4	14.3	15.3	15.5	17.9	18.7	20.7	23.7	28.7	32.8	37.1	41.7	43.0	46.7	49.8	52.4	57.4
450	PIPE TEMP	427.8	427.2	425.6	421.2	417.8	416.5	410.1	409.0	403.0	394.0	378.5	365.9	352.8	339.6	336.0	327.0	319.7	312.0	299.3
	MAX.W /FT	14.9	15.1	15.5	18.0	19.2	19.4	22.6	23.3	26.0	29.7	34.9	39.9	45.2	50.8	52.3	56.5	60.6	63.7	69.8
	MIN.W /FT	14.2	14.4	14.8	17.1	18.3	18.4	21.3	22.2	24.6	28.1	33.9	38.7	43.7	49.1	50.6	54.9	58.4	61.5	67.3
500	PIPE TEMP	473.0	472.2	471.5	466.3	462.4	461.4	453.5	452.2	445.4	435.0	417.1	402.7	387.7	372.6	368.6	358.3	350.3	341.3	326.8
	MAX.W /FT	17.5	17.8	18.1	21.1	22.5	22.6	26.4	27.2	30.3	34.6	40.5	46.2	52.2	58.6	60.4	65.6	69.8	73.4	80.5
	MIN.W /FT	16.2	16.9	17.3	20.0	21.4	21.5	24.9	25.8	28.6	32.7	39.3	44.7	50.5	56.6	58.3	63.3	67.3	70.7	77.4
550	PIPE TEMP	519.8	519.1	517.1	511.2	506.8	505.6	496.6	495.2	487.5	475.7	455.5	439.2	422.3	405.3	400.9	389.3	380.0	370.2	354.1
	MAX.W /FT	20.3	20.6	20.9	24.3	25.9	26.0	30.4	31.2	34.8	39.6	46.2	52.6	59.4	66.7	68.6	74.5	79.2	83.2	90.9
	MIN.W /FT	19.3	19.5	20.0	23.0	24.6	24.7	28.6	29.6	32.8	37.6	44.9	51.0	57.5	64.4	66.2	71.8	76.3	80.2	87.6
600	PIPE TEMP	565.5	564.8	562.6	556.0	551.0	549.7	539.6	538.1	529.4	516.2	493.5	475.4	456.6	437.7	432.8	419.5	409.7	398.8	381.0
	MAX.W /FT	23.2	23.5	23.8	27.7	29.4	29.6	34.4	35.4	39.4	44.7	52.1	59.2	66.8	74.9	77.0	83.5	88.7	93.2	101.8
	MIN.W /FT	22.0	22.2	22.7	26.2	27.9	28.0	32.4	33.5	37.3	42.2	50.6	57.3	64.6	72.2	74.3	80.5	85.5	89.7	98.0
650	PIPE TEMP	611.1	610.4	608.0	600.5	595.0	593.7	582.4	580.7	571.1	556.4	531.3	511.3	490.6	469.8	464.5	450.3	439.1	427.1	407.6
	MAX.W /FT	26.2	26.5	26.9	31.2	33.1	33.2	38.7	39.7	44.1	50.0	58.2	66.0	74.4	83.3	85.5	92.7	98.5	103.3	112.7
	MIN.W /FT	24.8	25.1	25.6	29.4	31.3	31.3	36.3	37.5	41.4	47.1	56.4	63.9	71.8	80.3	82.5	89.3	94.8	99.5	108.5
700	PIPE TEMP	656.6	655.8	653.2	645.0	638.9	637.4	625.0	623.2	612.6	596.6	568.9	547.0	524.3	501.6	495.8	480.6	468.1	455.2	434.0
	MAX.W /FT	29.3	29.6	30.0	34.8	36.9	37.0	43.0	44.1	49.0	55.5	64.6	72.9	82.1	91.8	94.3	102.1	108.4	113.6	123.9
	MIN.W /FT	27.7	28.0	28.5	32.8	34.9	35.0	40.3	41.7	45.9	52.2	62.4	70.5	79.2	88.5	90.8	98.3	104.3	109.3	119.1
750	PIPE TEMP	702.0	701.2	698.3	689.3	682.6	681.1	667.6	665.5	653.9	636.3	606.2	582.4	557.8	533.1	526.9	510.2	497.0	483.0	460.1
	MAX.W /FT	32.5	32.8	33.2	38.5	40.8	40.9	47.5	48.6	54.0	61.1	70.7	80.0	89.9	100.5	103.1	111.7	118.5	124.1	135.2
	MIN.W /FT	30.7	31.0	31.5	36.2	38.5	38.6	44.4	45.9	50.6	57.4	68.5	77.3	86.8	96.8	99.3	107.4	113.9	119.4	130.0
800	PIPE TEMP	747.3	746.4	743.3	733.5	726.2	724.4	709.7	707.6	695.1	676.0	643.4	617.6	591.1	564.6	557.8	539.8	525.6	510.5	485.9
	MAX.W /FT	35.9	36.2	36.6	42.3	44.8	44.9	52.1	53.3	59.1	66.9	77.2	87.2	98.0	109.4	112.2	121.6	128.7	135.4	146.7
	MIN.W /FT	33.8	34.1	34.7	39.8	42.3	42.3	48.7	50.3	55.3	62.8	74.7	84.3	94.5	105.3	108.0	116.7	123.7	129.5	140.9
850	PIPE TEMP	792.5	791.6	788.2	777.6	769.7	768.0	751.9	749.7	736.1	715.5	680.3	652.6	624.1	595.5	588.5	569.1	554.0	537.9	511.6
	MAX.W /FT	39.3	39.6	40.0	46.3	48.9	49.0	56.9	58.1	64.4	72.8	83.9	94.6	106.2	118.5	121.4	131.3	139.1	146.4	158.3
	MIN.W /FT	37.0	37.3	37.9	43.5	46.1	46.2	53.0	54.8	60.2	68.2	81.1	91.4	102.3	113.9	116.8	126.1	133.6	139.8	152.0
900	PIPE TEMP	837.6	836.7	833.1	821.6	813.1	811.2	793.9	791.6	777.0	756.8	717.0	687.4	657.0	626.3	618.9	598.3	582.1	565.0	537.1
	MAX.W /FT	42.9	43.3	43.6	50.4	53.2	53.3	61.8	63.1	69.9	78.9	90.7	102.2	114.5	127.7	130.8	141.3	149.7	156.6	170.1
	MIN.W /FT	40.4	40.7	41.2	47.3	50.1	50.2	57.5	59.4	65.3	73.9	87.7	98.6	110.3	122.7	125.7	135.7	143.7	150.3	163.3
950	PIPE TEMP	882.6	881.7	877.8	865.5	856.6	854.6	835.9	833.3	817.8	796.0	753.6	722.0	689.6	657.0	649.2	627.3	610.1	591.9	562.3
	MAX.W /FT	46.7	47.0	47.3	54.7	57.7	57.7	67.0	68.3	75.6	85.2	97.8	110.0	123.1	137.1	140.4	151.6	160.5	167.8	182.2
	MIN.W /FT	43.9	44.2	44.7	51.2	54.2	54.3	62.2	64.2	70.5	79.7	94.4	106.1	118.5	131.7	134.9	145.5	154.0	161.0	174.7

INSULATION THICKNESS REQUIREMENTS -

Service Designation T-64

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

3-1/2" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 90.0 F (32.2 C)

CABLE TEMP DEG F		PIPE SIZE 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
100	PIPE TEMP	99.6	99.5	99.5	99.4	99.3	99.3	99.2	99.1	99.0	98.8	98.6	98.1	97.8	97.5	97.3	97.1	96.9	96.7	96.4
	PAR.h /FT	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.8	0.9	1.0	1.2	1.2	1.3	1.4	1.5	1.7
	PIN.h /FT	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6
120	PIPE TEMP	118.7	118.6	118.5	118.2	117.9	117.8	117.6	117.3	116.9	116.3	115.2	114.2	113.3	112.3	112.0	111.3	110.7	110.1	109.1
	PAR.h /FT	0.5	0.5	0.6	0.7	0.8	0.8	0.9	1.0	1.1	1.3	1.7	1.9	2.3	2.7	3.1	3.5	3.8	4.3	4.9
	PIN.h /FT	0.5	0.5	0.5	0.6	0.7	0.8	0.8	0.9	1.0	1.1	1.4	1.5	1.6	1.9	2.3	2.6	3.0	3.4	3.9	4.5	5.0	5.6	6.9
140	PIPE TEMP	137.7	137.4	137.4	136.9	136.5	136.4	135.7	135.4	134.7	133.7	131.8	130.3	128.7	127.1	126.5	125.4	124.5	123.4	121.7
	PAR.h /FT	1.5	1.6	1.6	1.9	2.0	2.1	2.4	2.5	2.8	3.3	3.9	4.5	5.2	5.9	6.1	6.7	7.1	7.5	8.4
	PIN.h /FT	1.5	1.5	1.6	1.8	2.0	2.0	2.3	2.5	2.7	3.2	3.8	4.4	5.1	5.7	5.9	6.5	6.9	7.3	8.1
160	PIPE TEMP	156.7	156.4	156.3	155.6	155.1	154.9	153.8	153.5	152.5	151.1	148.5	146.3	144.0	141.8	141.0	139.5	138.1	136.7	134.3
	PAR.h /FT	2.2	2.2	2.3	2.7	2.9	2.9	3.4	3.6	4.0	4.6	5.6	6.4	7.3	8.1	8.6	9.4	10.0	10.6	11.8
	PIN.h /FT	2.1	2.2	2.3	2.6	2.8	2.9	3.3	3.5	3.9	4.5	5.4	6.3	7.1	8.0	8.4	9.1	9.8	10.3	11.4
180	PIPE TEMP	175.7	175.5	175.1	174.3	173.6	173.3	172.0	171.6	170.3	168.4	165.1	162.2	159.3	156.5	155.5	153.4	151.7	149.9	146.8
	PAR.h /FT	2.8	2.9	3.0	3.5	3.8	3.8	4.4	4.7	5.2	6.0	7.2	8.3	9.5	10.7	11.1	12.1	13.0	13.7	15.2
	PIN.h /FT	2.7	2.8	3.0	3.4	3.6	3.7	4.3	4.5	5.1	5.8	7.1	8.1	9.3	10.4	10.8	11.8	12.6	13.4	14.8
200	PIPE TEMP	194.7	194.5	194.0	192.9	192.0	191.7	190.1	189.6	188.0	185.7	181.6	178.1	174.5	171.0	169.8	167.3	165.2	163.0	159.2
	PAR.h /FT	3.5	3.6	3.8	4.4	4.7	4.8	5.5	5.8	6.5	7.4	8.9	10.2	11.7	13.2	13.7	14.9	16.0	16.9	18.7
	PIN.h /FT	3.4	3.5	3.7	4.2	4.5	4.6	5.3	5.6	6.2	7.2	8.7	10.0	11.4	12.8	13.3	14.5	15.5	16.4	18.1
220	PIPE TEMP	213.6	213.3	212.8	211.5	210.5	210.1	208.1	207.5	205.7	202.9	198.1	194.0	189.7	185.5	184.1	181.2	178.7	176.0	171.5
	PAR.h /FT	4.2	4.4	4.5	5.2	5.6	5.7	6.6	6.9	7.7	8.9	10.6	12.2	13.9	15.7	16.3	17.7	19.0	20.1	22.2
	PIN.h /FT	4.1	4.2	4.4	5.0	5.4	5.5	6.3	6.7	7.5	8.6	10.4	11.9	13.6	15.3	15.8	17.3	18.5	19.5	21.6
240	PIPE TEMP	232.5	232.2	231.5	230.1	228.8	228.4	226.1	225.5	223.3	220.1	214.5	209.7	204.8	200.0	198.4	194.9	192.1	189.0	183.8
	PAR.h /FT	5.0	5.1	5.3	6.1	6.5	6.6	7.7	8.1	9.0	10.3	12.3	14.2	16.2	18.2	18.9	20.6	22.0	23.3	25.7
	PIN.h /FT	4.8	4.9	5.1	5.9	6.3	6.4	7.4	7.8	8.7	10.0	12.1	13.9	15.8	17.7	18.4	20.0	21.4	22.6	25.0
260	PIPE TEMP	251.3	251.0	250.3	248.6	247.2	246.7	244.1	243.4	241.0	237.2	230.8	225.4	219.9	214.3	212.6	208.6	205.4	201.9	196.1
	PAR.h /FT	5.7	5.9	6.1	7.0	7.5	7.6	8.8	9.3	10.3	11.8	14.1	16.2	18.5	20.8	21.5	23.5	25.1	26.5	29.3
	PIN.h /FT	5.5	5.7	5.9	6.8	7.3	7.4	8.5	9.0	10.0	11.4	13.8	15.8	18.0	20.2	21.0	22.8	24.4	25.8	28.4
280	PIPE TEMP	270.2	269.8	269.0	267.1	265.5	265.0	262.0	261.2	258.5	254.3	247.1	241.1	234.8	228.6	226.7	222.3	218.7	214.7	208.2
	PAR.h /FT	6.5	6.7	6.9	8.0	8.5	8.6	10.0	10.5	11.7	13.3	15.9	18.3	20.8	23.4	24.2	26.4	28.2	29.8	32.9
	PIN.h /FT	6.3	6.4	6.7	7.7	8.2	8.3	9.6	10.1	11.2	12.9	15.5	17.8	20.2	22.8	23.6	25.7	27.4	29.0	31.9
300	PIPE TEMP	289.0	288.6	287.7	285.5	283.8	283.2	279.6	278.8	276.0	271.3	263.6	256.7	249.8	242.9	240.7	235.9	231.9	227.5	220.4
	PAR.h /FT	7.3	7.5	7.7	8.9	9.5	9.6	11.2	11.7	13.0	14.9	17.7	20.3	23.1	26.0	26.9	29.3	31.4	33.1	36.5
	PIN.h /FT	7.0	7.2	7.5	8.6	9.2	9.3	10.7	11.3	12.5	14.4	17.3	19.8	22.5	25.3	26.2	28.5	30.5	32.2	35.3
320	PIPE TEMP	309.8	309.4	308.2	305.5	303.3	302.7	298.4	297.3	293.6	288.4	279.9	272.6	265.4	258.2	255.8	250.6	246.3	241.6	234.0
	PAR.h /FT	8.1	8.4	8.6	9.9	10.6	10.7	12.5	13.0	14.5	16.6	19.7	22.6	25.6	28.8	29.8	32.4	34.8	36.7	40.4
	PIN.h /FT	7.8	8.0	8.3	9.6	10.2	10.4	12.0	12.6	14.0	16.1	19.2	21.9	25.0	28.1	29.1	31.6	33.9	35.8	39.4
340	PIPE TEMP	330.8	330.4	329.2	326.3	324.0	323.3	318.8	317.4	313.7	308.0	298.9	291.1	283.4	275.8	273.2	267.5	263.0	258.0	249.9
	PAR.h /FT	9.0	9.3	9.5	11.0	11.8	11.9	13.9	14.5	16.1	18.4	21.9	25.1	28.4	32.0	33.1	36.0	38.7	40.8	44.9
	PIN.h /FT	8.7	8.9	9.2	10.7	11.4	11.5	13.4	14.0	15.4	17.8	21.2	24.3	27.6	31.0	32.1	34.8	37.4	39.5	43.5
360	PIPE TEMP	352.4	352.0	350.8	348.0	345.7	345.1	340.4	338.9	334.8	328.7	319.0	310.7	302.4	294.3	291.7	285.5	280.7	275.3	266.7
	PAR.h /FT	10.0	10.3	10.6	12.2	13.1	13.2	15.4	16.1	17.8	20.4	24.3	27.8	31.5	35.5	36.7	40.0	42.9	45.3	49.8
	PIN.h /FT	9.6	9.9	10.2	11.8	12.6	12.8	14.8	15.5	17.1	19.7	23.4	26.8	30.4	34.1	35.3	38.4	41.3	43.6	48.0
380	PIPE TEMP	375.2	374.8	373.8	371.0	368.6	368.0	362.9	361.4	356.9	350.4	340.2	331.2	322.4	313.8	311.0	304.4	299.3	293.5	284.4
	PAR.h /FT	11.1	11.4	11.7	13.5	14.5	14.6	17.0	17.8	19.7	22.6	26.9	30.8	34.9	39.3	40.6	44.3	47.5	50.1	55.1
	PIN.h /FT	10.6	10.9	11.3	13.0	13.9	14.1	16.3	17.1	18.9	21.7	25.8	29.6	33.5	37.7	38.9	42.5	45.6	48.1	52.9
400	PIPE TEMP	398.5	398.1	396.8	393.8	391.3	390.7	385.1	383.4	378.6	371.7	360.9	351.3	341.8	332.6	329.7	322.7	317.4	311.3	301.6
	PAR.h /FT	12.2	12.5	12.8	14.8	15.9	16.0	18.6	19.5	21.6	24.8	29.5	33.8	38.3	43.1	44.5	48.6	52.1	54.9	60.4
	PIN.h /FT	11.6	11.9	12.4	14.2	15.2	15.4	17.9	18.7	20.7	23.8	28.3	32.4	36.7	41.3	42.7	46.6	49.9	52.6	57.8
420	PIPE TEMP	421.9	421.5	420.1	416.9	414.3	413.6	407.7	405.9	400.8	393.4	382.0	371.8	361.7	351.9	348.8	341.5	335.9	329.5	319.2
	PAR.h /FT	13.5	13.8	14.2	16.4	17.6	17.7	20.6	21.6	24.0	27.5	32.7	37.5	42.4	47.7	49.3	53.8	57.7	60.8	66.9
	PIN.h /FT	13.0	13.3	13.8	16.1	17.2	17.3	19.9	20.9	23.0	26.3	31.4	35.8	40.5	45.4	46.8	50.9	54.2	57.1	62.7
440	PIPE TEMP	445.2	444.8	443.4	440.2	437.6	437.0	430.9	428.9	423.6	415.9	403.7	392.9	382.0	371.6	368.5	360.6	354.8	348.0	337.1
	PAR.h /FT	14.8	15.1	15.5	17.9	19.2	19.3	22.5	23.6	26.2	30.0	35.7	40.9	46.3	52.0	53.8	58.7	62.9	66.3	73.0
	PIN.h /FT	14.2	14.5	15.0	17.5	18.7	18.9	21.7	22.7	25.2	28.8	34.3	39.2	44.4	49.8	51.5	56.2	60.2	63.5	69.9
460	PIPE TEMP	468.3	467.9	466.4	463.1	460.4	459.7	453.2	451.1	445.5	437.4	424.6	413.2	401.7	390.8	387.5	379.3	373.1	365.9	354.6
	PAR.h /FT	16.4	16.7	17.1	19.7	21.1	21.2	24.7	25.9	28.8	33.0	39.2	44.9	50.9	57.2	59.1	64.5	69.1	72.9	80.2
	PIN.h /FT	15.6	16.0	16.5	18.9	20.1	20.2	23.1	24.3	26.8	30.5	36.4	41.6	46.8	52.4	54.0	58.6	62.6	65.7	72.1
480	PIPE TEMP	521.3	520.7	518.7	513.6	509.3	508.2	500.3	498.3	491.6	483.5	469.2	457.2	445.2	433.6	429.5	420.8	414.0	406.4	394.0
	PAR.h /FT	18.5	18.9	19.3	22.2	24.0	24.1	27.8	29.0	32.1	36.4	43.2	49.5	56.0	63.0	65.2	71.1	76.2	80.3	88.4
	PIN.h /FT	18.2	18.6	19.0	21.7	23.1	23.2	26.6	27.9	30.7	34.9	41.6	47.2	53.2	59.5	61.5	66.5	70.8	74.5	81.7
500	PIPE TEMP	567.3	566.8	564.4	558.4	553.8	552.7	543.7	541.5	533.7	521.6	501.2	484.3	467.0	449.5	444.4	432.7	423.0	412.5	395.3
	PAR.h /FT	21.2	21.6	22.1	25.8	27.3	27.4	31.6	32.9	36.3	41.1	48.1	54.6	61.6	68.9	71.3	77.0	81.9	86.2	95.4
	PIN.h /FT	20.8	21.2	21.6	24.7	26.2	26.3	30.1	31.6	34.7	39.6	46.9	53.1	59.8	66.9	69.2	74.6	79.4	83.6	91.9
520	PIPE TEMP	635.1	634.5	632.0	625.3	619.8	618.5	608.1	605.4	596.4	583.1	559.8	539.9	519.8	499.8	493.7	479.9	468.8	456.4	436.5
	PAR.h /FT	24.5	24.9	25.3	29.1	30.7	30.8	35.4	36.9	40.7	46.0	53.7	60.9	68.6	76.7	78.9	85.5	90.9	95.6	105.6
	PIN.h /FT	23.6	23.9	24.3	27.7	29.4	29.5	33.7	35.4	38.8	44.1	52.3	59.2	66.6	74.3	76.6	82.8	88.0	92.5	101.2
540	PIPE TEMP	708.9	708.2	705.6	698.0	692.5	691.1	680.0	677.0	667.1	652.4	627.0	604.0	581.0	558.2	551.9	536.9	525.0	510.3	488.6
	PAR.h /FT	27.9	28.4	28.8	32.9	34.8	34.9	39.9	41.6	45.2	51.0	59.4	67.3	75.7	84.6	86.9	94.2	100.1	105.2	115.0
	PIN.h /FT	26.8	27.2	27.6	30.9	32.7	32.8	37.5	39.3	43.1	48.8	57.8	65.4	73.4	81.9	84.2	91.2	96.9	101.7	111.2
560	PIPE TEMP	784.3	783.7	780.8	772.8	766.8	765.1	753.0	749.6	738.6	722.6	694.5	669.1	643.5	618.5	611.5	594.3	581.5	565.4	541.2
	PAR.h /FT	30.4	30.9	31.2	35.8	37.8	37.9	43.5	45.2	49.0	56.1	65.3	73.8	82.9	92.6	95.1	103.0	109.4	114.9	125.5
	PIN.h /FT	29.6	29.9	29.9	34.1	36.2	36.2	41.3	43.3	47.6	53.7	63.5	71.7	80.4	89.6	92.1	99.7	105.8	111.1	121.3
580	PIPE TEMP	860.6	860.2	856.8	847.1	839.5	837.6	824.1	820.2	807.8	790.1	759.5	731.3	703.1	675.4	668.1	649.3	634.9	617.0	590.3
	PAR.h /FT	33.3	33.8	34.4	39.4	41.5	41.5	47.7	49.6	54.5	61.4	71.3	80.5	90.3	100.8	103.5	112.4	119.4	125.6	136.2
	PIN.h /FT	32.4	32.8	32.9	37.5	39.7	39.7	45.3	47.4	51.9	58.7	69.3	78.2	87.6	97.5	100.2	108.3	115.2	120.8	131.8
600	PIPE TEMP	939.5	939.1	935.2	924.5	916.4	914.3	899.4	895.1	881.4	862.3	828.3	797.5	766.4	736.2	728.3	707.5	691.4	671.8	642.9
	PAR.h /FT	36.7	37.2	37.6	43.1	45.3	45.4	52.0	54.0	59.4	66.8	77.6	87.3	97.9	109.1	112.0	121.6	129.2	135.8	147.2
	PIN.h /FT	34.6	35.2	36.0	40.6	43.3	43.3	49.3	51.6	56.5	63.8	75.2	84.8	94.9	105.5	108.4	117.1	124.2	130.4	142.0
620	PIPE TEMP	1040.8	1040.4	1036.2	1025.8	1018.2	1016.4	1001.6	997.5	984.4	965.4	931.5	900.8	870.1	840.0	831.9	812.0	796.5	777.4	748.0
	PAR.h /FT	40.5	41.0	41.6	47.8	50.2	50.3	57.6	59.8	65.8	74.0	86.0	96.8	108.4	120.9	124.0	134.7	143.2	150.4	163.1
	PIN.h /FT	38.2	38.9	39.8	44.9	47.9	47.9	54.5	57.0	62.4	70.5	83.0	93.5	104.9	116.7	119.8	129.6	137.8	144.8	157.3
640	PIPE TEMP	1141.1	1140.7	1135.6	1124.0	1115.1	1113.0	1096.7	1092.1	1077.3	1056.6	1019.7	986.1	952.6	919.8	910.9	889.1	872.1	851.4	819.0
	PAR.h /FT	43.5	43.9	44.4	50.6	53.3	53.3	61.1	63.4	69.6	78.1	90.2	101.5	113.6	126.6	129.8	140.6	149.4	155.5	169.2
	PIN.h /FT	41.3	41.6	42.4	48.2	50.8	50.9	57.8	60.5	66.0	74.5	87.5	98.6	109.9	122.1	125.2	135.2	143.2	150.0	163.1

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INSULATION THICKNESS REQUIREMENTS

Service Designation T-65

ELECTRIC HEAT TRACING -
MI CABLE BONDED TO PIPE WITH HEAT TRANSFER CEMENT

PIPE TEMPERATURE °F AND WATTAGE REQUIREMENTS DATA

4" NOMINAL INSULATION THICKNESS — AMBIENT AIR TEMP 90.0 F (32.2 C)

CABLE TEMP DEG F		PIPE SIZE																		
		3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
100	PIPE TEMP	99.6	99.6	99.5	99.4	99.3	99.3	99.2	99.1	99.0	98.8	98.5	98.2	97.9	97.6	97.5	97.3	97.1	96.9	96.6
	PARA /FT	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.8	1.0	1.1	1.1	1.2	1.3	1.4	1.5
	PIPE /FT	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5
120	PIPE TEMP	118.7	118.6	118.5	118.3	117.9	117.5	117.5	117.4	117.0	116.5	115.4	114.6	113.7	112.8	112.5	111.9	111.3	110.7	109.8
	PARA /FT	0.5	0.5	0.9	1.1	1.2	1.2	1.3	1.4	1.6	1.8	2.2	2.5	2.9	3.2	3.4	3.7	4.0	4.2	4.7
	PIPE /FT	0.8	0.5	0.9	1.0	1.2	1.2	1.3	1.4	1.5	1.8	2.1	2.5	2.8	3.2	3.3	3.6	3.9	4.1	4.5
140	PIPE TEMP	137.8	137.7	137.5	137.1	136.5	136.4	135.9	135.6	135.0	134.1	132.3	130.9	129.4	127.9	127.4	126.4	125.5	124.5	122.8
	PARA /FT	1.4	1.5	1.6	1.8	2.0	2.1	2.3	2.4	2.7	3.0	3.7	4.2	4.8	5.4	5.7	6.2	6.6	7.0	7.6
	PIPE /FT	1.4	1.5	1.5	1.7	2.0	2.0	2.2	2.3	2.6	3.0	3.6	4.2	4.7	5.3	5.5	6.0	6.5	6.9	7.6
160	PIPE TEMP	156.9	156.7	156.4	155.8	155.1	154.9	154.1	153.8	152.9	151.6	149.2	147.2	145.1	143.0	142.3	140.8	139.5	138.2	135.9
	PARA /FT	2.1	2.1	2.2	2.5	2.5	2.5	3.2	3.4	3.8	4.3	5.2	6.0	6.8	7.7	8.0	8.7	9.3	9.9	11.0
	PIPE /FT	2.0	2.1	2.2	2.5	2.8	2.5	3.1	3.3	3.7	4.2	5.1	5.9	6.7	7.5	7.8	8.5	9.1	9.7	10.7
180	PIPE TEMP	175.5	175.7	175.3	174.6	173.8	173.3	172.4	172.0	170.8	169.1	166.0	163.4	160.7	158.0	157.1	155.2	153.5	151.8	148.8
	PARA /FT	2.7	2.8	2.9	3.3	3.8	3.8	4.2	4.4	4.9	5.5	6.7	7.8	8.8	9.9	10.3	11.3	12.1	12.8	14.2
	PIPE /FT	2.6	2.7	2.8	3.2	3.6	3.7	4.1	4.3	4.8	5.4	6.6	7.6	8.7	9.7	10.1	11.0	11.8	12.5	13.8
200	PIPE TEMP	194.9	194.7	194.2	193.3	192.0	191.7	190.5	190.1	188.7	186.6	182.7	179.5	176.2	172.9	171.8	169.5	167.5	165.3	161.7
	PARA /FT	3.4	3.5	3.6	4.1	4.7	4.8	5.2	5.5	6.1	6.8	8.3	9.6	10.9	12.2	12.7	13.9	14.9	15.7	17.4
	PIPE /FT	3.3	3.4	3.5	4.0	4.5	4.6	5.0	5.3	5.9	6.7	8.1	9.4	10.7	12.0	12.4	13.6	14.5	15.4	17.0
220	PIPE TEMP	213.8	213.6	213.1	211.9	210.5	210.1	208.7	208.1	206.5	204.0	199.4	195.6	191.7	187.8	186.5	183.7	181.3	178.8	174.5
	PARA /FT	4.0	4.1	4.3	4.9	5.6	5.7	6.2	6.5	7.3	8.1	9.9	11.4	13.0	14.6	15.1	16.5	17.7	18.7	20.7
	PIPE /FT	3.9	4.0	4.2	4.8	5.4	5.5	6.0	6.4	7.1	8.0	9.7	11.2	12.7	14.2	14.8	16.1	17.2	18.2	20.2
240	PIPE TEMP	232.8	232.5	231.9	230.6	229.2	228.4	226.8	226.2	224.2	221.4	216.1	211.7	207.1	202.6	201.1	197.9	195.2	192.2	187.3
	PARA /FT	4.7	4.8	5.0	5.7	6.5	6.6	7.2	7.4	8.5	9.5	11.5	13.2	15.1	16.9	17.6	19.2	20.5	21.7	24.0
	PIPE /FT	4.6	4.7	4.9	5.6	6.3	6.4	7.0	7.4	8.2	9.3	11.3	13.0	14.7	16.5	17.2	18.7	20.0	21.2	23.4
260	PIPE TEMP	251.7	251.4	250.7	249.1	247.2	246.3	244.9	244.2	241.9	238.7	232.7	227.6	222.5	217.3	215.7	212.0	208.9	205.6	200.0
	PARA /FT	5.4	5.6	5.8	6.6	7.5	7.6	8.3	8.7	9.7	10.9	13.2	15.1	17.2	19.3	20.0	21.8	23.4	24.7	27.3
	PIPE /FT	5.3	5.4	5.6	6.4	7.3	7.4	8.1	8.5	9.4	10.7	12.9	14.8	16.8	18.9	19.6	21.3	22.8	24.1	26.7
280	PIPE TEMP	270.6	270.2	269.5	267.7	265.5	265.0	262.9	262.1	259.6	256.0	249.2	243.6	237.8	232.0	230.2	226.1	222.6	218.9	212.7
	PARA /FT	6.2	6.3	6.5	7.5	8.5	8.6	9.4	9.9	10.9	12.2	14.8	17.0	19.3	21.7	22.5	24.5	26.3	27.8	30.7
	PIPE /FT	6.0	6.1	6.4	7.3	8.2	8.3	9.1	9.6	10.6	12.0	14.5	16.7	18.9	21.2	22.0	24.0	25.8	27.1	29.9
300	PIPE TEMP	289.4	289.1	288.2	286.2	283.8	283.2	280.9	280.0	277.3	273.2	265.7	259.5	253.0	246.6	244.6	240.1	236.1	232.1	225.2
	PARA /FT	6.9	7.1	7.3	8.4	9.5	9.6	10.5	11.0	12.2	13.7	16.5	18.9	21.5	24.2	25.0	27.3	29.2	30.9	34.1
	PIPE /FT	6.7	6.9	7.1	8.1	9.2	9.3	10.2	10.8	11.9	13.4	16.2	18.6	21.0	23.6	24.5	26.6	28.5	30.1	33.2
350	PIPE TEMP	336.4	336.0	334.9	332.4	329.3	328.2	325.7	324.6	321.2	316.1	306.2	298.9	290.9	282.9	280.5	274.8	270.1	265.0	256.5
	PARA /FT	8.5	9.1	9.3	10.7	12.2	12.3	13.3	14.0	15.5	17.3	20.9	23.9	27.1	30.4	31.5	34.3	36.6	38.7	42.7
	PIPE /FT	8.4	8.8	9.1	10.4	11.7	11.9	12.9	13.7	15.0	17.0	20.5	23.4	26.5	29.7	30.7	33.4	35.7	37.7	41.6
400	PIPE TEMP	383.2	382.7	381.5	378.4	374.6	373.4	370.3	369.0	364.9	358.7	347.4	338.1	328.5	318.9	316.0	309.2	303.6	297.5	287.3
	PARA /FT	11.0	11.2	11.5	13.2	14.5	15.1	16.3	17.1	18.9	21.1	25.4	29.0	32.8	36.6	38.1	41.4	44.2	46.7	51.5
	PIPE /FT	10.7	10.8	11.2	12.8	14.4	14.5	15.8	16.7	18.3	20.7	24.9	28.4	32.1	35.9	37.1	40.4	43.1	45.5	50.1
450	PIPE TEMP	429.2	428.3	427.8	424.2	419.7	418.5	414.7	413.2	408.3	401.0	387.9	376.9	365.7	354.5	351.2	343.4	336.7	329.6	317.9
	PARA /FT	13.2	13.4	13.8	15.7	17.8	18.0	19.5	20.4	22.5	25.0	30.0	34.2	38.7	43.4	44.8	48.7	52.0	54.9	60.4
	PIPE /FT	12.8	13.0	13.4	15.2	17.2	17.2	18.8	19.8	21.8	24.5	29.4	33.5	37.8	42.3	43.7	47.5	50.8	53.4	58.8
500	PIPE TEMP	474.3	473.7	474.0	469.8	464.8	463.7	458.8	457.1	451.5	443.1	428.0	415.5	402.6	389.7	386.0	377.0	369.5	361.4	348.1
	PARA /FT	15.3	15.6	16.1	18.4	20.9	21.0	22.7	23.8	26.1	29.1	34.8	39.6	44.6	50.2	51.7	56.2	60.3	63.2	69.5
	PIPE /FT	15.0	15.2	15.7	17.8	20.1	20.2	21.9	23.1	25.3	28.5	34.1	38.8	43.7	48.9	50.4	54.7	58.4	61.5	67.8
550	PIPE TEMP	522.6	522.0	520.1	515.3	509.3	508.1	502.8	500.9	494.5	485.0	467.8	453.7	439.2	424.7	420.5	410.4	402.1	393.9	378.0
	PARA /FT	18.0	18.2	18.6	21.2	24.0	24.1	26.1	27.3	30.0	33.3	39.8	45.2	51.0	57.0	58.8	63.9	68.1	71.7	78.8
	PIPE /FT	17.6	17.8	18.1	20.9	23.1	23.2	25.2	26.5	29.0	32.6	38.9	44.2	49.7	55.6	57.3	62.2	66.2	69.7	76.9
600	PIPE TEMP	568.7	568.1	566.0	560.6	553.8	552.7	546.5	544.4	537.3	528.6	507.4	491.7	475.5	459.3	454.8	445.4	436.2	426.1	407.5
	PARA /FT	20.5	20.3	21.2	24.2	27.3	27.4	29.8	30.9	33.9	37.6	44.8	50.9	57.3	64.1	66.0	71.7	76.3	80.4	87.5
	PIPE /FT	19.8	20.0	20.5	23.3	26.2	26.2	28.5	30.0	32.8	36.9	43.8	49.7	55.9	62.4	64.3	69.7	74.2	78.1	85.8
650	PIPE TEMP	614.8	614.1	611.8	605.7	598.2	597.0	590.1	587.8	579.9	569.0	546.8	529.4	511.5	493.7	488.7	476.3	466.1	455.1	435.6
	PARA /FT	23.1	23.4	23.8	27.2	30.7	30.8	33.2	34.7	38.0	42.1	50.1	56.7	63.8	71.3	73.4	79.6	84.7	89.2	97.0
	PIPE /FT	22.3	22.5	23.1	26.2	29.4	29.5	32.0	33.6	36.7	41.2	48.9	55.4	62.2	69.6	71.4	77.4	82.4	86.7	95.0
700	PIPE TEMP	660.7	660.0	657.5	650.7	642.5	641.1	633.5	631.0	622.3	609.2	585.9	566.9	547.3	527.8	522.4	508.8	497.7	485.7	465.8
	PARA /FT	25.9	26.1	26.6	30.3	34.2	34.3	36.9	38.5	42.1	46.7	55.4	62.7	70.5	78.6	80.9	87.7	93.3	98.1	107.3
	PIPE /FT	24.9	25.2	25.8	29.2	32.7	32.8	35.5	37.3	40.7	45.7	54.1	61.2	68.7	76.5	78.7	85.3	90.7	95.4	104.9
750	PIPE TEMP	706.5	705.8	703.0	695.6	686.8	685.1	676.8	674.0	664.5	650.2	624.9	604.1	582.9	561.6	555.8	541.0	529.0	516.0	494.8
	PARA /FT	28.7	29.0	29.6	33.5	37.9	40.7	42.5	44.4	51.4	60.9	68.4	77.2	86.1	88.6	96.0	102.0	107.3	112.4	122.4
	PIPE /FT	27.6	27.8	28.5	32.3	36.2	36.2	39.2	41.1	44.8	50.2	59.4	67.1	75.2	83.8	86.2	93.2	99.1	104.2	114.6
800	PIPE TEMP	752.2	751.5	748.5	740.4	730.5	729.0	720.0	716.9	706.6	691.0	663.6	641.1	618.2	595.2	589.0	573.1	560.1	546.2	523.1
	PARA /FT	31.6	31.9	32.4	36.8	41.5	44.6	46.5	48.6	56.2	66.5	75.1	84.2	93.8	96.4	104.3	111.0	116.5	122.0	132.6
	PIPE /FT	30.4	30.6	31.3	35.4	39.7	39.7	42.9	45.0	48.9	54.9	64.9	73.2	81.9	91.1	93.7	101.3	107.7	113.1	123.7
850	PIPE TEMP	797.9	797.1	793.8	785.1	774.4	772.8	763.0	759.7	748.8	731.7	702.1	678.0	653.3	628.6	622.0	606.9	591.0	576.1	551.5
	PARA /FT	34.6	34.9	35.4	40.2	45.3	45.4	48.7	50.7	59.4	61.1	72.2	81.4	91.2	101.4	104.4	112.9	119.7	125.9	137.6
	PIPE /FT	33.3	33.5	34.2	38.7	43.3	43.3	46.8	49.1	53.4	59.7	70.4	79.3	88.4	98.7	101.4	109.8	116.4	122.2	133.5
900	PIPE TEMP	843.4	842.6	839.1	829.7	818.2	816.4	805.9	802.4	790.4	772.2	740.5	714.6	688.2	661.8	654.7	638.5	621.7	605.6	579.6
	PARA /FT	37.6	38.0	38.5	43.8	49.2	49.3	52.9	55.0	64.1	66.2	78.1	88.0	98.6	109.5	112.5	121.8	129.1	135.5	146.0
	PIPE /FT	36.2	36.5	37.2	42.0	47.0	47.0	50.7	53.2	57.9	64.7	76.1	85.7	95.7	106.3	109.2	118.0	125.2	131.4	143.5
950	PIPE TEMP	888.9	888.1	884.3	874.2	861.8	860.0	848.7	845.0	832.1	812.6	778.7	751.1	722.9	694.8	687.3	669.9	652.2	635.3	607.5
	PARA /FT	41.0	41.3	41.8	47.4	53.3	53.3	57.2	59.4	69.2	71.4	84.1	94.7	105.8	117.6	120.8	130.5	138.5	145.3	156.5
	PIPE /FT	39.3	39.5	40.3	45.5	50.8	50.9	54.8	57.4	62.4	69.7	82.0	92.2	102.9	114.2	117.2	126.8	134.9	140.8	151.0

INSULATION THICKNESS REQUIREMENTS

Service Designation U-1
U-2

UNDERGROUND INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: SILICONES, SISTERSVILLE, MONTREAL 053, TORRANCE 513, NIAGARA FALLS 516

SPEC. NO'S: 38-H URETHANE FOAM SERVICE: PROCESS AND LOW PRESSURE STEAM
PVA JACKET

NOM PIPE SIZE	OPERATING TEMPERATURE ° C			
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119
½	1	1	1	1	1
¾	1	1	1	1	1
1	1	1	1	1	1
1¼	1	1	1	1	1
1½	1	1	1	1	1
2	1	1	1	1	1
2½	1	1	1	1	1
3	1	1	1	1	1
3½	1	1	1	1	2
4	1	1	1	2	2
6	1	1	2	2	2
8	1	1	2	2	2
10	1	1			
12	1	1			

	OPERATING TEMPERATURE ° F				
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247

UNDERGROUND INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: KANAWHA VALLEY PLANTS, GULF COAST PLANTS, AND WHITING PLANT

SPEC. NO'S 38-H URETHANE FOAM - SERVICE: PROCESS AND LOW PRESSURE STEAM LINES
PVC-JACKET

NOM PIPE SIZE	OPERATING TEMPERATURE ° C			
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119
½	1	1	1	1	1
¾	1	1	1	1	1
1	1	1	1	1	1
1¼	1	1	1	1	1
1½	1	1	1	1	1
2	1	1	1	1	1
2½	1	1	1	1	1
3	1	1	1	1	1
3½	1	1	1	1	1
4	1	1	1	1	1
6	1	1	1	1	1
8	1	1	1	1	1
10	1	1	1	1	1

	OPERATING TEMPERATURE ° F				
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247

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INSULATION THICKNESS REQUIREMENTS

Service Designation U-3

UNDERGROUND INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: PONCE
SPEC. NO'S: 38-H URETHANE FOAM PVC JACKET

SERVICE: PROCESS & LOW PRESSURE STEAM

NOM PIPE SIZE	OPERATING TEMPERATURE °C				
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119
1½	1	1	1	1	1
3/4	1	1	1	1	1
1	1	1	1	1	1
1½	1	1	1	1	1
1½	1	1	1	1	1
2	1	1	1	1	1
2½	1	1	1	1	1
3	1	1	1	1	1
3½	1	1	1	1	1
4	1	1	1	1	1
6	1	1	1	1	2
8	1	1	1	2	2
10	1	1	1		
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247
	OPERATING TEMPERATURE °F				

Note Maximum size conduit jacket 12" ID

INSULATION THICKNESS REQUIREMENTS

Service Designation U-4
U-5

UNDERGROUND INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: GULF COAST PLANTS - SEADRIFT 510, TEXAS CITY 515, TAFT 519, BROWNSVILLE 526
SPEC. NO's: 10-U and 10-USS SERVICE: STEAM AND PROCESS PIPE - CELLULAR GLASS UNDERGROUND

NOM PIPE SIZE	OPERATING TEMPERATURE ° C											
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259
¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
3	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
3½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
4	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
6	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2
8	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2
10	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2
12	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
14	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½
16	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½
18	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
20	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½
22	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½
24	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½
26	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½
28	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½
30	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	3
36	1½	1½	1½	1½	1½	2	2	2	2½	2½	3	3
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499
	OPERATING TEMPERATURE ° F											

UNDERGROUND INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: KANAWHA VALLEY PLANTS - INSTITUTE 512, S.CHAS. 514
SPEC. NO'S: 10-U and 10-USS SERVICE: STEAM AND PROCESS LINES
CELLULAR GLASS UNDERGROUND

NOM PIPE SIZE	OPERATING TEMPERATURE ° C											
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259
¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
3	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2
3½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2
4	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2
6	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½
8	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½
10	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3
12	1½	1½	2	2	2	2	2	2½	2½	2½	3	3
14	1½	1½	2	2	2	2	2½	2½	2½	3	3	3
16	1½	1½	2	2	2	2	2½	2½	2½	3	3	3
18	1½	2	2	2	2	2½	2½	2½	3	3	3	3
20	1½	2	2	2	2	2½	2½	2½	3	3	3	3
22	1½	2	2	2	2	2½	2½	2½	3	3	3	3
24	1½	2	2	2	2	2½	2½	2½	3	3	3	3
26	1½	2	2	2	2	2½	2½	2½	3	3	3	3
28	1½	2	2	2	2	2½	2½	2½	3	3	3	3
30	1½	2	2	2	2	2½	2½	3	3	3	3	3
36	1½	2	2	2	2	2½	2½	3	3	3	3	3
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499
	OPERATING TEMPERATURE ° F											

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INSULATION THICKNESS REQUIREMENTS

Service Designation U-6
U-7

UNDERGROUND INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: TORRANCE PLANT 513
SPEC. NO'S: 10-U and 10-USS SERVICE: STEAM AND PROCESS PIPE - UNDERGROUND
CELLULAR GLASS

NOM PIPE SIZE	OPERATING TEMPERATURE ° C										
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2
1¼	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2
2	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2
2½	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½
3	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
3½	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	3
4	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	3
6	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3
8	1½	1½	2	2	2	2½	2½	3	3	3	3	3½
10	1½	1½	2	2	2	2½	2½	3	3	3	3½	3½
12	1½	1½	2	2	2	2½	2½	3	3	3	3½	3½
14	1½	1½	2	2	2½	2½	3	3	3	3½	3½	3½
16	1½	1½	2	2	2½	2½	3	3	3	3½	3½	3½
18	1½	1½	2	2	2½	2½	3	3	3	3½	3½	3½
20	1½	1½	2	2	2½	3	3	3	3½	3½	3½	4
22	1½	1½	2	2	2½	3	3	3	3½	3½	4	4
24	1½	1½	2	2	2½	3	3	3	3½	3½	4	4
26	1½	1½	2	2	2½	3	3	3½	3½	3½	4	4
28	1½	1½	2	2	2½	3	3	3½	3½	3½	4	4
30	1½	1½	2	2½	2½	3	3½	3½	3½	4	4	4½
36	1½	2	2½	2½	3	3	3½	3½	4	4	4	4½
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 463
	OPERATING TEMPERATURE ° F											

UNDERGROUND INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: WHITING PLANT, SILICONE PLANT-SISTERSVILLE, MONTREAL 053, NIAGARA FALLS 516
SPEC. NO's: 10-U and 10-USS CELLULAR GLASS SERVICE: STEAM AND PROCESS PIPE - UNDERGROUND

NOM PIPE SIZE	OPERATING TEMPERATURE ° C										
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
¾	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2
1¼	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
2	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2
2½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
3	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
3½	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	3
4	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	3
6	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3
8	1½	1½	2	2	2	2½	2½	3	3	3	3	3½
10	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½
12	1½	1½	2	2	2½	2½	2½	3	3	3	3½	3½
14	1½	1½	2	2	2½	2½	3	3	3	3½	3½	3½
16	1½	1½	2	2½	2½	3	3	3	3½	3½	3½	3½
18	1½	2	2	2½	2½	3	3	3	3½	3½	3½	4
20	1½	2	2	2½	2½	3	3	3	3½	3½	3½	4
22	1½	2	2	2½	2½	3	3	3	3½	3½	3½	4
24	1½	2	2	2½	3	3	3	3	3½	3½	3½	4
26	1½	2	2	2½	2½	3	3	3	3½	3½	3½	4
28	1½	2	2	2½	2½	3	3	3	3½	3½	3½	4
30	1½	2	2½	2½	3	3	3	3½	3½	3½	4	4
36	1½	2	2½	2½	3	3	3	3½	3½	4	4	4
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499
	OPERATING TEMPERATURE ° F											

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

Service Designation U-8

INSULATION THICKNESS REQUIREMENTS

UNDERGROUND INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: PONCE
SPEC. NO'S: 10-U and 10-USS CELLULAR GLASS
SERVICE: STEAM AND PROCESS PIPE-UNDERGROUND

NOM PIPE SIZE	OPERATING TEMPERATURE °C											
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259
½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
3/4	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
2	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2
2½	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2
3	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2
3½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
4	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2
6	1½	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½
8	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
10	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	3
12	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3
14	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3
16	1½	1½	1½	1½	2	2	2½	2½	2½	3	3	3
18	1½	1½	1½	1½	2	2	2½	2½	2½	3	3	3
20	1½	1½	1½	1½	2	2	2½	2½	2½	3	3	3
22	1½	1½	1½	1½	2	2	2½	2½	2½	3	3	3
24	1½	1½	1½	1½	2	2	2½	2½	2½	3	3	3
26	1½	1½	1½	1½	2	2	2½	2½	2½	3	3	3
28	1½	1½	1½	1½	2	2½	2½	2½	3	3	3	3½
30	1½	1½	1½	2	2	2½	2½	2½	3	3	3	3½
36	1½	1½	1½	2	2	2½	2½	2½	3	3	3	3½
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499
	OPERATING TEMPERATURE °F											

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INSULATION THICKNESS REQUIREMENTS

Service Designation U-9

UNDERGROUND INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: KANAWHA VALLEY PLANTS - INSTITURE 512, S. CHARLESTON 514 SERVICE: STEAM AND PROCESS PIPE - UNDERGROUND
SPEC. NO'S: 37-H

NOM PIPE SIZE	OPERATING TEMPERATURE °C																										
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559
½	1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2
¾	1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2
1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2½	2½	2½
1¼	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2½	2½	2½
1½	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2½	2½	2½
2	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2½	2½	2½
2½	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½
3	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3
3½	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3
4	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3
6	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	3½
8	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	3	3	3	3	3½	3½	3½	3½	4	4	4	4
10	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	3½	----	----	----	----
12	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3	3	3½	3½	3½	3½	3½	3½	----	----	----	----
14	1½	1½	1½	1½	1½	2	2	2	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039
	OPERATING TEMPERATURE °F																										

NOTE: Largest standard size of conduit is 18" ID

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INSULATION THICKNESS REQUIREMENTS

Service Designation U-10

UNDERGROUND INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: WHITING PLANT 517, SILICONE PLANT-SISTERSVILLE, MONTREAL 053, NIAGARA FALLS 516
SPEC. NO'S: 37-H
SERVICE: STEAM AND PROCESS PIPE - UNDERGROUND

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																														
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559
½	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2	2½	2½	2½	2½
¾	1	1	1	1	1	1	1	1½	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½
1	1	1	1	1	1	1	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3	3
1¼	1	1	1	1	1	1	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3	3
1½	1	1	1	1	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3	3	3½	3½	3½	3½
2	1	1	1	1	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	3	3	3	3	3	3	3	3½	3½	3½	3½
2½	1	1	1	1	1½	1½	1½	2	2	2	2	2	2½	2½	2½	3	3	3	3	3	3	3	3½	3½	3½	4	4
3	1	1	1	1½	1½	1½	2	2	2	2	2	2	2½	2½	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4
3½	1	1	1	1½	1½	1½	2	2	2	2	2	2	2½	2½	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4
4	1	1	1	1½	1½	1½	2	2	2	2	2	2	2½	2½	3	3	3	3	3	3½	3½	3½	3½	4	4	4	4
6	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3½	3½	4	4	4	4	4	4	4½	4½	4½
8	1½	1½	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	3½	3½	4	4	4	4	4	4	4½	4½	4½	4½	5
10	1½	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3	3½	3½	3½	4	4	4	4	----------						
12	1½	1½	1½	1½	2	2	2½	2½	2½																		
14	1½	1½	1½	1½	2	2	----------																				
	OPERATING TEMPERATURE ° F																										
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039

NOTE: Largest standard size of conduit is 18" ID

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INSULATION THICKNESS REQUIREMENTS

Service Designation U-11

UNDERGROUND INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: TORRANCE PLANT 513
SPEC. NO'S: 37-H

SERVICE: STEAM AND PROCESS PIPE - UNDERGROUND

NOM PIPE SIZE	OPERATING TEMPERATURE ° C																										
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559
1/2	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2	2½	2½	2½
3/4	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	2½	2½
1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	2½	2½	3	3	3
1¼	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	3	3	3	3	3
1½	1	1	1	1	1	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½
2	1	1	1	1	1	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½
2½	1	1	1	1	1	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½
3	1	1	1	1	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	3½	4	4
3½	1	1	1	1	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	3½	3½	4	4
4	1	1	1	1	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	3	3	3	3½	3½	3½	3½	4	4	4	4
6	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4	4½
8	1½	1½	1½	1½	1½	2	2	2	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	4	4	4	4	4	4½	4½	4½
10	1½	1½	1½	1½	1½	2	2	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	4	4	4	4	4	---	---	---	---
12	1½	1½	1½	1½	1½	2	2	2½	2½	2½	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
14	1½	1½	1½	1½	1½	2	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039
	OPERATING TEMPERATURE ° F																										

INSULATION THICKNESS REQUIREMENTS

Service Designation U-12

UNDERGROUND INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

PLANTS: GULF COAST PLANTS - SEADRIFT 510, TEXAS CITY 515, TAFT 519, BROWNSVILLE 526
SPEC. NO'S:

SERVICE: STEAM AND PROCESS PIPE - UNDERGROUND

NOM PIPE SIZE	OPERATING TEMPERATURE °C																										
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	360 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559
½	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2
¾	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2
1	1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2
1¼	1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2
1½	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2½	2½	2½	2½	2½
2	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2½	2½	2½	2½	2½
2½	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2½	2½	2½	2½	2½
3	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	2½	3
3½	1	1.	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	3	3
4	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2½	2½	2½	2½	2½	3	3	3
6	1½	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	2½	3	3	3	3	3½	3½	3½	3½
8	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	3½	4
10	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	3½	4
12	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3	3½	3½	3½	3½	--
14	1½	1½	1½	1½	1½	2	2	2	2	2	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	68 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039
	OPERATING TEMPERATURE °F																										

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INSULATION THICKNESS REQUIREMENTS

Service Designation U-13

UNDERGROUND INSULATION THICKNESSES
HIGH TEMPERATURE SERVICE

SERVICE: STEAM AND PROCESS PIPE - UNDERGROUND

PLANTS: PONCE
SPEC. NO'S: 37-H

NOM PIPE SIZE	OPERATING TEMPERATURE °C																														
	20 to 39	40 to 59	60 to 79	80 to 99	100 to 119	120 to 139	140 to 159	160 to 179	180 to 199	200 to 219	220 to 239	240 to 259	260 to 279	280 to 299	300 to 319	320 to 339	340 to 359	350 to 379	380 to 399	400 to 419	420 to 439	440 to 459	460 to 479	480 to 499	500 to 519	520 to 539	540 to 559
¼	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1½	2	2	2
3/4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½
1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2	2	2	2½	2½	2½	2½
1¼	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	2	2	2	2	2	2	2	2½	2½	2½	2½	3	3	3
1½	1	1	1	1	1	1	1	1	1	1½	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	3	3	3	3	3
2	1	1	1	1	1	1	1	1	1½	1½	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	3	3	3	3	3
2½	1	1	1	1	1	1	1	1	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	2½	2½	2½	3	3	3	3	3
3	1	1	1	1	1	1	1	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	2½	3	3	3	3	3	3½
3½	1	1	1	1	1	1½	1½	1½	1½	2	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3½	3½	3½
4	1	1	1	1	1	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	2½	3	3	3	3	3	3½	3½	3½	4
6	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3	3½	3½	3½	3½	4	4	4	4	4
8	1½	1½	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	3	3	3	3	3½	3½	3½	4	4	4	4	4½	4½
10	1½	1½	1½	1½	1½	1½	2	2	2	2	2½	2½	2½	3	3	3	3	3	3½	3½	3½	4	4	4	4	4½	4½
12	1½	1½	1½	1½	1½	2	2	2	2	2	2½	2½	2½	3	3	3	3	3	3½	3½	3½	4	4	4			
14	1½	1½	1½	1½	2	2	2	2																			
EQUIP FLAT																											
	OPERATING TEMPERATURE °F																										
	39 to 103	104 to 139	140 to 175	176 to 211	212 to 247	248 to 283	284 to 319	320 to 355	356 to 391	392 to 427	428 to 463	464 to 499	500 to 535	536 to 571	572 to 607	608 to 643	644 to 679	680 to 715	716 to 751	752 to 787	788 to 823	824 to 859	860 to 895	896 to 931	932 to 967	968 to 1003	1004 to 1039

Note Largest standard size of conduit is 18" ID

SHORT FORM JOB SHEETS

The short form job sheets included in this section do not constitute a part of Insulation Design. They are included to serve requests for a short single page instruction sheet for individual field applications. These sheets are presented so that copies of them could be made to serve that need.

For this reason the first part of the sheet was layed out as a form which could be filled in to direct work on a specific individual piece of equipment, pipe or duct to be insulated. The required information could be entered on the form by construction or maintenance engineer or designer and directed through correct channels to procure materials and their field application.

The List of Materials was given so that it would not be necessary, for each case, to refer back to the "Thermal Insulation Manual - Volume 1 Specifications". It would serve both as a list for procurement and a check list by the applicator to determine that material required was available at the point of installation. It is suggested that sheets, given the field applicator, the numbers referring to "MATERIAL SPECIFICATION" be removed and that individual store room numbers for each item be inserted.

Preparation was listed so that important preinsulation preparations such as to see that correct insulation supports are available and that proper surface preparation is not overlooked.

Where heat tracers are required, these too must be properly installed before application of insulation.

References to proper "MANUALS" or "ENGINEERING STANDARDS" are given so that in case of question the individual is directed to the proper information for answers.

Application is listed in brief form to assist and guide the applicator. The condensed brief form specification only points out what is to be done in very broad manner. Applicators with firm knowledge and experience of the individual specification could follow these directions with little reference to THERMAL INSULATION MANUAL - VOLUME 1, SPECIFICATIONS. Where specific detailed information is needed, the proper references are provided.

A listing of the Short Form Job Sheets provided in this section follows.

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Specification Number	Insulation Material	Operating Temperature °F	Type of Service
10-H & HSS	Cellular glass	50 to 600	Equip & Piping
10-J & JSS	Cellular glass	50 to 400	Equip & Piping
10-JU & JUSS	Cellular glass	50 to 350	Underground piping
10-L & LSS	Cellular glass	-250 to 400	Equip & piping
10-LSP	Cellular glass	-40 to 150	Spheres
10-LOX	Cellular glass	-250 to Atmos	Oxygen equip & piping
12-H & HSS	Rigid urethane foam	50 to 250	Equip & piping
14-J	Flexible plastic foam	32 to 180	Equip & piping
15-H	Heavy density fibrous glass	70 to 750	Equip & piping
16-H	Low density fibrous glass	70 to 350	Equip & piping
17-RX	Rigid fibrous glass	60 to 150	Exterior of A. C. ducts
17-RY	Rigid fibrous glass	60 to 150	Interior of A. C. ducts
18-FX	Flexible fibrous glass	60 to 150	Exterior of A. C. ducts
18-FY	Flexible fibrous glass	60 to 150	Interior of A. C. ducts
19-H	Mineral wool with facing	60 to 450	Large diameter vessels
19-J	Fibrous glass with facing	60 to 350	Large diameter vessels
21-H & HSS	Asbestos fibers	70 to 1000	Piping
22-H & HSS	Bonded expanded silica	70F to 1600	Equip & piping
22-HSP & HSPSS	Bonded expanded silica	70F to 500	Spheres
23-H & HSS	Calcium silicate(regular)	70 to 950	Equip & piping

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Specification Number	Insulation Material	Operating Temperature °F	Type of Service
25-H	Calcium silicate (high temp.)	750 to 1600	Equip & piping
31-H & HSS	Stainless cased-reflective	33 to 1000	Equip & piping
32-HFP & HFPSS	Bonded expanded silica	40 to 1600	Fire protection, equip & piping
32-LFP & LFPSS	Cellular glass & bonded expanded silica	-250 to 400	Fire protection equip & piping
37-H	Metal conduit - insul as selected	40 to 750	Underground piping
38-H	Urethane foam, PVC jacket pipe system	50 to 250	Underground piping
39-H	Bituminous fill	220 to 550	Underground piping
40-J	Cork filled PVA mastic	34 to 180	Equip & piping
41-H	Sprayed asbestos fibers	70 to 700	Equip
42-H	Sprayed asbestos fibers	70 to 1350	Equip
43-H & HSS	Sprayed urethane foam	50 to 250	Equip

Note: SS in specification number indicates suitable for use on stainless steel surface.

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 10-H, 10-HSS, CELLULAR GLASS

(High Temperature Service Max. 600F)

EQUIPMENT INSULATION

PLANT _____
UNIT _____
WORK ORDER _____
ACCOUNT NO. _____
DATE _____

VESSEL OR COLUMN
ITEM NO. _____ METAL _____
BODY: Dia. _____ LENGTH _____
HEADS _____ SHAPE _____
VESSEL FLANGES _____
MANHOLES _____
NOZZLES _____
SKIRT OR LEGS _____

DUCT OR FLAT SURFACE
TOP AND BOTTOM:
WIDTH _____
LENGTH _____
SIDES:
WIDTH _____
LENGTH _____

INSULATION THICKNESS " _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIAL SPECIFICATIONS

Cellular Glass	Spec. 10.	Strapping Tape	VII. A. 33.
Cushioning Material		High Temperature	
Equipment above 350F	VII. A. 1.	Fabricating Cement	VII. A. 91.
Equipment at 350F and below	VII. A. 2.	Heat Resistant Sealer	VII. A. 42.
Insulating Cement	VII. A. 6.	Non Setting Sealer	VII. A. 88.
Equipment Insulation Strap	VII. A. 11.	Mastic (Caulking)	VII. A. 45.
Clips for Equipment Strap	VII. A. 12.	Weather Barrier	
Stainless Steel Wire	VII. A. 17.	Mastic, color as specified,	
Welding Pins	VII. A. 19.	Trowel Grade,	
Stainless Steel Pins	VII. A. 20.	Designation WC	VII. B. 1. a.
Stainless Steel Skewers	VII. A. 21.	Mastic, color as specified,	
Strap Anchor Clips	VII. A. 24.	Spray Grade,	
Staples	VII. A. 25.	Designation WB	VII. B. 1. a.
		Reinforcing Cloth	VII. B. 1. b.

Note: For 10-HSS (on stainless steel equipment), use only Cushioning Material VII. A. 1.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", GENERAL SPECIFICATIONS

Surface:

Surface shall be clean and dry and, where required, steel or stainless steel shall be coated in accordance with "COATING MANUAL".

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PREPARATION: Continued (10-H, 10-HSS Equip. Contd)

Insulation Supports:

Welded (vendor installed where possible) as per Standards EQ-64. Bolted on as per Standards IS-31, 31A, 36, 42.

Tracing: (Where Required)

Heat Transfer Cement, Materials, MATERIAL SPECIFICATIONS VII. C. Application, GENERAL SPECIFICATIONS XIII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL, VOLUME 1", SPECIFICATIONS NO. 10-H, 10-HSS

Component	Type and Form of Insulation	Securement	Weather Barrier
Curved Side Walls	Curved block (single layer to 2 1/2" thick, double above). 1" cushion blanket under curved blocks	Strap for Wire for Blanket	Mastic
Heads	Preformed block 2" cushion blanket under curved block as shown in Figure 10-H. 1	Strap and Wire	Mastic
Vessel Flanges	Preformed covers as shown in Figure 10-H. 3	Strap, Skewers, Wire	Mastic and Stainless Steel
Nozzles	Preformed covers as shown in Figure 10-H. 6	Strap, Skewers, Wire	Mastic
Legs - Channel	Block down to fire proofing as shown in Figure 10-H. 10	Strap Wire	Mastic
Legs - Concrete Filled	Not insulated		
Flat Surfaces	Block and insulating cement as shown in Figure 10-H. 2	Pins, Pin Clips	Mastic
Skirts & Cradles	Not insulated unless required for fire protection		

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 10-H, 10-HSS, CELLULAR GLASS

(High Temperature Service
Max 600F)

PIPING INSULATION

	PIPE				
	LINE NO.	SIZE	LOCATION	METAL	INSUL THK "
PLANT					
UNIT					
WORK ORDER					
ACCOUNT NO.					
DATE					

WEATHER BARRIER: STRAIGHT PIPE _____ FITTINGS MASTIC

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIAL SPECIFICATIONS

Cellular Glass Insulation	Spec. 10.	Strapping Tape	VII. A. 33.
Cushioning Material		High Temperature Fabrication Cement	VII. A. 34.
Piping above 350F	VII. A. 3.	Heat Resistant Sealer	VII. A. 42.
Piping 350F and below	VII. A. 4.	Non Setting Sealer	VII. A. 88.
Insulating Cement	VII. A. 6.	Mastic (Caulking)	VII. A. 45.
Pipe Insulation Support	VII. A. 9.	Weather Barrier: As Specified	
Pipe Insulation Strap	VII. A. 13.	Mastic, color as specified,	
Clips for Pipe Strap	VII. A. 14.	Trowel Grade,	
Stainless Steel Wire	VII. A. 17.	Designation WC	VII. B. 1. a.
Stainless Steel Skewers	VII. A. 21.	Reinforcing Cloth	VII. B. 1. b.
		Stainless Steel Jacket,	
		Designation M	VII. B. 2.
		Treated Steel Jacket,	
		Designation MT	VII. B. 3.

Note: For 10-HSS(on Stainless Steel Piping) Use Only Cushion Material VII. A. 1.

PREPARATION: As specified in "THERMAL INSULATION MANUAL, VOLUME 1", GENERAL SPECIFICATIONS

Surface:

Steel shall be clean and dry. Stainless steel shall be coated as per "COATING MANUAL".

Insulation Supports:

Vertical pipe, over 4" NPS, as shown in Figure 10-H-18.

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PREPARATION: Continued (10-H, 10-HSS Piping, Contd)

Tracing: (Where Required)

Steam, installed per Standard P-140, P-140A. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Electric, installed per Standard EL-43. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Heat Transfer Cement, Materials. MATERIAL SPECIFICATIONS VII. C. Application, GENERAL SPECIFICATIONS XIII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION 10-H, HSS

Component	Type and Form Of Insulation	Securement	Weather-Barrier
Straight Pipe	Cushion blanket under all sectional pipe and fitting insulation. Sectional insulation (single layer to 2 1/2" think. Double layer 3" thick and above.	For All Pipe and Fittings Wire for blanket Wire for inner layers Strap for all other	Mastic or Steel Jacket
Insulation Expansion Joints	Install: Up to 2 1/2" thick one each 60 ft, 3" to 5" thick one every 45 ft, 5 1/2" to 7 1/2" one every 30 ft	Strap	Mastic and Stainless Steel Sleeves
Gate and Globe Values	Preformed as per "UCC Fab. Manual"* as shown in Figure 10-H-16	Strap	Mastic
Ball & Plug Valves	Field cut from sectional covering	Strap	Mastic
Flanged Fittings	Preformed as per "UCC Fab. Manual"* as shown in Figure 10-H-15	Strap	Mastic
Welded Ells	Preformed as per "UCC Fab. Manual"* as shown in Figure 10-H-12	Strap	Mastic
Screwed Fittings	Preformed as per "UCC Fab. Manual"*	Strap	Mastic

* Or ASTM Recommended Practice C-450, Latest Revision.

UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 10-J, 10-JSS, CELLULAR GLASS

(Moderate Temperature Service, Max. 400F)

EQUIPMENT INSULATION

PLANT _____
UNIT _____
WORK ORDER _____
ACCOUNT NO. _____
DATE _____

VESSEL OR COLUMN
ITEM NO. _____ METAL _____
BODY: Dia. _____ LENGTH _____
HEADS _____ SHAPE _____
VESSEL FLANGES _____
MANHOLES _____
NOZZLES _____
SKIRT OR LEGS _____

DUCT OR FLAT SURFACE
TOP AND BOTTOM:
WIDTH _____
LENGTH _____
SIDES:
WIDTH _____
LENGTH _____

WEATHER BARRIER _____ INSULATION THICKNESS " _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIAL SPECIFICATIONS

Cellular Glass	Spec. 10.	High and Low Temperature Anti-Abrasive Coating	VII. A. 40.
Equipment Insulation Strap	VII. A. 11.	Mastic (Caulking)	VII. A. 45.
Clips for Equipment Strap	VII. A. 12.	Weather Barrier, as specified	
Stainless Steel Wire	VII. A. 17.	Mastic, color as specified,	
Welding Pins	VII. A. 19.	Trowel Grade,	
Stainless Steel Pins	VII. A. 20.	Designation WC	VII. B. 1. a.
Stainless Steel Skewers	VII. A. 21.	Mastic, color as specified,	
Strap Anchor Clip	VII. A. 24.	Spray Grade,	
Strapping Tape	VII. A. 33.	Designation WB	VII. B. 1. a.
Insulating Cement	VII. A. 6.	Reinforcing Cloth	VII. B. 1. b.
Moderate Temperature Fabrication Cement	VII. A. 35.	Stainless Steel Jacket, Designation M	VII. B. 2.
Heat Resistant Sealer	VII. A. 42.	Treated Steel Jacket, Designation MT	VII. B. 3.
Glass Wool Metal Mesh Blanket	VII. A. 86.		
Non Setting Sealer	VII. A. 88.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", GENERAL SPECIFICATIONS

Surface:

Surface shall be clean and dry. Steel or stainless steel, where required, shall be coated in accordance with "COATINGS MANUAL".

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PREPARATION: Continued (10-J, 10-JSS Equip, Contd)

Insulation Supports:

Welded (vendor installed where possible) as per Standards EQ-64. Bolted as per Standards EQ-67, 68, 69.

Tracing: (Where Required)

Heat Transfer Cement, Materials - MATERIAL SPECIFICATIONS VII. C. Application, GENERAL SPECIFICATIONS XIII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 10-J, 10-JSS

Component	Type and Form of Insulation	Securement	Weather Barrier
Curved Side Walls	Curved block (single layer to 2 1/2" thick, double above)	Strap	Mastic or Steel Jacket
Heads	Preformed block as shown in Figure 10-J. 1	Strap, Wire	Mastic
Vessel Flanges	Preformed covers, as shown in Figure 10-J. 3	Strap, Skewers, Wire	Mastic
Nozzles	Preformed covers, as shown in Figure 10-J. 6	Strap, Skewers, Wire	Mastic
Legs-Channel	Block down to fire proofing as shown in Figure 10-J-8	Strap, Wire	Mastic
Legs-Concrete Filled	Not insulated		
Flat Surfaces	Block and insulating cement as shown in Figure 10-J. 2	Pin, Pin Clips, Wire, Netting	Mastic
Skirts & Cradles	Not insulated unless required for fire protection		

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 10-J, 10-JSS, CELLULAR GLASS

(Moderate Temperature Service
Max 400F)

PIPING INSULATION

	PIPE				
	LINE NO.	SIZE	LOCATION	METAL	INSUL THK "
PLANT					
UNIT					
WORK ORDER					
ACCOUNT NO.					
DATE					

WEATHER BARRIER: STRAIGHT PIPE _____ FITTINGS MASTIC

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME I" MATERIAL SPECIFICATIONS

Cellular Glass	Spec. 10.	Strapping Tape	VII. A. 33.
Insulating Cement	VII. A. 6.	Moderate Temperature Fabrication Cement	VII. A. 33.
Pipe Insulation Support	VII. A. 9.	Heat-Resistant Sealer	VII. A. 42.
Pipe Insulation Strap	VII. A. 12.	Glass Wool Metal Mesh Blanket	VII. A. 86
Clips for Pipe Strap	VII A. 13.	Non-Setting Sealer	VII. A. 88.
Stainless Steel Wire	VII. A. 17.	High & Low Temperature Anti Abrasive Coating	VII. A. 40.
Welding Pins	VII. A. 10.	Mastic (Caulking)	VII. A. 45.
Stainless Steel Pins	VII. A. 20.	Weather Barrier: As specified	
Stainless Steel Skewers	VII. A. 21.	Mastic, Color as specified	VII. B. 1. a.
		Reinforcing Cloth	VII. B. 1. b.
		Stainless Steel Jacket, Designation M	VII. B. 2.
		Treated Steel Jacket, Designation MT	VII. B. 3.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME I" GENERAL SPECIFICATIONS

Surface:

Steel shall be clean and dry. Stainless steel shall be coated as per "COATING MANUAL".

Insulation Supports:

Vertical pipes over 4" NPS as shown in Figure 10-J-16.

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PREPARATION: Continued (10-J, 10-JSS, Piping, Contd)

Tracing:

Steam, installed as per Standard P-140, P-140A. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Electric, installed as per Standard EL-43. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Heat Transfer Cement, Materials - MATERIAL SPECIFICATIONS VII. C. Application, GENERAL SPECIFICATIONS XIII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME I", SPECIFICATION 10-J, 10-JSS

Component	Type and Form of Insulation	Securement	Weather-Barrier
Straight Pipe	Sectional insulation single layer to 2 1/2" thick, double layer 3" thick and above	Inner layer-wire; single and outer layer strap	Mastic or Steel Jacket
Insulation Expansion Joints	Install: Up to 2 1/2" thick one each 60 ft, 3" to 5" thick - one each 30 ft. As shown in Figures 10-J-15 and 10-J-16	Strap	Mastic and Stainless Steel Sleeves
Gate & Globe Valves	Preformed as per UCC Fab. Manual*, as shown in Figure 10-J-14	Strap	Mastic
Ball & Plug Valves	Field cut from sectional covering	Strap	Mastic
Flanged Fittings	Preformed as per UCC Fab. Manual*, as shown in Figure 10-J-13	Strap	Mastic
Welded Fittings	Preformed as per UCC Fab. Manual*, as shown in Figure 10-J-10	Strap	Mastic
Screwed Fittings	Preformed as per UCC Fab. Manual*	Strap	Mastic

* Or ASTM Recommended Practice C-450, Latest Revision

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 10-JU, 10-JUSS, CELLULAR GLASS

(Moderate Temperature Service Max. 350F)

UNDERGROUND PIPING

	LINE NO.	SIZE	LOCATION	METAL	INSUL. THK
PLANT _____					
UNIT _____					
WORK ORDER _____					
ACCOUNT NO. _____					
DATE _____					

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" MATERIAL SPECIFICATIONS

Cellular Glass	Spec. 10	High Temperature Fabrication Cement	VII. A. 3
Pipe Insulation Strap	VII. A. 13.	Joint Sealer	VII. A. 8
Clips for Insulation Strap	VII. A. 14.	Reinforcing Cloth	VII. A. 8
Stainless Steel Wire	VII. A. 17.	Water - Barrier Coating	VII. A. 7
Anti-Abrasive Coating (for stainless steel)	VII. A. 40.	Concrete support Pad (field poured)	
Anti-Abrasive Coating	VII. A. 39.	Carbon Pipe Slides for Support Pads	Std. P. -

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" GENERAL SPECIFICATIONS

Surface:

Steel shall be clean and dry. Stainless steel shall be coated as per "COATING MANUAL".

Tracing: (Where Required)

Steam, installed as per Standards P-140,P-140A. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Electric installed as per Standard EL-43. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Heat Transfer Cement, Materials, MATERIAL SPECIFICATION VII. A. Application, GENERAL SPECIFICATIONS XIII. B.

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(10-JU, 10-JJSS, Contd)

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL VOLUME 1", SPECIFICATION NO. 10-J, 10-JSS

Component	Type and Form of Insulation	Securement	Water-Barrier
Straight Pipe	Sectional insulation (single layer to 2 1/2" thick, double layer 3" thick and above	Wire inner layers, strap single and outer layers	Mastic* Mastic*
Elbow and Tee	Oversize sectional pipe insulation	Strap	
Expansion Chamber	Construction as shown in Figures 10-JU-3, 4, 5, & 6		
*Water-Barrier	Application as given in Spec. No. 10-J, 10-JSS B. 2. b.		

Cathodic Protection:

Where required, cathodic protection shall be installed as specified by Mecnanical and Electrical Groups, and in accordance with STANDARD SPECIFICATIONS B. 2. 60 and STANDARDS EL-75, 76 and 77. Details shall be coordinated so that the purpose of each system is retained. Special attention is required at electrical isolating joints.

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 10-L, 10-LSS, CELLULAR GLASS

(Low Temperature Service)

EQUIPMENT INSULATION

PLANT _____
UNIT _____
WORK ORDER _____
ACCOUNT NO. _____
DATE _____

VESSEL OR COLUMN
ITEM NO. _____ METAL _____
BODY: Dia. _____ LENGTH _____
HEADS _____ SHAPE _____
VESSEL FLANGES _____
MANHOLES _____
NOZZLES _____
SKIRT OR LEGS _____

DUCT OR FLAT SURFACE
TOP AND BOTTOM:
WIDTH _____
LENGTH _____
SIDES:
WIDTH _____
LENGTH _____

WEATHER BARRIER Mastic INSULATION THICKNESS " _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIAL SPECIFICATIONS

Cellular Glass Insulation	Spec. 10.	Mastic	VII. A. 45.
Cushioning Material		Lap Sealer	VII. A. 46.
Equipment operating above 350F	VII. A. 1.	Non Setting Sealer	VII. A. 88.
Equipment operating at 350F and below	VII. A. 2.	Joint Sealer	VII. A. 43.
Equipment Insulation Strap	VII. A. 11.	Modified Asphalt Sealer	VII. A. 116.
Clips for Equipment Strap	VII. A. 12.	Mastic (Caulking)	VII. A. 45.
Stainless Steel Wire	VII. A. 17.	Weather Barrier Mastic, (color as specified)	
Welding Pins	VII. A. 19.	Trowel Grade, Designation WC	VII. B. 1. a.
Stainless Steel Skewers	VII. A. 21.	Spray Grade, Designation WB	VII. B. 1. a.
Strap Anchor Clip	VII. A. 24.	Reinforcing Cloth	VII. B. 1. b.
Fabrication Cement	VII. A. 36.		

Note: For 10-LSS (on stainless steel equipment) use only Cushioning Material VII. A. 1 Do not use Joint Sealer VII. A. 43. Do use Joint Sealer VII. A. 116.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", GENERAL SPECIFICATIONS

Surface:

Steel shall be clean and dry. Stainless steel shall be coated, if so required, as per "COATINGS MANUAL".

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PREPARATION: Continued (10-L, 10-LSS, Equip, Conts)

Insulation Supports:

Welded (vendor installed where possible) as per Standard EQ-64. Bolted on as per Standards EQ-67, 68, 69.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL, VOLUME 1", SPECIFICATION NO. 10-L, 10-LSS

Component	Type and Form of Insulation	Securement	Weather Barrier
Curved Side Walls	Curved block (single layer to 2 1/2" thick, double above) 1" cushion blanket under curved blocks	Strap	Mastic
Heads	Preformed block, 1" cushion blanket under block as shown in Figure 10-L. 2	Strap and Wire	Mastic
Vessel Flanges	Preformed covers as shown in Figure 10-L. 3.	Strap, Skewers, Wire	Mastic
Nozzles	Preformed covers as shown in Figure 10-L. 5	Strap, Skewers, Wire	Mastic
Legs - Channel	Block down to fire proofing as shown in Figure 10-L. 9	Strap, Wire	Mastic
Legs - Concrete Filled	Block down 4 times specified thickness with 1/2 specified thickness insulation	Strap, Wire	Mastic
Skirts & Cradles	Block down 4 times specified thickness with 1/2 specified thickness insulation as shown in Figures 10-L. 10, 11 & 12	Strap, Wire	Mastic
Flat Surfaces	Block up to 2 1/2" to surface with adhesive	Adhesive	Mastic

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 10-L, 10-LSS, CELLULAR GLASS
(Low Temperature Service)

PIPING INSULATION

			PIPE		
	LINE NO.	SIZE	LOCATION	METAL	INSUL THICK"
PLANT					
UNIT					
WORK ORDER					
ACCOUNT NO.					
DATE					

WEATHER BARRIER: Mastic

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" MATERIAL SPECIFICATIONS

Cellular Glass Insulation	Spec. 10.	Joint Sealer	VII. A. 43.
Pipe Insulation Support	VII. A. 9.	Mastic	VII. A. 45.
Pipe Insulation Strap	VII. A. 13.	Lap Sealer	VII. A. 46.
Clips for Pipe Strap	VII. A. 14.	Curved Wood Block	
Stainless Steel Wire	VII. A. 17.	Insulation Support	VII. A. 87.
Welding Pins	VII. A. 19.	Non Setting Sealer	VII. A. 88.
Stainless Steel Skewers	VII. A. 21.	Modified Asphalt Sealer	VII. A. 116.
Strapping Tape	VII. A. 33.	Mastic (Caulking)	VII. A. 45.
Fabrication Cement	VII. A. 36.	Weather-Barrier Mastic (color as specified) Trowel Grade, Designation WC	VII, B. 1. a
		Reinforcing Cloth	VII. B. 1. b.

Note: For 10-LSS (on stainless steel piping) do not use joint sealer VII. A. 43. Do use modified asphalt sealer VII. A. 116.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" GENERAL SPECIFICATIONS

Surface:

Steel shall be clean and dry. Stainless steel shall be coated, if so required, as per "COATINGS MANUAL".

Insulation Support:

Vertical pipes over 4" NPS as shown in Figure 10-L-20.

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PREPARATION: Continued (10-L, 10-LSS, Piping, Contd)

Pipe Supports:

Horizontal piping, supported by insulation in cradles, as per Standard P-82. At bottom of vertical risers curved wood block (VII. A. 87) must be inserted between cradle and pipe to support pipe load.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL VOLUME 1", SPECIFICATION NO. 10-L, 10-LSS

Component	Type and Form of Insulation	Securement	Weather-Barrier
Straight Pipe	Sectional insulation (single layer up to 2 1/2" thick, double layer 3" thick and above)	Inner layers Tape Single and outer layer up to 4 1/2" OD Tape, above strap	Mastic
Insulation Expansion	Up to 2 1/2" thick insulation 1 for each 60'	Strap	Mastic
Contraction Joints	3" to 5" thick insulation 1 for each 45', 5 1/2 and above 1 each 30' as shown in Figures 10-L-19 & 20		
Gate and Globe Valves	Preformed as per UCC Fab. Manual* as shown in Figure 10-L-17	Strap	Mastic
Ball & Plug Valves	Preformed as per UCC Fab. Manual*	Strap	Mastic
Flanged Fittings	Preformed as per UCC Fab. Manual,* as shown in Figure 10-L-16.	Strap	Mastic
Welded Fittings	Preformed as per UCC Fab. Manual, * as shown in Figure 10-L-13, 14	Strap	Mastic
Screwed Fittings	Preformed as per UCC Fab. Manual*	Strap	Mastic
Hanger Rods	Insulated as shown in Figure 10-L-8	Strap & Tape	Mastic

* Or ASTM Recommended Practice C-450, latest revision.

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 10-LSP, CELLULAR GLASS (Insulation for Sphere Minus 40F to 15

SPHERE INSULATION

SPHERE

PLANT _____ ITEM NO. _____

UNIT _____ BODY: DIA. _____

WORK ORDER _____ MANHOLES _____

ACCOUNT NO. _____ NOZZLES _____

DATE _____ PROJECTIONS _____

LEGS _____

WEATHER BARRIER: Mastic INSULATION THICKNESS " _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" MATERIAL SPECIFICATIONS

Cellular Glass Insulation	Spec. 10.	Water Sealer	VII. A. 116.
Nylon Strap	VII. A. 114.	Fireproofing Insulation	Spec. 22.
Crimp Clip, for Nylon Strap	VII. A. 115.	Mastic (Caulking)	VII A. 45.
Pipe Insulation Strap	VII. A. 13.	Non Setting Sealer	VII A. 88.
Clips for Pipe Strap	VII. A. 14.	Cushioning Material	VII. A. 2.
Stainless Steel Wire	VII. A. 17.	Stainless Steel Wire	VII. A. 117.
Insulation Adhesive (two part)	VII. A. 105.	Weather-Barrier Mastic, color as specified	
Joint Sealer	VII. A. 43	Trowel Grade, Designation WC	VII. B. 1. a.
		Spray Grade Designation WB	VII. B. 1. a.
		Reinforcing Cloth	VII. B. 1. b.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" SPECIFICATION NO. 10-LSP

Surface:

Steel sphere shall be cleaned and coated with Dimetcote No. 3 or 4, in accordance with "COATING MANUAL"

Insulation Supports:

Shall be provided as shown on drawings. One to be located at equator. One to be approximately 30° below and another to be approximately 30° above equator. Bottom support to be slotted for band attachment.

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(10-LSP, Sphere, Contd)

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL VOLUME 1", SPECIFICATION NO. 10-LSP

Component	Type and Form of Insulation	Securement	Weather-Barrier
Body	Insulation shall be shop fabricated, geodesically shaped to fit sphere body. Bottom section of insulation shall be adhered to sphere with insulation adhesive and nylon bands. Midsection and upper section shall be secured to sphere by adhesive only. Edges and ends of blocks vapor sealed, as shown in Figure 10-LSP-1	Adhesive and Nylon Bands	Mastic
Insulation Supports	Preformed cellular glass blocks fit over insulation sealed as shown in Figure 10-LSP-2	Insulation Adhesive	Mastic
Nozzles & Manholes	Preformed cellular glass covers installed as shown in Figures 10-LSP-3, 4	Wire and Strap	Mastic
Legs - Concrete Filled	Preformed cellular glass down 4 times specified thickness with 1/2 specified thickness as shown in Figure 10-LSP-5	Strap	Mastic
Legs - Not filled	Preformed cellular glass down 4 times specified thickness with 1/2 specified thickness. Below this preformed expanded silica insulation to fire proofing or base as shown in Figure 10-LSP-5	Strap	Mastic
Tie Rods	2" thick sec. expaned silica as per Spec. No. 22-H	Strap	Steel Jacket

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SPECIFICATION NO. 10-OX, CELLULAR GLASS (Low Temperatu Oxygen Servic

EQUIPMENT INSULATION

VESSEL OR COLUMN

PLANT _____ ITEM NO. _____ METAL _____

UNIT _____ BODY: Dia. _____ LENGTH _____

WORK ORDER _____ HEADS _____ SHAPE _____

ACCOUNT NO. _____ VESSEL FLANGES _____

DATE _____ MANHOLES _____

NOZZLES _____

SKIRT OR LEGS _____

WEATHER BARRIER: Mastic INSULATION THICKNESS" _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIAL SPECIFICATIONS

Cellular Glass Insulation	Spec. 10.	Neoprene - 1/16" thick U.S.	
Cushion Material for		Rubber No. M-8891, or	
Equipment and Pipe	VII. A. 1.	Hercules No. 765-N, or	
Equipment Insulation Strap	VII. A. 11.	approved equal	
Clips for Equipment Strap	VII. A. 13.	Weather Barrier Mastic,	
Stainless Steel Wire	VII. A. 17.	color as specified,	
Strap Anchor Clip	VII. A. 24.	Trowel Grade,	
Anti-Abrasive Coating	VII. A. 39.	Designation WC	VII. B. 1.
Fabrication Cement	VII. A. 34.	Spray Grade,	
Stainless Steel Skewers	VII. A. 21	Designation WB	VII. B. 1.
Welding Pins	VII. A. 19.	Reinforcing Cloth	VII. B. 1.
Adhesive Cement	VII. A. 47.		
Joint Sealer - Vimasco Lax-Seal F or approved equal			

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", GENERAL SPECIFICATIONS

Surface:

Surface shall be clean and dry

Insulation Supports:

Welded (vendor installed where possible) as per Standards EQ-64. Bolted as per Standards EQ-67, 68, 69.

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(10-OX Equip., Contd)

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 10-OX

Component	Type and Form of Insulation	Securement	Weather Barrier
*Curved Side Walls	Curved block (single layer to 2 1/2" thick, double above) 1" cushion blanket compressed to 1/2" under curved blocks	Strap	Mastic
*Vessel Head	Preformed block, 2" cushion blanket compressed to 1" on top head, 1" cushion blanket compressed to 1/2" on bottom head	Strap and Wire	Mastic

*Inner layer blocks on side walls and heads given a coat of anti-abrasive coating and allowed to dry before application. Outer layer edges and ends of blocks vapor sealed as applied.

Vessel Flanges	Preformed covers as shown in Figure 10-OX. 3	Strap, Skewers, Wire	Mastic
Nozzles	Preformed covers as shown in Figure 10-OX. 5	Strap, Skewers, Wire	Mastic
Legs-Channel	Block down to fireproofing as shown in Figure 10-OX. 9	Strap, Wire	Mastic
Skirts & Cradles & Supports	Block down 4 times specified thickness with 1/2 specified thickness as shown in Figure 10-OX. 10, 11, 12	Strap, Wire	Mastic

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 10-OX, CELLULAR GLASS
(Low Temperature Oxygen Service)

PIPING INSULATION

		PIPE			
	LINE NO.	SIZE	LOCATION	METAL	INSUL THK
PLANT					
UNIT					
WORK ORDER					
ACCOUNT NO.					
DATE					

WEATHER BARRIER: Mastic

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" MATERIAL SPECIFICATIONS

Cellular Glass Insulation	Spec. 10.	Fabrication Cement	VII. A. 34
Cushioning Material	VII. A. 1.	Adhesive Cement	VII. A. 47
Pipe Insulation Strap	VII. A. 12.	Joint Sealer, Vimasco Lax-	
Clips for Pipe Strap	VII. A. 14.	Seal F, or approved equal	
Stainless Steel Wire	VII. A. 17.	Neoprene 1/16" thick	
Stainless Steel Skewers	VII. A. 21.	U. S. Rubber No. M-8891,	
Pipe Insulation Support as shown in Figure 10-OX-18		Hercules No. 765-N, or approved equal	
Anti-Abrasive Coating	VII. A. 39.	Weather-Barrier Mastic (color as specified)	
		Trowel Grade, Designation WC	VII. B. 1.
		Reinforcing Cloth	VII. B. 1.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" GENERAL SPECIFICATIONS

Surface:

Surface shall be clean

Insulation Support:

Insulation support, for vertical pipe, shall be fabricated of Everdur and installed as shown in Figure 10-OX-8.

Pipe Supports:

Horizontal piping, supported by insulation in cradles, shall be as per Standard P-8

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(10-OX Piping,. Contd)

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL VOLUME 1", SPECIFICATION NO. 10-OX

Component	Type and Form of Insulation	Securement	Weather-Barrier
Straight Pipe	Sectional insulation (single layer up to 2 1/2" thick, double layer 3" thick and above. 1" cushion blanket, compressed to 1/2", secured with wire shall be applied prior to application of sectional insulation.	Wire, Strap	Mastic
Insulation Expansion - Contraction Joints	Shall be installed in both horizontal and vertical straight run piping at 10' intervals and shall be constructed of cushing material between butt ends of section insulation as shown in Figures 10-OX. 19, 20	Strap, Skewers	Neoprene
Gate & Globe Valves	Preformed as per UCC Fab. Manual*, installed as shown in Figure 10-OX. 17	Strap	Mastic
Flanged Fittings	Preformed as per UCC Fab. Manual*, 1" installed as shown in Figures 10-OX. 15, 16	Strap	Mastic
Welded Fittings	Preformed as per UCC Fab. Manual*, 1" cushion blanket, compress to 1/2 under fitting cover installed as shown in Figure 10-OX. 13, 14	Strap, Wire	Mastic
Hanger Rods	Installed as shown in Figure 10-OX. 23	Strap	Mastic

*Or ASTM Recommended Practice C-450, latest revision.

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 12-H, 12-HSS, RIGID URETHANE FOAM

(Moderate Temperature
50F to 250F)

EQUIPMENT INSULATION

	VESSEL OR COLUMN	DUCT OR FLAT SURFACE
PLANT_____	ITEM NO._____ METAL_____	TOP AND BOTTOM:
UNIT_____	BODY: Dia._____ LENGTH____	WIDTH_____
WORK ORDER_____	HEADS_____ SHAPE_____	LENGTH_____
ACCOUNT NO._____	VESSEL FLANGES_____	SIDES:
DATE_____	MANHOLES_____	WIDTH_____
	SKIRT OR LEGS_____	LENGTH_____
	INSULATION THICKNESS "_____	

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIAL SPECIFICATIONS

Rigid Urethane Foam Insulation	Spec. 12.	Contact Adhesive (Standard)	VII. A. 65.
Insulating Cement	VII. A. 6.	Contact Adhesive	
Equipment Insulation Strap	VII. A. 11.	(high temperature)	VII. A. 66.
Clips for Equipment Strap	VII. A. 12.	Mastic (Caulking)	VII. A. 45.
Stainless steel Wire	VII. A. 17.	Weather Barrier Mastic,	
Welding Pins	VII. A. 19.	(color as specified)	
Stainless Steel Pins	VII. A. 20.	Trowel Grade,	
Welding Pin Insulation Fasteners	VII. A. 22.	Designation WC	VII. 1. B. a
Cork Filled Polyvinyl Acetate		Spray Grade,	
Mastic	Spec. 40.	Designation WB	VII. 1. B. a.
Strapping Tape	VII. A. 33.	Reinforcing Cloth	VII. 1. B. b.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", GENERAL SPECIFICATIONS

Surface:

Steel shall be clean and dry and coated in accordance with "COATING MANUAL". Stainless steel shall be coated in accordance with "COATING MANUAL".

Insulation Supports:

Welded (vendor installed where possible) as per Standards EQ-64. Bolted on as per Standards EQ-67, 68, 69.

Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation D...
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ACL Doc 19432 · Page 445 of 559
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(12-H, 12-HSS, Equip, Contd)

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL, VOLUME 1," SPECIFICATION NO. 12-H, 12-HSS

Component	Type and Form of Insulation	Securement	Weather Barrier
Curved Side Walls	Curved block as shown in Figures 12-H. 1, 2	Strap	Mastic
Heads	Preformed block to fit head as shown in Figures 12-H. 1, 2	Strap, Wire	Mastic
Vessel Flanges	Preformed covers as shown in Figure 12-H. 4	Strap, Skewers, Wire	Mastic and Stainless Steel Sleeves
Nozzles	Preformed covers as shown in Figure 12-H-B	Strap, Skewers, Wire	Mastic
Legs	Do not insulate		
Skirts & Cradles	Outside of skirt down 4 times thickness of insulation, as shown in Figure 12-H. 9	Strap	Mastic
Flat Surfaces	Block, secured with pins and pin clips for temperature above 180F, secured to surface with adhesive temperatures 50F to 18F	Pins, Pin Clips, Adhesives	Mastic

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SPECIFICATION NO. 12-H, 12-HSS, RIGID URETHANE FOAM

(Moderate Temperature Service
50 F to 250F)

PIPING INSULATION

	PIPE				
	LINE NO.	SIZE	LOCATION	METAL	INSUL THK"
PLANT _____					
UNIT _____					
WORK ORDER _____					
ACCOUNT NO. _____					
DATE _____					

WEATHER BARRIER: _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" MATERIAL SPECIFICATIONS

Rigid Urethane Foam Insulation	Spec. 12.	Contact Adhesive(Standard)	VII. A. 65.
Insulating Cement	VII. A. 6.	Contact Adhesive (High Temperature)	VII. A. 66.
Pipe Insulation Support	VII. A. 9.	Weather-Barrier, as specified	
Stainless Steel Wire	VII. A. 17.	Mastic, color as specified	
Cork Filled Polyvinyl Acetate Mastic	Spec. 40.	Trowel Grade, Designation WC	VII. B. 1. a.
Mastic (Caulking)	VII. A. 45.	Reinforcing Cloth	VII. B. 1. b.
Strapping Tape	VII. A. 33.	Stainless Steel Jacket, Designation M	VII. B. 2.
		Treated Steel Jacket, Designation MT	VII. B. 3.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" GENERAL SPECIFICATIONS

Surface:

Steel shall be clean and dry and coated in accordance with "COATING MANUAL". Stainless steel shall be coated in accordance with "COATING MANUAL".

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL VOLUME 1", SPECIFICATION NO. 12-H, 12-HSS

Component	Type and Form of Insulation	Securement	Weather-Barrier
Straight Pipe	Sectional insulation	Tape	Mastic or Steel

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APPLICATION: Continued (12-H, 12-HSS, Piping, Contd)

Gate and Globe Valves	Preformed as per UCC Fab. Manual*, installed as shown in Figure 12-H-12	Tape, Wire	Mastic
Ball and Plug Valves	Field fabricated of sectional insulation	Tape	Mastic
Flanged Fittings	Preformed as per UCC Fab. Manual*, installed as shown in Figures 12-H-10, 11	Tape	Mastic
Screwed and Welded Fittings	1" NPS and less - insulating cement, 1 1/2" to 3" NPS field fabricated, or preformed 3 1/2" NPS and above shall be preformed in accordance with UCC Fab. Manual*	Tape, Wire	Mastic

* Or ASTM Recommended Practice C-450, latest revision.

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SPECIFICATION NO. 14-J, PREFORMED FLEXIBLE PLASTIC FOAM

(Moderate Temperature
33F to 180F)

PIPING INSULATION

		PIPE			
	LINE NO.	SIZE	LOCATION	METAL	INSUL THK"
PLANT _____					
UNIT _____					
WORK ORDER _____					
ACCOUNT NO. _____					
DATE _____					

MATERIALS: As specified in "THERMAL INSULATION MANUAL, VOLUME 1" MATERIAL SPECIFICATIONS

Cellular Glass Insulation	Spec. 14.	Flexible Sealer	VII. A. 68.
Contact Adhesive (Standard)	VII. A. 65.	PVA Finish Coating	
Contact Adhesive (High Temp.)	VII. A. 66.	(Color as specified)	VII. A. 69
Vinyl Finish	VII. A. 67.	Weather-Barrier Mastic	
Strapping Tape	VII. A. 89	(Color as specified)	
Mastic (Caulking	VII. A. 45.	Trowel Grade,	
		Designation WC	VII. B. 1. a.
		Reinforcing Cloth	VII. B. 1. b.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" SPECIFICATION NO. 14-J

Surface:

Steel shall be clean and dry and coated in accordance with "COATING MANUAL".

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 14-J

Component	Type and Form of Insulation	Securement	Weather-Barrier
Straight Pipe	Before pipe erection: Up to 5" NPS, slip cylindrical, unslit insulation on pipe, push insulation back 8" from ends of pipe as pipe is being fitted. After pipe erection: slip cylindrical insulation, install, brush contact adhesive on slit surfaces, press together	None	All piping: Concealed-none Indoors, exposed to water-vinyl finish
		Contact Adhesive	Indoors-PVA finish Outdoors-Mastic

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(14-J, Contd) .

APPLICATION: Continued

Flanges and Valves	Preform covers of pipe covering in accordance with UCC Fabrication Manual*	Contact Adhesive
Welded Ells	Sheets cut to dimensions on Figure 14-J-2	Contact Adhesive

*Or ASTM Recommended Practice C-450, latest revision.

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SPECIFICATION NO. 14-J, PREFORMED FLEXIBLE PLASTIC FOAM

(Moderate Temperature 33F to 180F)

EQUIPMENT INSULATION

PLANT _____
UNIT _____
WORK ORDER _____
ACCOUNT NO. _____
DATE _____

VESSEL OR COLUMN
ITEM NO. _____ METAL _____
BODY: Dia. _____ LENGTH _____
HEADS _____ SHAPE _____
SKIRT OR LEGS _____

DUCT OR FLAT SURFACE _____
TOP AND BOTTOM:
WIDTH _____
LENGTH _____
SIDES:
WIDTH _____
LENGTH _____

WEATHER BARRIER _____ INSULATION THICKNESS " _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIAL SPECIFICATIONS

Preformed Flexible Plastic Foam Insulation	Spec. 14.	Flexible Sealer	VII. A. 68.
Contact Adhesive (Standard)	VII. A. 65.	PVA Finish Coating (color as specified)	VII. A. 69.
Contact Adhesive (High Temp.)	VII. A. 66.	Weather Barrier Mastic, (color as specified)	
Vinyl Finish	VII. A. 67.	Trowel Grade, Designation WC	VII. B. 1. a.
Strapping Tape	VII. A. 89.	Spray Grade, Designation WB	VII. B. 1. a.
Mastic (Caulking)	VII. A. 45.	Reinforcing Cloth	VII. B. 1. b.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 14-J

Surface:

Steel surfaces shall be sandblasted and coated with zinc silicate inorganic coating in accordance with "COATINGS MANUAL". Aluminum, copper or galvanized steel shall be clean and dry.

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(14-J, Piping, Contd)

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 14-J

Component	Type and Form of Insulation	Securement	Weather Barrier
Vessel Body	Sheets cut slightly oversize - adhesive applied to surface and cut side of sheet, then applied from center of sheet outward. Edges bonded together with adhesive. Voids and termination sealed with flexible sealer.	Contact Adhesive	Vinyl finish-Indoors Mastic-Outdoors
Ducts	Same as for vessel body. Duct seam insulated as shown in Figure 14-J.1	Contact Adhesive	Vinyl finisn-Indoors where exposed to water. PVA Finish-Indoors Mastic-Outdoors
Vessel Flanges	Not insulated unless otherwise specified		
Legs	Not insulated unless otherwise specified.		
Skirts & Cradles	Down a minimum 6" from vessel	Contact Adhesive	As used on vessel

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 15-H, HEAVY DENSITY FIBROUS GLASS

(Moderate to High Temperature
70F to 750F)

EQUIPMENT INSULATION

PLANT _____
UNIT _____
WORK ORDER _____
ACCOUNT NO. _____
DATE _____

VESSEL OR COLUMN
ITEM NO. _____ METAL _____
BODY: Dia. _____ LENGTH ____
HEADS _____ SHAPE _____
VESSEL FLANGES _____
MANHOLES _____
NOZZLES _____
SKIRT OR LEGS _____

DUCT OR FLAT SURFACES
TOP AND BOTTOM:
WIDTH _____
LENGTH _____
SIDES:
WIDTH _____
LENGTH _____

WEATHER BARRIER _____ INSULATION THICKNESS " _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIAL SPECIFICATIONS

Preformed Heavy Density Fibrous Glass Insulation	Spec. 15.	Bonding Adhesive	VII. A. 92.
Glass Wool Blanket	VII. A. 1.	Glass Wool Metal Mesh Blanket	VII. A. 93.
Expansion Sleeve	VII. A. 10.	PVA Finish Coating (indoor finish)	VII. A. 95
Equipment Insulation Strap	VII A. 11.	Glass Cloth Jacket (indoor finish cloth)	VII. A. 90.
Clips for Equipment Strap	VII. A. 12.	Weather Barrier, as specified	
Stainless Steel Wire	VII. A. 17.	Mastic, color as specified Designation WC	VII. B. 1. a.
Welding Pins	VII. A. 19.	Reinforcing Cloth	VII. B. 1. b.
Stainless Steel Pins	VII. A. 20.	Stainless Steel Jacket Designation M	VII. B. 2.
Stainless Steel Skewers	VII. A. 21.	Treated Steel Jacket Designation MT	VII. B. 3.
Welding Pin Insulation Fasteners	VII. A. 22.		
Pin Clips	VII. A. 23.		
Insulating Cement	VII. A. 6.		
Heat Resistant Sealer	VII. A. 42.		
Mastic (Caulking)	VII. A. 45.		
High Temp. Fabricating Cement	VII. A. 91.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"., GENERAL SPECIFICATIONS

Surface:

Steel shall be clean and dry, and when required shall be coated in accordance with "COATING MANUAL". Stainless steel shall be coated in accordance with "COATING MANUAL".

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PREPARATION: (Continued) (15-H, Equip, Contd)

Insulation Supports:

Welded (vendor applied where possible) as per Standard EQ-64. Bolted on as per Standards IS-31, 31A, 36, 42.

Tracing: (Where Required)

Heat Transfer Cement, Materials, MATERIAL SPECIFICATION VII. C. Application, GENERAL SPECIFICATION XIII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 15-H.

Component	Type and Form of Insulation	Securement	Weather Barrier
Curved Side Wall	Under 30" OD. Sectional pipe insulation, over 30" OD shop fabricated block	Strap	Indoor-PVA Finish Outdoors-Mastic or Steel Jacket
Heads	Preformed Block	Strap, Wire	All fittings and projections: Indoors-PVA Finish Outdoors-Mastic
Vessel Flanges	Preformed Covers as shown in Figure 15-H-8.	Strap, Skewers, Wire	
Nozzles	Preformed covers as shown in Figure 15-H-10	Strap, Wire	
Legs - Channel	Block down to fireproofing as shown in Figure 15-H-4	Strap, Wire	
Legs - Concrete Filled	Not insulated		
Skirts & Cradles	Not insulated		
Flat Surfaces	Block and insulating cement as shown in Figure 15-H-3	Pins and Pin Clips	

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 15-H, HEAVY DENSITY FIBROUS GLASS

(Moderate to High Temperature
70F to 750F)

PIPING INSULATION

		PIPE			
	LINE NO.	SIZE	LOCATION	METAL	INSUL THICK"
PLANT					
UNIT					
WORK ORDER					
ACCOUNT NO.					
DATE					

WEATHER BARRIER: _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
MATERIAL SPECIFICATION

Preformed Heavy Density Fibrous Glass Insulation	Spec. 15	Bonding Adhesive	VII. A. 92.
Glass Wool Blanket	VII. A. 1.	PVA Finish Coating (Indoor finish)	VII. A. 95.
Expansion Sleeve	VII. A. 10.	Glass Cloth Jacket (Indoor finish cloth)	VII. A. 90
Pipe Insulation Strap	VII. A. 13.	Weather-Barrier - as specified	
Clips for Pipe Strap	VII. A. 14.	Mastic-color as specified(Designation WC)	VII. B. 1. a.
Stainless Steel Wire	VII. A. 17.	Reinforcing Cloth	VII. B. 1. b.
Heat Resistant Sealer	VII. A. 42.	Stainless Steel Jacket (Designation M)	VII. B. 2.
Mastic (Caulking)	VII. A. 45.	Treated Steel Jacket (Designation MT)	VII. B. 3.
High Temp. Fabricating Cement	VII. A. 91.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1"
GENERAL SPECIFICATIONS

Surface:

Steel and stainless steel shall be clean and dry and, when required, shall be coated in accordance with "COATINGS MANUAL".

Insulation Supports:

Vertical pipe, over 4" NPS. As shown in Figure 15-L-16.

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PREPARATION: Continued (15-H, Piping, Contd)

Tracing: Where required.

Steam, installed per Standards P-140, P-140A, Insulation Details. GENERAL SPECIFICATIONS VII. A. & B.

Electric, installed per Standard EL-43, Insulation Details. GENERAL SPECIFICATIONS XIII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1". SPECIFICATION NO. 15-H

Component	Type and Form of Insulation	Securement	Weather-Barrier
Straight Pipe	Sectional insulation, single layer up to 3" thk; double layer 3 1/2" thk and above as per GEN SPEC GA-1, GA-2	For all pipe & fitting wire up to 11" OD Strap above 11" OD	Indoors-PVA finish Outdoors-Mastic or steel jacket expansion sleeves
Insulation Expansion Joint	Horizontal, 1 every 21' straight pipe, Fig. 15-H-19; vertical 1 every 15' straight pipe, Fig. 15-H-13		
Gate and Globe Valves	Preformed covers as per UCC Fabrication Manual*, installed as per 15-H-18		All fittings: Indoors-PVA finish
Ball and Plug Valves	Field cut from sectional covering		Outdoors-Mastic
Flanged & Screwed Fittings Over 3" NPS	Preformed covers as per UCC Fabrication Manual, installed as per 15-H-14, 15, 16, 17		
Fittings Under 3" NPS	May be field fabricated		

* Or ASTM Recommended Practice C-450, latest revision.

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 16-H, LOW DENSITY FIBROUS GLASS-

(Moderate Temperature
70F to 350F)

PIPING INSULATION

	PIPE				
	LINE NO.	SIZE	LOCATION	METAL	INSUL THK "
PLANT _____					
UNIT _____					
WORK ORDER _____					
ACCOUNT NO _____					
DATE _____					

WEATHER-BARRIER or INDOOR FINISH _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" MATERIALS SPECIFICATION

Preformed Low Density Fibrous Glass Insulation	Spec. 16.	PVA Finish Coating & Lagging Adhesive	VII. A. 99.
Pipe Insulation Support	VII. A. 9.	Weather-Barrier Mastic (color as specified) Trowel Grade, Designation WC	VII. B. 1. a.
Fabrication Cement	VII. A. 47.		
Fire-Retardant Vapor-Barrier Jacket & Butt Joint Strips	VII. A. 72.		
Strapping Tape	VII. A. 33.	Reinforcing Cloth	VII. B. 1. b.
Mastic (Caulking)	VII. A. 45.		
Vapor Seal Lap Cement	VII. A. 98.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" GENERAL SPECIFICATIONS

Surface:

Steel shall be clean and dry, and when required shall be coated in accordance with "COATINGS MANUAL". Stainless steel shall be coated in accordance with "COATINGS MANUAL".

Insulation Supports:

Vertical pipe, over 4" NPS shall be equipped with insulation supports directly above bottom fitting.

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(16-H, Piping, Contd)

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL VOLUME 1". SPECIFICATION NO. 16-H

Component	Type and Form of Insulation	Securement	Weather-Barrier or Indoor Finish
Straight Pipe	Sectional insulation		
	Pipe insulation with factory attached jacket	Self-sealing lap	
	Pipe insulation without factory attached jacket	tape	
Gate and Glove Valves	Preformed as per UCC Fabrication Manual*, installed as shown in 16-H-2		
Flanged & Screwed Fittings over 3" NPS	Preformed as per UCC Fabrication Manual*, installed as shown in 16-H-1		
Ball and Plug Valves Fittings under 3" NPS	Field cut from sectional covering May be field fabricated	Strapping tape	

*Or ASTM Recommended Practice C-450, latest revision

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SPECIFICATION NO. 17-RX, RIGID FIBROUS GLASS HEATING, VENTILATION AND AIR CONDITIONING DUCT INSULATION

(On Interior of Duct)

DUCTS

	DUCT NO.	WIDTH	HEIGHT	LENGTH	METAL	INSUL THICK "
PLANT _____						
BLDG. NO. _____						
WORK ORDER _____						
ACCOUNT NO. _____						
DATE _____						

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIAL SPECIFICATION.

Fibrous Glass Board with Factory Vapor Barrier	Spec. 17-RX	Weather-Barrier Mastic (color as specified) Trowel Grade, Designation WC	VII. B. 1. a.
Welding Pin Insulation Fasteners	VII. A. 22.		
Pin Clips	VII. A. 23.		
Adhesive Type Pins	VII. A. 75.	Spray Grade, Designation WB	VII. B. 1. a.
Fire Resistant Adhesive	VII. A. 100.		
Outer Covering (8 oz canvas)	VII. A. 102.	Reinforcing Cloth	VII. A. 1. b.
Joint Sealing Tape	VII. A. 103.		
PVA Finish Coating and Lagging Adhesive	VII. A. 99.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL, VOLUME 1", SPECIFICATION NO. 17-RX.

Securement:

Where welding is permitted, use welding pins. Where welding is not permitted, use adhesive pins attached to duct with fire resistant adhesive. Spacing of pins shall be longitudinal 12" to 18". On surfaces less than 8" in width, one row down center. Above 8" one row each side. As shown in Figure 17-RX-1.

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UNION CARBIDE
STANDARD
CHEMICALS AND PLASTICS OPERATIONS DIVISION AND UNION CARBIDE CANADA LIMITED (17-RX, Ducts, Contd)

APPLICATION: As specified in "THERMAL INSULATIONMANUAL - VOLUME 1"., SPECIFICATION NO. 17-RX.

Insulation Application	Finish Coating or Weather-Barrier		
	Concealed From View	Indoors	Outdoors
Block impailed on pins, pins pressed into surface 1/4" pins clipped of 1/16" below surface, pin holes sealed with adhesive, cracks and joints sealed with joint tape embedded in adhesive	None	Canvas embedded in PV finish, and overcoated with PVA finish	Mastic and reinforcing cloth as per XIV. b.

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 17-RY, RIGID FIBROUS GLASS HEATING, VENTILATION AND AIR CONDITIONING DUCT INSULATION
(On Interior of Duct)

DUCTS

	DUCT NO.	WIDTH	HEIGHT	LENGTH	METAL	INSUL THICK "
PLANT						
BLDG. NO.						
WORK ORDER						
ACCOUNT NO.						
DATE						

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIALS SPECIFICATION

Fibrous Glass Board - Neoprene Coated	Spec. No. 17-RY	PVA Finish Coating	VII. A. 99.
Welding Pin Insulation Fasteners	VII. A. 22.	Fire - Resistant Adhesive	VII. A. 100.
Pin Clips	VII. A. 23.	Fire - Resistant Caulking Mastic	VII. A. 101.
Adhesive Type Pins	VII. A. 75.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 17-RY

Securement: Ducts up to 3000 FPM Air Velocity

Welding pins or adhesive pins shall be installed on interior top and side surfaces of the duct where the width of duct exceeds 12" and 24", respectively, on 16" maximum centers.

Ducts over 3000 FPM Air Velocity

Welding pins or adhesive pins shall be installed on interior top, side and bottom of duct on 16" maximum centers.

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(15-RY, Duct, Contd)

APPLICATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 17-RY

Ducts Up to 3000 FPM Air Velocity

Insulation with neoprene coating facing air flow shall be impaled on pins and adhered to the interior surfaces of the duct with fire resistant adhesive applied a minimum of 50% of the surface. Pin clips or speed washers shall be pushed on clips to secure insulation in place. Joints shall be tightly butted and caulked with fire resistant caulking mastic. As shown in Figure 17-RY-1.

Ducts Over 3000 FPM Air Velocity

All edges and ends of insulation shall be given heavy coat of fire resistant caulking mastic prior to application. Application shall be same as given above, with addition that a light brush coat (100 sq ft per gallon) of PVA finish coating and lagging adhesive shall be applied to all interior surfaces of the insulation.

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 18-FX, FIBROUS GLASS BLANKET HEATING, VENTILATION, AND AIR CONDITIONING DUCT INSULATION

(On Exterior of Duct)

DUCTS LOCATED IN CONCEALED INDOOR SPACE

DUCTS

	DUCT NO.	WIDTH	HEIGHT	LENGTH	METAL	INSUL THICK "
PLANT						
BLDG. NO.						
WORK ORDER						
ACCOUNT NO.						
DATE						

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIALS SPECIFICATION

Fibrous Glass Blanket With Fire-Retardant Vapor Barrier	Spec. 18-FX
Fire-Resistant Adhesive	VII. A. 100.
Joint Tape	VII. A. 104.

APPLICATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 18-FX

Insulation shall be adhered to ducts with fire-resistant adhesive. All joints shall be tightly butted and sealed with joint tape or with 2 inch wide flanges of factory applied vapor barrier facing, sealed with the fire-resistant adhesive. As shown in Figure 18-FX-1.

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(18-FX, Contd)

SPECIFICATION NO. 18-FY, FIBROUS GLASS BLANKET HEATING, VENTILATION AND AIR CONDITIONING DUCT INSULATION

(On Interior of Duct)

DUCTS

	DUCT NO.	WIDTH	HEIGHT	LENGTH	METAL	INSUL THICK "
PLANT						
BLDG. NO.						
WORK ORDER						
ACCOUNT NO.						
DATE						

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIALS SPECIFICATION

Fibrous Glass Blanket Coated One Side With Neoprene	Spec. 18-FY
Welding Pin Insulation Fasteners	VII. A. 22.
Pin Clips	VII. A. 23.
Grip Nails	VII. A. 73.
Fire Resistant Adhesive	VII. A. 100.

APPLICATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 18-FY.

Insulation installed to flat sheet metal before it is formed into ducts. The insulation liner and the metal shall be formed in the break as a unit. Application depends on duct air velocity.

Ducts With Air Flow Velocity Up To 1500 FPM

Edges of liner coated with adhesive. Liner attached to metal with grip nails, applied 3" from each corner and ends, spaced on 6" centers. Lines of grip nails shall be used to support liner between edges, one row for 10" span, two rows 10" to 22", three rows 22" to 36". Alternate Method: Adhere liner with adhesive, minimum adhered area not less than 50% with additional fastening of grip nails or welding pins and clips 3" from edges on 6" centers. Where width of duct exceeds 12", use one row down center, and where height exceeds 24", use one row down center.

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APPLICATION: Continued (18-FY, Duct, Contd)

Ducts With Air Flow Velocity 1500 to 4000 FPM

Metal 6" back from all edges, and edges shall be coated.

Ducts With Air Flow Velocity 4000 to 6000 FPM

Welding pins shall be placed 3" from all edges on 6" centers. Rows of pins between edges must be placed not over 12" apart. Liner shall be adhered to metal with adhesive at a minimum of 50% of areas. Liner 6" back from edges to be completely adhered with adhesive to duct. Edges of liner must be coated with adhesive. Typical installation shown in Figure 18-FY-1.

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 19-J, FIBROUS GLASS with INTEGRAL FACING (On Side Wall), FIBROUS GLASS (On Roof) (60F to 350F)

VESSEL INSULATION

VESSEL OR COLUMN
(Must be over 12' 0" in diameter)

PLANT _____ ITEM NO. _____ METAL _____

UNIT _____ BODY: Dia. _____ HEIGHT _____

WORK ORDER _____ HEADS _____ SHAPE _____

ACCOUNT NO. _____ VESSEL FLANGES _____

DATE _____ MANHOLES _____

NOZZLES _____

INSULATION THICKNESS": Side Walls _____ Heads _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIAL SPECIFICATIONS

Aluminum Faced Fibrous Glass	Spec. 19. J.	Battens	VII. A. 108.
Fibrous Glass Roof Insulation	Spec. 19. J.	Studs	VII. A. 109.
Equipment Insulation Strap	VII. A. 11.	Caps for Grooved Studs	VII. A. 110.
Clips for Equipment Strap	VII. A. 12.	Roof Tape	VII. A. 111
Expansion Springs or Bands	VII. A. 15.	Incombustible Adhesive	VII. A. 112.
Clips for Expansion Bands	VII. A. 16.	Flashing	VII. A. 31.
Stainless Steel Wire	VII. A. 17.	Weather Barrier Mastic	
Welding Pin Insulation Fasteners	VII. A. 22.	(color as specified)	
Pin Clips	VII. A. 23.	Trowel Grade,	
Sheet Metal Screws	VII. A. 32.	Designation WC	VII. B. 1. a.
Mastic	VII. A. 45.	Spray Grade,	
Lap Sealer	VII. A. 46.	Designation WB	VII. B. 1. a.
"S" Clips	VII. A. 107.	Reinforcing Cloth	VII. B. 1. b.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", GENERAL SPECIFICATIONS

Surface:

Steel shall be clean and dry and, when required, shall be coated in accordance with "COATING MANUAL". Stainless steel shall be coated in accordance with "COATING MANUAL".

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PRE PARATION: Continued (19-J, Vessel, Contd)

Insulation Supports:

Welded (vendor applied where possible) as per Standard EQ-64. Bolted on as per Standards IS-31, 31A. Head securement - welding pins as per Figure 19. J. 1. Water shed, plate or angle, at top of cone head vessels as shown in Figure 19. J. 1.

Tracing: (Where Required)

Heat Transfer Cement Materials - MATERIAL SPECIFICATION VII. C., Application GENERAL SPECIFICATION XII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION No. 19. J.

Component	Type and Form of Insulation	Securement	Weather Barrier
Curved Side Wall	Fibrous glass panels as shown in Figures 19. J. 1, 2, 3	Strap or Studs	Factory attached Al
Head (cone shaped)	Fibrous glass roof insulation and 1/2" thick fibrous glass sheet insulation as shown in Figure 19. J. 1	Pins and Clips	Mastic
Nozzles	Preformed covers as shown in Figure 19. J. 4	Strap and Wire	Mastic

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 19-H, MINERAL WOOL with INTEGRAL FACING (On Side Walls)
EXPANDED SILICA (On Roof) (60F to 450F)

VESSEL INSULATION

VESSEL OR COLUMN
(Must be over 12'0" in diameter)

PLANT_____ ITEM NO._____ METAL_____
UNIT_____ BODY: Dia._____ HEIGHT_____
WORK ORDER_____ HEADS_____ SHAPE_____
ACCOUNT NO._____ VESSEL FLANGES_____
DATE_____ MANHOLES_____
NOZZLES_____
SKIRT OR LEGS_____

INSULATION THICKNESS": Side Walls_____ Heads_____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIAL SPECIFICATIONS

Mineral Wool with Integral Aluminum Facing	Spec. 19-H	Sheet Metal Screws	VII. A. 32.
Expanded Silica Insulation	Spec. 22.	Aluminum Flashing	VII. A. 31.
Cellular Glass Insulation	Spec. 10.	High Temperature Fabrication Cement	VII. A. 34.
Equipment Insulation Strap	VII. A. 11.	Mastic	VII. A. 45.
Clips for Equipment Strap	VII. A. 12.	Lap Setting Sealer	VII. A. 46.
Expansion Springs or Bands	VII. A. 15.	"S" Clips	VII. A. 27.
Clips for Expansion Bands	VII. A. 16.	Weather Barrier Mastic (color as specified)	
Stainless Steel Wire	VII. A. 17.	Trowel Grade,	
Insulating Cement	VII. A. 7.	Designation WC	VII. B. 1. a.
Welding Pins	VII. A. 19.	Spray Grade,	
Studs (supplied by mfg. for punched panels)	VII. A. 29.	Designation WB	VII. B. 1. a.
Stud Nuts (supplied by mfg. for punched panels)	VII. A. 30.	Reinforcing Cloth	VII. B. 1. b.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", GENERAL SPECIFICATIONS

Surface:

Steel shall be clean and dry, and when required shall be coated in accordance with "COATING MANUAL". Stainless steel shall be coated in accordance with "COATING MANUAL".

Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation D...
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PREPARATION: Continued (19-H, Vessel, Contd)

Insulation Supports:

Welded (vendor applied where possible) as per Standard EQ-64, bolted on as per Standards IS-31, 31A. Head securement pins as per Standard IS-40. Water shed plate or angle at top of cone head vessels as per Figure 19.H.1.

Tracing: (Where Required)

Heat Transfer Cement Materials - MATERIAL SPECIFICATION VII.C., Application - GENERAL SPECIFICATION XIII.B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL, VOLUME 1", SPECIFICATION NO. 19.H.

Component	Type and Form Of Insulation	Securement	Weather Barrier
Curved Side Wall	Mineral wool, aluminum faced panels as shown in Figure 19.H.1, 2, & 3	Studs or Strap	Factory Attached Aluminum
Heads	Preformed block as shown in Figure 19.H.1 & 5	Strap or Wire	Mastic
Nozzles	Preformed covers as shown in Figure 19.H.4	Strap and Wire	Mastic
Legs - Channel	Block	Strap and Wire	Mastic
Legs - Concrete Filled	Not Insulated		
Skirts - Outside	Mineral wool aluminum faced panel	Studs or Strap	Factory Attached Aluminum

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SPECIFICATION NO. 21-H & HSS, ASBESTOS FIBER (High Temperature Service - Max. 10(

PIPING INSULATION

	LINE NO.	SIZE	LOCATION	METAL	INSUL THK "
PLANT					
UNIT					
WORK ORDER					
ACCOUNT NO.					
DATE					

WEATHER BARRIER: Straight Pipe _____ Fittings: Mastic - Designation WC

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIAL SPECIFICATIONS

Asbestos Fiber	Spec. 21.	Heat Resistant Sealer	VII. A. 42.
Cushioning Blanket	VII. A. 1.	Mastic (Caulking)	VII. A. 45
Insulating Cement	VII. A. 7.	Weather-Barrier: As Specified	
Pipe Insulation Support	VII. A. 9.	Mastic, color as specified,	
Pipe Insulation Strap	VII. A. 13.	Designation WC	VII. B. 1. a.
Clips for Pipe Strap	VII. A. 14.	Reinforcing Cloth	VII. B. 1. b.
Stainless Steel Wire	VII. A. 17.	Stainless Steel Jacket,	
Stainless Steel Pins	VII. A. 20.	Designation M	VII. B. 2.
High Temp. Fab. Cement	VII. A. 37.	Treated Steel Jacket,	
		Designation MT	VII. B. 3.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" GENERAL SPECIFICATIONS AND "ENGINEERING STANDARDS".

Surface:

Surface shall be clean and dry. Steel and stainless steel, when required, shall be coated in accordance with "COATINGS MANUAL".

Insulation Supports:

Vertical pipes over 4" NPS as shown in Figure 21-H-1.

Tracing: (Where Required)

Steam, installed per Standards P-140, P-140; Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Electric, installed per Standard EL-43; Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Heat Transfer Cement, Materials, MATERIAL SPECIFICATIONS VII. C. Application, GENERAL SPECIFICATIONS XIII. B.

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(21-H, 21-HSS, Piping, Contd)

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL VOLUME 1", SPECIFICATION NO. 21-H & HSS

Component	Type and Form of Insulation	Securement	Weather-Barrier
Straight Pipe	Sectional insulation (double layer 3 1/2" thick and over)	For all pipe and fittings: Wire up to 11" OD, Strap above 11" OD	Mastic or Steel Jacket
Insul. Expansion Joints	Install one every 21' of straight pipe, as shown in Figure 21-H-1. & 5.		Mastic
Gate and Globe Valves	Preformed as per "UCC Fab. Manual"*, as shown in Figure 21-H-4.		Mastic
Ball and Plug Valves	Field cut from sectional covering		Mastic
Flanged Fittings	Preformed as per "UCC Fab. Manual"*, as shown in Figure 21-H-3.		Mastic
Welded Ells	Preformed as per "UCC Fab. Manual"*, as shown in Figure 21-H-2.		Mastic
Screwed Fittings	Over 3" preformed. Under 3" may be field formed of pipe covering or insulating cement		Mastic

* Or ASTM Recommended Practice C-450, latest revision.

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 22-H, 22-HSS, EXPANDED SILICA

(Moderate and High Temperature Service, 70F to 1600F)

EQUIPMENT INSULATION

PLANT _____
UNIT _____
WORK ORDERS _____
ACCOUNT NO. _____
DATE _____

VESSEL OR COLUMN
ITEM NO. _____ METAL _____
BODY: Dia. _____ LENGTH _____
HEADS _____ SHAPE _____
VESSEL FLANGES _____
MANHOLES _____
NOZZLES _____
SKIRT OR LEGS _____

DUCT OR FLAT SURFACES
TOP AND BOTTOM:
WIDTH _____
LENGTH _____
SIDES:
HEIGHT _____
LENGTH _____

WEATHER BARRIER _____ INSULATION THICKNESS " _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIALS SPECIFICATION

Expanded Silica Insulation	Spec. 22.	Fabrication Cement	VII. A. 38.
Cushioning Blanket	VII. A. 1.	Heat Resistant Sealer	VII. A. 42.
Mineral Wool Blanket (netting - both sides)	VII. A. 5.	Mastic (Caulking)	VII. A. 45.
Mineral Wool Blanket (one side netting, other lath)	VII. A. 106.	Weather Barrier - as specified Mastic, color as specified, Trowel Grade, Designation WC	VII. B. 1. a.
Insulating Cement	VII. A. 7.		
Equipment Insulation Strap	VII. A. 11.	Mastic, color as specified, Spray Grade, Designation WB	VII. B. 1. a.
Clips for Equipment Strap	VII. A. 12.		
Stainless Steel Wire	VII. A. 17.		
Wire Netting	VII. A. 18.	Reinforcing Cloth	VII. B. 1. b.
Welding Pins	VII. A. 19.	Metal Jacket, stainless steel, Designation M	VII. B. 2.
Stainless Steel Pins	VII. A. 20		
Stainless Steel Skewers	VII. A. 21.	Treated steel, Designation MT	VII. B. 3.
Welding Pin Insul Fasteners	VII. A. 22.		
Pin Clips	VII. A. 23.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", GENERAL SPECIFICATIONS and "ENGINEERING STANDARDS"

Surface:

Steel shall be clean and dry, and when required shall be coated in accordance with "COATING MANUAL".

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PREPARATION: Continued (22-H, 22-HSS, Equip, Contd)

Insulation Supports:

Welded (vendor applied where possible) as per Standard EQ-64. Bolted on as per Standards IS-31, 31-A, 36, 42.

Tracing: (Where Required)

Heat Transfer Cement, Materials - MATERIAL SPECIFICATION VII. C. Application, GENERAL SPECIFICATION XIII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 22-H, 22-HSS

Component	Type and Form of Insulation	Securement	Weather Barrier
Curved Side Walls			
Below 600F	Curved segments (double layer 3 1/2" thick and over)	Strap	Mastic or Steel
Above 600F and 12' OD	Glass blanket to 950F, mineral wool blanket over 950F. Inner layer under curved segments	Wire for Blanket Strap for Segments	Mastic or Steel
Heads	Same as for curved side wall	Strap & Wire	Mastic
Vessel Flanges	Preformed as shown in Figure 22-H-6	Strap & Wire	Mastic & stainless steel sleeves
Nozzles	Preformed as per "UCC Fab. Manual, as shown in Figure 22-H-10	Strap & Wire	Mastic
Irregular Surfaces	Block and insulating cement or insulating cement only	Strap & Wire	Mastic
Legs - Channel	Block down to fireproofing, as shown in Figure 22-H-11	Strap & Wire	Mastic
Legs - Concrete Filled	Not insulated		
Skirts & Cradles	Not insulated, unless required for protection		
Flat Surfaces	Flat block and insulating cement as shown in Figure 22-H-2	Pins, Clips, Wire, Netting	Mastic
Flat Surfaces Expansion Joint	Mineral wool blanket - lath one side, and insulating cement	Pins, Clips Wire	Mastic

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO 22-H & HSS, EXPANDED SILICA - (Moderate and High Temp. Service, 70F to 1600F)

PIPING INSULATION

		PIPE			
	LINE NO.	SIZE	LOCATION	METAL	INSUL THK "
PLANT					
UNIT					
WORK ORDER					
ACCOUNT NO					
DATE					

WEATHER-BARRIER: Straight Pipe _____ Fittings: Mastic, Designation WC

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" MATERIALS SPECIFICATION

Expanded Silica Insulation	Spec. 22.	Heat Resistant Sealer	VII. A. 42.
Cushioning Blanket	VII. A. 1.	Mastic (Caulking)	VII. A. 45.
Insulating Cement	VII. A. 7.	Weather-Barrier: As Specified	
Pipe Insulation Support	VII. A. 9.	Mastic, color as specified,	
Pipe Insulation Strap	VII. A. 13.	Designation WC	VII. B. 1. a.
Clips for Pipe Strap	VII. A. 14.	Reinforcing Cloth	VII. B. 1. b.
Stainless Steel Wire	VII. A. 17.	Stainless Steel Jacket,	
Stainless Steel Pins	VII. A. 20.	Designation M	VII. B. 2.
High Temperature Fabrication		Treated Steel Jacket,	
Cement	VII. A. 37.	Designation MT	VII. B. 3.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", GENERAL SPECIFICATIONS and "ENGINEERING STANDARDS"

Surface:

Surface shall be clean and dry. Steel and stainless steel, when required, shall be coated in accordance with "COATING MANUAL".

Insulation Supports:

Vertical pipe over 4" NPS as shown in Figure 22-H-13.

Tracing: (Where Required)

Steam, installed per Standards P-140, P-140A. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Electric, installed per Standard EL-43. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

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PREPARATION: (Continued) (22-H, 22-HSS, Piping, Contd)

Tracing: (Continued)

Heat Transfer Cement, Materials, MATERIAL SPECIFICATIONS VII. C.
Application, GENERAL SPECIFICATIONS XIII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 22-H & HSS

Component	Type and Form of Insulation	Securement	Weather-Barrier
Straight Pipe	Sectional insulation (double layer 3 1/2" thick and over)	For all pipe and fittings: Wire up to 11" OD, Strap over 11" OD	Mastic or Steel Jacket
Insulation Expansion Joints	Install one every 21' of straight pipe, as per Figure 22-H-13,17.		Mastic and Stainless Steel Sleeves
Gate and Globe Valves	Preformed as per "UCC Fab. Manual"*, as shown in Figure 22-H-16.		Mastic
Ball and Plug Valves	Field cut from sectional covering		Mastic
Flanged Fittings	Preformed as per "UCC Fab. Manual"*, as shown in Figure 22-H-15.		Mastic
Welded Ells	Preformed as per "UCC Fab. Manual"*, as shown in Figure 22-H-14.		Mastic
Screwed Fittings	Over 3" preformed. Under 3" may be field formed of pipe covering or insulating cement		Mastic

* Or ASTM Recommended Practice C-450, latest revision.

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 22-HSP, EXPANDED SILICA SPHERE INSULATION (Moderate to High Temperature Service, 70F to 500F)

SPHERE

PLANT _____ ITEM NO. _____

UNIT _____ BODY: Dia. _____

WORK ORDER _____ MANHOLES _____

ACCOUNT NO. _____ NOZZLES _____

DATE _____ PROJECTIONS _____

LEGS _____

WEATHER BARRIER Mastic INSULATION THICKNESS" _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIALS SPECIFICATION

Expanded Silicate Insulation	Spec. 22.	Weather Barrier Mastic, color as specified, Trowel Grade, Designation WC	VII. B. 1. a.
Insulating Cement	VII. A. 7.		
Equipment Insulation Strap	VII. A. 11.		
Clips for Equipment Strap	VII. A. 12.		
Wire Netting	VII. A. 18.	Mastic, color as specified Spray Grade, Designation WB	VII. B. 1. b.
Welding Pin Insulation Fasteners	VII. A. 22.		
Pin Clips	VII. A. 23.		
Stainless Steel Skewers	VII. A. 21.	Reinforcing Cloth	
Fabrication Cement	VII. A. 38.	Metal Jacket, Treated Steel, Designation MT	VII. B. 3.
Heat Resistant Sealer	VII. A. 42.		
Mastic (Caulking)	VII. A. 45.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", and "ENGINEERING STANDARDS"

Surface:

Steel shall be clean and dry, and when required shall be coated in accordance with "COATINGS MANUAL". Stainless steel shall be coated in accordance with "COATINGS MANUAL".

Insulation Supports:

Shall be provided as shown on drawing. One to be located at equator, one to be approximately 30° below and another to be approximately 30° above the equator. These are primarily used as water stops. Welding pins space 4 to block, supports the insulation to the sphere body.

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(22-HSP, Sphere, Contd)

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL, VOLUME 1", SPECIFICATION NO. 22-HSP

Component	Type and Form of Insulation	Securement	Weather Barrier
Body	Insulation shall be shop fabricated, geodesically shaped to fit sphere body. Impaled on pins, then secured by clips pressed into surface. Depression filled flush with caulking mastic as shown in Figure 22-H-SP-1	Pins, Clips	Mastic
Insulation Support	As shown in Figure 22-HSP-2		Mastic
Nozzles and Manholes	Preformed covers, as shown in Figures 22-HSP-3, 4	Strap, Wire	Mastic
Legs-Concrete Filled	Not insulated		
Legs-Not Filled	Block or preformed insulation to fire protection	Strap, Wire	Mastic
Tie Rods	2" thick sec. insulation as per Spec. 22-H	Strap	Steel Jacket

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 23-H, 23-HSS, CALCIUM SILICATE

(High Temperature Service
Max. 950F)

EQUIPMENT INSULATION

PLANT _____
UNIT _____
WORK ORDER _____
ACCOUNT NO. _____
DATE _____

VESSEL OR COLUMN
ITEM NO. _____ METAL _____
BODY: Dia. _____ LENGTH _____
HEADS _____ SHAPE _____
VESSEL FLANGES _____
MANHOLES _____
NOZZLES _____
SKIRT OR LEGS _____

DUCT OR FLAT SURFACES
TOP AND BOTTOM:
WIDTH _____
LENGTH _____
SIDES:
WIDTH _____
LENGTH _____

WEATHER BARRIER _____ INSULATION THICKNESS " _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIALS SPECIFICATION

Calcium Silicate Insulation	Spec. 23.	Fabrication Cement	VII. A. 38.
Cushioning Blanket	VII. A. 1.	Heat Resistant Sealer	VII. A. 42.
Mineral Wool Blanket (netting both sides)	VII. A. 5.	Mastic (Caulking)	VII. A. 45.
Mineral Wool Blanket (one side netting - other lath)	VII. A. 106.	Weather Barrier - as specified	
Insulating Cement	VII. A. 7.	Mastic, color as specified Trowel Grade - Designation WC	VII. B. 1. a.
Equipment Insulation Strap	VII. A. 11.	Mastic, color as specified, Spray Grade - Designation WB	VII. B. 1. a.
Clips for Equipment Strap	VII. A. 12.	Reinforcing Cloth	VII. B. 1. b.
Stainless Steel Wire	VII. A. 17.	Metal Jacket, stainless steel Designation M	VII. B. 2.
Wire Netting	VII. A. 18.	Treated Steel, Designation MT	VII. B. 3.
Welding Pins	VII. A. 19.		
Stainless Steel Pins	VII. A. 20.		
Stainless Steel Skewers	VII. A. 21.		
Welding Pin Insul Fasteners	VII. A. 22.		
Pin Clips	VII. A. 23.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", and "ENGINEERING STANDARDS"

Surface:

Steel shall be clean and dry, and when required shall be coated in accordance with "COATINGS MANUAL"

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PREPARATION: Continued (22-H, 22-HSS, Equip, Contd)

Insulation Supports:

Welded (vendor applied where possible) as per Standard EQ-64. Bolted on as per Standard IS-31, 31A, 36, 42

Tracing: (Where Required)

Heat Transfer Cement, Materials - MATERIAL SPECIFICATION VII. C. Application - GENERAL SPECIFICATION XIII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 23-H, 23-HSS

Component	Type and Form of Insulation	Securement	Weather Barrier
Curved Side Walls			
Below 600F	Curved segments (double layer 3 1/2" thick and above)	Strap	Mastic or Steel
Above 600F and 12' OD	Glass blanket inner layer under curved segment	Strap and Wire	Mastic or Steel
Heads	Same as for curved side wall	Strap & Wire	Mastic
Vessel Flanges	Preformed as shown in Figure 23-HSS-6	Strap and Wire	Mastic
Nozzles	Preformed as per "UCC Fab. Manual", as shown in Figure 23-HSS-9, 10	Strap and Wire	Mastic
Irregular Surfaces	Block and insul cement or insul cement only	Strap & Wire	Mastic
Legs - Channel	Block down to fireproofing, as shown in Figure 23-HSS-12	Strap & Wire	Mastic
Legs - Concrete Filled	Not insulated		
Skirts and Cradles	Not insulated, unless required for protection		
Flat Surfaces	Flat block and insul cement as shown in Figure 23-HSS-2	Pins, Clips, Wire, Netting	Mastic
Flat Surface Expansion Joint	Mineral wool blanket - lath one side and insul cement	Pins, Clips, Wire	Mastic

Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation D...
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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 23-H & HSS, CALCIUM SILICATE (High Tempera Service - Max. 950°)

PIPING INSULATION

		PIPE			
	LINE NO.	SIZE	LOCATION	METAL	INSUL THK "
PLANT					
UNIT					
WORK ORDER					
ACCOUNT NO.					
DATE					

WEATHER BARRIER: Straight Pipe _____ Fittings: Mastic-Designation WC

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIALS SPECIFICATION

Calcium Silicate Insulation	Spec. 23.	High Temp. Fab. Cement	VII. A. 37.
Cushioning Blanket	VII. A. 1.	Heat Resistant Sealer	VII. A. 42.
Insulating Cement	VII. A. 7.	Mastic (Caulking)	VII A. 45.
Pipe Insulation Support	VII. A. 9.	Weather-Barrier: As Specified	
Pipe Insulation Strap	VII. A. 13.	Mastic, color as specified,	
Clips for Pipe Strap	VII. A. 14.	Designation WC	VII. B. 1. a.
Stainless Steel Wire	VII. A. 17.	Reinforcing Cloth	VII. B. 1. b.
Stainless Steel Pins	VII. A. 20.	Stainless Steel Jacket,	
		Designation M	VII. B. 2.
		Treated Steel Jacket,	
		Designation MT	VII. A. 3.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", "GENERAL SPECIFICATIONS" and "ENGINEERING STANDARDS"

Surface:

Surface shall be clean and dry. Steel and stainless steel, when required, shall be coated in accordance with "COATING MANUAL".

Insulation Supports:

Vertical pipe over 4" NPS as shown in Figure 23-HSS-13.

Tracing: (Where Required)

Steam, installed per Standards P-140, P-140A. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Electric, installed per Standard EL-43. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

PREPARATION: Continued (22-H, 22-HSS, Piping, Contd)

Tracing: Continued

Heat transfer cement, Materials, MATERIALS SPECIFICATIONS VII. C.
Application, GENERAL SPECIFICATIONS XIII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL VOLUME 1", SPECIFICATION NO. 23-H & HSS

Component	Type and Form of Insulation	Securement	Weather-Barrier
Straight Pipe	Sectional insulation (double layer 3 1/2" thick and over)	For all pipe and fittings: Wire up to 11" OD Strap over 11" OD	Mastic or Steel Jacket
Insul. Expansion Joints	Install one every 21' of straight pipe, as per Figure 23-HSS-13,17		Mastic and Stainless Steel Sleeves
Gate and Globe Valves	Preformed as per "UCC Fab. Manual"*, as shown in Figure 23-HSS-		Mastic
Ball & Plug Valves	Field cut from sectional covering		Mastic
Flanged Fittings	Preformed as per "UCC Fab. Manual"*, as shown in Figure 23-HSS-15		Mastic
Welded Ells	Preformed as per "UCC Fab. Manual*, as shown in Figure 23-HSS-14		Mastic
Screwed Fittings	Over 3" preformed. Under 3" may be field formed		Mastic

* Or ASTM Recommended Practice C-450, latest revision.

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 25-H, "HIGH TEMPERATURE CALCIUM SILICATE

(High Temperature Service
750F to 1600F)

EQUIPMENT INSULATION

VESSEL OR COLUMN

DUCT OR FLAT SURFACE

PLANT _____ ITEM NO. _____ METAL _____ TOP OR BOTTOM:

UNIT _____ BODY:DIA. _____ LENGTH _____ WIDTH _____

WORK ORDER _____ HEADS _____ LENGTH _____

ACCOUNT NO. _____ VESSEL FLANGES _____ SIDE:

DATE _____ NOZZLES _____ WIDTH _____

SKIRT OR LEGS _____ LENGTH _____

WEATHER-BARRIER _____ INSULATION THICKNESS " _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIALS SPECIFICATION

Calcium Silicate-"High Temperature Insulation	Spec. 25.	Pin Clips	VII. A. 23.
Calcium Silicate Insulation	Spec. 23.	Fabrication Cement	VII. A. 38.
Mineral Wool Blanket (Netting both sides)	VII. A. 5.	Heat Resistant Sealer	VII. A. 42.
		Mastic (Caulking)	VII. A. 45.
Mineral Wool Blanket (One side netting - other lath)	VII. A. 106.	Weather Barrier - as specified	
		Mastic, color as specified, Trowel Grade - Designation WC	VII. B. 1. a.
Insulating Cement	VII. A. 7.		
Equipment Insulation Strap	VII. A. 11.	Mastic, color as specified, Spray Grade - Designation WB	VII. B. 1. a.
Clips for Equipment Strap	VII. A. 12.		
Stainless Steel Wire	VII. A. 17.	Reinforcing Cloth	VII. B. 1. b.
Wire Netting	VII. A. 18.	Metal Jacket	
Welding Pins	VII. A. 19.	Stainless Steel, Designation M	VII. B. 2.
Stainless Steel Pins	VII. A. 20.		
Stainless Steel Skewers	VII. A. 21.	Treated Steel, Designation MT	VII. B. 3.
Welding Pin Insulation Fasteners	VII. A. 22.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", and "ENGINEERING STANDARDS"

Surface:

Surface shall be clean and dry, and when required shall be coated in accordance with "COATING MANUAL".

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PREPARATION: Continued (25-H, Equip, Contd)

Insulation Supports:

Welded (vendor applied where possible) as per Standard EQ-64. Bolted on as per Standard IS-31, 31A, 36, 42.

Tracing: (Where Required)

Heat Transfer Cement, Materials - MATERIAL SPECIFICATION VII. C. Application - GENERAL SPECIFICATION XII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION 25-H

Component	Type and Form of Insulation	Securement	Weather-Barrier
Curved Side Walls	Double layer - inner layer, high temperature calcium silicate, outer "Standard" calcium silicate	Strap	Mastic or Steel
Larger than 6'0" OD	Mineral Wool Blanket (wire netting both sides) under cured segment	Strap and Wire	Mastic or Steel
Heads	Same as for curved side walls	Strap and Wire	Mastic
Vessel Flanges	Preformed as shown in Figure 25-H-6	Strap and Wire	Mastic
Nozzles	Preformed as per "UCC Fab. Manual", as shown in Figure 25-H-8, 9	Strap and Wire	Mastic
Irregular Surfaces	Block and Insulating Cement	Strap and Wire	Mastic
Legs - Channel	Block down to fire proofing as shown in Figure 25-H-10	Strap and Wire	Mastic
Legs - Concrete Filled	Not insulated		
Skirts & Cradles	Not insulated, unless required for fire protection		
Flat Surfaces	Flat block, inner layer, high temperature calcium silicate, outer "Standard" calcium silicate and insulating cement as shown in Figure 25-H-2	Pins, Clips, Wire, Netting	Mastic
Flat Surface Expansion Joint	Mineral wool blanket - lath one	Pins, Clips, Wire	Mastic

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 25H, HIGH TEMPERATURE CALCIUM SILICATE PIPING INSULATION

(High Temperature Service 750F to 1600F)

	PIPE				
	LINE NO.	SIZE	LOCATION	METAL	INSUL THK "
PLANT _____	_____	____	_____	_____	_____
UNIT _____	_____	____	_____	_____	_____
WORK ORDER _____	_____	____	_____	_____	_____
ACCOUNT NO _____	_____	____	_____	_____	_____
DATE _____	_____	____	_____	_____	_____

WEATHER-BARRIER: Straight Pipe _____ Fittings: Mastic - Designation WC

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" MATERIALS SPECIFICATION

Calcium Silicate - "High Temp." Insulation	Spec. 25.	Heat Resistant Sealer	VII. A. 42.
		Mastic (Caulking)	VII. A. 45.
Calcium Silicate Insulation	Spec. 23.	Weather-Barrier: As specified	
Mineral Wool Blanket	VII. A. 5.	Mastic, color as specified,	
Insulating Cement	VII. A. 7.	Designation WC	VII. B. 1. a.
Pipe Insulation Strap	VII. A. 13.	Reinforcing Cloth	VII. B. 1. b.
Clips for Pipe Strap	VII. A. 14	Stainless steel Jacket	
Stainless Steel Wire	VII. A. 17.	Designation M	VII. B. 2.
Wire Netting	VII. A. 18.	Treated Steel Jacket,	
Stainless Steel Skewers	VII. A. 21.	Designation MT	VII. B. 3.
High Temp. Fabrication Cement	VII. A. 37.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" "GENERAL SPECIFICATIONS" and "ENGINEERING STANDARDS"

Surface:

Surface shall be clean and dry. Steel, where required, shall be coated in accordance with "COATING MANUAL".

Insulation Supports:

Vertical pipe over 4" NPS, as shown in Figure 25-H-12.

Tracing: (Where Required)

Steam, installed per Standards P-140, P-140A. Insulation Details. GENERAL SPECIFICATION VII. A. & B.

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PREPARATION: Continued (25-H, Piping, Contd)

Tracing: Continued

Electric, installed per Standard EL-43. Insulation Details, GENERAL SPECIFICATION VII. A. & B.

Heat Transfer Cement, Materials, MATERIALS SPECIFICATIONS VII. C. Application, GENERAL SPECIFICATIONS XII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 25-H.

Straight Pipe	Sectional Insulation (double layer 3 1/2" thick and over) H. T. calcium silicate single and inner layers. Standard calcium silicate outer layer.	For all pipe and fittings: Wire up to 11" OD Strap over 11" OD	Mastic or Steel Jacket
Insul. Expansion Joints	Install one every 21' single layer. Every 15' on multiple layers as shown in Figure 25-H-12		Mastic and Stainless Steel Sleeves
Gate & Globe Valves	Preformed as per "UCC Fab. Manual"*, as shown in Figure 25-H-15		Mastic
Ball & Plug Valves	Field cut from sectional covering		Mastic
Flanged Fittings	Preformed as per "UCC Fab. Manual"*, as shown in Figure 25-H-14		Mastic
Welded Ells	Preformed as per "UCC Fab. Manual"*, as shown in Figure 25-H-13		Mastic
Screwed Fittings	Preformed as per "UCC Fab. Manual"*		Mastic

* Or ASTM Recommended Practice C-450, latest revision.

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 31-H, 31-HSS, PREFABRICATED STAINLESS-CASED ALUMINUM

(High Temperature Service up to 1000F)

PLANT _____

UNIT _____

WORK ORDER _____

ACCOUNT NO. _____

DATE _____

EQUIPMENT

ITEM NO. _____

Insulation custom made to fit item

PIPING

Insulation custom made to fit pipe valves and fittings. Drawings to manufacture must also show supports and their details and all interferences.

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIALS SPECIFICATION

Prefabricated Stainless Cased Aluminum	Spec. 31.
Stainless Steel Insulation Strap	VII. A. 13.
Clips for Insulation Strap	VII. A. 14.
Stainless Steel Sheet Metal Screws	VII. A. 32.
Snap-Lock type Fasteners	Furnished by Mfg.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", GENERAL SPECIFICATIONS and "ENGINEERING STANDARDS"

Surface:

Surface shall be clean and dry. Steel and stainless steel, where required, shall be coated in accordance with "COATING MANUAL".

Insulation Supports:

Equipment supports shall be as per GENERAL SPECIFICATIONS° ARTICLE II.

Tracing: (Where Required)

Steam, installed per Standards P-140, & -140. A. Insulation details - custom made insulation to fit. Electric, installed per Standard EL-43. Insulation details - custom made insulation to fit. Heat Transfer Cement, materials - MATERIALS SPECIFICATIONS VII. C. Application, GENERAL SPECIFICATIONS XII. B.

APPLICATION: Insulation details as specified in "THERMAL INSULATION MANUAL, VOLUME 1", SPECIFICATION NOS. 3-1H, 31-HSS

Thickness: Unless otherwise specified, insulation will be applied in single layer.

Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation D...
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APPLICATION: Continued (31-H, 31-HSS, Equip & Piping, Contd)

Equipment: Panels installed to shed water, secured in position by metal screws, strap or latches.

Piping: Pipe covering and fitting covers installed to shed water. Secured in position with strap or latches.

Weather Barrier: Casing furnished on prefabricated units serves as weather barrier.

Note: Insulation must be installed in sequence as designated on manufacturer's drawings.

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION No. 32-HFP and 32-HFPSS, BONDED EXPANDED SILICA

EQUIPMENT INSULATION

(Atmospheric to Max. 1200F)

PLANT _____ UNIT _____ WORK ORDER _____ ACCOUNT NO. _____ DATE _____

VESSEL OR COLUMN

ITEM NO. _____ METAL _____
BODY: Dia. _____ LENGTH _____
HEADS _____
VESSEL FLANGES _____
NOZZLES _____
SKIRT OR LEGS _____

DUCT OR FLAT SURFACE

TOP AND BOTTOM:
WIDTH _____
LENGTH _____
SIDES:
WIDTH _____
LENGTH _____

WEATHER BARRIER _____ INSULATED THICKNESS" _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIALS SPECIFICATION

Expanded Silica Insulation	Spec. 22.	Heat Resistant Sealer	VII. A. 42.
Cushioning Blanket	VII. A. 1.	Mastic (Caulking)	VII. A. 45.
Mineral Wool Blanket (wire netting both sides)	VII. A. 5.	Adhesive Type Pins	VII. A. 75.
Insulating Cement	VII. A. 7.	Weather Barrier, as specified	
Equipment Insulation Strap	VII. A. 11.	Mastic, color as specified, Trowel Grade	
Clips for Equipment Strap	VII. A. 12.	Designation WC	VII. B. 1. a.
Stainless Steel Wire	VII. A. 17.	Mastic, color as specified,	
Wire Netting	VII. A. 18.	Spray Grade	
Welding Pins	VII. A. 19.	Designation WB	VII. B. 1. a.
Stainless Steel Pins	VII. A. 20.	Reinforcing Cloth	VII. B. 1. b.
Stainless Steel Skewers	VII. A. 21.	Metal Jacket	
Welding Pin Insulation Fasteners	VII. A. 22.	Stainless Steel,	
Pin Clips	VII. A. 23.	Designation M	VII. B. 2.
Mineral Wool Blanket (wire netting on one side, expanded metal on the other)	VII. A. 106.	Treated Steel, Designation MT	VII. B. 2.
Fabrication Cement	VII. A. 38.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", and "ENGINEERING STANDARDS"

Surface:

Surface shall be clean and dry. Steel and stainless steel, where required, shall be coated in accordance with "COATINGS MANUAL".

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PREPARATION: Continued (32-HFP, 32-HFPSS,. Equip, Contd)

Insulation Supports:

Welded (vendor applied where possible) as per Standard EQ-64. Bolted as per IS-31, 31A, 36, 42.

Tracing: (Where Required)

Heat Transfer Cement, Materials - MATERIAL SPECIFICATION VII. C. Application - GENERAL SPECIFICATIONS

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATIONS 32-HP, 32-HPSS

Component	Type and Form of Insulation	Securement	Weather Barrier
Curved Side Walls	Single layer to 3" thick, double layer 3 1/2" thick and greater where required by size or temperature. Cushion blanket shall be under curved block	Strap Strap & Wire	Mastic or Steel
Heads	Same as for curved side walls	Strap & Wire	Mastic
Vessel Flanges	Preformed as shown in Figure 32-H-6.		
Nozzles	Preformed as per "UCC Fab. Manual as shown in Figure 32-H-9.	Strap & Wire	Mastic
Irregular Surfaces	Block and insulating cement	Strap, Wire, Netting	Mastic
Legs - Channel	Block down to fire proofing, as shown in Figure 32-H-10	Strap & Wire	Mastic
Legs - Concrete Filled	Not insulated.		
Skirts & Cradles	Curved block same as vessel	Strap & Wire	Mastic or Steel
Flat Surfaces	Flat block, double layer 3 1/2" and over and insulating cement as shown in Figure 32-H-2	Pins, Clips, Wire, Netting	Mastic
Flat Surface Expansion Joint	Mineral Wool Blanket - lath one side, and insul. cement	Pins, Clips Wire	Mastic

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 32-HFP and 32 HFPSS, BONDED EXPANDED SILICA PIPING INSULATION (Atmospheric to Max. 1200F)

	PIPE LINE NO.	SIZE	LOCATION	METAL	INSUL THK "
PLANT					
UNIT					
WORK ORDER					
ACCOUNT NO.					
DATE					

WEATHER-BARRIER, STRAIGHT PIPE _____ FITTINGS _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" MATERIALS SPECIFICATION

Expanded Silica Insulation	Spec. 22.	Heat Resistant Sealer	VII. A. 42.
Cushioning Blanket	VII. A. 1.	Mastic (Caulking)	VII. A. 45.
Insulating Cement	VII. A. 7.	Weather-Barrier:	
Pipe Insulation Support	VII. A. 9.	As Specified	
Pipe Insulation Strap	VII. A. 13.	Mastic, color as specified, Designation WC	VII. B. 1. a.
Clips for Pipe Strap	VII. A. 14.	Reinforcing Cloth	VII. B. 1. b.
Stainless Steel Wire	VII. A. 17.	Stainless Steel Jacket, Designation M	VII. B. 2.
Stainless Steel Skewers	VII. A. 21.	Treated Steel Jacket, Designation MT	VII. B. 3.
Fabrication Cement	VII. A. 21.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" GENERAL SPECIFICATIONS and ENGINEERING STANDARDS

Surface:

Surface shall be clean and dry. Steel and stainless steel, where required, shall be coated in accordance with "COATING MANUAL".

Insulation Supports:

Vertical pipe over 4" NPS as shown in Figure 32-H-12.

Tracing: (Where Required)

Steam, installed per Standards P-140, P-140A. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

Electric, installed per Standard EL-43. Insulation Details, GENERAL SPECIFICATIONS VII. A. & B.

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PREPARATION: Continued (32-HFP, HFPSS, Piping, Contd)

Tracing: Continued

Heat Transfer Cement, Materials - MATERIAL SPECIFICATIONS VII. C.
Application GENERAL SPECIFICATIONS XII. B.

APPLICATION: Installation details as specified in THERMAL INSULATION MANUAL VOLUME 1. SPECIFICATIONS NO. 32-HFP & HFPSS

Component	Type and Form of Insulation	Securement	Weather-Barrier
Straight Pipe	Sectional insulation, thickness schedule as per Spec. No. 32-HFP and HFPSS B. 2. 0. (2).	For all pipe and fittings: Wire up to 11" OD Strap over 11 OD	Mastic or Steel
Insul. Expansion Joint	Install one every 21 as shown in 32-H-16		Mastic and Stainless Steel
Gate and Globe Valves	Preformed as per "UCC Fab. Manual"* as shown in Figure 32-H-15	Strap over 11" OD	Mastic
Ball & Plug Valves	Field cut from sectional covering		Mastic
Flanged Fittings	Preformed as per "UCC Fab. Manual"* as shown in Figure 32-H-14		Mastic
Welded Ells	Preformed as per "UCC Fab. Manual"* as shown in Figure 32-H-13		Mastic
Screwed Fittings	Preformed as per "UCC Fab. Manual"*		Mastic

* Or ASTM Recommended Practice C-450, latest revision.

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 32-LFP and 32-LFPSS, CELLULAR GLASS and BONDED EXPANDED SILICA (Ambient to Low Temp.)

EQUIPMENT INSULATION

VESSEL OR COLUMN

PLANT _____ ITEM NO. _____ METAL _____

UNIT _____ BODY: Dia. _____ LENGTH _____

WORK ORDER _____ HEADS _____

ACCOUNT NO. _____ VESSEL FLANGES _____

DATE _____ NOZZLES _____

SKIRT OR LEGS _____

WEATHER BARRIER _____ INSULATION THICKNESS" _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIAL SPECIFICATIONS

Cellular Glass Insulation	Spec. 10.	Anti-Abrasive Coating	
Expanded Silica Insulation	Spec. 22.	(Stainless steel substrate)	VII. A. 40.
Cushioning Blanket	VII. A. 1.	Joint Sealer	VII. A. 43.
Insulating Cement	VII. A. 7.	Lap Sealer	VII. A. 46.
Equipment Insulation Strap	VII. A. 11.	Adhesive Cement	VII. A. 65.
Clips for Equipment Strap	VII. A. 12.	Mastic (Caulking)	VII. A. 45.
Stainless Steel Wire	VII. A. 17.	Weather Barrier, as specified	
Stainless Steel Skewers	VII. A. 21.	Mastic, color as specified, Designation WC	VII. B. 1. a.
Fabrication Cement for Cellular Glass	VII. A. 36.	Reinforcing Cloth	VII. B. 1. b.
Fabrication Cement for Expanded Silica	VII. A. 38.	Stainless Steel Jacket, Designation M	VII. B. 2.
Anti-Abrasive Coating (steel substrate)	VII. A. 39.	Treated Steel Jacket, Designation MT	VII. B. 3.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", and "ENGINEERING STANDARDS"

Surface:

Surface shall be clean and dry and, where required, shall be coated in accordance with "COATING MANUAL"

Insulation Supports:

Welded (vendor applied where possible) as per Standard EQ-64. Bolted on as per Standards IS. 31, 31.a, 36, 42.

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PREPARATION: Continued (32-LFP, LFPSS, Equip, Contd)

Tracing: (Where Required)

Heat Transfer Cement, Materials - MATERIALS SPECIFICATION VII. C.
Application - GENERAL SPECIFICATION XII. B.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATIONS 32-LFP & LFPSS

Component	Type and Form of Insulation	Securement	Weather Barrier
Curved Side Walls	1/2" cushion blanket, curved cellular glass block, single or multiple layer - depending upon specified thickness, and outer layer of 1 1/2" thick expanded silica	Wire and Strap	Mastic or Steel
Heads	Same as for curved side walls	Wire and Strap	Mastic
Vessel Flanges & Nozzles	Preformed of specified thickness of cellular glass and expanded silica as shown in Figures 32-LFP. 3, 4. & 5.	Wire and Strap	Mastic
Legs, Skirts & Cradles	Same as for curved side walls, carried down to concrete fire proofing or base pad	Wire and Strap	Mastic

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 32-LFP and 32-LFPSS, CELLULAR GLASS and BONDED EXPANDED SILICA (Ambient to Low Temperature)

PIPING INSULATION

	PIPE				
	LINE NO.	SIZE	LOCATION	METAL	INSUL. THK "
PLANT					
UNIT					
WORK ORDER					
ACCOUNT NO.					
DATE					

WEATHER-BARRIER, STRAIGHT PIPE _____ FITTINGS _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" MATERIALS SPECIFICATION

Cellular Glass Insulation	Spec. 10	Anti-Abrasive Coating	VII. A. 39.
Expanded Silica Insulation	Spec. 22.	Joint Sealer	VII. A. 43.
Cushioning Blanket	VII. A. 1.	Lap Sealer	VII. A. 46.
Cushioning Glass Fiber Molded Pipe Insulation	VII. A. 4.	Adhesive Cement	VII. A. 65
		Mastic (Caulking)	VII. A. 45
Pipe Insulation Strap	VII. A. 13.	Weather Barrier: As Specified Mastic, Color as Specified, Designation WC	VII. B. 1. a.
Clips for Pipe Strap	VII. A. 14.		
Stainless Steel Wire	VII. A. 17.		
Strapping Tape	VII. A. 33.	Reinforcing Cloth	VII. B. 1. b.
Stainless Steel Skewers	VII. A. 21.	Stainless Steel Jacket, Designation M	VII. B. 2.
Fabrication Cement for Cellular Glass	VII. A. 36.	Treated Steel Jacket, Designation MT	VII. B. 3.
Fabrication Cement for Expanded Silica	VII. A. 38.		

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" GENERAL SPECIFICATIONS and "ENGINEERING STANDARDS"

Surface:

Surface shall be clean and dry. Steel and stainless steel, where required, shall be coated in accordance with "COATING MANUAL".

Insulation Supports:

Vertical Pipe over 4" NPS as shown in Figure 32-H-12.

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PREPARATION: Continued (32-LFP, LFPSS, Piping, Contd)

Tracing: (Where Required)

Steam, installed per Standards P-140, P-140A. Insulation details, GENERAL SPECIFICATIONS VII. A. & B.

Electric, installed per Standard EL-43. Insulation details, GENERAL SPECIFICATIONS VII. A. & B.

Heat transfer cement, materials - MATERIAL SPECIFICATIONS VII. C. Application GENERAL SPECIFICATIONS XIII. B.

APPLICATION: Installation details as specified in 'THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 32-LFP & LFPSS

Component	Type and Form of Insulation	Securement	Weather-Barrier
Straight Pipe	Inner layer or layers - the required thickness of cellular glass. Outer layer 1 1/2" bonded expanded silica. Where internal thermal shock is expected, molded glass fiber applied under cellular glass.	Inner layer of cellular glass, strapping tape; strap for all other.	Mastic or Steel
Insulation Contraction Joints	Up to 2 1/2" thick insul - one for each 45', 3" to 5" thick--one for each 33', 5" to 7 1/2" thick--one each 21" of straight pipe.		Mastic and Stainless Steel Sleeves
Gate & Globe Values	Preformed - same layers as for straight pipe, as shown in Figure 32-LFP-16.		Mastic
Ball & Plug Valves	Field fabricated.		Mastic
Flanged Fittings	Preformed - same layers as for straight pipe, as shown in Figure 32-LFP-14.		Mastic
Welded Ells	Preformed - same layers as for straight pipe, as shown in Figure 32-LFP-12.		
Screwed Fittings	Preformed - same layers as for straight pipe		Mastic

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 37-H, INSULATED METAL CONDUIT (Temp. up to 750F)

UNDERGROUND PIPE INSULATION

PIPING

PLANT _____

UNIT _____

WORK ORDER _____

ACCOUNT NO. _____

DATE _____

Sections of piping are insulated and encased in metal conduit by manufacturer in accordance with drawings for specific installation. Sections are placed in position intrench and pipe, insulation and conduit are field connected.

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIALS SPECIFICATION

Metal Conduit	Spec. 37.	Weather Barrier Mastic	VII. b. 1. a.
Insulation as Specified		Reinforcing Cloth	VII. b. 1. b.
Molded Glass Fiber Insulation	Spec. 15.	Pipe Insulation Strap	VII. A. 13.
Asbestos Fiber Insulation	Spec. 21.	Clips for Pipe Strap	VII. A. 14.
Expanded Silica Insulation	Spec. 22.		
Calcium Silicate Insulation	Spec. 23.		

TRENCH PREPARATION:

Bottom of trench shall be smooth, clean and dry.

PREPARATION:

Pipe shall be welded and tested before insulation over joints is installed.

FIELD CONNECTIONS: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPEC. No. 37-H

Field Welded Conduit Connections

Asbestos jacket shall be installed over insulation, conduit closure shall be installed over joint and seal welded. After testing with 15 psi air, welds shall be smoothed and entire connection wrapped with tape. Installation shown in Figure 37-H-1

Mechanical Conduit Connections

Exposed insulation shall be covered with mastic and reinforcing cloth. Metal jacket closure shall be installed over conduit with pour hole at top and secured with insulation strap. Space between insulation and metal jacket closure shall be filled with hot asphalt as shown in Figure 37-H-2.

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(37-H, Piping, Underground, Contd)

CONDUIT TERMINALS:

Where the conduit terminates at a building, manhole, or pit, it shall extend through the concrete to the inner face. A water seal shall be applied between the conduit and the concrete. A water seal shall be applied to the conduit end.

BACKFILL:

Soil shall be carefully deposited in uniform layers not over 6" thick, carefully tamped, both sides being done simultaneously so as to not disturb the conduit. Boulders and concrete debris shall not be used as part of backfilling material.

CATHODIC PROTECTION:

Where required, cathodic protection shall be installed as specified by Electrical and Mechanical Groups in accordance with STANDARD SPECIFICATIONS B. 2. 60 and STANDARDS EL-75, 76 and 77. Details shall be coordinated so that purpose of each system is retained. Special attention is required at electrical isolating joints.

UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 38-H, URETHANE FOAM, (Atmospheric PVC JACKETED PREINSULATED PIPE up to 250F)

PREINSULATED PIPE SYSTEM

PIPING

PLANT _____

UNIT _____

WORK ORDER _____

ACCOUNT NO. _____

DATE _____

Sections of insulated and encased PVC jacket by manufacturer. Pipe fittings are likewise so produced. These pipe sections and fitting assemblies are field connected, junctions insulated and jacket joined together with manufactured compression couplings.

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIALS SPECIFICATION

Pipe or Tube Insulated With Urethane Foam Encased in PVC Conduit	Spec. 38.
Pipe or Tube Fittings Insulated With Urethane Foam Encased in PVC Conduit	Spec. 38.
Compression Coupling	Spec. 38.
Urethane Insulation for Coupling	Spec. 38.

TRENCH PREPARATION: Underground Installations.

Bottom of trench shall be smooth, clean and dry.

PREPARATION:

Compression coupling and its components must be placed on the conduit adjacent to points where sections of pipe, tube or fittings are to be joined prior to assembly. Pipe, tube and fittings are to be welded, or sweated, together at joints and tested.

FIELD CONNECTIONS: Installation details as specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPEC. NO. 38-H.

Urethane insulation shall be installed over uninsulated pipe at joints. The joining sleeves shall be slid in position over the insulated joints and the rubber gaskets compressed to seal around the conduit by tightening the clamp ring. As shown in Figure 38-H. 3.

PIPE ANCHOR, UNDERGROUND:

Underground pipe anchors are constructed as shown in Figure 38-H. 4.

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CONDUIT TERMINALS: (38-H Continued)

Where the conduit terminates at a building, manhole, or pit, it shall extend through the concrete to the inner face. A water stop sleeve shall be installed between the conduit and the concrete. A water seal shall be applied at end of the conduit. As shown in Figure 38-H. 5.

BACKFILL:

Soil shall be carefully deposited in uniform layers not over 6" thick, carefully tamped, both sides being done simultaneously so as to not disturb the conduit. Boulders and concrete debris shall not be used as part of backfill material.

CATHODIC PROTECTION

Where required, cathodic protection shall be installed as specified by Electrical and Mechanical Groups, and in accordance with STANDARD SPECIFICATIONS B. 2. 60, and STANDARDS EL-75, 76 and 77. Details shall be coordinated so that purpose of each system is retained. Special attention is required at electrical isolating joints.

UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
AND UNION CARBIDE CANADA LIMITED

SPECIFICATION NO. 39-H, UNDERGROUND BITUMINOUS FILL

(From 220F to 520F)

PIPING INSULATING

	LINE NO.	SIZE	LOCATION	METAL	INSUL THICK "
PLANT					
UNIT					
WORK ORDER					
ACCOUNT NO					
DATE					

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1" MATERIAL SPECIFICATIONS

Bituminous Fill Insulation Grade, depending on temperature	Spec. 39.	20-Gage Galvanized Steel Jacket	Spec. 39.
		Weather-Barrier Mastic	VII. B. 1. a
Corrosion-Resistant Coating 40F to 120F	VII. A. 70.		

PREPARATION:

Bottom of trench shall be smooth, clean and dry. Piping shall be installed, supported and tested. Pipe surface shall be clean and dry and, where required, painted before installation of fill insulation.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL VOLUME 1", SPECIFICATION NO. 39.

Piping:

Thickness of insulation about pipe shall be as per Figure 39-H-1. If system passes under roads or other areas of heavy loads, thickness on top shall be increased 3". Fill insulation shall be tamped in position. Curing shall be at temperature and for period of time recommended by the manufacturer.

Expansion Loops:

Thickness of insulation shall be as per Figure 39-H-2. Installation shall be same as for pipe.

Transition and Termination:

Where the system emerges above surface, a sleeve of 20-gage galvanized steel shall extend from below grade to insulation used 12" above grade, as shown in Figure 39-H-3.

Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation D... Published by AsbestosClaims.Law
ACL Doc 19432 · Page 501 of 559 asbestosclaims.law/library/19432/501

PREPARATION: Continued (39-H, Piping, Underground, Contd)

Transition and Termination: Continued

Where lines enter manhole or building wall, an asbestos rope or packing shall be applied between the pipe and the sleeves. Outer surface of galvanized steel jacket shall be coated with specified corrosion-resistant coating before it is installed.

BACKFILL:

Backfill shall not be installed before insulation is cured. Soil shall be carefully deposited in uniform layers of 6" thick and carefully tamped.

CATHODIC PROTECTION:

Where required, cathodic protection shall be installed as specified by Electrical and Mechanical Groups and in accordance with STANDARD SPECIFICATIONS B. 2. 60, and STANDARDS EL-75, 76 and 77. Details shall be coordinated so that purpose of each system is retained. Special attention is required at electrical isolating joints.

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
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SPECIFICATION NO. 40-J, CORK FILLED PVA MASTIC EQUIPMENT OR PIPE INSULATION (34F to 180F)

EQUIPMENT

VESSEL OR COLUMN

PLANT_____
UNIT_____
WORK ORDER_____
ACCOUNT NO._____
DATE_____

ITEM NO._____ METAL_____
BODY: Dia._____ LENGTH_____
HEADS_____ SHAPE_____
INSUL. THICK._____

DUCT OR FLAT SURFACE

TOP AND BOTTOM:
WIDTH_____
LENGTH_____
SIDES:
WIDTH_____
LENGTH_____

LINE NO.	SIZE	LOCATION	METAL	INSUL. THK"

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIAL SPECIFICATIONS

Cork Filled PVA Mastic	Spec. 40.
Primer (In Application Section)	Spec. 40-J

PREPARATION:

Surface of equipment or pipe should be clean and dry then painted with primer.

APPLICATION:

Surface temperature must be above dew point of ambient air but not above 180F. Surface must be clean and dry. PVA mastic shall be applied in one coat by palming, troweling or spraying. Spraying not to be done on pipe less than 24". Material shall be allowed to dry a minimum of 24 hours for each 1/8" of thickness, plus an additional 24 hours if equipment or pipe is to be operated at a temperature less than dew point of ambient air.

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THICKNESS AND COVERAGE

(40-J, Equip, Contd)

Thickness shall be as specified.

Coverage is as follows:	1/8" thickness	8 1/2 to 10 gallons per 100 sq ft
	1/4" thickness	17 to 20 gallons per 100 sq ft

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
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SPECIFICATION NO. 41-H and 42-H, SPRAYABLE ASBESTOS FIBERS

(41-H, Max. 700F,
42-H, Max. 1350F)

EQUIPMENT INSULATION

PLANT _____
UNIT _____
WORK ORDER _____
ACCOUNT NO. _____
DATE _____

VESSEL OR COLUMN
ITEM NO. _____ METAL _____
BODY: Dia. _____ LENGTH _____
HEADS _____
VESSEL FLANGES _____
MANHOLES _____
NOZZLES _____
SKIRT OR LEGS _____

DUCT OR FLAT SURFACE
TOP AND BOTTOM:
WIDTH _____
LENGTH _____
SIDES:
WIDTH _____
LENGTH _____

WEATHER BARRIER _____ INSULATION THICKNESS " _____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIAL SPECIFICATIONS

Sprayable Amosite Asbestos Fiber Insulation	Spec. 41.	Cellular Glass Insulation	Spec. 10.
Sprayable Crocidolite Asbestos Fiber Insulation	Spec. 42.	Finishing Cement	VII. A. 78.
Equipment Insulation Strap	VII. A. 11.	Asbestos Paper	VII. A. 80.
Clips for Equipment Strap	VII. A. 12.	Asbestos Paper Adhesive	VII. A. 81.
Expansion Springs	VII. A. 15.	Lap Sealer	VII. A. 46.
Stainless Steel Wire	VII. A. 17.	"S" Clips	VII. A. 107.
Wire Netting	VII. A. 18.	Weather Barrier, as specified	
Welding Pin Insulation Fasteners	VII. A. 22.	Mastic, color as specified Designation WC	VII. B. 1. a.
Pin Clips	VII. A. 23.	Reinforcing Cloth	VII. B. 1. b.
Sheet Metal Screws	VII. A. 32.	Stainless Steel Jacket, Designation M	VII. B. 2.
Split Welding Pins	VII. A. 79.	Treated Steel Jacket, Designation MT	VII. B. 3.

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", GENERAL SPECIFICATIONS

Surface:

Surface shall be clean and dry. Steel and stainless steel, where required, shall be coated in accordance with "COATING MANUAL".

Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation D...
ACL Doc 19432 · Page 505 of 559
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asbestosclaims.law/library/19432/505

PREPARATION: Continued (41-H, 42-H, Equip, Contd)

Insulation Supports:

Vessels and ducts over 24" shall be provided with pins as specified in Specification 41-H and 42-H to reinforce the insulation, as shown in Figures 41-H/42-H.1 and 41-H/42-H.2.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL, VOLUME 1", SPECIFICATION NO. 41-H, 42-H

Component	Type and Form of Insulation	Securement	Weather Barrier
Curved Side Walls	Spray and compacted asbestos fiber as shown in Figure 41-H/42-H.1	Pins, Clips, Wire and Netting	Steel or Mastic
Heads	Same as for curved side walls	"	Mastic
Vessel Flanges and Nozzles	Bolt head wrapped with asbestos paper prior to spraying of asbestos fiber	"	Mastic
Legs - Channel	Insulated down to concrete	"	Mastic
Flat Surface	Same as for curved side walls, with other surface of finishing cement reinforced with netting	"	Mastic

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UNION CARBIDE **STANDARD**
CHEMICALS AND PLASTICS OPERATIONS DIVISION
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SPECIFICATION NO. 43-H, 43-HSS, SPRAYED RIGID URETHANE FOAM
(50F to 250F)

EQUIPMENT INSULATION

	VESSEL OR COLUMN	DUCT OR FLAT SURFACE
PLANT_____	ITEM NO._____ METAL_____	TOP AND BOTTOM
UNIT_____	BODY: Dia._____ LENGTH_____	WIDTH_____
WORK ORDER_____	HEADS_____	LENGTH_____
ACCOUNT NO._____	VESSEL FLANGES_____	SIDES:
DATE_____	MANHOLES_____	WIDTH_____
	SKIRTS OR LEGS_____	LENGTH_____

INSULATION THICKNESS "_____

MATERIALS: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", MATERIAL SPECIFICATIONS

Urethane Foam System - Liquids		Weather-Barrier, as specified	
UCC NIAS Foam System		Mastic, color as specified	
T-352/T-624		Trowel Grade	
Urethane Rigid Foam Block	Spec. 12.	Designation WC	VII. b. 1. a.
Bonded Expanded Silica Block	Spec. 23.	Mastic, color as specified,	
Equipment Insulation Strap	VII. A. 11.	Spray Grade,	
Clips for Equipment Strap	VII. A. 12.	Designation WB	VII. b. 1. a.
Stainless Steel Wire	VII. A. 17.	Stainless Steel Jacket	VII. b. 2.
Asbestos Paper	VII. A. 80.	Treated Steel Jacket	VII. b. 3.
		Contact Adhesive	VII. A. 65 or 66

PREPARATION: As specified in "THERMAL INSULATION MANUAL - VOLUME 1", SPECIFICATION NO. 43-H, 43-HSS

Surfaces to be Insulated

Carbon steel shall be cleaned of rust, mill scale, dirt or other contamination.
Painted steel shall be clean of dirt and paint and shall be fully dry.
Stainless steel shall be coated in accordance with Coating Manual prior to application of insulation.
Aluminum shall be cleaned of dirt or other contamination.

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PREPARATION: Continued (43-H, HSS, Equip, Contd)

Prior to application, flanges, manholes and all other surfaces not to be insulated shall be wrapped with suitable covering. Instruments, equipment or piping within 25 feet shall be covered or screened for protection against overspray.

APPLICATION: Installation details as specified in "THERMAL INSULATION MANUAL, VOLUME 1", SPECIFICATION NOS. 43-H, 43-HS

Component	Type and Form of Insulation	Securement	Weather Barrier
Curved Side Walls	Sprayed urethane rigid foam	None	Steel or Mastic
Heads	Sprayed urethane rigid foam	None	Mastic
Vessel Flanges	None, unless specified. Preformed from rigid urethane block, where required. As shown in Figure 43-H-4		
Nozzles	Preformed from rigid urethane block. As shown in Figure 43-H-2	Contact Adhesive	Mastic
Legs - Channel	Expanded silica block to concrete	Wire	Mastic
Legs - Concrete Filled	None		Mastic
Flat Surfaces	Sprayed urethane rigid foam	None	Mastic

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THERMAL INSULATION SPECIFICATIONS

INTRODUCTION

i. General

These Specifications describe the essential requirements for the purchase and application of thermal insulation materials.

They consist of General Specifications, Material Specifications, and Application Specifications. General Specifications are identified by the letters GS, Material Specifications by the letter M, and the Application Specifications by a two-digit number followed by one or more letters.

All materials required in the application of thermal insulation shall be as specified in Material Specifications - M.

The required Application Specification and the thickness of insulation to be used shall be indicated in an Insulation Design Schedule.

ii. Letter Designations for Application Specifications

Letters following numbers in designations of Application Specifications (example: H or HSS in Specification No. 10-H, 10-HSS) indicate that the specified insulation is intended for a particular use, as follows:

B	Building construction
FP	Fire Protection
FX	Flexible insulation for exterior surface of ducts
FY	Flexible insulation for interior surface of ducts
H	Equipment and piping operating at high temperatures
J	Equipment and piping operating at moderate temperatures
OX.	Equipment and piping in oxygen service
L	Equipment and piping operating at low temperatures
RX	Rigid insulation for exterior surface of ducts
RY	Rigid insulation for interior surface of ducts
SP	Spheres
SS	Insulation to be installed on stainless steel surfaces
U	Underground piping

iii. Presentation of Format

GS, M, 10-H, etc (SPECIFICATION IDENTIFICATION)
I., II., III., etc (ARTICLES)
A., B., C., etc (SECTIONS)
1., 2., 3., etc (Items)
a., b., c., etc (Subsections)
(1), (2), (3), etc (Paragraphs)
(a), (b), (c), etc (Units)

Reference to a particular Paragraph (4) of Specification GS shall be indicated thus: GS.XV.B.2.a.(4). Closely related references within a division may be identified thus: Article XIV.B of this specification, Item 2.a.(4) of this section, or Paragraph (3) above.

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THERMAL INSULATION SPECIFICATIONS

CONTENTS

SPECIFICATION - GS

General Specifications and Engineering Standards

ARTICLES:

I. Condition of surfaces
II. Insulation supports
III. Securement
IV. Nameplate clips
V. Junction of thermal insulation with fire-resistant materials
VI. Flashing
VII. Sealing of hot projection
VIII. Coating
IX. Protection from abuse
X. Protection cover
XI. Appearance
XII. Insulation for safety
XIII. Steam or electric traced installations
XIV. Weather-barrier mastic coating
XV. Metal jackets - stainless steel or treated steel

STANDARDS: EL-43, IS-31, IS-31A, IS-36, IS-40, IS-42, P-82, P-140, and P-140A.

SPECIFICATION - M

Material Specifications for Thermal Insulation and Accessories

ARTICLES:

I. Material - General
II. Properties
III. Dimensions of Curved Segments, Lagging, and Pipe Insulation
IV. Condition of Material
V. Preformed Valve, Fitting, and Flange Covers
VI. Specifications for Individual Insulation Materials
VII. Specifications for Individual Accessory Materials

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CONTENTS - contd

APPLICATION SPECIFICATIONS - (as listed)

Individual Material Specifications and Accessories

Symbols: P & E = Piping and Equipment SS = Stainless Steel AD = Air Ducts

Specification Number and Designation	Description of Material	Operating Temperature Range, Degrees F	Miscellaneous Remarks: Location of Application - Type of Service, etc -
10-B	Cellular Glass	Atmospheric	Buildings
10-H & HSS	Cellular Glass	+70 to +600	P & E, SS P & E
10-J & JSS	Cellular Glass	+50 to +400	P & E, SS P & E
10-JU & JUSS	Cellular Glass	+50 to +350	Underground Piping, SS Piping
10-L & LSS	Cellular Glass	-200 to +400	P & E, SS P & E Low Temperature Service
10-LSP	Cellular Glass	-40 to +150	Sphere
10-OX	Cellular Glass	-200 to Atmos	P & E - Oxygen Service
11-			
12-H & HSS	Rigid Urethane Foam	+50 to +250	AD, P & E and SS P & E
14-J	Flexible Plastic Foam	+32 to +180	AD, P & E
15-H	Fibrous Glass, high density	+70 to +750	P & E
15-L	Fibrous Glass, high density	-20 to +100	P & E
16-H	Fibrous Glass, low density	+70 to +350	P & E
17-RX	Fibrous Glass, rigid	+60 to +150	AD - Exposed - Exterior Surface
17-RY	Fibrous Glass, rigid	+60 to +150	AD - Interior Surface
18-FX	Fibrous Glass, flexible	+60 to +150	AD - Concealed - Exterior Surface
18-FY	Fibrous Glass, flexible	+60 to +150	AD - Interior Surface
19-H	Mineral Wool, aluminum faced	+60 to +450	Large diameter storage tanks
19-J	Fibrous Glass, aluminum faced	+60 to +350	Large diameter storage tanks
21-H & HSS	Asbestos Fibers	+70 to +1000	Piping, SS Piping
22-H & HSS	Bonded Expanded Silica	+40 to +1600	P & E, SS P & E - High Temperature
22-HSP	Bonded Expanded Silica	+70 to +500	Sphere
23-H & HSS	Inhibited Calcium Silicate	+70 to +750	P & E, SS P & E
25-H	Hydrous Calcium Silicate	+750 to +1600	P & E - High Temperature
31-H, HSS	Stainless Steel - Cased - Reflective	+33 to +1000	P & E, SS P & E
32-HFP & HFPSS	Bonded Expanded Silica	+40 to +1600	P & E - Fire Protection
32-LFP & LFPSS	Bonded Expanded Silica - Cellular Glass	-200 to +400	P & E, SS P & E - Fire Protection
37-H	Insulation as Specified	+40 to +750	Underground Conduit
38-H	Urethane Foam - PVC Jacket	+50 to +250	Underground Piping
39-H	Bituminous Fill	+220 to +520	Underground Piping
40-J	Cork Filled PVA Mastic	+34 to +180	P & E
41-H	Sprayed Asbestos - "Amosite"	+40 to +700	Equipment, Ducts, Steel, etc
42-H	Sprayed Asbestos - "Crocidolite"	+40 to +1350	Equipment, Ducts, Steel, etc
43-H & HSS	Sprayed Urethane Foam	+50 to +250	Equipment, Storage Tanks

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THERMAL INSULATION GENERAL SPECIFICATIONS

SCOPE

These specifications describe the essential requirements for the application of thermal insulation materials. They also constitute an integral part of each individual specification.

I. CONDITION OF SURFACES

A. Insulating materials shall be applied to clean, dry surfaces only.

B. Where insulation is applied to carbon steel piping and equipment operating in the temperature range of 0 F to 150 F, the metal surfaces of said piping and equipment shall be coated by others, in accordance with Owner's Coating Specifications, prior to application of insulation.

C. Where insulation is applied to stainless steel piping and equipment, the metal surfaces of such piping and equipment shall be coated by others, in accordance with Owner's Coating Specifications, prior to application of insulation.

D. Where insulation is to be installed on equipment or piping flanges or flanged valves which are to be hot bolted, the insulation must not be installed until these are released by Owner's representative.

II. INSULATION SUPPORTS

A. Insulation on vertical equipment exceeding 3 ft 0 in. OD, where welding is permitted, shall be supported in accordance with Owner's Standard EQ-64. Where welding is not permitted, insulation shall be supported in accordance with Standard EQ-68.

B. Insulation on horizontal equipment, 3 ft 0 in. diameter and larger, where welding is permitted, shall be supported in accordance with Owner's Standard EQ-65. Where welding is not permitted, insulation shall be supported in accordance with Owner's Standard EQ-69.

C. Insulation applied to bottom head, inside of skirt, on skirt supported vessels, shall be supported in accordance with Owner's Standard EQ-64 or EQ-70, depending upon whether or not welding is permitted.

D. Insulation on dished heads of vertical equipment shall be supported in accordance with Owner's Standard EQ-64, EQ-68 and EQ-67.

E. Insulation on spherical vessels operating lower than 70 F shall be supported in accordance with Owner's Standard EQ-66.

F. Where necessary to prevent entrance of moisture, uppermost support shall be replaced with a metal protective plate, as described in Article X of this specification, entitled "Protective Cover".

G. Insulation on 3-inch NPS and larger vertical pipe and vertical vessels up to 1 ft 5 in. in diameter shall be supported by formed steel strapping (Spec VII.A.9) bolted around pipe near bottom of run. Additional supports shall be installed on pipe at intervals of 21 feet of vertical run.

III. SECUREMENT

A. Tie-Wire Anchors. Angle clips, flat rectangular punched pins, and other approved attachments shall be used as insulation tie-wire anchors, where shape of vessel prevents normal methods of securement of preformed insulating materials. Blank nuts, where required, shall be attached, standing-edge to vessel surface, by light fillet welds. Angle clips shall be installed in accordance with Owner's Standard EQ-67. Pins shall be carbon steel or stainless steel to correspond with metal of the vessel.

B. Wire

1. Insulation shall be secured by wire applied at proper intervals by looping about the circumference, twisting ends tightly together to provide proper securement, and pressing wire ends into insulation to prevent projection. Wire shall be used for securement of all inner layers of pipe insulation, and outer layers up to and including 12-inch OD. Wire shall be used for securement of all outer layers of pipe insulation, and outer layers up to and including 12-inch OD. Wire shall be used for securement of all outer layers of pipe insulation, regaraless of diameter, where weather-barrier is specified to be metal jacket.

2. Where shape of vessel prevents complete encirclement, securement shall be made to other tie-wires, wire cables, or anchors approved for this purpose.

C. Insulation Strap

1. All pipe insulation on traced lines shall be secured as noted in the individual specification.

2. Outer layers of pipe insulation over 12-inch OD shall be secured with insulation strap except when metal jacket is used.

3. Strap shall be applied to cylindrical insulation at proper intervals by looping strap about the circumference, stretching to suitable tightness with an approved banding machine, and clamping in place at joint. Strap joint shall consist of one double-prong clip. Clips shall be located on the vertical side of pipe insulation.

4. Where shape of vessel prevents complete encirclement by strap, securement shall be made to tie-wires, wire cables, or other devices approved for this purpose.

5. Insulation strap shall be divided into lengths based on one strap joint for the first 15 feet of vessel circumference. These joints shall be spaced at equal distances around the vessel. Vessels over 15 feet in diameter (except where factory preformed panel insulation is specified) shall be equipped with vertical strap anchor angles spaced as shown on Owner's Standard EQ-64 or EQ-66.

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C. Insulation Strap - Cont'd

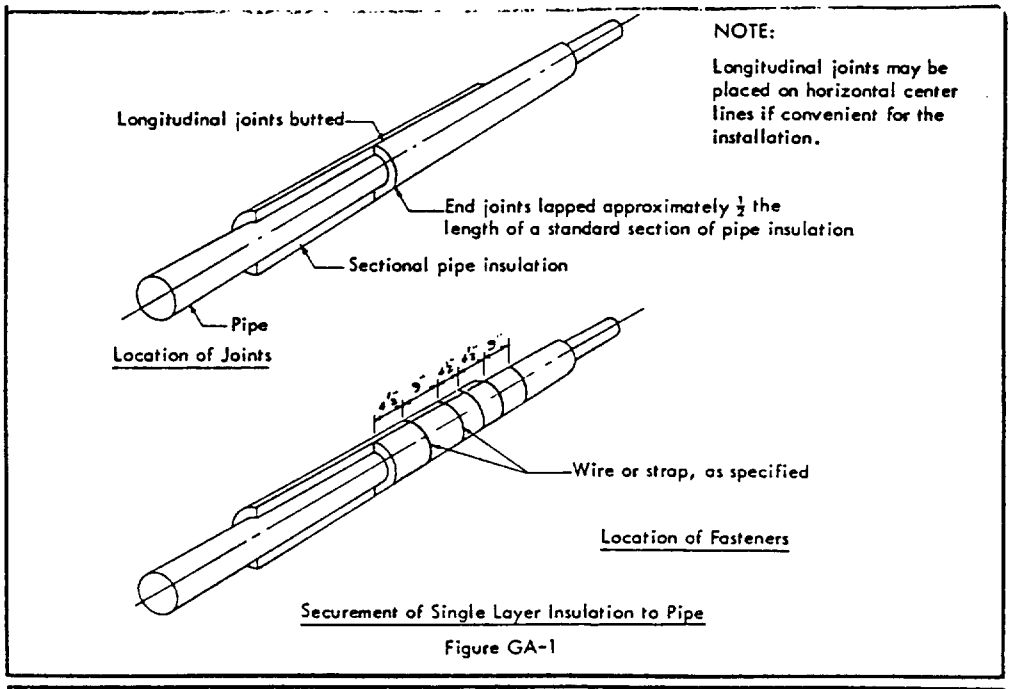
6. Insulation secured to interior or exterior of heating, ventilating, and air-conditioning ducts shall be as specified in individual specifications.

7. The inner layer and outer layer up to 4½ inches in outside diameter of low temperature cellular glass insulation shall be secured with strapping tape.

D. Location of Insulation Joints and Spacing of Straps and Wire

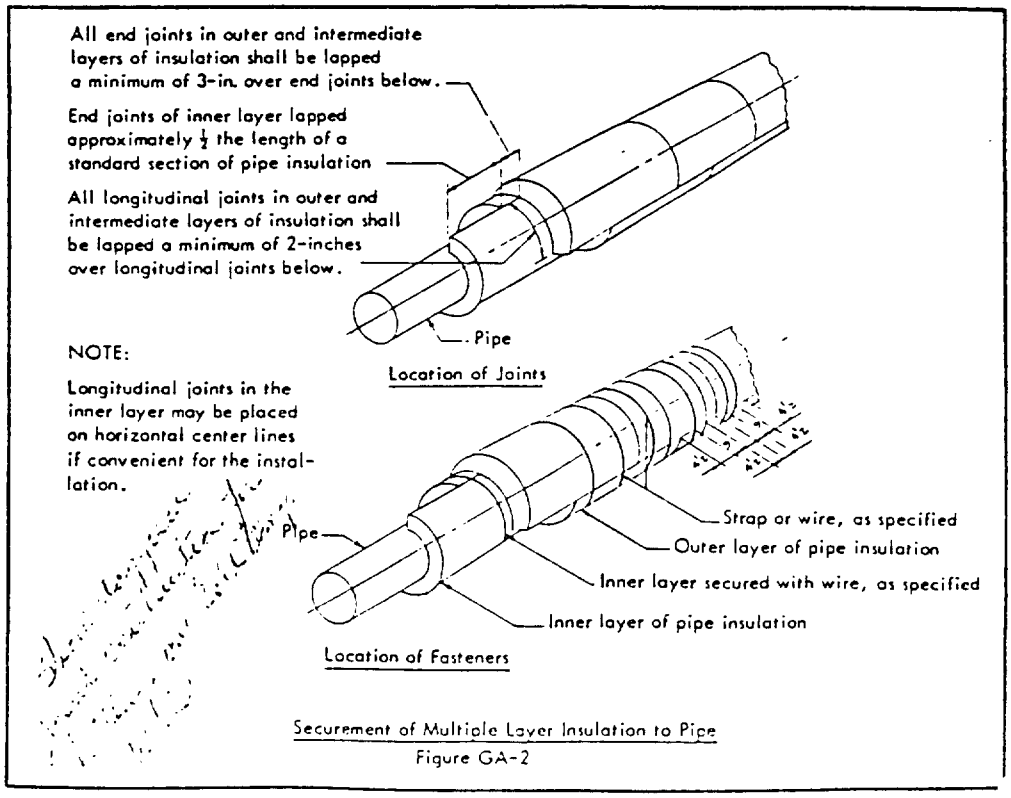
1. Spacing of insulation strap and/or securing wire shall be based on length of insulation block or section for equipment and pipe. Where 36-inch lengths of insulation are applied in staggered arrangement, four loops will be required at approximately 9-inch intervals, so that no loop is located more than 4½ inches from any end joint. Where 24-inch lengths are applied, in staggered arrangement, three loops per length will be required. Where 18-inch lengths are applied in staggered arrangement, two loops per length will be required.

2. Spacing of strap and wire on pipe insulation shall be as shown in Figures GA-1 and GA-2.



Securement of Single Layer Insulation to Pipe

Figure GA-1



Securement of Multiple Layer Insulation to Pipe

Figure GA-2

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IV. NAMEPLATE CLIPS

A. Insulation mechanics shall cooperate with other crafts in the placement of nameplates and nameplate clips.

B. On vessels insulated for service primarily above 32 F, nameplates shall not be covered by the insulation. The opening in the insulation shall be tapered to the nameplate perimeter.

C. For vessels and equipment which operate at or below 32 F, the Field Inspector will provide a nameplate extension clip in accordance wit Owner's Standard EQ-15.

V. JUNCTION OF THERMAL INSULATION WITH FIRE-RESISTANT MATERIALS

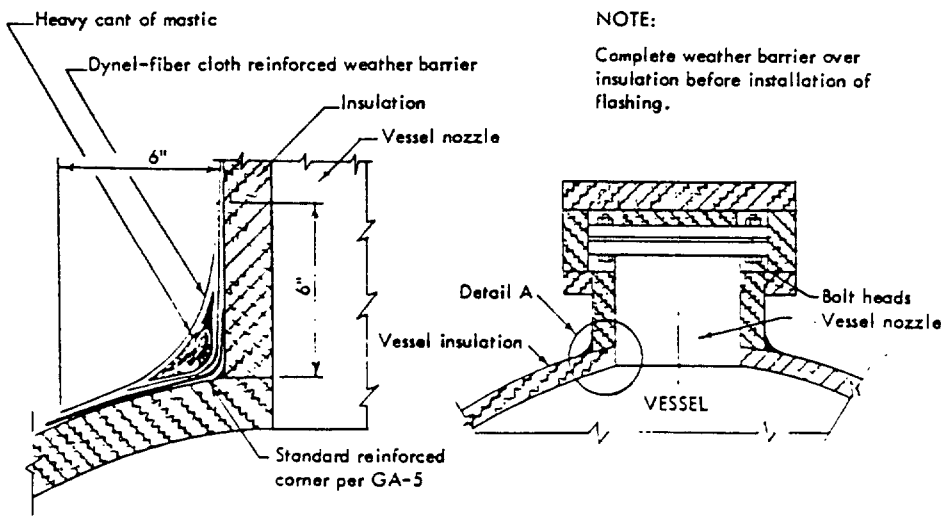
A. Insulation thickness on channel tank legs and similar equipment supports shall be not less than adjoining fire-resistant materials. Where thickness of thermal insulation exceeds that of fire-resistant materials, surface of insulation shall be neatly and uniformly finished with a wide bevel, and feathered to provide the appearance of a continuous surface.

B. Junction of insulation with fire-resistant materials shall be sealed with weather-barrier coating.

C. Concrete-filled structural tubing tank legs do not require external fireproofing. Vessel insulation shall butt against legs, and junction shall be sealed with weather-barrier coating. Covering for temperature control shall be the same as for channel legs, including weather barrie

VI. FLASHING

A. All nozzles on top of insulated equipment shall be provided with flashing as shown in Figure GA-3.



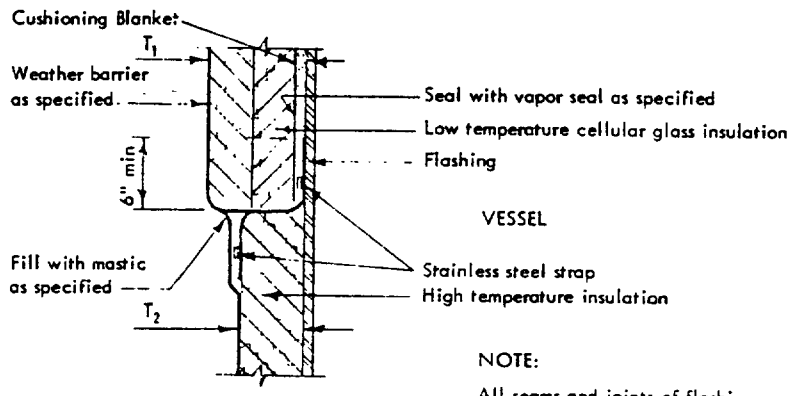
Flashing on Top Nozzles of Equipment

Figure GA-3

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VI. FLASHING - contd

B. Where a vertical vessel such as a column is insulated for gradient temperatures, with the low temperature above, flashing shall be installed between different thicknesses of insulation where noted in schedule to prevent condensate from entering the high temperature insulation on the lower side of the joint. Flashing material shall be as specified in the MATERIAL SPECIFICATIONS, Article VII. A. 83. It shall be secured to the vessel and the outside of the insulation with the equipment insulation straps specified in the MATERIAL SPECIFICATIONS, Article VII. A. 11. All seams and joints of flashing shall be sealed with vapor seal as specified in the individual specifications. Typical installation is shown in Figure GA-3A.



Flashing at Butt Joints of Different Thicknesses of Insulation

Figure GA-3A

VII. SEALING OF HOT PROJECTION

Where hot brackets, hangers, or supports project through the insulation and weather-barrier mastic or metal jackets, the junction shall be sealed with heat-resistant sealer as specified in Article XIV.B.6 of this specification.

VIII. COATING

Coating of bare and insulated surfaces, where required, shall be done by others in accordance with Owner's Coating Specification. Insulation shall not be applied on painted surfaces until such surfaces are completely finished and dry in accordance with coating specification.

IX. PROTECTION FROM ABUSE

A. Insulation subject to mechanical abuse, such as abrasion or brushing, or where otherwise required, as designated by the Owner, shall be protected with a covering jacket of not thinner than 18 gage (minimum) galvanized sheet metal. Jacket shall be secured firmly in place with insulation strap, spaced 10 inches (maximum) on centers, or sheet metal screws where use of strap is impracticable. Sheet metal screws shall not be used on jackets on low temperature insulation where possibility exists of piercing weather-vapor barrier membrane.

B. Corners of insulated ducts, breechings, and other flat-surfaced equipment shall be reinforced by installation of expanded metal lath corner bead. Bead shall be provided by the Insulation Contractor and installed by insulation mechanics, following application of insulation block, securing it firmly to block tie wires. Cement shall be forced through lath flange to provide proper key.

X. PROTECTIVE COVER

Insulation terminating at an intermediate point in the height of a vessel shall be protected from physical abuse and moisture penetration by installation of a continuous metal plate attached to vessel by means of a continuous weld immediately above insulation. This protection shall be provided by others in accordance with Owner's specification. Insulation may be bevelled and mastic sealed to shell if desirable and operating temperature is below 250 F.

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XI. APPEARANCE

Lapped joints, selvage ends, and other irregularities of surfacing materials shall be concealed from general view wherever possible.

XII. INSULATION FOR SAFETY

A. Where it is required to insulate piping or equipment for safety, only that portion shall be insulated which is located 6 ft 0 in. or less above an floor or operating level if the axis of the pipe or equipment is vertical, and, for horizontal axes, at all elevations 7 ft 0 in. or less above any floc or operating level. Piping in trenches, unless otherwise specified, shall not be insulated for safety below grating level. Exposed ends of insulatic shall be beveled to provide proper seal and drainage.

B. Where specified, thermal insulation shall be omitted and protection provided by erection of a suitable safety guard. This guard will be provided by the Owner.

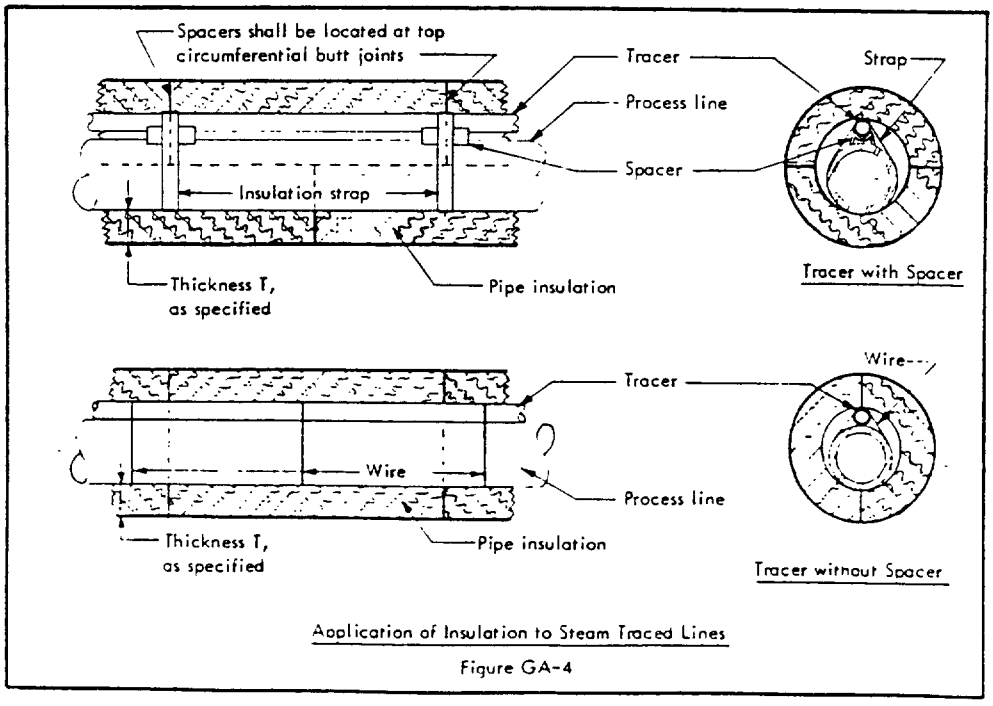
XIII. STEAM OR ELECTRIC TRACED INSTALLATIONS (as specified)

A. Air Convection Tracing System

1. Insulation Schedules and/or tracing drawings shall designate traced lines with the symbol ST (steam traced without spacers), or STW (steam traced with spacers).

2. Accessories. Pressed steel spacers shall be used only when specifically required for separation between the tracer and pipe. These space shall be furnished by the Insulation Contractor and as specified in the MATERIAL SPECIFICATIONS, Article VII.C.1.a.

3. Assembly. Type and size of tracer lines, methods of clamping, hanging and supporting them, and size of pipe insulation to be applied sh be in accordance with Owner's Standards P-140 and P-140A, and Figure GA-4 supplemented by Insulation Design Schedules and steam or elec tracing drawings, where required. In addition to assembly directions contained in Standards EL-43, P-140 and P-140A, pressed steel spacers (and pressed steel clamps, where installed) shall be spaced on 18-inch centers for copper tracer lines. Temporary installation of assemb will be done by the Owner.



Application of Insulation to Steam Traced Lines

Figure GA-4

4. Pipe insulation shall be applied in required sizes and carefully fitted to heated companion lines in the manner prescribed in these specifications and in the individual specifications. Tracer assembly shall be firmly and permanently secured in place before application of insulation. Where spacers are specified, they shall be added or relocated where required to ensure firmness and separation of tracer from pipe.

5. Protective Wrapping. When aluminum piping is to be traced, or when otherwise required, aluminum piping shall be separated from tracer assembly by not less than two wrappings of glass cloth tape applied to the line. Care shall be taken that tracer line does not contact aluminum line at any point. Where tracer may touch the aluminum between supports, the line shall be wrapped with glass cloth tape to prevent contact. Glass cloth tape shall be as specified in MATERIAL SPECIFICATIONS, Article VII.C.2.b.(6).

XIII. STEAM OR ELECTRIC TRACED INSTALLATIONS - contd

B. Heat Transfer Cement Tracing System

1. The heat transfer cement used shall be suitable for the temperature and installation requirements. It shall be as called for on Insulation Design Schedule, Insulation Equipment and/or Line List, or as otherwise prescribed by the designer of the tracing system.

2. Materials

a. Heat Transfer Cement (See MATERIALS SPECIFICATIONS, Article Numbers as Noted)

(1) Standard Grade - VII. C. 2. a. (1).

(2) T-3 Grade - VII. C. 2. a. (2).

(3) T-63 Grade - VII. C. 2. a. (3).

(4) T-85 Grade - VII. C. 2. a. (4).

(5) T-80 Grade - VII. C. 2. a. (5).

(6) T-5 Grade - VII. C. 2. a. (6).

b. Accessories (See MATERIALS SPECIFICATIONS, Article Numbers as Noted)

(1) Primer for coating of aluminum surfaces prior to application of Standard Grade, T-3 Grade, and T-63 Grade heat transfer cements - VII. C. 2. b. (1).

(2) Mill Varnish Stripper - VII. C. 2. b. (2).

(3) Metal Retainer for Cement - VII. C. 2. b. (3).

(4) Pipe Insulation Strap - VII. A. 13.

(5) Clips for Pipe Strap - VII. A. 14.

3. Surface Preparation

a. Surface of pipe, or equipment to which heat transfer cement is to be applied shall be cleaned of dirt, rust, scale, paint, and varnish. Paint or varnish shall be removed with mill varnish stripper, in accordance with manufacturer's directions, on areas to which tracers and heat transfer cement are to be applied. Badly scaled or rusted steel shall be cleaned by sandblasting before application of tracer or heat transfer cement.

b. Galvanized or aluminum surfaces shall be primed with ALP Primer after cleaning, before application of Standard Grade, T-3 Grade, or T-63 Grade of heat transfer cement.

4. Application of Tracers - Type and size of tracers shall be as scheduled. Steam and liquid tracers shall be secured to pipe by strap or wire in accordance with Owner's Standard P-140. Electric tracers shall be installed in accordance with Owner's Standards EL-41 through EL-47. Tracers or plate coils shall be installed on equipment as scheduled, or shown on drawings. Care shall be taken if coils or tracers are installed on aluminum equipment or piping that the two metals do not come into contact. See Section A.5 of this Article.

5. Application of Heat Transfer Cements - After installation of tracers, except plate coils, on pipe and equipment, the specified grade of heat transfer cement shall be applied in accordance with one of the following procedures, as required:

a. Standard Grade and T-63 Grade cements shall be applied with hand tools, or with manual or power caulking guns having special nozzles. The cement shall be applied over the tracer in a layer approximately 1/4-inch thick, and forced into the spaces adjacent to the line of contact between the tracer and the traced pipe or equipment. Special care shall be exercised to fill these spaces completely, to ensure maximum surface contact. The width of the peripheral contact of cement and pipe, pipe fittings, or equipment shall be a minimum of three times the diameter of the tracer. Over irregular surfaces such as pumps and valves, and where tracers are closely spaced, cement may be troweled over tracers in a solid layer 1/4-inch thick. If thickness in excess of 3/4 inch is required, cement shall be installed in two layers, with air drying of at least 24 hours between applications. Application details are shown in Figure GA-4A.

b. Where it is impossible or impracticable to clean pipe surfaces, or where vibration is excessive, e.g. pipe connected to reciprocating machinery, or where curing may be delayed, the Standard Grade and T-63 Grade cements shall be applied to straight pipe by means of metal retainers. The retainer shall be filled with sufficient cement to fill all voids between it, the pipe, and the tracer. The filled retainer shall be placed over the tracer and pulled tight with strap. Straps shall be placed on 24-inch centers with a common band at overlap of adjoining retainers. Application details are shown in Figure GA-4A. The retainers are shown in Figure GA-48.

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XIII. STEAM OR ELECTRIC TRACED SYSTEMS - contd

B. Heat Transfer Cement Tracing System - contd

5. Application of Heat Transfer Cements - contd

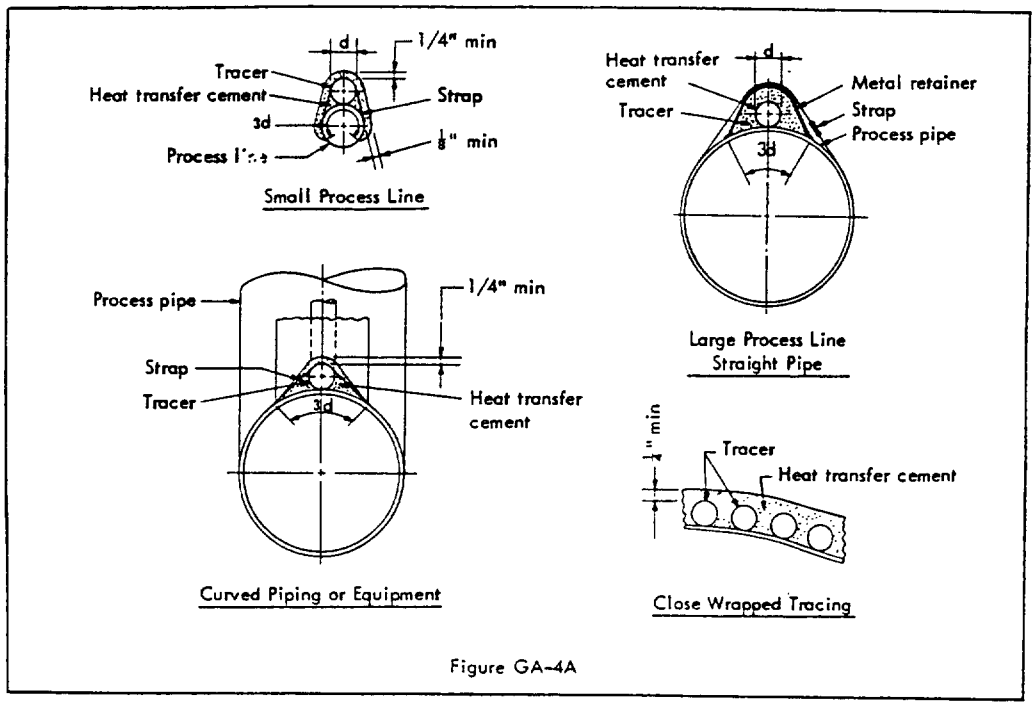
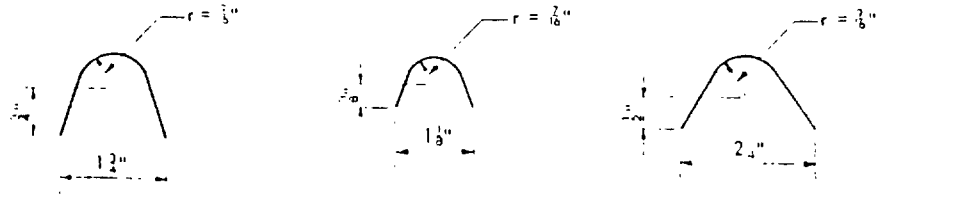


Figure GA-4A

NOTE: Use No. 22 gage galvanized sheet steel on carbon steel pipes.
No. 26 gage stainless steel on stainless steel pipes.
No. 18 gage Series 3000 or 5000 aluminum alloy on aluminum pipes.



Cement Retainer

Figure GA-4B

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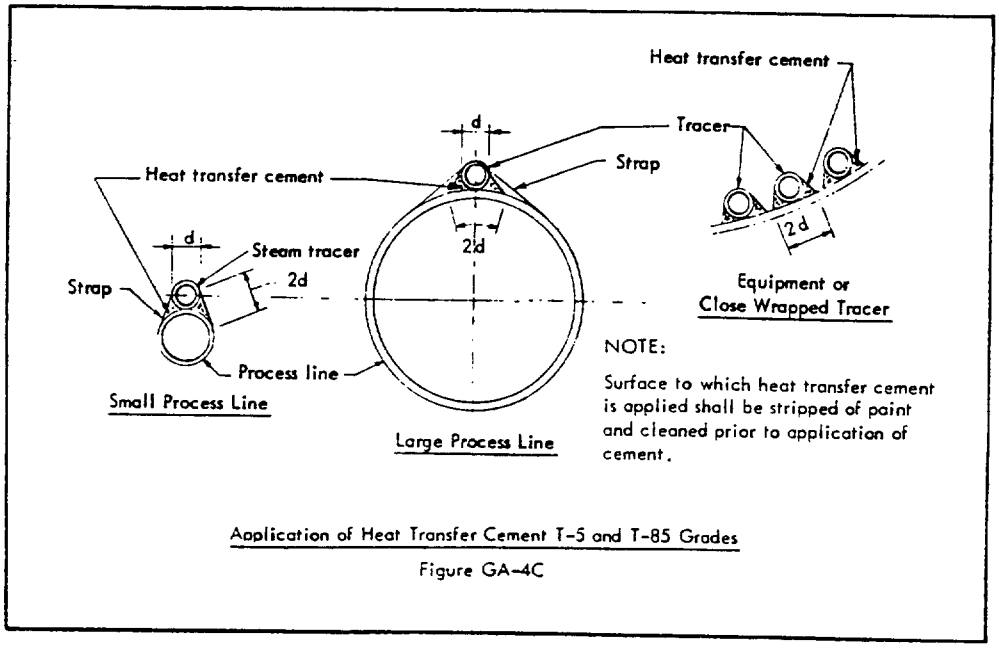
XIII. STEAM OR ELECTRIC TRACED SYSTEMS – contd

B. Heat Transfer Cement Tracing System – contd

5. Application of Heat Transfer Cement – contd

c. T-3 Grade cement, for plate coils, shall be applied to surfaces prepared in accordance with Articles XIII. B. 3. a. and b. Thickness of the cement shall be not less than 1/16 inch nor more than 1/8 inch. The plate coil, with the cement on the surface toward the vessel to which the coil is to be attached, shall be firmly and carefully pressed to the surface of the vessel to obtain a tight cemented bond. Securement of the plate to the vessel shall be as shown or called for on the drawings.

d. T-5 Grade, T-85 Grade, and T-80 Grade cements, which are supplied in cartridges, shall be applied with manual or power caulking guns. The cement shall be forced into the spaces adjacent to the line of contact between the tracer and the traced pipe or equipment. Special care shall be exercised to fill these spaces completely, to ensure maximum surface contact. The width of the peripheral contact of cement and pipe, pipe fittings, or equipment shall be a minimum of twice the diameter of the tracer. Application details are shown in Figure GA-4C.



Application of Heat Transfer Cement T-5 and T-85 Grades

Figure GA-4C

6. Weather and Temperature Restrictions

a. Standard Grade, T-3 Grade, and T-63 Grade heat transfer cements contain water and are water soluble. If these cements are applied without the use of metal retainers, a period of eight hours shall elapse before application of insulation and weather barrier. During this period and until insulation and weather barrier are installed, these cements shall be protected from rain, sleet, and snow with temporary waterproofing.

b. The minimum application temperature for T-5 Grade and T-85 Grade heat transfer cement is 70 F. If the ambient temperature or the temperature of the cartridges of cement is below 70 F, the cartridges shall be heated above 70 F before application. T-85 Grade and T-80 Grade cements should be stored under refrigeration, but shall be heated above 70 F before use. If they have been stored at room temperature longer than 90 days, they shall be heated above 120 F before use, then shall be used within 24 hours.

7. Curing

a. Standard Grade, T-3 Grade, and T-63 Grade heat transfer cements shall be allowed to air set for a minimum of four hours prior to startup of tracer for heat curing. Heat curing shall be done by gradually raising the temperature of the tracer to not less than 160 F nor more than 212 F. The cement shall be cured for four to six hours, except that large masses of cement, such as those on valves, and on close wrapped tracers for equipment such as pumps and vessels, shall be cured for 24 hours. T-63 Grade cement, because of its slower setting time, shall be given a minimum of four hours of additional curing at 250 F.

b. Curing procedures are as follows:

Steam tracing systems: Open trap end of tracer to atmosphere, then open valve at header just sufficiently to bleed steam and condensate through the tracer. Maintain steam on the tracer for the period of time specified above.

Electric tracing systems: Set thermostat at 200 F, or, if this is impossible, reduce voltage so that temperature of the tracer cannot exceed 212 F for the period of time specified above.

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XIII. STEAM OR ELECTRIC TRACED SYSTEMS - contd

B. Heat Transfer Cement Tracing System - contd

7. Curing - contd

c. T-85 Grade cement requires no special curing technique. The setting or hardening time is proportional to the operating temperatu If installation operates at fairly low temperature (100 F to 150 F), this cement will remain soft and tacky for several months. If operatir temperature is above 250 F, it will set hard in a few hours. T-85 Grade cement may be subjected to temperatures up to 375 F immediat after application.

d. T-80 Grade cement, for use at temperatures from below freezing to 300 F, requires no special curing. Its properties are similar to those of T-85 Grade cement.

e. T-5 Grade cement requires no curing, as it does not harden or set.

8. Application of Insulation

a. Insulation shall be as scheduled and shall be applied in accordance with the individual specifications.

b. Inside diameter of insulation to fit over traced piping shall be as called for in Owner's Standard P-140A.

XIV. WEATHER-BARRIER MASTIC COATING

Insulation shall be protected with a weather-barrier mastic coating unless otherwise specified.

A. Materials (See MATERIAL SPECIFICATIONS, Article Numbers as Noted)

1. Weather-Barrier Mastic - Trowel Grade - VII.B.1.a.

2. Weather-Barrier Mastic - Spray Grade - VII.B.1.a.

3. Reinforcing Cloth - VII.B.1.b.

4. Mastic (Caulking) - VII.A.45.

5. Heat-Resistant Sealer - VII.A.42.

6. Expansion Strip - VII.A.10.

7. Lap Sealer - VII.A.46.

B. Application

1. Insulation shall be installed before application of weather barrier.

2. Surface of insulation shall be smooth, even and free of voids, and in relatively dry state.

3. On outside installations, insulation shall be sloped for water drainage.

4. Sharp outside corners of insulation shall be rounded off as shown in Figure GA-5.

5. A heavy fillet of mastic shall be applied to all inside corners of insulation, and to inside corners of metal projections of moderate and low temperatures, prior to application of weather-barrier mastic.

6. A heavy fillet of heat-resistant sealer shall be applied around all metal projections which will be above 180 F in service. The sealer shall be applied outward from the junction of the projection for a distance six inches on the metal and six inches over the surface of the insulc tion.

7. Insulation shall be protected from weather as soon after installation as possible. However, standard mastic shall not be applied when atmospheric temperature is below 32 F or when temperature is expected to be as low as 25 F within the next 24 hours. Low temperature mastic shall be used when atmospheric temperature is less than 32 F but above 20 F.

8. Where mastic is to be spray applied, adjacent areas not to be coated, such as valve stems, handles, gauge glasses, instruments, equipment, structural steel, floors or walls, shall be masked or otherwise protected.

9. Spray application shall consist first of a spray tack coat of spray grade weather-barrier mastic into which the reinforcing cloth is thoroughl embeaded. Joints of reinforcing shall be uniform and not less than two inches in width, and shall have a smooth unbroken surface. All inside and outside corners shall be rounded and the weather-barrier coating provided with an overlapped layer of reinforcing cloth as shown in Figure GA-5. After the first coat has taken its set, a second coat shall be spray applied which completely covers and fills all voids in the cloth. The combined thickness of the weather-barrier coating and reinforcing cloth shall not be less than 55 mils when dry, or approximately 3/32 to 4/32-in. total wet film.

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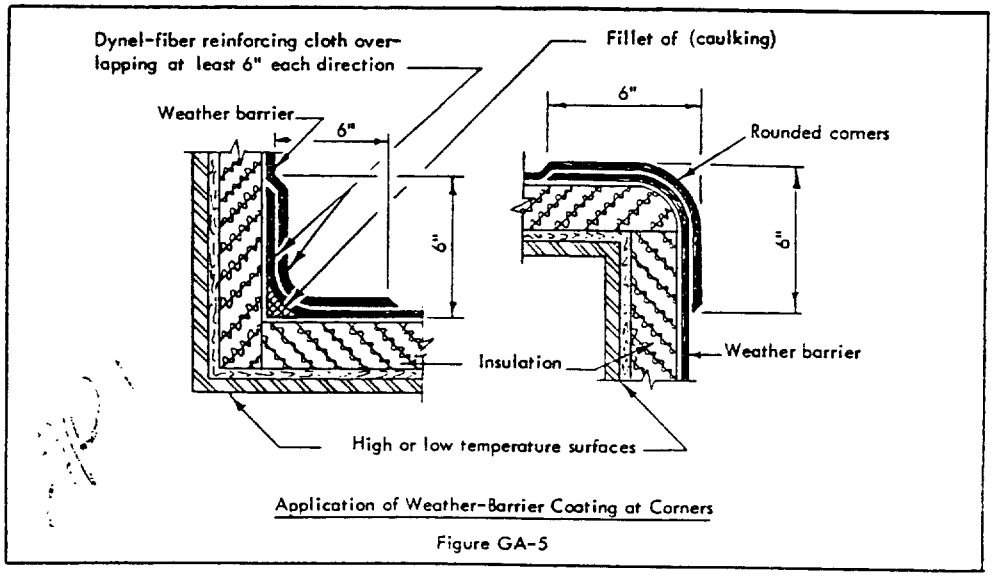
XIV. WEATHER-BARRIER MASTIC COATING - contd

8. Application - contd

10. Palmed or troweled application shall consist of first bonding the reinforcing cloth to the surface with small amounts of weather-barrier mastic. Cloth shall be pulled taut with joints overlapped uniformly two inches. All inside and outside corners shall be rounded and the weather-barrier coating provided with an overlapped layer of reinforcing cloth as shown in Figure GA-5. Trowel grade weather-barrier mastic shall then be troweled or palmed over cloth, pressing it through the mesh to obtain bond with insulation surface. Care shall be taken that openings in weave of cloth are completely sealed. After weather barrier has partly set, it shall be water brushed to a smooth, even surface. The combined thickness of the weather-barrier coating and reinforcing cloth shall not be less than 1/16 inch when dry, or approximately 3/32 to 4/32-in. total wet film.

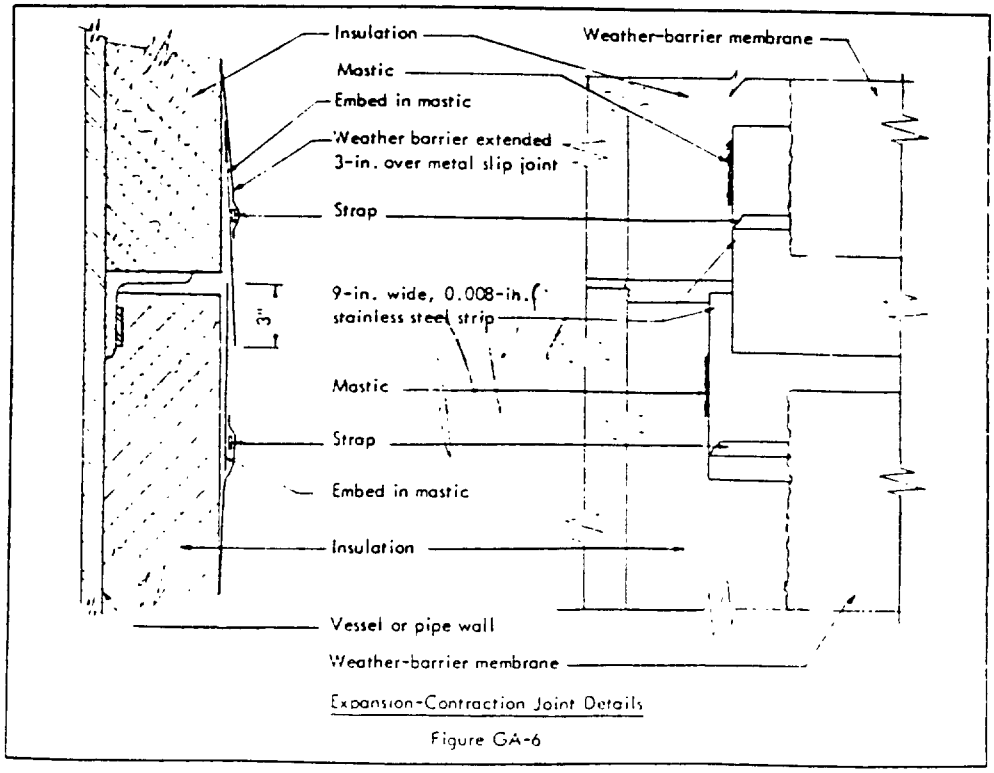
11. Weather-barrier membrane shall be carried out six inches onto metal, beyond termination of insulation and supports, skirts, or other projections, and shall be sealed to the metal.

12. Expansion joints in weather barrier over expansion openings in high temperature insulation shall be constructed with expansion strip, as shown in Figure GA-6. Joints installed in vertical position shall be arranged to shed water. Joints installed in horizontal position shall be constructed in similar manner except that a bead of lap sealer shall be placed between the two layers of expansion strip so as to prevent entry of water, but not to restrict movement between sheets.



Application of Weather-Barrier Coating at Corners

Figure GA-5



Expansion-Contraction Joint Details

Figure GA-6

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XIV. WEATHER-BARRIER MASTIC COATING - contd

B. Application - contd

13. Contraction joints in low-temperature insulation shall be as called for in individual specifications.

14. Unless otherwise specified, outer finish of indoor insulation shall be same as called for in these weather-barrier specifications.

XV. METAL JACKETS - STAINLESS STEEL OR TREATED STEEL

The letter M added to the regular designation of any application specification (examples: 10-HM, 10-JM, etc) indicates that the weather barrier shall consist of a jacket of Type 430, or any austenitic type, stainless steel. The letters MT added to the regular designation indicate that the weather barrier shall consist of vinyl-coated galvanized steel. Split systems of weather barrier shall be specifically designated (example: 23-H on fittings and 23-HM for straight pipe).

A. Materials

1. Weather-Barrier Stainless Steel and Carbon Steel Jackets (See MATERIAL SPECIFICATIONS, Article Numbers as Noted)

a. Equipment over 24 inches OD - VII. B. 2. a. and VII.B.3.a.

b. Equipment 24 inches OD and under - VII. B. 2. b. and VII.B.3.b.

c. Pipe Preformed Jacket - VII. B. 2. c.

d. Smooth jacket for pipe - VII. B. 2. d.

e. Closure band for both ends of pipe jackets - VII. B. 2. e. and VII.B.3.c.

f. Preformed jackets for fitting covers - VII. B. 2. f.

2. Accessories (See MATERIAL SPECIFICATIONS, Article Numbers as Noted)

a. Sheet Metal Screws - VII. A. 32.

b. Equipment Insulation Strap - VII. A. 11.

c. Pipe Insulation Strap - VII. A. 13.

d. Clips for Equipment Strap - VII. A. 12.

e. Clips for Pipe Strap - VII. A. 14.

f. "S" Clips - VII. A. 27.

g. Jacket Support Clips - VII. A. 28.

h. Stainless Steel Wire - VII. A. 17.

i. Expansion Strip - VII. A. 10.

j. Lap Sealer - VII. A. 46.

k. Heat-Resistant Sealer - VII. A. 42.

B. Application

1. Equipment

a. Equipment insulation secured with bands shall be recessed under band clips. Clips shall be embedded flush with insulation to provide a smooth, even surface for application of jacket.

b. Jacket shall be installed from bottom up. The first course shall be supported by jacket support clips attached to insulation support. Vertical joints shall be lapped to a minimum of three inches. A bead of lap sealer shall be placed between the layers of metal on all vertical joints before joint is fastened together with screws on six-inch centers. Care shall be taken that screws do not bind circumferential joint preventing relative motion between two courses of jacket. Subsequent courses of jacket shall be supported by "S" clips, overlapped three inches to shed water. At top of vessel a six-inch wide stainless steel flashing strip shall be embedded in weather-barrier mastic and banded in place. It shall lap top course of jacketing three inches, but shall not be attached to the jacket. Additional weather barrier, used over vessel head, shall be applied down over flashing to provide water shed. Details are shown in Figure GA-7 for corrugated metal jacket.

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XV. METAL JACKETS – STAINLESS STEEL OR TREATED STEEL – contd

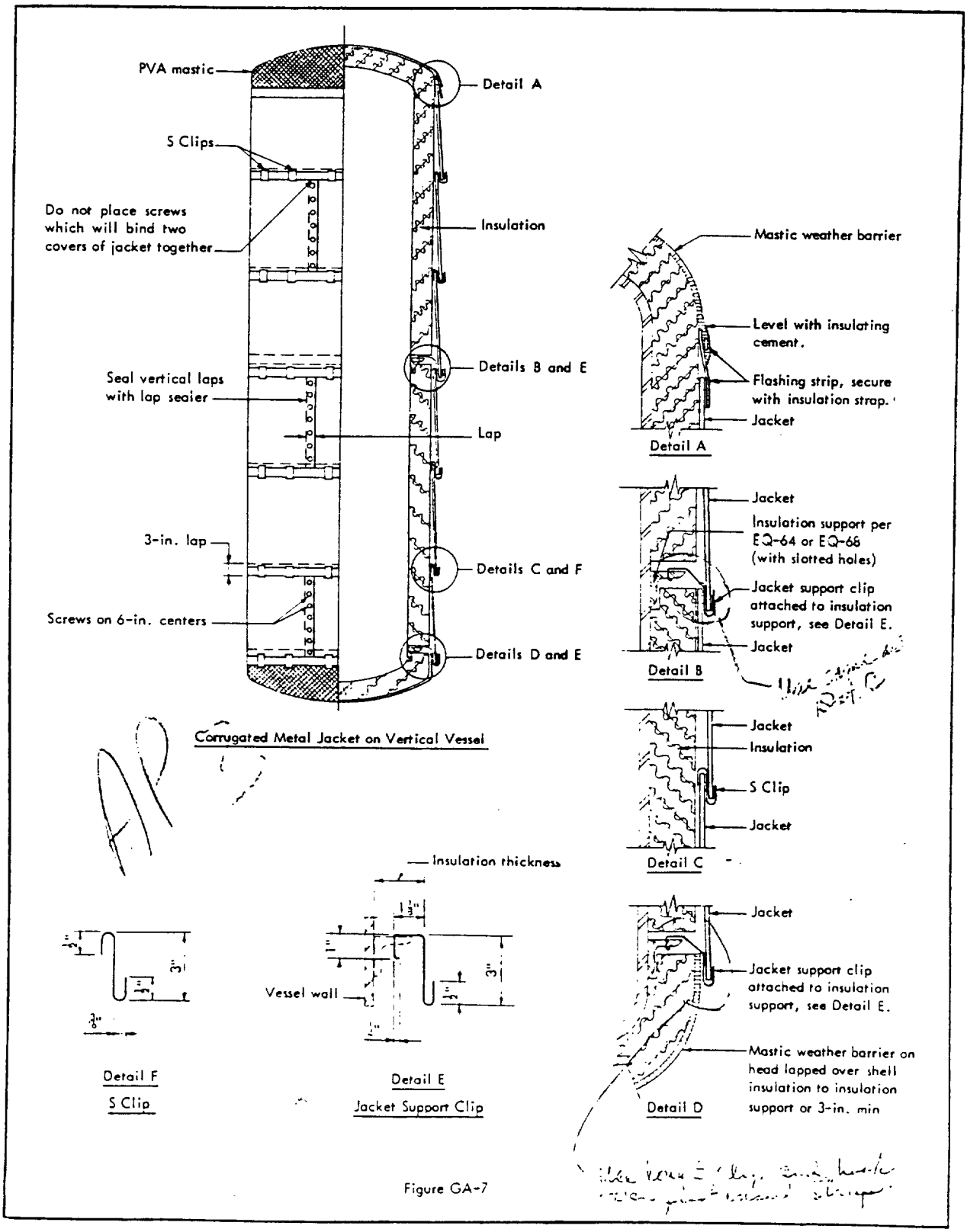


Figure GA-7

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XV. METAL JACKETS - STAINLESS STEEL OR TREATED STEEL - contd

B. Application - contd

1. Equipment - contd

c. When smooth stainless steel jacket is used, a bead of lap sealer shall be placed between the layers on each vertical joint before joint is fastened together with screws on six-inch centers. Vertical and circumferential joints shall be lapped a minimum of three inches. The first course of jacket shall be supported by jacket support clips attached to the vessel insulation support. Subsequent courses of jacket shall be supported by "S" clips, overlapped three inches to shed water. Jacket shall be secured circumferentially with 1/2-inch stainless steel bands, above circumferential joint, and on 18-inch centers. Sheet metal screws shall be installed in jacket to aid in spacing and to prevent slipping of bands. Care shall be taken that neither the screws nor the bands bind the circumferential joint preventing relative motion between two courses of jacket. Top flashing shall be as specified for vertical vessels over 2 ft 0 in. in diameter. Details are shown in Figure GA-8 and GA-7. Expansion strap shall be used to secure metal jackets on vessels over 15' 0" in diameter.
When preformed stainless steel jacket with "Z" joint is used to cover small vessels, vertical or horizontal, it shall be installed in the manner specified for application of preformed pipe jacket in Item 2.a of this section. Details are shown in Figure GA-9.

d. Horizontal vessels jacketed with smooth stainless steel shall be insulated in same manner as vertical vessels except that all circumferential joints shall be sealed with a bead of lap sealer placed between the layers of metal before securing the jacket in place with strap. Strap shall be placed directly over the joint. The longitudinal laps shall be installed on sides to shed water, and shall be secured on six-inch centers with screws. Details are shown in Figure GA-10.

e. Heads of vessels shall be jacketed with preformed or field formed smooth surface stainless steel jacket. All joints of preformed head jackets shall be fastened together to form a watertight assembly. Field formed jacket joints, or joints where preformed jackets fit together, shall have laps sealed with joint sealer. Jacketing shall be secured in place by straps, screws, or other approved fasteners.

f. Insulation on irregular surfaces and vessel trim, where use of metal jacket is impracticable, shall be protected with mastic weather-barrier coating as called for in Article XIV.B. of this specification.

2. Piping

a. Preformed and preapplied stainless, or treated, steel jackets with preformed longitudinal "Z" joint shall be applied as follows:

(1) Inner layer of insulation, if any, shall be secured with stainless steel wire if high temperature, or with glass filament tape if low temperature.

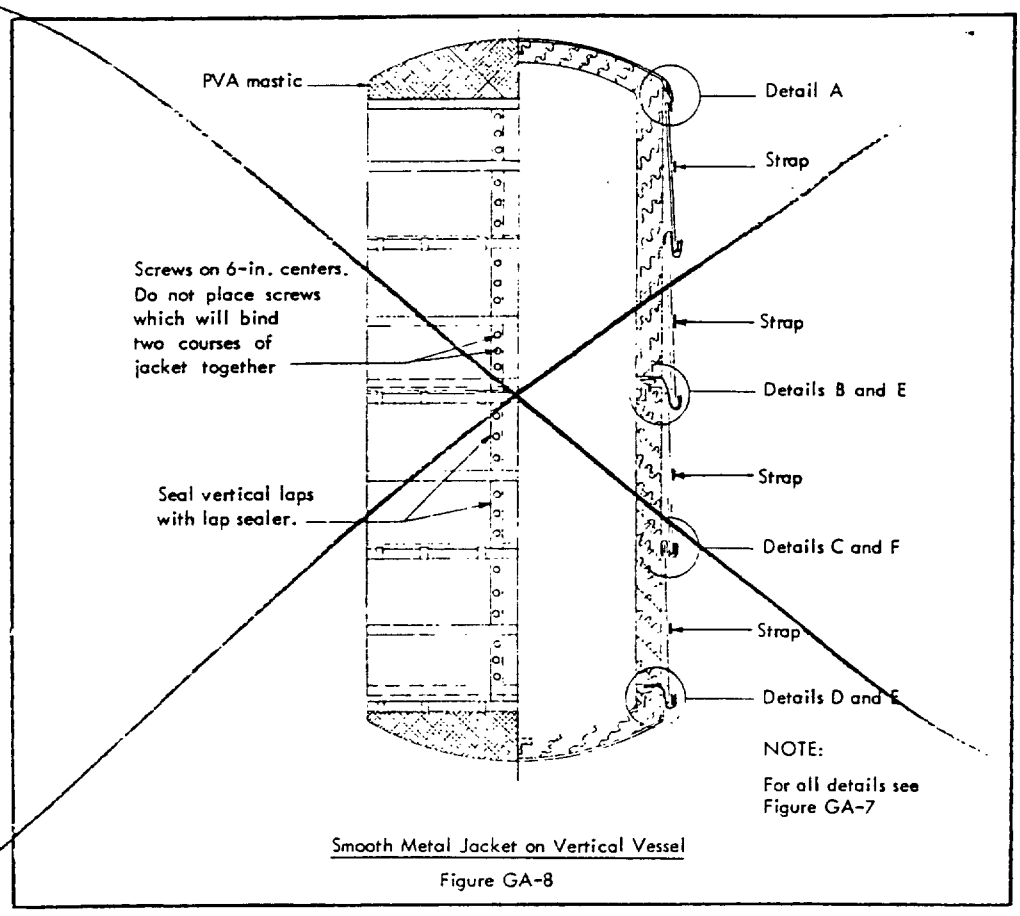
(2) Factory attached jacket to a single or outer layer insulation shall be installed with the insulation. Insulation and jacket shall be installed by placing the insulation around the pipe, or inner layer, and engaging the "Z" joint. Longitudinal joint on horizontal pipe shall be located on horizontal centerline of pipe with open end down to ensure runoff of water. Jacketing 6-5/8 inches and smaller shall be secured with one strap at center of the assembly. Larger diameter insulation and jacketing shall be secured with two straps, each approximately 12 inches from end of assembly. Details are shown in Figure GA-9.

(3) Where necessary (such as where insulation must be cut to fit around obstructions) to install the single or outer layer of insulation prior to the installation of jacket, the insulation shall be secured with wire. Ends of wire shall be twisted and embedded in surface of insulation so as to provide a smooth even surface for application of the jacket. Jacket shall then be installed as specified above.

(4) The butt joint between adjacent assemblies shall be sealed with a closure band. If non-setting sealer of closure band is protected with paper, the paper shall be removed before installation. Closure bands shall be secured with stainless steel strap.

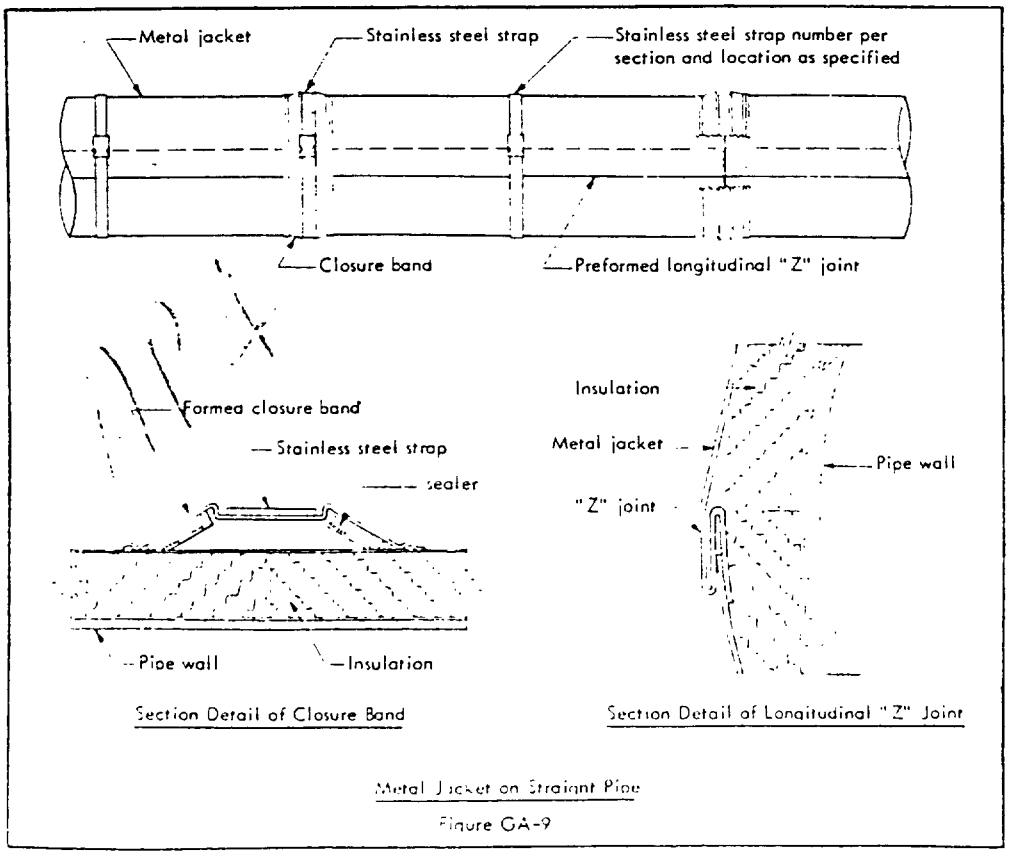
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XV. METAL JACKETS - STAINLESS STEEL OR TREATED STEEL - contd



Smooth Metal Jacket on Vertical Vessel

Figure GA-8



Section Detail of Closure Band

Section Detail of Longitudinal "Z" Joint

Metal Jacket on Straight Pipe

Figure GA-9

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XV. METAL JACKETS - STAINLESS STEEL OR TREATED STEEL - contd

B. Application - contd

2. Piping - contd

c. Stainless steel jackets for insulation valve covers and insulation fitting covers shall, where possible, be factory or shop preforme to fit the covers in accordance with ASTM Recommended Practice C 450, latest revision. Jackets shall be secured to covers by screw strap, or fasteners furnished by the manufacturer, depending upon their design. All laps shall be installed to shed water or shall be sealed with lap sealer.

d. Field cut and formed jackets for closely connected and special fittings shall be fabricated and formed of soft annealed stainless steel strip. All joints shall be lapped a minimum of two inches and shall be sealed with lap sealer. Formed pieces shall be secured with stainless steel strap or screws.

e. Hot metal projections through the insulation and weather-barrier jackets shall be seal caulked with heat-resistant sealer.

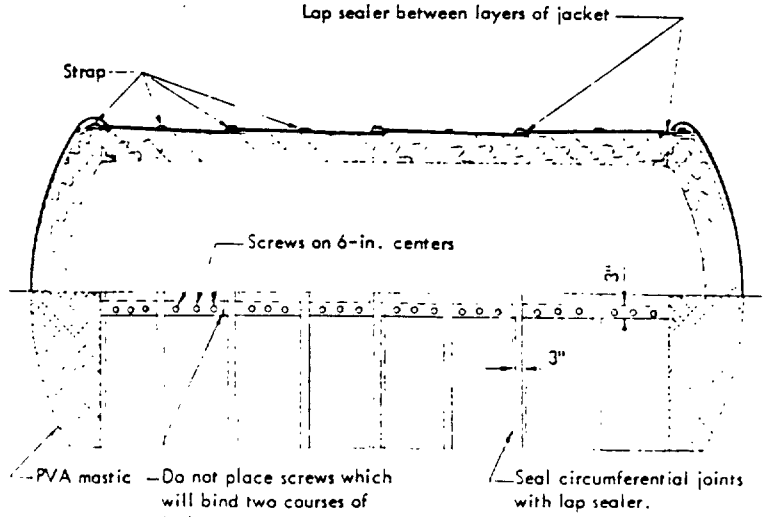
3. Metal Jackets in Combination with Weather-Barrier Mastics - Where especially specified, the stainless steel jacketing may be used in combination with weather-barrier mastics.

a. Equipment

(1) Where vessel heads are specified to be weather protected with mastic and the cylindrical section to be protected with metal jacketing, the mastic shall be installed in accordance with Article XIV.B. of this specification. Metal of cylindrical section of vertical vessel shall be lapped over bottom head mastic at least three inches. At top of vessel a six-inch wide stainless steel flashing strip shall be embedded into weather-barrier mastic and banded into place. It shall lap top course of jacketing three inches, but it shall not be attached to the jacket. Additional weather-barrier mastic used over head insulation shall be carried down over the flashing to provide water shed. Details are shown in Figure GA-7.

(2) At junction of weather-barrier mastic and jacket of horizontal vessel the mastic shall be lapped over the metal jacket for a minimum of three inches.

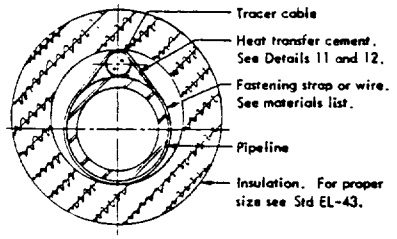
b. Piping - Where straight pipe is metal jacketed and fittings weather protected with mastic, the mastic weather barrier shall be installed in accordance with Article XIV.B. of this specification. The mastic weather barrier on fittings shall be lapped over the me jacketing one inch. Where possible, over this butt joint between the mastic weather barrier on fittings and the metal pipe jacket, a closure band shall be installed as specified in Article XV. B. 2. a. (4) of this specification.



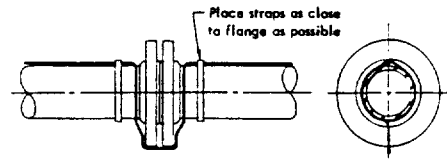
Metal Jacket on Horizontal Vessel
Figure GA-10

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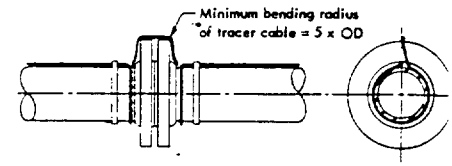
ELECTRIC TRACING SYSTEM DETAILS AND MATERIALS



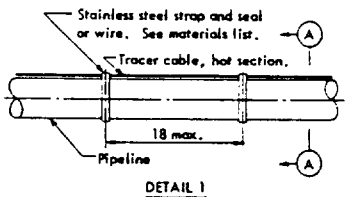
Section A-A
Typical cross section of completely installed tracer cable



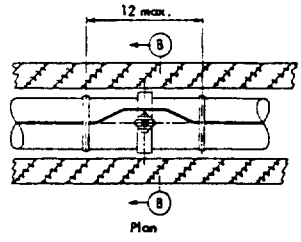
DETAIL 5
Elevation - Tracer cable on pipe flange 2-inches nominal size and smaller



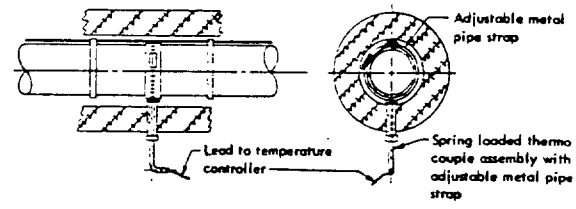
DETAIL 6
Elevation - Tracer cable on pipe flange larger than 2-inches nominal size



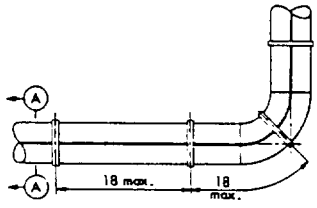
DETAIL 1
Elevation - Tracer cable on straight pipe run



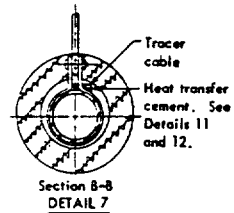
Plan



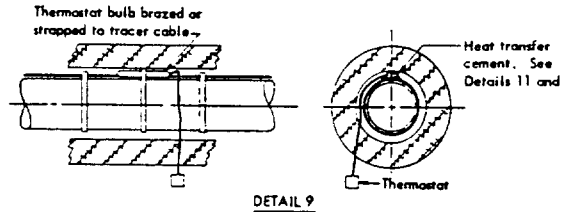
DETAIL 8
Elevation - Thermocouple installation for pipeline temperature control



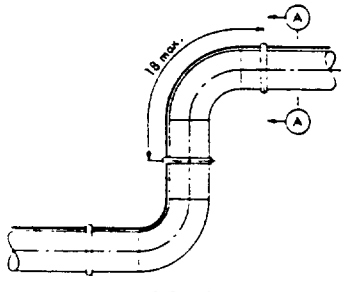
DETAIL 2
Plan - Tracer cable on pipe run with 90° elbow



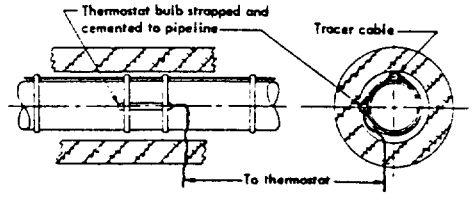
Section B-B
DETAIL 7
Tracer cable at pipe hanger



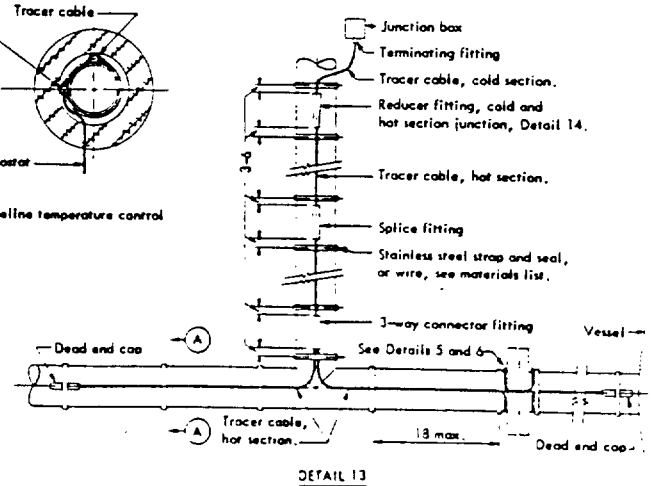
DETAIL 9
Elevation - Thermostat bulb installation for tracer cable sheath temperature control



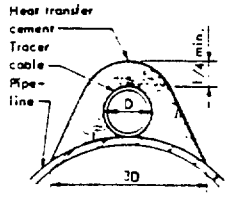
DETAIL 3
Elevation - Tracer cable on vertical pipe run of less than 3-inches nominal size



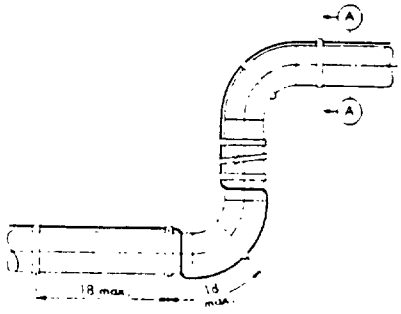
DETAIL 10
Elevation - Thermostat bulb installation for pipeline temperature control



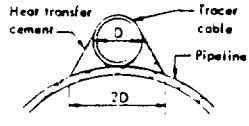
DETAIL 13
Plan - Typical installation of tracer cable fittings (See Stds EL-41, 42, 45 and 46).



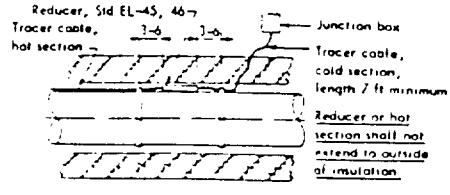
DETAIL 11
Installation of tracer cable with heat transfer cement type T-63 or Std



DETAIL 4
Elevation - Tracer cable on vertical pipe run of 3-inches nominal size and larger



DETAIL 12
Installation of tracer cable with heat transfer cement type T-85



DETAIL 14
Elevation - Tracer cable, cold and hot section junction.

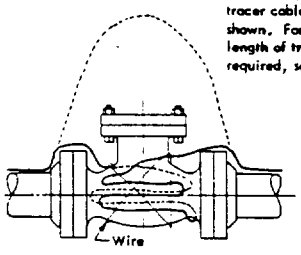
All dimensions given in inches

NOTE: Notes and dimensions not given for various details are the same as for details 1 and 2.

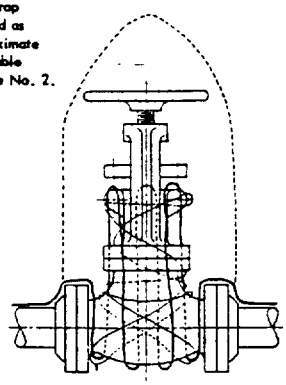
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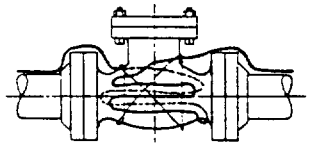
Form a loop and wrap tracer cable around as shown. For approximate length of tracer cable required, see table No. 2.



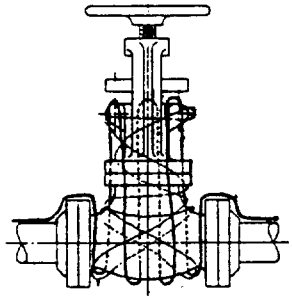
DETAIL 15
Tracer cable applied to check valve



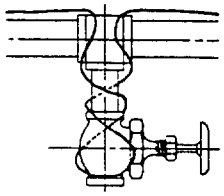
DETAIL 16
Tracer cable applied to globe or gate valve



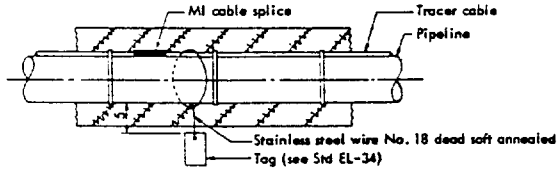
DETAIL 17
Valve electrically traced and heat transfer cement applied



DETAIL 18
Valve electrically traced and heat transfer cement applied



DETAIL 19
Elevation - Tracer cable run on blow-off valve



Detail 20
Installation Detail of Identification Tag for the Location of Tracer Cable Hot Splices on Long Tracer Systems

MINERAL INSULATED CABLE INSTALLATION DETAILS

In order to provide an efficient and dependable electric tracing system, it is mandatory that the installation instructions be followed carefully and that good workmanship be applied.

Tracer Cable Installation:

The size of the tracer cable (No. and size of conductors) shall be as specified on the electrical tracer system design drawing.

The tracer cable shall be installed on top of, parallel to, and as much as possible in direct contact with the pipeline; and shall be fastened with stainless steel wire (up to 2-inch diameter lines), or stainless steel straps (over 2-inch diameter lines), at a spacing not to exceed 18-inches. At tracer fittings the fastening wire or strap shall be installed within 3 to 6 inches from the fitting. At pipe flanges or valves, the fasteners shall be as close to these items as possible and in no case shall this distance be more than 3-inches.

The configuration of the tracer cable shall follow the design drawing when special layouts are given for vessels or other equipment.

No allowance for expansion shall be made by forming loops in the tracer cable hot section. A normal installation contains sufficient irregularities to allow for expansion between fastening wires or straps.

The entire hot section of the tracer cable shall be contained under the pipeline insulation; the connecting cold section shall be fastened under the insulation in accordance with Detail 14, and then be continued to the outside of the insulation.

All tracer cable fittings shall be cemented to the pipeline in a manner similar to Details 11 and 12, as shown for tracer cables.

Proper insulation sizes for electrically traced pipelines may be selected from Standard EL-140A.

Heat Transfer Cement Installation:

Heat transfer cement shall be applied to pipeline surfaces that should be essentially free of loose paint, mill scale, rust or dirt, and of grease, oil or mill varnish. Wire brushing, sandblasting and solvent cleaners for the removing of oil and grease, shall be used to clean pipeline surfaces in order that heat transfer cements may be applied properly.

If heat transfer cement is to be applied to aluminum or galvanized surfaces, Thermon[1] ALP primer should be used. The to be primed surface shall be wiped free of loose scale, dirt or oil. The primer shall be applied with a stiff brush, and then be allowed to set for 24 hours before the heat transfer cement is applied. Only the surface to be covered by cement needs to be primed.

Heat transfer cements types T-63 or Standard by Thermon[1] shall be applied by a hand trowel, a caulking gun or pumping equipment using a special nozzle (see Detail 11). Thermon type T-85 cement shall be applied by a caulking gun covering the tracer and pipeline as shown in Detail 12. For best results, care should be taken to force heat transfer cement thoroughly around and under the tracer cable.

The same general technique as explained above in applying heat transfer cement is applicable to vessels, valves, flanges and other equipment where tracer cable is used.

The curing of heat transfer cement shall be in strict accordance with manufacturers recommendations (see table 1).

[1]As manufactured by Thermon Manufacturing Company, Houston, Texas, or approved equal.

REFERENCES:

List of all Standards on MI Cable and Electric Tracing Data . . . . . STD EL-40

STAINLESS STEEL BANDING DATA

Pipe Size, In.	½	¾	1	1½	2	3	4	6	8
Feet per Band	.46	.521	.593	.746	.870	1.16	1.42	1.98	2.50
Pipe Size, In.	10	12	14	16	18	20	24	30	36
Feet per Band	3.06	3.60	3.91	4.43	4.96	5.48	6.53	8.10	9.66

TABLE 3 - HEAT TRANSFER CEMENT REQUIREMENTS

MI Cable OD In.	Process Line Size In.	Ft of Tracing per Gal. Std or T-63, Hand Trowel Appl.	Ft of Tracing per 1/6 Gal. Cartridge T-85
.246	All	50	40
.340	All	49	30
.543	½ - 1½	30	16
.543	All other	33	16

It is suggested to add 10% to amounts given for estimating and waste.

TABLE 2 - ELECTRICALLY TRACED VALVES
Tracer Cable and Heat Transfer Cement Data

Valve Size In.	Feet of Tracer Cable Required	Gallon per Valve (Std & T-63)[1]	Cartridge per Valve (T-85)[2]
1/2	1 - 2	0.14	.03- 07
3/4	1 - 3	0.21	.03-0.1
1	2 - 3	0.29	.07-0.1
1 1/2	2 1/2 - 4	0.36	.08-0.13
2	3 - 5	0.43	0.20-0.33
3	4 - 7	0.71	0.27-0.47
4	6 - 10	1.00	0.40-0.67
6	9 - 15	1.43	0.60-1.00
8	12 - 20	2.00	0.80-1.34
10	15 - 25	2.50	1.00-1.67
12	18 - 30	3.00	1.20-2.00
14	21 - 35	3.50	1.75-2.82
16	24 - 40	4.00	2.00-3.33
18	27 - 45	4.50	2.25-3.75
20	30 - 50	5.00	2.50-4.16
24	36 - 60	6.00	3.00-5.00
30	45 - 75	7.50	3.75-6.25
36	54 - 90	9.00	4.50-7.50

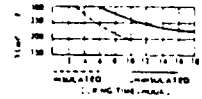
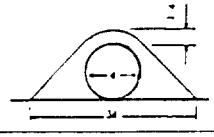
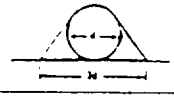
[1]Hand trowel application completely covering valve surface is recommended.

[2]Hand gun application at fillet on each side of tracing is recommended.

MATERIALS FOR ELECTRIC TRACING SYSTEMS

Item	Description
Tracer Cable	Mineral insulated cable by General Cable Corp., 1, 2, or 3 copper or alloy conductors, bare copper sheath, for use up to 250 C temperatures. For temperatures over 250 C the cable sheath shall consist of stainless steel or other suitable metal.
Fittings	Terminations and seals for cold sections by General Cable Corporation. Splices, reducer, 3-way connectors and dead-end caps for hot sections by Burndy Corporation.
Straps and Clips	For pipeline tracers: 3/8-in. x 0.015-in. thick dead soft annealed stainless steel straps, with double pronged 3/8-in x 1/2-in. Econ-O-Clips, by Techalloy Company, Rahns, Pennsylvania, or approved equal. For vessels and equipment tracers: Same as above except 1/2-in. x 0.020-in. straps and 1/2-in. x 1/2-in. Econ-O-Clips.
Strapping Tool	No. 111 steelbinder with stainless steel nose, by A. J. Gerrard & Company, Des Plaines, Illinois, or approved equal.
Wire	18 gage (0.047-in. Dia.) dead soft annealed stainless steel wire.
Heat Transfer Cement	Thermon, types T-63, T-80, T-85, or Std., as manufactured by Thermon Manufacturing Company, Houston, Texas, or approved equal.

TABLE 1 - PROPERTIES OF THERMON HEAT TRANSFER CEMENTS

DATA	STANDARD	T-63	T-80[1]	T-85
Maximum Temp F	600 Cont. 750 Int.	1250	325	375
Minimum Temp F	-320	-100	-320	
Shear Bond lb/sq in	150		1000 - 1800	
Start-up Curing Each curing time and temperature indicated must be executed in sequence.	4 Hrs-Air Dry 4-24 Hrs-180-212 F	4 Hrs-Air Dry 4 Hrs-180-212 F 4 Hrs-250 F		
Installation				
Shelf Life	One Year *		60-90 Days	
Water Soluble	Yes		No	
Volume Resistivity	0.267 OHM IN.	3.3 OHM IN	146 OHM IN.	

[1]Ambient Temperature for Application is +10 F or above.

WELDED-ON INSULATION SUPPORTS FOR VERTICAL VESSELS, INCLUDING TANKS, OVER 3-FT O.D.

(Designed for use with preformed shapes, panel, and block form insulation)

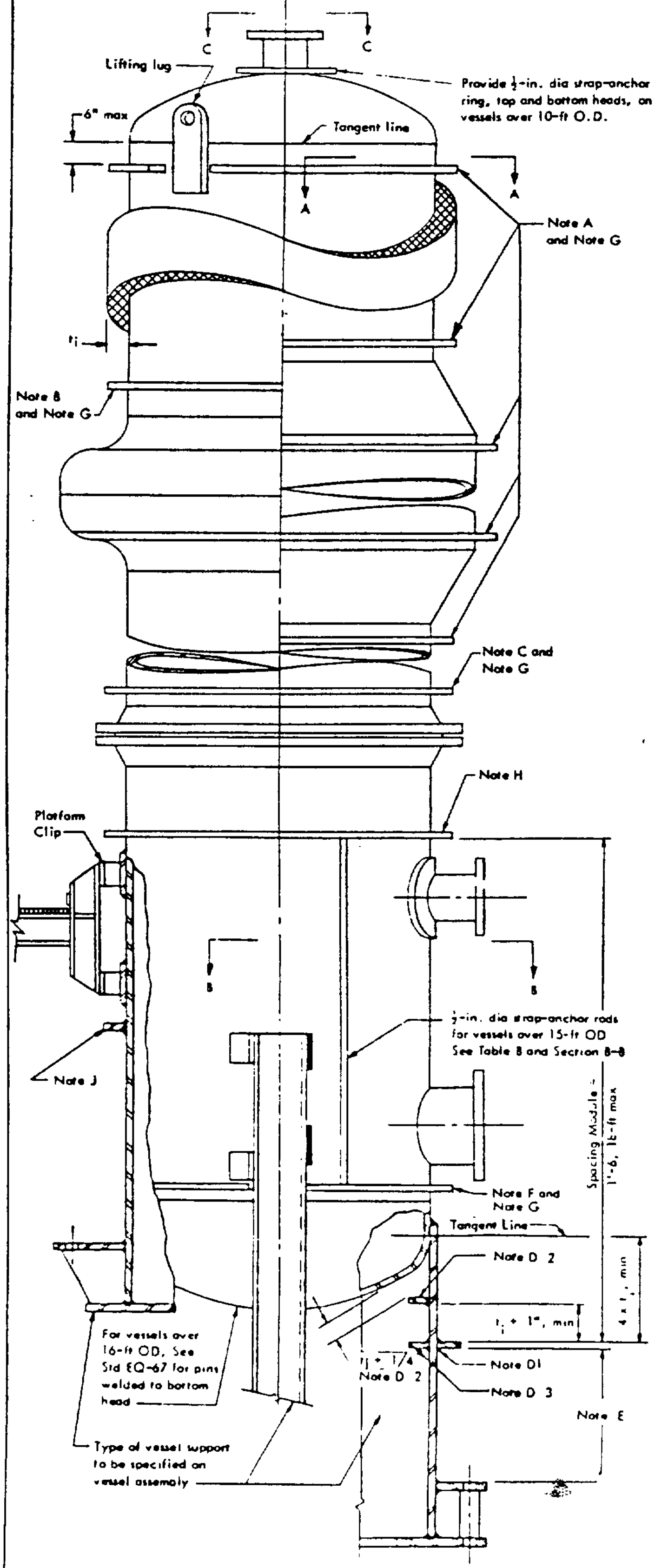


TABLE A

Insulation Thickness, t_i (in.)	Bar Size		Weld Size, t_w (in. x 45°)
	Thickness, t_r (in.)	Width, w_r (in.)	
$1 < t_i \le 1\text{-}1/2$	3/16	1	3/16
$1\text{-}1/2 < t_i \le 3\text{-}1/2$	3/16	1-1/2	3/16
$3\text{-}1/2 < t_i \le 9$	1/4	3	1/4

GENERAL NOTES

All support rings shall be slotted except where noted otherwise. Provide insulation support rings at maximum spacing of 18-ft. Shorter spaces shall be a multiple of 1-ft 6-in. Select support ring size from Table A.

Material for supports shall be as noted on vessel assembly drawing or in the vessel specifications. Welding procedure for attaching supports to a new vessel shall be equal to that for the pressure-containing enclosure. Attachment of supports to an existing (used) ASME Code Vessel shall be in conformance with the applicable Code requirements including postweld heat treatment when required. Stiffening rings should be spaced at insulating support ring modules, if practicable, and may be used in lieu of standard insulating support rings on vessels subject to external pressure. Do not slot stiffening rings.

SPECIFIC NOTES

A. Provide insulation support rings at the top and bottom of each shell transition section. For dished top heads, provide ring on the straight flange of the head or on the shell adjacent to the head.

B. Provide support ring above shell expansion joint.

C. Provide an insulation support ring above each flanged shell joint. Clearance between the top (back) of the flange and the top of the ring shall be sufficient to provide access for tightening flange bolts but not less than 9-inches.

D. Provide the following insulation support rings on vessel skirts:

1. One ring on the outside of the skirt at 4 x t_i inches minimum, below the head tangent line.
2. One ⅜-in. x 1-in. slotted ring inside skirt. Locate this ring to provide t_i + ¼-in. clearance between the bottom head and the inner edge of the ring. Weld on low side only.
3. On vessels designed for service below 0° C (32° F), provide a second (lower) ring inside the skirt opposite the ring of D.1. above. The lower inside ring shall be of the same thickness and width as the outside (opposite) ring. Slots are not required in the inside, lower ring.

E. Welded-on insulation support ring on the outside of skirt with double-ring type base for use with prestressed anchor bolts must be spaced at least 3-ft 2-in. above the top base ring. Install bolted-on insulation support ring per Std EQ-68 where this clearance cannot be obtained.

F. For leg or lug-supported vessels with dished bottom heads, provide an insulation support ring on the straight flange of the bottom head or on the shell adjacent to the bottom head.

G. Locate rings and rods to provide minimum clearance of 1-inch between the ring or rod attachment weld and the vessel circumferential or longitudinal seam edges. Ring or rod attachment welds shall not cross seams in the vessel.

H. Locate rings and rods to clear shell connections, reinforcement pads, lifting lugs, etc., where possible. Ring locations above nozzles are preferred to those below nozzles.

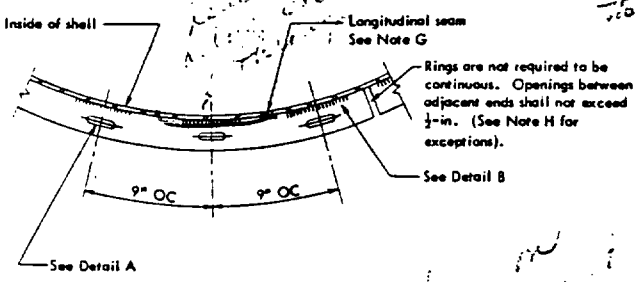
Where impossible to avoid interference between shell openings or attachments and rings, an opening of minimum practicable length shall be left in the ring. Provide 1-inch, minimum, clearance between ring or rod attachment welds and attachment weld of the interfering item.

J. Provide support ring below Platform Clip Attachment. Locate at nearest multiple of 9-inches above next lower ring.

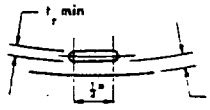
(SEE OVER FOR TYPICAL DETAILS)

Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation D…
ACL Doc 19432 · Page 529 of 559
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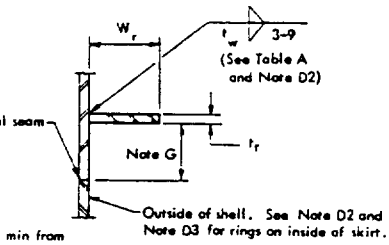
WELDED-ON INSULATION SUPPORTS FOR VERTICAL VESSELS, INCLUDING TANKS, OVER 3-FT O.D.



SECTION A-A
Typical



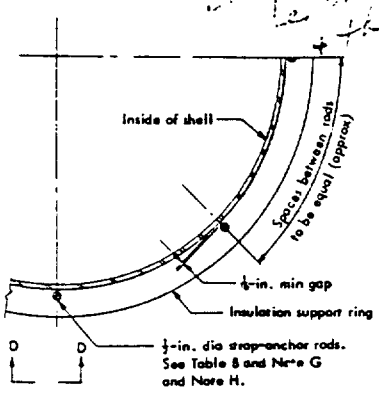
DETAIL A
Typical



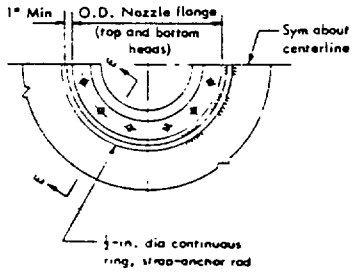
DETAIL B
Typical

TABLE B

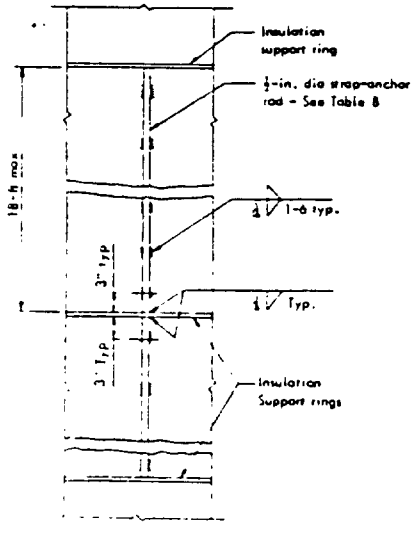
O.D. of Vessel	No. of Strap-Anchor Rods Required
15'-0 to 27'-0	4
27'-1 to 36'-0	8
36'-1 to 50'-0	16
Over 50'-0	One rod for each 9-ft of circumference or fraction thereof



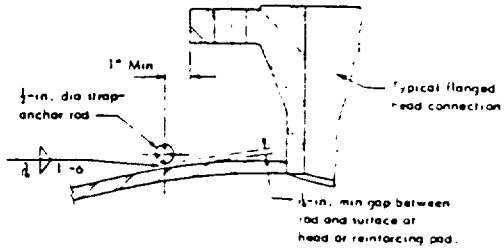
SECTION B-B
Typical



VIEW C-C
Typical



ELEVATION D-D
Typical

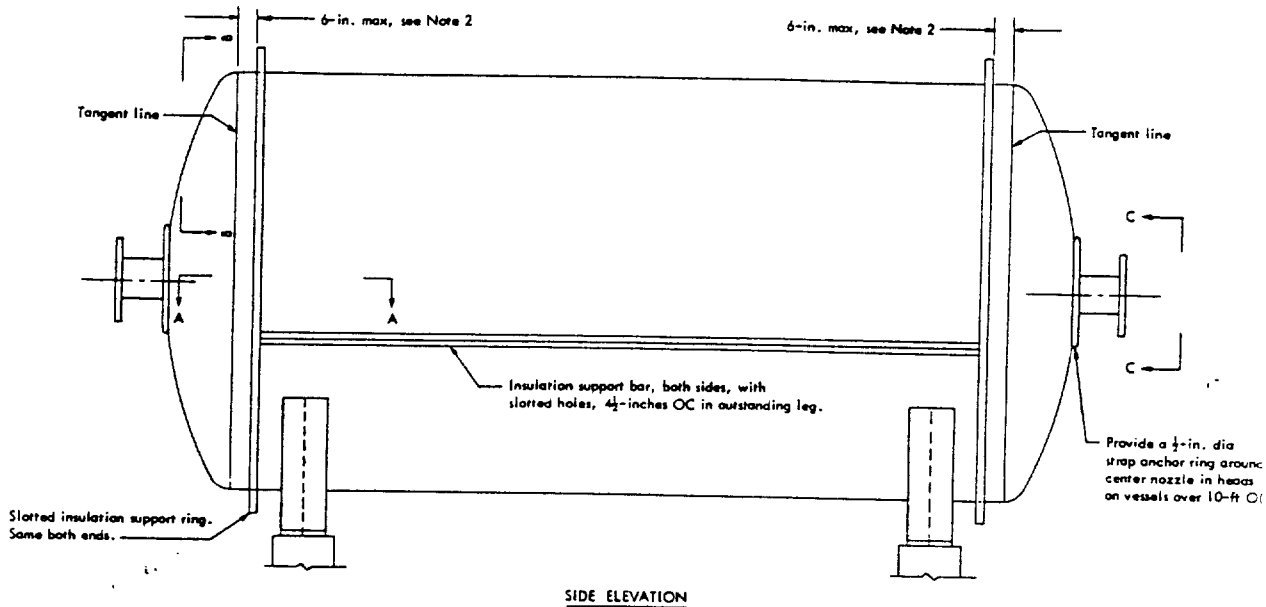


SECTION E-E
Typical

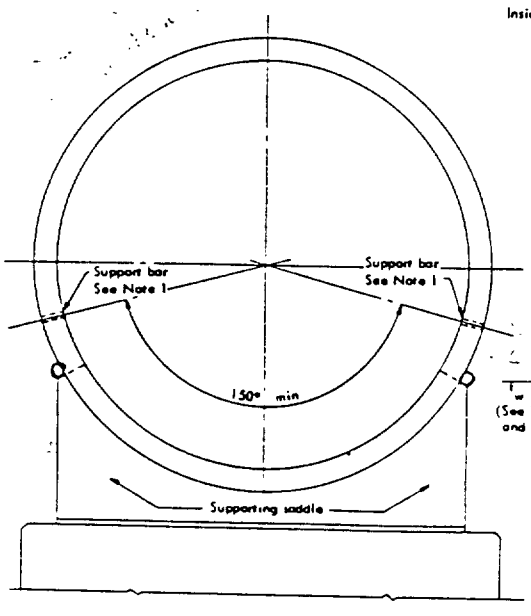
Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation D…
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WELDED-ON INSULATION SUPPORTS FOR HORIZONTAL VESSELS OVER 3-FT O.D.

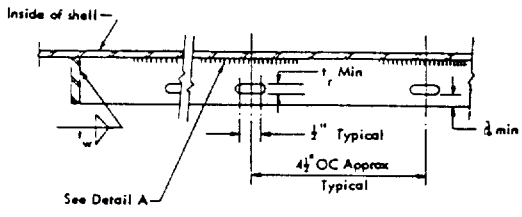
(Designed for use with preformed shapes, panel, and block form insulation)



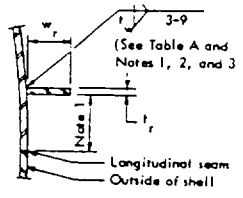
SIDE ELEVATION



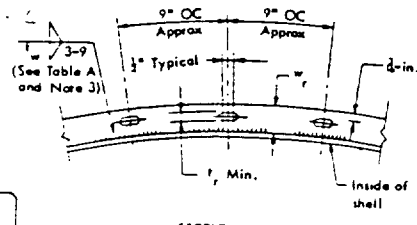
END ELEVATION



SECTION A-A
Typical



DETAIL A
Typical

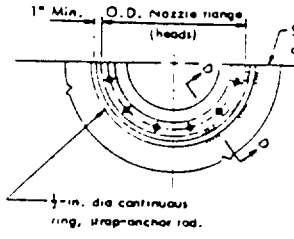


SECTION B-B
Typical

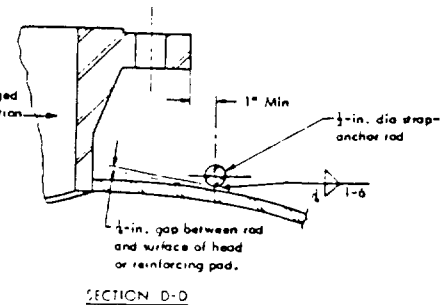
TABLE A

Insulation Thickness, t_i* (in.)	Bar Size: Thickness, t_r (in.)	Bar Size: Width, W_r (in.)	Weld Size, (in. x 45°
1 < t_i ≤ 1½	¾	1	¼
1½ < t_i ≤ 3½	¾	1½	¼
3½ < t_i ≤ 9	1	3	¼

*t_i = Nominal thickness of insulation including final installed thickness of cushioning blanket (if required).



VIEW C-C
Typical



SECTION D-D
Typical

GENERAL NOTES

Material for support rings and bars shall be as specified in the Vessel Specifications. Select ring (bar) size from Table A.

Welding procedure for attaching supports to a new vessel shall be equal to that for the pressure-containing enclosure. Attachment of supports to an existing (used) ASME Code vessel shall be in conformance with the applicable Code requirements including postweld heat treatment when required.

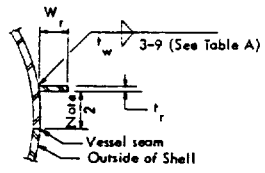
DETAIL NOTES

1. Locate horizontal support bars to provide minimum clearance of 1-inch between the bar attachment weld and the vessel longitudinal seam edges.
2. Locate rings and bars to clear shell connections and reinforcement pads. Provide minimum clearance of 1-inc between ring or bar attachment welds and attachment weld of any adjacent item.
3. Support attachment welds shall not cross longitudinal or circumferential welds in the vessel.

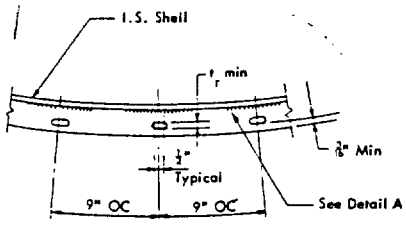
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WELDED-ON INSULATION SUPPORTS FOR SPHERICAL VESSELS FOR OPERATING TEMPERATURES LOWER THAN 70F (21C)

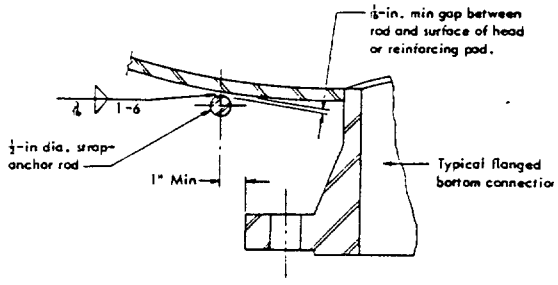
(Designed for use with preformed shapes, panel, and block form insulation)



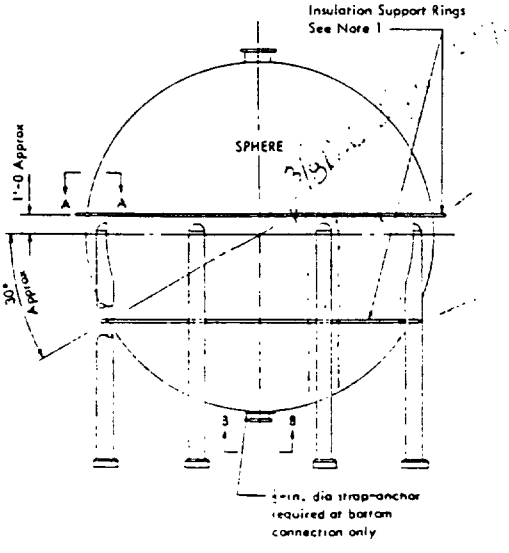
DETAIL A
See Notes 2 & 3



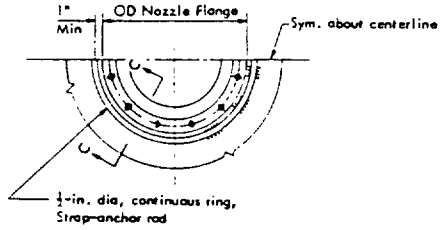
SECTION A-A
Typical



SECTION C-C



ELEVATION



VIEW B-B

TABLE A

Insulation Thickness, t_i (in.)	Bar Size		
	Thickness, t_r (in.)	Width, W (in.)	Weld Size, t (in. x 45°)
$1 < t_i \leq 1\text{-}1/2$	1/2	1	1/2
$1\text{-}1/2 < t_i \leq 3\text{-}1/2$	1/2	1 1/2	1/2
$3\text{-}1/2 < t_i \leq 9$	1/2	3	1/2

GENERAL NOTES

Provide each sphere with two slotted insulation support rings as shown on this Standard. Other insulation supports, where required, shall be as specified in the Vessel Specifications. Select support size from TABLE A.

Material for supports shall be as noted in the Vessel Specifications. Welding procedure for attaching supports to sphere shall be equal to that for the pressure containing enclosure.

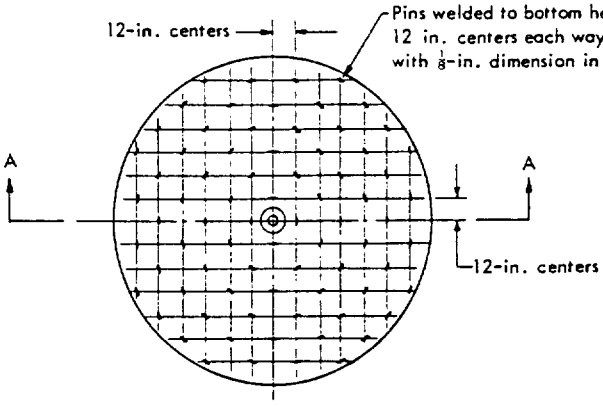
DETAIL NOTES

1. Support rings shall be provided for all spheres to be insulated for operating temperatures lower than 70F (21C). Rings are not to be continuous. Openings between adjacent ends shall not exceed 1/2-inch.
2. Adjust ring location, if necessary, to provide minimum clearance of 1-inch between the ring attachment weld and sphere girth weld edges. Locate rings to clear shell connections and reinforcement pads. Provide minimum clearance of 1-inch between ring attachment welds and attachment weld of any adjacent item.
3. Support attachment welds shall not cross meridional welds

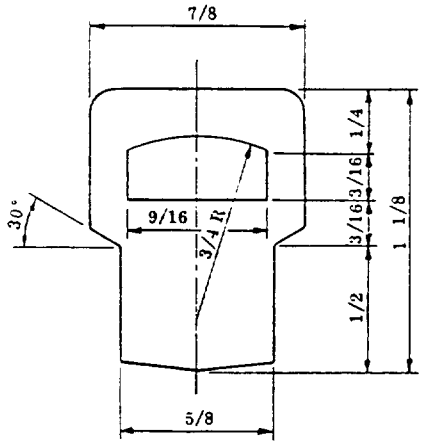
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INSULATION SUPPORT PINS FOR WELDING TO CARBON STEEL BOTTOM HEADS OR TO FLAT SURFACES

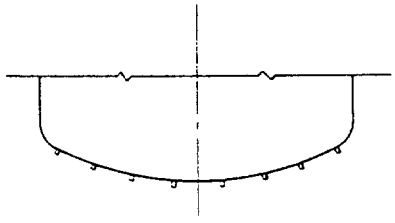
(Designed for use with preformed shapes, panel, and block form insulation)



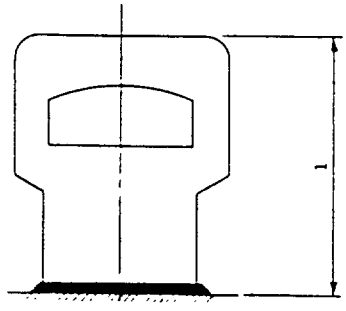
VIEW OF BOTTOM HEAD



Before Welding

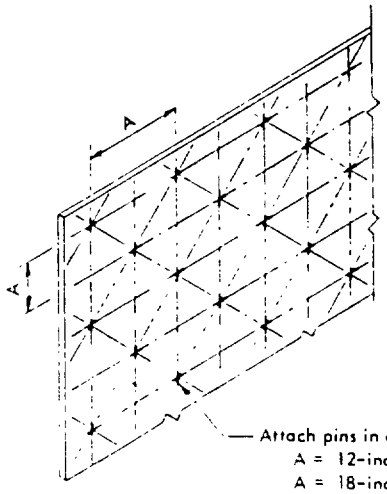


ELEVATION A-A



After Welding

Front Elevations of Pin



Attach pins in diamond pattern as follows:
A = 12-inch centers for bottom surfaces.
A = 18-inch centers for side surfaces.
A = 24-inch centers for top surfaces.

TYPICAL FLAT SURFACES

NOTE:

This standard applies to flat surfaces and to bottom heads of carbon steel vessels over 16-ft OD for operating temperatures above 70F.

Pins shall be as manufactured by KSM Products, Inc., Moorestown, New Jersey, or other approved securement.

Pins shall be welded to vessel with a KSM-CD-60 Capacitor Discharge Stud Welding Unit (or approved equal) with accessory chuck to suit pins.

Pins shown are ⅛-in. thick.

Pins shall be welded to vessels subject to postweld heat treatment before the final heat treatment.

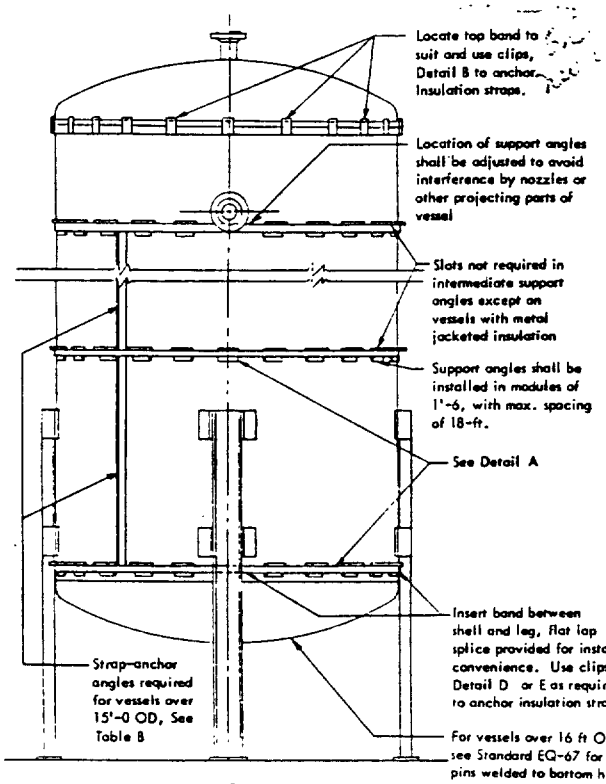
Pins may be welded in the field to vessels and other equipment not subject to postweld heat treatment.

All dimensions given in inches.

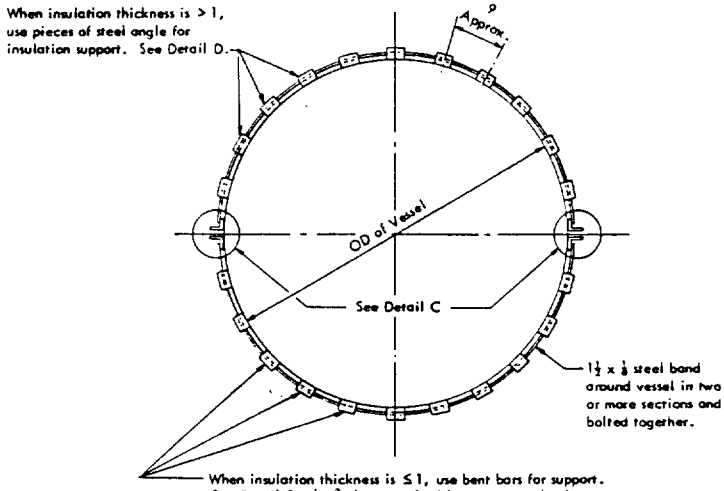
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BOLTED-ON[1] INSULATION SUPPORTS FOR VERTICAL VESSELS OVER 3-FT O.D.

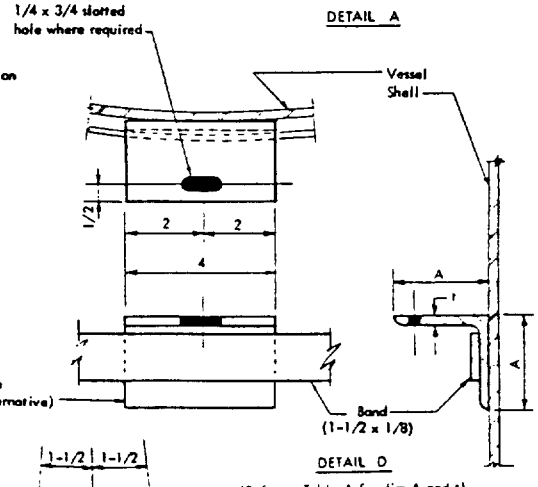
(Designed for use with preformed shapes, panel, and block form insulation)



ELEVATION

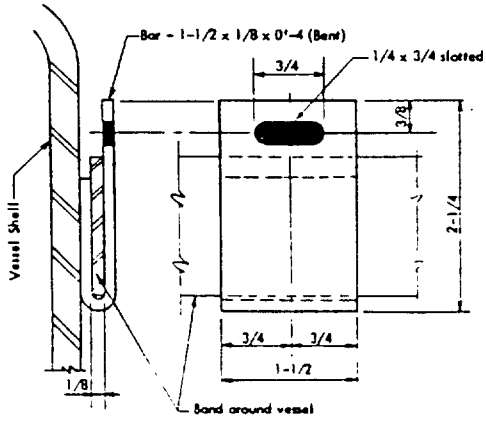


DETAIL A

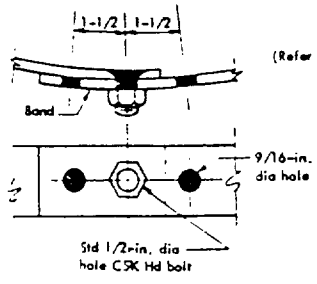


DETAIL D

(Refer to Table A for dim A and t)



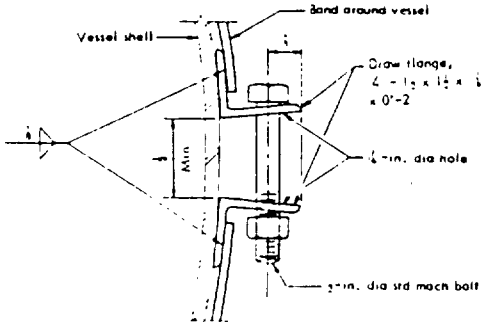
DETAIL B



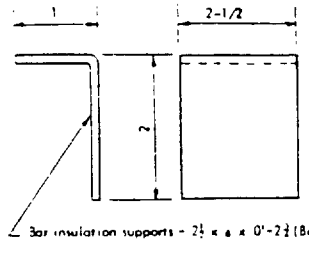
BAND SPLICE

TABLE A

Insulation Thickness, t_i (in.)	Angle Thickness, t (in.)	Angle Leg A (in.)
$1 < t_i \leq 3\frac{1}{2}$	$\frac{3}{8}$	$1\frac{1}{2}$
$3\frac{1}{2} < t_i \leq 9$	$\frac{1}{2}$	3



DETAIL C



DETAIL E

[1] Bolted-on insulation supports are to be used only for FIELD INSTALLATIONS on vessels on which welding is either not permissible without postweld heat treatment or because of area conditions, or when welded-on insulation supports are not otherwise practicable

NOTE:

Bolts shall be ½-in. dia standard machine bolts with square heads and hex nuts, unless otherwise indicated.

All steel parts shall be coated, or otherwise protected the same as the vessel to which they are attached, prior to the attachment.

Use stainless steel bands and aluminum clips on aluminum vessels

REFERENCES

Bolted on Insulation Support Angle for Inside of Skirt for Vertical Vessels . . . Std EQ-70

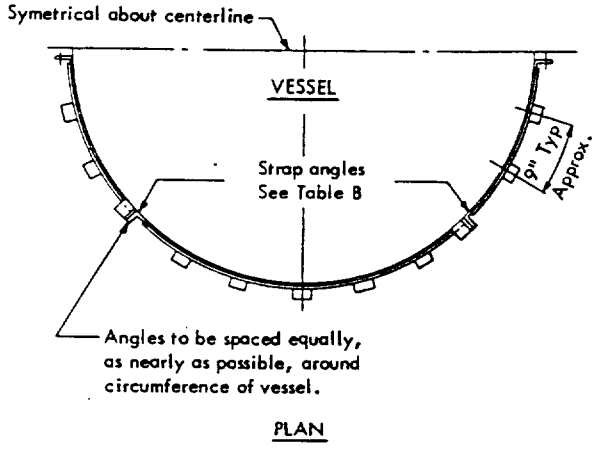
Strap-Anchor Angles for Vessels Over [illegible] OD . . . See Over

UNLESS OTHERWISE INDICATED, ALL DIMENSIONS GIVEN IN INCHES

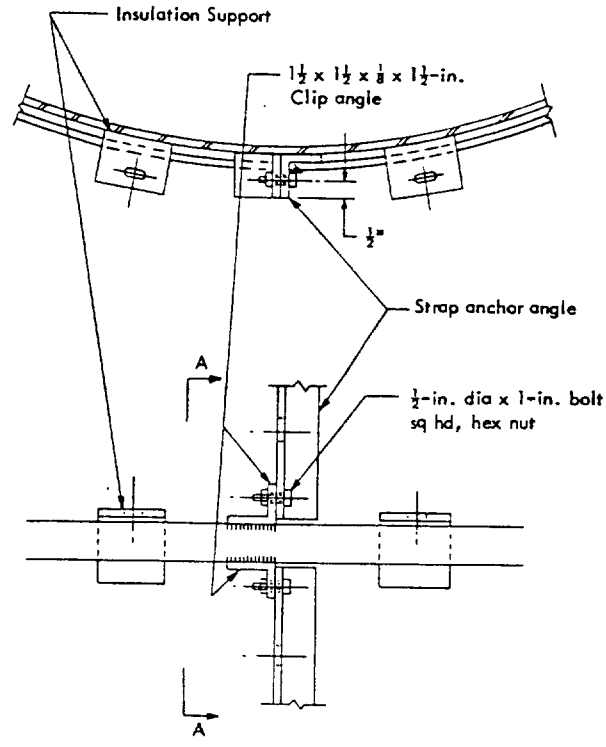
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BOLTED-ON INSULATION SUPPORTS FOR VERTICAL VESSELS OVER 3-FT O.D.

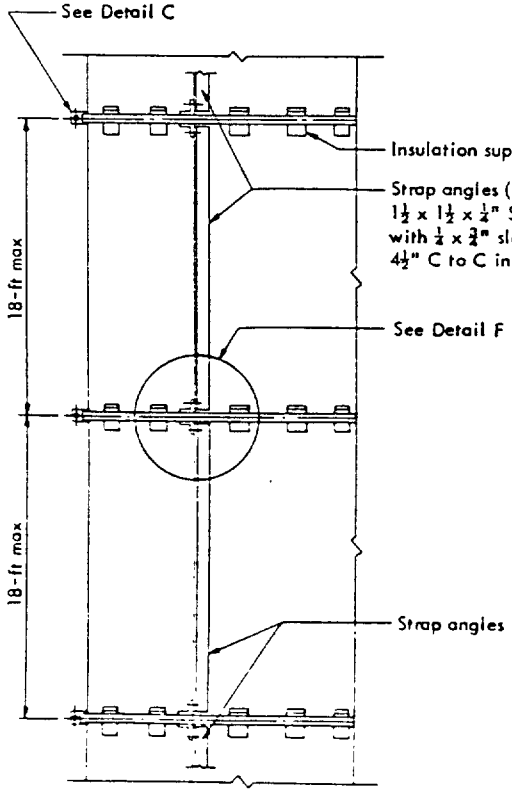
STRAP-ANCHOR ANGLES FOR VESSELS OVER 15-FT O.D.



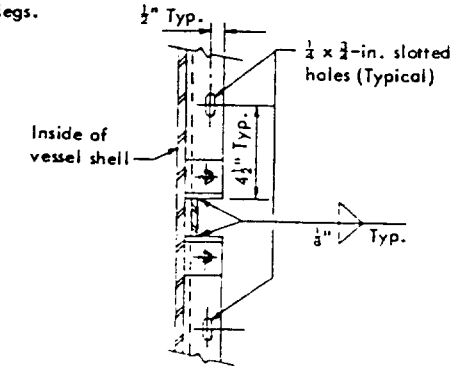
PLAN



DETAIL F



ELEVATION



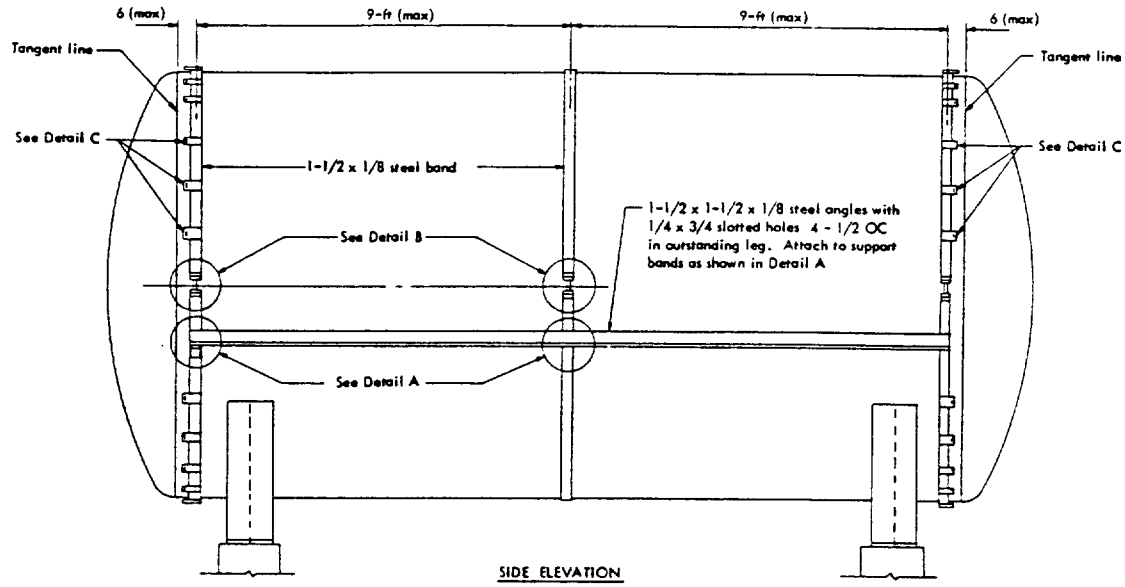
SECTION A-A

TABLE B	
Outside Diameter of Vessel	Number of Vertical Angles Required
15'-0 to 27'-0	4
27'-1 to 36'-0	8
36'-1 to 50'-0	16
Over 50'-0	One angle for each 9-ft of circumference, or fraction thereof

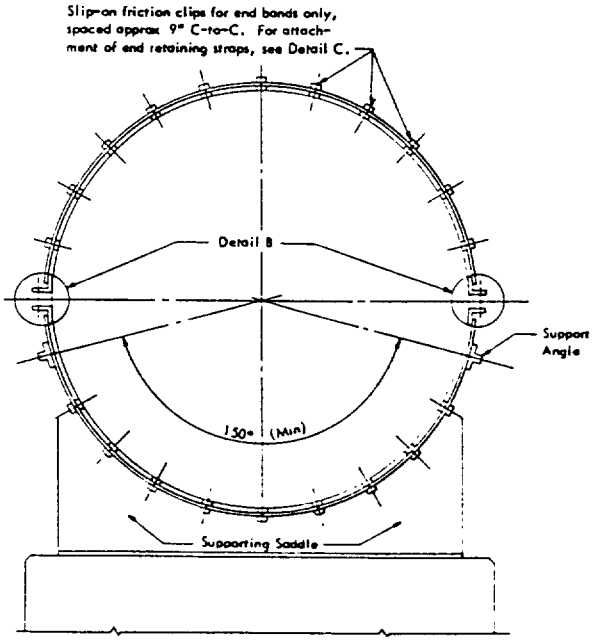
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BOLTED-ON[1] INSULATION SUPPORTS FOR HORIZONTAL VESSELS OVER 3-FT OD

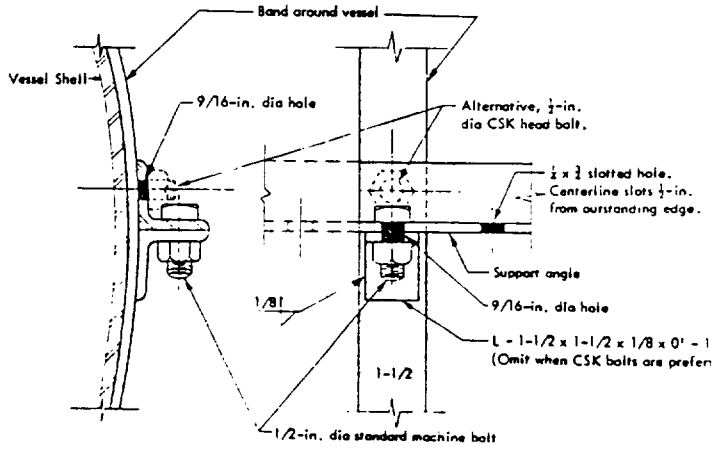
(Designed for use with preformed shapes, panel, and block form insulation)



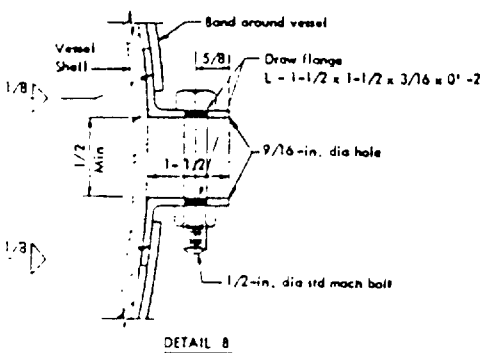
SIDE ELEVATION



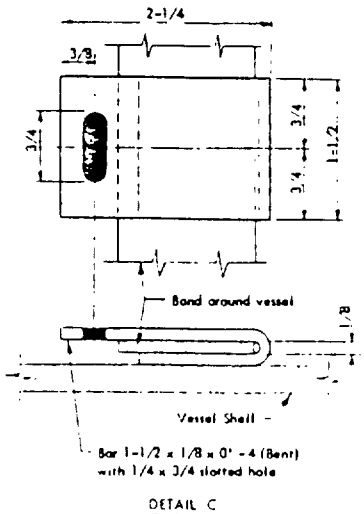
END ELEVATION



DETAIL A
Typical



DETAIL B



DETAIL C

NOTE.

Bolts shall be 1/2-in. dia standard machine bolts with square heads and hex nuts, unless otherwise indicated.

All steel parts shall be coated, or otherwise protected the same as the vessel to which they are attached, prior to the attachment.

Use stainless steel bands and aluminum clips on aluminum vessels.

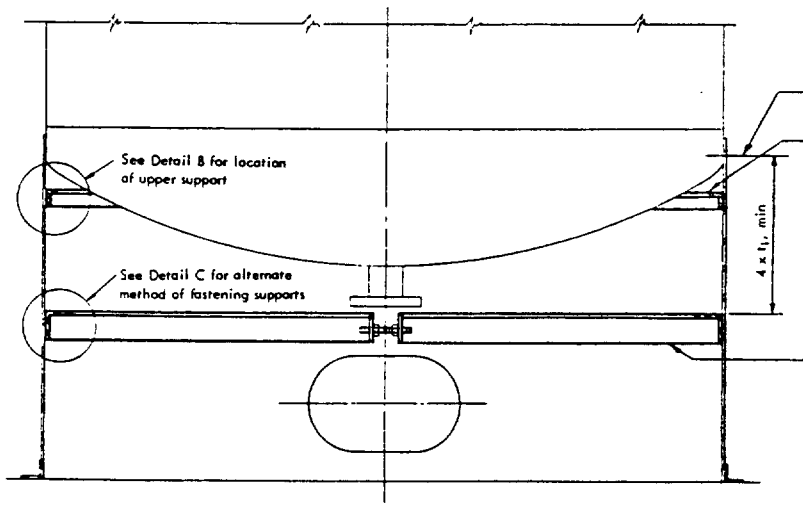
[1]Bolted-on insulation supports are to be used only for FIELD INSTALLATIONS on vessels on which welding either not permissible without postweld heat treatment because of area conditions, or when welded-on insulation supports are not otherwise practicable.

UNLESS OTHERWISE INDICATED, ALL DIMENSIONS GIVEN IN INCHES

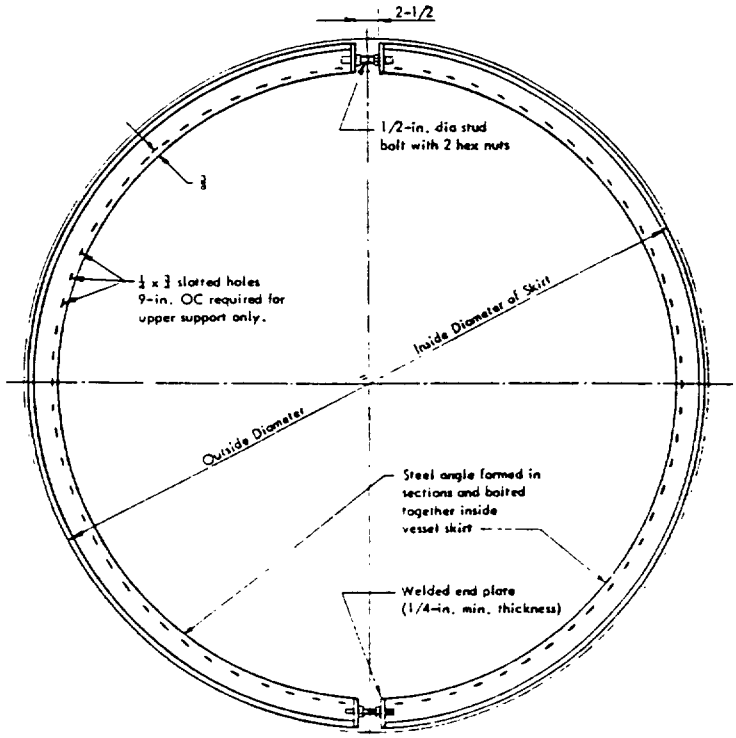
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BOLTED-ON[1] INSULATION SUPPORT ANGLE FOR INSIDE OF SKIRT FOR VERTICAL VESSELS

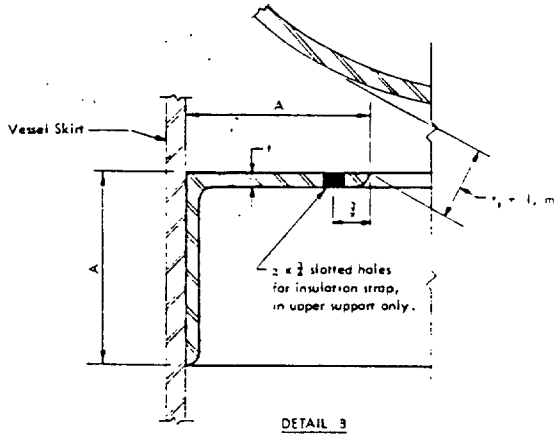
(Designed for use with Preformed Shapes, Panel, and Block Form Insulation)



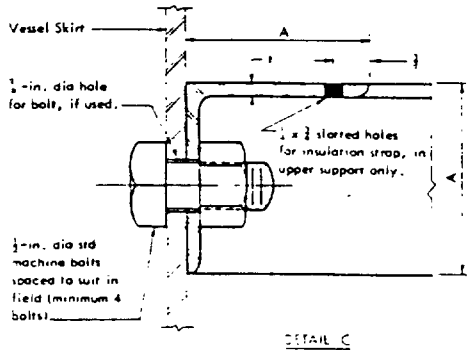
SECTION



DETAIL A
(Bottom View)



DETAIL B



DETAIL C
Alternate method of fastening angle support.

Dimensions "t" and "A" for Details B and C.

Insulation Thickness, t_1 (in.)	Angle Thickness, t (in.)	Angle Leg "A" (in.)
1 < t_1 ≤ 3½		1½
3½ < t_1 ≤ 9		3

[1]Bolted-on insulation supports are to be used only for FIELD INSTALLATIONS on vessels on which welding is either not permissible without postweld heat treatment or because of area conditions, or when welded-on insulation supports are otherwise not practicable.

NOTE:

All steel parts shall be coated, or otherwise protected the same as the vessel to which they are attached, prior to the attachment.

Use aluminum angles on aluminum vessels

REFERENCES

...ction on insulation supports for vertical ...vessels over 3-ft OD ... std EQ-6d

UNLESS OTHERWISE INDICATED, ALL DIMENSIONS GIVEN IN INCHES.

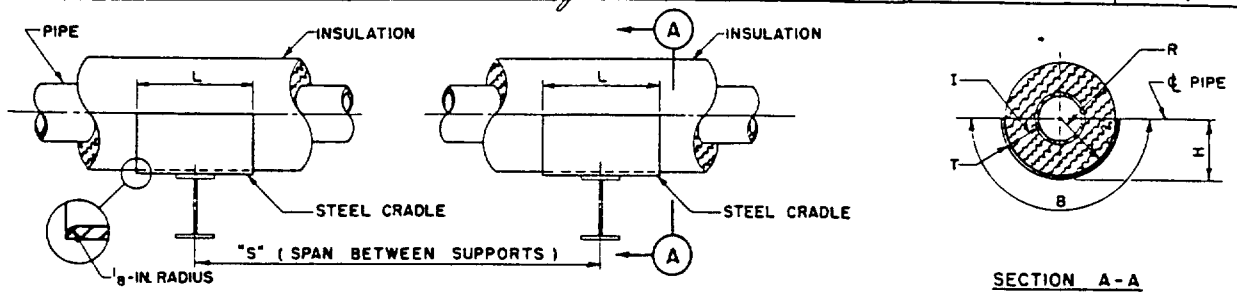
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UNION CARBIDE CORPORATION
UNION CARBIDE — CHEMICALS, OLEFINS, PLASTICS AND SILICONES DIVISIONS

CRADLE SUPPORTS FOR INSULATED PIPES

ENGINEERING STANDARD No. P-82

CLASSIFICATION:	SPONSOR:	REVIEWED BY	APPROVED BY	ISSUED (AS IS-IS)	REVISED:
DATA	DEPT 936	S.H. Smith, Jr.	L.S. Dreyer	5-25-51	9-1-65



SECTION A-A

LEGEND:
H = DIMENSION FROM ℄ OF PIPE TO BOTTOM OF CRADLE
T = CRADLE THICKNESS
L = CRADLE LENGTH

B = PLATE WIDTH BEFORE FORMING
R = BENDING RADIUS FOR PLATE ("H" MINUS "T")
S = SPAN, IN FEET, BETWEEN SUPPORTS.

NOM PIPE SIZE	DIMENSIONS	"I" INSULATION THICKNESSES (NOMINAL)																	"L" CRADLE LENGTH "S" SPAN						NPS
		1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7	7 1/2	8	8 1/2	9	10	10-FT	12-FT	15-FT	18-FT	20-FT	25-FT	
1/2	H	1 1/2	2	2 1/2	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7 1/4	7 3/4	8 1/4	—	—	—	—	—	10	—	—	—	—	—	
	T	14 GA				1/8				3/16			1/4		—	—	—	—	—							
	B	4 1/2	6 1/4	7 3/4	10 3/8	12	13 1/2	15	17	18 1/2	20	22	23 1/2	25	—	—	—	—	—							
3/4	H	1 1/2	2	2 1/2	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7 1/4	7 3/4	8 1/4	—	—	—	—	—	10	—	—	—	—	—	
	T	14 GA				1/8				3/16			1/4		—	—	—	—	—							
	B	4 1/2	6 1/4	7 3/4	10 3/8	12	13 1/2	15	17	18 1/2	20	22	23 1/2	25	—	—	—	—	—							
1	H	1 3/4	2 1/4	2 7/8	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7 1/4	7 3/4	8 1/4	—	—	—	—	—	10	10	—	—	—	—	
	T	14 GA				1/8				3/16			1/4		—	—	—	—	—							
	B	5 1/2	7	8 3/4	10 3/8	12	13 1/2	15	17	18 1/2	20	22	23 1/2	25	—	—	—	—	—							
1 1/2	H	2	2 1/2	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7 1/4	7 3/4	8 1/4	8 3/4	9 1/4	9 3/4	10 1/4	10 3/4	11 3/4	10	10	—	—	—	—	
	T	14 GA			1/8			3/16			1/4							5/16								
	B	6 1/4	7 3/4	10 3/8	12	13 1/2	15	17	18 1/2	20	22	23 1/2	25	26 1/2	28	30	31 1/2	33	36							
2	H	2 1/4	2 7/8	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7 1/4	7 3/4	8 1/4	8 3/4	9 1/4	9 3/4	10 1/4	10 3/4	11 3/4	10	10	10	—	—	—	
	T	14 GA			1/8			3/16			1/4							5/16								
	B	7	8 3/4	10 3/8	12	13 1/2	15	17	18 1/2	20	22	23 1/2	25	26 1/2	28	30	31 1/2	33	36							
3	H	2 7/8	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7 1/4	7 3/4	8 1/4	8 3/4	9 1/4	9 3/4	10 1/4	10 3/4	11 1/4	12 1/4	10	10	10	—	—	—	
	T	14 GA		1/8			3/16			1/4						5/16										
	B	8 3/4	10 3/8	12	13 1/2	15	17	18 1/2	20	22	23 1/2	25	26 1/2	28	30	31 1/2	33	34 1/2	37 1/2							
4	H	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7 1/4	7 3/4	8 1/4	8 3/4	9 1/4	9 3/4	10 1/4	10 3/4	11 1/4	11 3/4	12 3/4	10	10	10	12	—	—	
	T	1/8			3/16			1/4				5/16														
	B	10 3/8	12	13 1/2	15	17	18 1/2	20	22	23 1/2	25	26 1/2	28	30	31 1/2	33	34 1/2	36	39							
6	H	4 1/2	5	5 1/2	6	6 1/2	7 1/4	7 3/4	8 1/4	8 3/4	9 1/4	9 3/4	10 1/4	10 3/4	11 1/4	11 3/4	12 1/4	12 3/4	13 7/8	10	10	12	16	16	—	
	T	1/8		3/16			1/4				5/16							3/8								
	B	13 1/2	15	17	18 1/2	20	22	23 1/2	25	26 1/2	28	30	31 1/2	33	34 1/2	36	37 1/2	39	42 1/2							
8	H		6	6 1/2	7 1/4	7 3/4	8 1/4	8 3/4	9 1/4	9 3/4	10 1/4	10 3/4	11 1/4	11 3/4	12 1/4	12 3/4	13 3/8	13 7/8	14 7/8	10	12	16	16	20	—	
	T	—	3/16			1/4				5/16						3/8										
	B		18 1/2	20	22	23 1/2	25	26 1/2	28	30	31 1/2	33	34 1/2	36	37 1/2	39	40 3/4	42 1/2	45 1/2							
10	H		7 1/4	7 3/4	8 1/4	8 3/4	9 1/4	9 3/4	10 1/4	10 3/4	11 1/4	11 3/4	12 1/4	12 3/4	13 3/8	13 7/8	14 3/8	14 7/8	15 7/8	12	16	20	20	24	—	
	T	—	3/16		1/4				5/16					3/8					7/16							
	B		22	23 1/2	25	26 1/2	28	30	31 1/2	33	34 1/2	36	37 1/2	39	40 3/4	42 1/2	44	45 1/2	48 3/4							
12	H		8 1/4	8 3/4	9 1/4	9 3/4	10 1/4	10 3/4	11 1/4	11 3/4	12 1/4	12 3/4	13 3/8	13 7/8	14 3/8	14 7/8	15 3/8	15 7/8	16 7/8	12	16	20	24	24	—	
	T	—	1/4				5/16					3/8						7/16								
	B		25	26 1/2	28	30	31 1/2	33	34 1/2	36	37 1/2	39	40 3/4	42 1/2	44	45 1/2	47	48 3/4	51 3/4							
14	H		8 3/4	9 1/4	9 3/4	10 1/4	10 3/4	11 1/4	11 3/4	12 1/4	12 3/4	13 3/8	13 7/8	14 3/8	14 7/8	15 3/8	15 7/8	16 3/8	17 3/8	16	20	24	24	30	36	
	T	—	1/4			5/16					3/8						7/16									
	B		26 1/2	28	30	31 1/2	33	34 1/2	36	37 1/2	39	40 3/4	42 1/2	44	45 1/2	47	48 3/4	50 1/4	53 1/2							
16	H		9 3/4	10 1/4	10 3/4	11 1/4	11 3/4	12 1/4	12 3/4	13 3/8	13 7/8	14 3/8	14 7/8	15 3/8	15 7/8	16 3/8	16 7/8	17 3/8	18 1/2	16	20	24	30	36	42	
	T	—	1/4			5/16					3/8						7/16									
	B		30	31 1/2	33	34 1/2	36	37 1/2	39	40 3/4	42 1/2	44	45 1/2	47	48 3/4	50 1/4	51 3/4	53 1/2	56 1/2							
18	H		10 3/4	11 1/4	11 3/4	12 1/4	12 3/4	13 3/8	13 7/8	14 3/8	14 7/8	15 3/8	15 7/8	16 3/8	16 7/8	17 3/8	17 7/8	18 1/2	19 1/2	20	24	30	36	36	42	
	T	—	5/16			3/8					7/16						1/2									
	B		33	34 1/2	36	37 1/2	39	40 3/4	42 1/2	44	45 1/2	47	48 3/4	50 1/4	51 3/4	53 1/2	55	56 1/2	59 1/2							
20	H		11 3/4	12 1/4	12 3/4	13 3/8	13 7/8	14 3/8	14 7/8	15 3/8	15 7/8	16 3/8	16 7/8	17 3/8	17 7/8	18 1/2	19	19 1/2	20 1/2	24	24	30	36	42	48	2
	T	—	5/16			3/8					7/16						1/2									
	B		35	37 1/2	39	40 3/4	42 1/2	44	45 1/2	47	48 3/4	50 1/4	51 3/4	53 1/2	55	56 1/2	58	59 1/2	62 1/2							
24	H		13 7/8	14 3/8	14 7/8	15 3/8	15 7/8	16 3/8	16 7/8	17 3/8	17 7/8	18 1/2	19	19 1/2	20	20 1/2	21 1/8	21 3/8	22 3/8	30	30	36	42	48	54	2
	T	—	3/8			7/16					1/2						5/8									
	B		42 1/2	44	45 1/2	47	48 3/4	50 1/4	51 3/4	53 1/2	55	56 1/2	58	59 1/2	61	62 1/2	64 1/2	66	69							

ALL DIMENSIONS GIVEN IN INCHES

(OVER

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NOTE:

Dimensional insulation data is taken from standard insulation tables. It should be noted that the insulation OD and ID are standardized to match the OD of standard nominal pipe sizes, and for thicknesses over 2 1/2-in., multilayer construction is used.

Cradle design is based on a maximum bearing value of 20 lb per sq in. for cellular glass, with one percent allowable deformation without damage to the insulation. Other types of insulation will tolerate greater pressures and higher percentages of deformation without loss of insulation values.

The bottom 120° arc has been established as the effective cross-sectional bearing area for insulation and supporting cradles, with the first inch of insulation next to the pipe absorbing the greatest proportion of the load pressure. Cradle material beyond the 120° arc is useful for installation and retention only.

The following equations are the results of complex formulae reduced to simplified ratios for ease of application.

$$T = .0125\, D_2 \qquad L = .0125\, \frac{12wS}{D_2} \text{ or } .15\, \frac{wS}{D_2}$$

Where:

T = thickness of cradle in inches
L = length of cradle in inches
D_1 = OD of bare pipe in inches
D_2 = OD of insulation in inches
S = span between supports in feet
w = unit wt per foot of pipe, water, and insulation, plus 10% safety factor.
f = (20 lb/sq in.) bearing value for insulation
c = (1.5) coefficient of friction for longitudinal movement.

"T" and "L" have been adjusted to increments most suitable for practical application. "L" has been further controlled by the greater of three minimum values as follows:

(1) ten inches (2) one pipe diameter (3) $\frac{wcS}{D_1 f}$

Cradles are intended for use in straight run horizontal piping with flanges and fittings, short vertical runs less than S/2, and installations not subject to vibration.

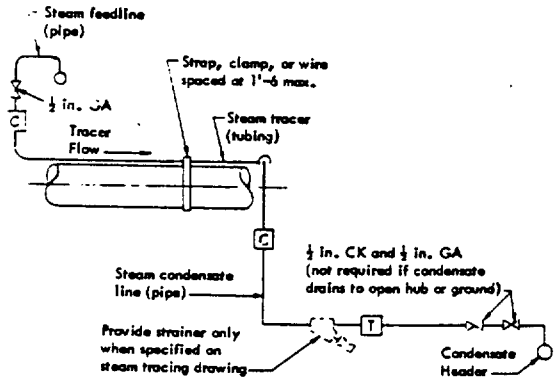
Runs including valves or long vertical portions shall be treated with special consideration.

Where severe vibration is anticipated, such as in compressor lines, the insulation between the cradle and the pipe shall be resistant to vibration.

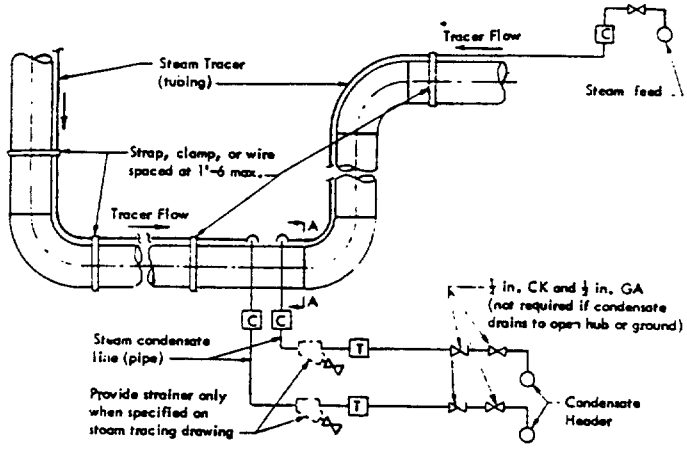
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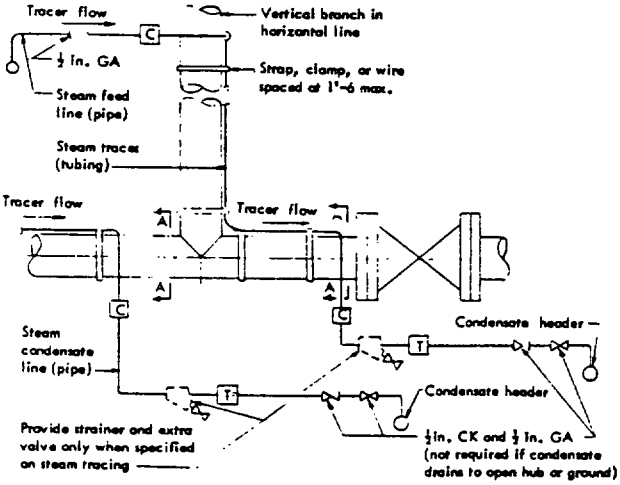
STEAM TRACING SYSTEM DETAILS AND MATERIALS



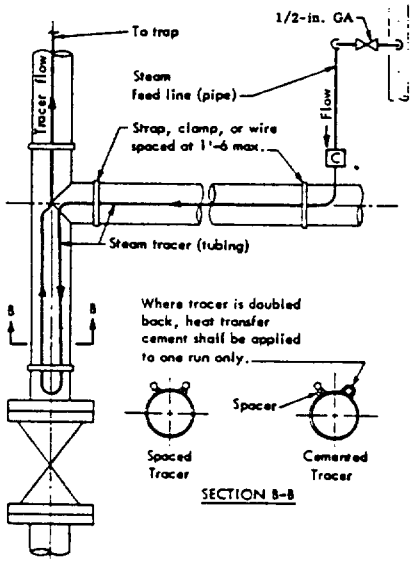
ELEVATION OF TYPICAL STRAIGHT RUN



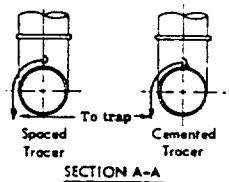
ELEVATION OF POCKET IN VERTICAL RUN



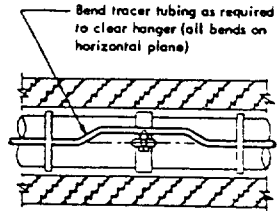
ELEVATION OF VERTICAL BRANCH IN HORIZONTAL LINE



SECTION B-B

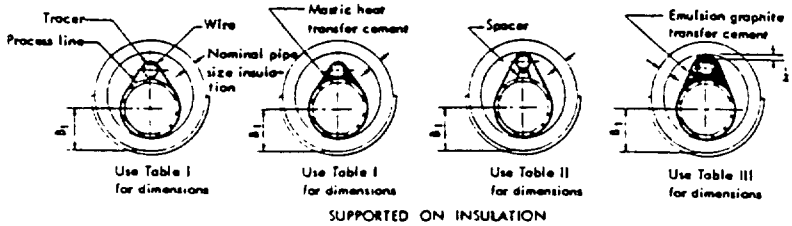


SECTION A-A

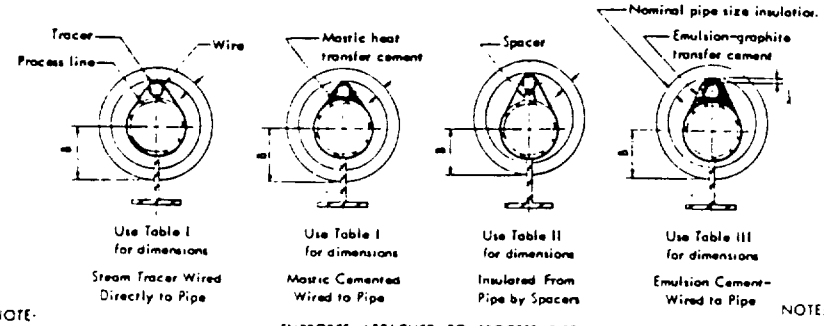


PLAN

PLAN OF HORIZONTAL BRANCH IN HORIZONTAL RUN



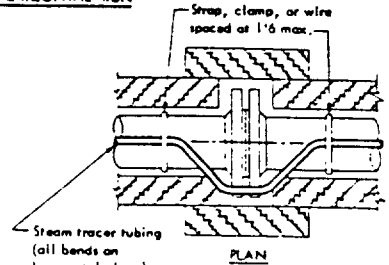
SUPPORTED ON INSULATION



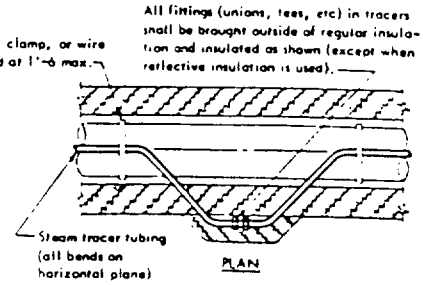
SUPPORTS ATTACHED TO PROCESS PIPE

DETAILS OF STEAM TRACER ATTACHMENT

NOTE:
Refer to Std P-140A for Tables I, II and III.



PLAN

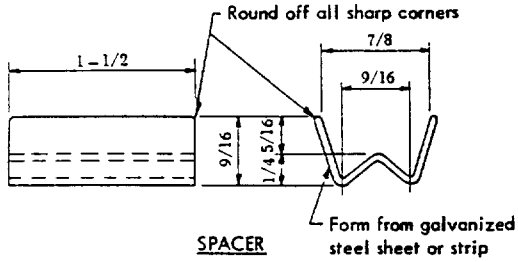


PLAN

NOTE:
Units containing lines with high freezing points shall be termed Special Requirement. These lines should be given special instruction by the Process engineer for Control. Details for this Control should be shown on the steam tracer design drawings.

Unless otherwise indicated, all dimensions given in inches.

Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation D...
ACL Doc 19432 · Page 540 of 559
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asbestosclaims.law/library/19432/540

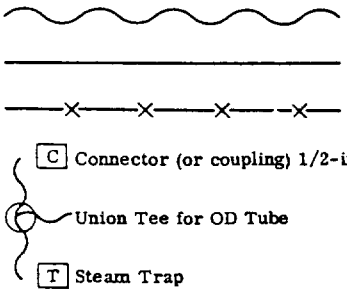


SPACER

NOTE:

Size of tracer (3/8-in. OD or 5/8-in. OD), material of tracer (copper, stainless steel, or aluminum), and type of tracing system (spaced or cemented) shall be as specified on the steam tracing drawings. Nominal size, thickness, and specification of insulation for traced line shall be as specified in the insulation schedule. Insulation for steam supply and condensate lines that do not have line numbers shall be as specified on the steam tracing drawings.

All steam tracing is shown diagrammatically on steam tracing drawings with symbols having the following meanings:



All aluminum tubing tracers shall be insulated from system components of other materials by inserting a stainless steel connector at all points where the aluminum tubing connects to components of other materials.

Shop-fabricated piping that is to be steam traced shall be supported as shown or specified on the piping drawings. Field-fabricated piping that is to be steam traced, and for which supports are not detailed on the piping drawings, shall be supported in accordance with Standards P-77 or P-81, or as otherwise necessitated by job conditions. Lines less than 3/4-in. OD may be supported by cradles as shown on Standard P-82. Except for lines less than 3/4-in. OD, methods of support that would impose a load on the insulation or tracer shall not be used.

Steam tracer tubing shall extend beyond pipe insulation only far enough to make feed and condensate line connections. Fittings shall be used only at beginning and end of tracer, at branches, and at ends of standard lengths of tubing. Changes in direction shall be made by bending the tubing. Tracer tubing shall be installed parallel to, and along the top of the line being traced.

REFERENCES:

Steam Tracing System —
Insulation Sizes and Assembly
Dimensions . . . . . Std P-140A
Spaced Tracer Data . . . . . Std P-141
Cemented Tracer Data . . . . . Std P-142

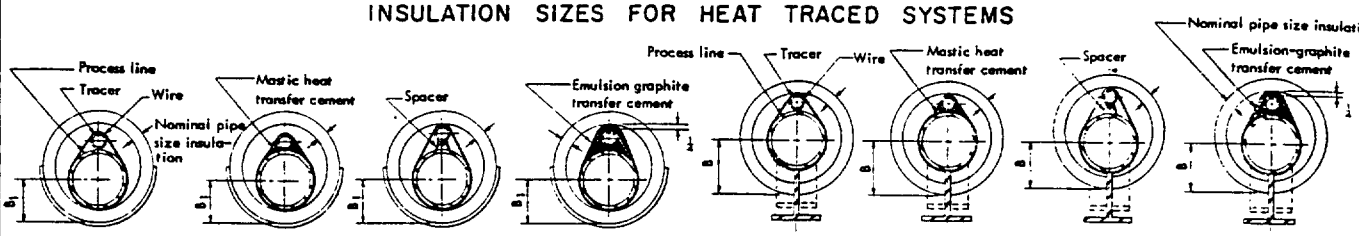
*Do not use aluminum tubing at direction changes of 90 degrees or more. Where such changes occur at intervals of 20 feet or less, use stainless steel throughout. For intervals greater than 20 feet, make the direction change with stainless steel tubing, and use a stainless steel tubing union with an aluminum sleeve at each joint, installed so that aluminum connects to aluminum.

MATERIALS FOR STEAM TRACING SYSTEMS

ITEM	COPPER	STAINLESS STEEL	ALUMINUM*
Tracer Tubing	ASTM B88 Type L annealed copper tube in 60-ft coils (3/8-in. OD x .030-in. thk, or 5/8-in. OD x .040-in. thk)	ASTM A269 TP304 Stainless Steel tube for use in steam service. Flaring Test (Section 8) is required and good bending properties are necessary. (3/8-in. or 5/8-in. OD x .035-in. thk)	5050-0 Aluminum Alloy, Alcoa "Utilitube", or approved equal. (3/8-in. OD x .035-in. thk or 5/8-in. OD x .049-in. thk)
Fittings for Tracer (Connectors, Unions, Tees, etc)	Brass, Ferrule-type with cutting edge. (Imperial Hi-Seal", Crawford "Swagelok", or approved equal.)	AISI Type 316 Stainless Steel, Ferrule-type with cutting edge. (Imperial "Hi-Seal", Crawford "Swagelok", Parker "Ferrulok", or approved equal)	Ferrule-type with cutting edge (Imperial "Hi-Seal", Crawford "Swagelok", Parker "Ferrulok", or approved equal). Connectors (IPS to OD) shall be AISI Type 316 stainless steel, all other fittings shall be aluminum alloy.
Spacers	Per this Standard	Per this Standard	Per this Standard
Straps	1/2-in. wide x .020-in. thk soft annealed stainless steel (any 18-8 type) straps with double pronged clips.		1/2-in. wide x .034-in. thk aluminum alloy straps with double pronged clips.
Wire	18 gage (.047-in. dia) annealed temper (bright annealed, or annealed and pickled) stainless steel (any 18-8 type) wire.		16 gage (.0508-in. dia) aluminum alloy wire.
Steam Traps	Size, manufacturer and model number as specified on steam tracing drawings.		
Steam Supply Header and Feed Lines, and Steam Condensate Lines	Valve and Piping Specification as called for on steam tracing drawings.		
Heat Transfer Cement	Standard Thermon, manufactured by Thermon Manufacturing Company, Houston, Texas, or approved equal.		

Union Carbide trial exhibit UC-4925: Union Carbide Standard Thermal Insulation Manual, Volume 2: Insulation D...
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INSULATION SIZES FOR HEAT TRACED SYSTEMS



For Graphite Slide-Supports, see Std P-226.

For Tee Slide-Supports, see Std P-86C

TABLE I — WITHOUT SPACERS

Supported on Insulation

PROCESS LINE SIZE	TRACER SIZE OD	NOMINAL PIPE SIZE INSULATION	DIMENSION B, FOR NOMINAL INSULATION THICKNESS 1	1½	2	2½	3
⅜	⅜	½	1¼	1⅜	2¼	3⅜	3½
½ OD	⅜	½	1¼	1⅜	2¼	3⅜	3⅜
½	⅜ ½	¾ 1	1⅞ 1½	1⅞ 2	2⅜ 2⅜	3½ 3½	3⅜ 3⅜
¾ OD	⅜ ½	1 1	1⅜ 1⅜	2½ 1⅜	2⅜ 2⅜	3½ 3	3⅜ 3½

TABLE II — WITH SPACERS

Supported on Insulation

PROCESS LINE SIZE	TRACER SIZE OD	NOMINAL PIPE SIZE INSULATION	DIMENSION B, FOR NOMINAL INSULATION THICKNESS 1	1½	2	2½	3
⅜	⅜	1	1¼	1⅜	2¼	3⅜	3½
½ OD	⅜	1	1¼	1⅜	2⅜	3⅜	3⅜
½	⅜ ½	1½ 1½	2⅛ 1½	2⅜ 2⅜	3½ 3½	4 3½	4½ 4
¾ OD	⅜ ½	1½ 1½	1⅜ 1⅜	1⅜ 1⅜	2⅛ 2⅛	3⅜ 3⅜	3⅞ 3⅞

TABLE III — WITHOUT SPACERS EMULSION-GRAPHITE HEAT TRANSFER CEMENT

Supported on Insulation

PROCESS LINE SIZE	TRACER SIZE OD	NOMINAL PIPE SIZE INSULATION	DIMENSION B, FOR NOMINAL INSULATION THICKNE 1	1½	2	2½	3
⅜	⅜	1	1¼	1⅜	2¼	3⅜	3½
½ OD	⅜	1	1¼	1⅜	2⅜	3⅜	3½
½	⅜ ½	1½ 1½	2⅛ 1½	2⅜ 2⅜	3½ 3½	4 3⅜	4½ 4
¾ OD	⅜ ½	1½ 1½	1⅜ 1⅜	1⅞ 1⅜	2⅛ 2⅛	3⅜ 3⅜	3⅞ 3⅞

Supports Attached to Process Pipe

PROCESS LINE SIZE	TRACER SIZE OD	NOMINAL PIPE SIZE INSULATION	DIMENSION B, FOR NOMINAL INSULATION THICKNESS 1	1½	2	2½	3
⅜	⅜	½	1¼	1⅜	2⅜	3⅜	3⅜
½ OD	⅜	½	1¼	1⅜	2⅜	3⅜	3⅜
½	⅜ ½	¾ 1	1⅞ 1½	1⅞ 2	2⅜ 2½	3⅜ 3	3⅜ 3½
¾ OD	⅜ ½	1 1	1⅜ 1⅜	2 1⅜	2½ 2½	3 3	3½ 3½
¾	⅜ ½	1 1½	1⅜ 1½	2⅛ 2	2⅜ 2⅜	3⅜ 3⅜	3⅜ 3⅜
⅞ OD	⅜ ½	1 1½	1½ 1½	2 2	2½ 2½	3 3⅛	3⅜ 3⅜
1 OD	⅜ ½	1 1½	1⅜ 1½	2 2	2⅜ 2⅜	3⅜ 3⅜	3⅜ 3⅜
1	⅜ ½	1½ 1½	1⅜ 1⅜	2⅛ 2⅛	3 3	3½ 3½	4 4
1⅛ OD	⅜ ½	1½ 1½	1⅜ 1⅜	2⅛ 2⅛	2⅜ 2⅜	3⅜ 3⅜	3⅜ 3⅜
1¼ OD	⅜ ½	1½ 1½	1⅜ 1⅜	2⅛ 2⅛	3 3	3½ 3½	4 4
1¼	⅜ ½	1½ 2	1⅜ 1⅜	2⅜ 2⅛	3⅛ 2⅜	3⅜ 3⅜	4⅛ 3⅜
1⅜ OD	⅜ ½	1½ 1½	1⅜ 1⅜	2⅛ 2⅛	3 3	3⅜ 3⅜	4 4
1½ OD	⅜ ½	1½ 2	1⅜ 1⅜	2⅛ 2⅛	3⅛ 3	3⅜ 3⅜	4 4
1½	⅜ ½	2 2	2 2	2⅜ 2⅜	3 3	3⅜ 3⅜	4 4
2 OD	⅜ ½	2 2½	2 2	2⅜ 2⅛	3⅛ 3⅛	3⅜ 3⅜	4⅛ 4⅛
2	⅜ ½	2½ 2½	2⅛ 2⅛	3 3	3⅜ 3⅜	4 4	4⅜ 4⅜
2⅛ OD	⅜ ½	2 2½	2⅛ 2⅛	3⅛ 3	3⅜ 3⅜	4 4	4⅛ 4⅛
2½ OD	⅜ ½	2½ 2½	2⅛ 2⅛	3⅛ 3	3⅜ 3⅜	4 4	4⅛ 4⅛
2½	⅜ ½	3 3	2⅛ 2⅛	3⅛ 3	4⅛ 3⅝	4⅛ 4⅛	5⅛ 5
3 OD	⅜ ½	3½ 3½	2⅛ 2⅛	3⅛ 3⅛	4⅛ 4	4⅛ 4⅛	5⅛ 5⅛
3 and 3½ OD	⅜ ½	3½ 3½	3 3	3⅛ 3⅛	4 4	4⅛ 4⅛	5⅛ 5⅛
4 OD	⅜ ½	4 4	3⅛ 3	3⅛ 3⅛	4⅛ 4	4⅛ 4⅛	5⅛ 5⅛

Supports Attached to Process Pipe

PROCESS LINE SIZE	TRACER SIZE OD	NOMINAL PIPE SIZE INSULATION	DIMENSION B, FOR NOMINAL INSULATION THICKNESS 1	1½	2	2½	3
⅜	⅜	1					
½ OD	⅜	1					
½	⅜ ½	1½ 1½					
¾ OD	⅜ ½	1½ 1½					
¾ OD	⅜ ½	1½ 1½					
¾	⅜ ½	1½ 1½*					
⅞ OD	⅜ ½	1½ 1½*					
1 OD	⅜ ½	1½ 1½*					
1	⅜ ½	2 2	2⅛ 2	2⅜ 2⅛	3⅛ 3	3⅜ 3⅛	4⅛ 4
1⅛ OD	⅜ ½	2 2	2⅜ 2	3 2⅛	3⅛ 3	4 3⅛	4⅛ 4
1¼ OD	⅜ ½	2 2	2⅛ 2	2⅜ 2⅛	3⅛ 3	3⅜ 3⅛	4⅛ 4
1¼	⅜ ½	2½ 2½	2⅜ 2⅛	3⅜ 3⅛	4⅛ 3⅜	4⅜ 4⅛	4⅜ 4⅜
1⅜ OD	⅜ ½	2 2	2⅜ 1⅛	2⅜ 2⅜	3⅛ 3	3⅜ 3⅛	4⅛ 4
1½ OD	⅜ ½	2 1½*	2 1⅜	2⅜ 2⅛	3⅛ 3⅛	3⅜ 3⅜	4⅛ 4⅛
1½	⅜ ½	2½ 2½	2⅜ 2	3 2⅜	3⅜ 3⅜	4⅛ 3⅜	4⅜ 4⅛
1¾ OD	⅜ ½	2½ 2½	2⅛ 2⅛	3 2⅛	3⅜ 3⅛	4⅛ 4	4⅜ 4⅛
2 OD	⅜ ½	2½ 3	2⅛ 2⅜	2⅜ 3	3⅛ 3⅛	4 4	4⅛ 4⅛
2	⅜ ½	3 3	2⅛ 2⅛	3⅛ 3⅛	4⅛ 3⅛	4⅛ 4⅛	
2⅛ OD	⅜ ½	3 3	2⅜ 2⅜	3⅛ 3	3⅜ 3⅜	4 4	4⅛ 4⅛
2½ OD	⅜ ½	3 3	2⅜ 2	3 2⅜	3⅜ 3	4 3⅛	4⅛ 4
2½	⅜ ½	3½ 3½	3⅛ 2⅛	3⅛ 3⅛	4 3⅛	4⅛ 4⅛	5⅛ 5
3 OD	⅜ ½	4 4	3⅛ 3	3⅛ 3⅛	4⅛ 4	4⅛ 4⅛	5⅛ 5⅛
3 and 3½ OD	⅜ ½	4 4	3 2⅜	3⅛ 3⅛	4 3⅛	4⅛ 4⅛	5⅛ 4⅛
4 OD	⅜ ½	5 5	3⅛ 3⅛	4 4	4⅛ 4⅛	5⅛ 5	5⅛ 5⅛

Supports Attached to Process Pipe

PROCESS LINE SIZE	TRACER SIZE OD	NOMINAL PIPE SIZE INSULATION	DIMENSION B, FOR NOMINAL INSULATION THICKNE 1	1½	2	2½	3
⅜	⅜	1		1⅜	2	2⅜	3
½ OD	⅜	1		1⅜	2⅜	2⅜	3⅜
½	⅜ ½	1½ 1½		1⅜ 1⅜	2⅜ 2⅜	3⅜ 3	3⅜ 4
¾ OD	⅜ ½	1½ 1½		2 1⅜	2⅜ 2⅜	3⅜ 3	3⅜ 4
¾	⅜ ½	1½ 1½		1⅜ 1⅜	2⅜ 2	3 2⅜	3⅜ 4
⅞ OD	⅜ ½	1½ 1½		1⅜ 1⅜	2⅜ 2	3⅛ 2⅜	3⅜ 3
1 OD	⅜ ½	1½ 1½		1⅜ 1⅜	2⅜ 2	3 2⅜	3⅜ 4
1	⅜ ½	2 2		2⅛ 1⅛	2⅜ 2⅜	3⅜ 3	3⅜ 4
1⅛ OD	⅜ ½	2 2		2⅛ 2	2⅜ 2⅜	3⅛ 3	3⅜ 3
1¼ OD	⅜ ½	2 2		2⅛ 2	2⅜ 2⅜	3⅛ 3	3⅜ 4
1¼	⅜ ½	2½ 2½		2⅛ 1⅛	3⅛ 2⅜	3⅜ 3	4⅛ 4
1⅜ OD	⅜ ½	2 2		2⅛ 1⅛	2⅜ 2⅜	3⅛ 3	3⅜ 4
1½ OD	⅜ ½	2 2		2⅛ 1⅛	2⅜ 2⅜	3⅛ 3	3⅜ 4
1½	⅜ ½	2½ 2½		2⅛ 1⅛	3⅛ 2⅜	3⅜ 3	4⅛ 4
1¾ OD	⅜ ½	2½ 2½		2⅛ 2⅛	3⅛ 2⅜	3⅜ 3	4⅛ 4
2 OD	⅜ ½	2½ 2½		2⅛ 2⅛	3⅛ 2⅜	3⅜ 3	4⅛ 4
2	⅜ ½	3 3		2⅛ 2⅛	3⅛ 2⅜	3⅜ 3	4⅛ 4
2⅛ OD	⅜ ½	3 3		2⅜ 2⅛	3⅛ 2⅜	3⅜ 3	4⅛ 4
2½ OD	⅜ ½	3 3		2⅜ 2⅛	3⅛ 2⅜	3⅜ 3	4⅛ 4
2½	⅜ ½	3½ 3½		3⅛ 2⅛	3⅛ 3⅛	4 3⅛	4⅛ 4
3 OD	⅜ ½	4 4		3⅛ 3⅛	3⅛ 3⅛	4⅛ 4⅛	4⅛ 5⅛
3 and 3½ OD	⅜ ½	4 4		3⅛ 3⅛	3⅛ 3⅛	4⅛ 4⅛	5⅛ 5
4 OD	⅜ ½	5 5		4 3⅛	4⅛ 4	4⅛ 4⅛	5⅛ 5⅛

* Same nominal pipe size insulation as Table I.

All dimensions given in inches

For Steam Tracer System, see Std P-140.
For Electric Tracer System, see Std EL-45.

(OVER)

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TABLE I - WITHOUT SPACERS - contd

Supports Attached to Process Pipe

PROCESS LINE SIZE	TRACER SIZE OD	NOMINAL PIPE SIZE INSULATION	DIMENSION B FOR NOMINAL INSULATION THICKNESS 1	1	2	2	3
4	3/8 1/2	4 1/2 5	3 7/8 3 3/4	4 3/8 4 1/2	3 7/8 4 3/4	5 3/8 5 1/2	5 7/8 5 7/8
5 OD	3/8 1/2	5 5	3 3/4 3 1/2	4 1/2 4	4 3/4 4 1/2	5 3/8 5	5 7/8 5 1/2
6 OD	3/8 1/2	6 6	4 1/2 4	4 3/4 4 1/2	5 3/8 5	5 7/8 5 1/2	6 3/8 6
6	3/8 1/2	7 7		5 1/2 5 3/8	6 5 7/8	6 1/2 6 3/8	7 1/8 7
8 OD	3/8 1/2	8 8		5 7/8 5 1/2	6 3/8 6	7 6 3/4	7 1/2 7 1/8
8	3/8 1/2	9 9		6 3/4 6 1/2	7 3/8 7 1/8	7 7/8 7 3/8	8 3/8 8 1/8
10 OD	3/8 1/2	10 10		7 6 3/4	7 1/2 7 1/4	8 7 3/4	8 1/2 8 1/4
10	3/8 1/2	11 11		7 7/8 7 3/8	8 1/8 7 3/4	8 3/8 8 1/8	9 1/8 8 3/4
12 OD	3/8 1/2	12 12		8 7 3/4	8 1/2 8 1/4	9 8 3/4	9 1/2 9 1/4
12	3/8 1/2	14 14		8 3/4 8 1/2	9 1/2 9	9 3/4 9 1/2	10 1/2 10
14	3/8 1/2	15 15		9 1/8 9	9 3/4 9 1/2	10 1/8 10	10 3/4 10 1/2
16	3/8 1/2	17 17		10 1/8 9 3/4	10 3/4 10 3/8	11 1/8 10 7/8	11 3/4 11 3/8
18	3/8 1/2	19 19		11 1/8 10 7/8	11 3/4 11 1/2	12 1/8 11 7/8	12 3/4 12 1/2
20	3/8 1/2	21 21		12 1/8 11 7/8	12 3/4 12 1/2	12 1/8 12 7/8	12 3/4 13 1/2
24	3/8 1/2	25 25		14 1/8 13 7/8	14 3/4 14 1/2	15 1/8 14 7/8	15 3/4 15 1/2

TABLE II - WITH SPACERS - contd

Supports Attached to Process Pipe

PROCESS LINE SIZE	TRACER SIZE OD	NOMINAL PIPE SIZE INSULATION	DIMENSION B FOR NOMINAL INSULATION THICKNESS 1	1	2	2	3
4	3/8 1/2	5* 5*	3 3/8 3 1/8	4 1/8 3 7/8	4 3/8 4 1/8	5 1/8 5	5 3/8 5 1/8
5 OD	3/8 1/2	6 6	4 1/2 4	4 3/8 4 1/8	5 3/8 5	5 7/8 5 3/8	6 3/8 6
6 OD	3/8 1/2	7 7		5 3/8 5	5 7/8 5 3/8	6 3/8 6	7 6 7/8
6	3/8 1/2	7* 7*		5 4 7/8	5 1/2 5 3/8	6 5 7/8	6 3/8 6 1/8
8 OD	3/8 1/2	9 9		6 3/8 6	6 7/8 6 3/4	7 1/2 7 1/4	8 7 3/4
8	3/8 1/2	9* 9*		6 5 7/8	6 1/2 6 3/8	7 1/8 7	7 7/8 7 1/2
10 OD	3/8 1/2	11 11		7 1/2 7 1/4	8 7 3/4	8 1/2 8 1/4	9 8 3/4
10	3/8 1/2	11* 11*		7 1/8 7	7 7/8 7 1/2	8 1/8 8	8 3/4 8 1/2
12 OD	3/8 1/2	14 14		8 3/4 8 1/2	9 1/2 9	9 3/4 9 1/2	10 1/2 10
12	3/8 1/2	14* 14*		8 1/2 8 1/8	9 8 7/8	9 1/2 9 1/8	10 9 7/8
14	3/8 1/2	15* 15*		8 3/4 8 1/2	9 1/8 9	9 3/4 9 1/2	10 1/8 10
16	3/8 1/2	17* 17*		9 1/8 9 1/2	10 1/8 10	10 3/4 10 1/2	11 1/8 11
18	3/8 1/2	19* 19*		10 3/4 10 1/2	11 1/8 11	11 3/4 11 1/2	12 1/8 12
20	3/8 1/2	21* 21*		11 3/4 11 1/2	12 1/8 12	12 3/4 12 1/2	13 1/8 13
24	3/8 1/2	25* 25*		13 3/4 13 1/2	14 1/8 14	14 3/8 14 1/2	15 1/8 15

*Same nominal pipe size insulation as Table I.

TABLE III - WITHOUT SPACERS

EMULSION-GRAPHITE HEAT TRANSFER CEMENT - contd

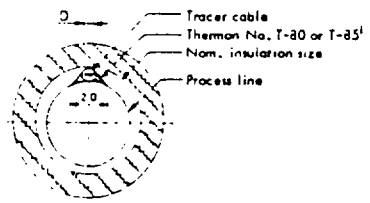
Supports Attached to Process Pipe

PROCESS LINE SIZE	TRACER SIZE OD	NOMINAL PIPE SIZE INSULATION	DIMENSION B FOR NOMINAL INSULATION THICKNESS 1	1	2	2	3
4	3/8 1/2	5 5	3 3/4 4 1/8	4 1/4 4	4 3/4 4 1/2	5 1/4 5	5 3/4 5 1/2
5 OD	3/8 1/2	6 6	4 1/2 4 1/4	4 1/2 4 3/8	5 1/2 5 1/4	6 5 3/8	6 1/2 6 1/4
6 OD	3/8 1/2	7 7		5 3/8 5 1/4	5 7/8 5 3/8	6 3/8 6 1/4	7 6 7/8
6	3/8 1/2	7 7		5 1/4 5	5 3/8 5 1/4	6 1/4 6	6 3/8 6 3/8
8 OD	3/8 1/2	9 9		6 1/4 6 1/4	7 6 3/4	7 3/8 7 3/8	8 1/4 7 3/4
8	3/8 1/2	9 9		6 1/4 6	6 3/4 6 1/4	7 3/8 7 1/8	7 7/8 7 3/8
10 OD	3/8 1/2	11 11		7 3/4 7 1/4	8 1/4 8	8 3/4 8 1/4	9 1/8 9
10	3/8 1/2	11 11		7 3/4 7 1/8	7 7/8 7 3/8	8 3/8 8 1/8	8 7/8 8 3/8
12 OD	3/8 1/2	14 14		8 1/8 8 3/8	9 3/8 9 1/8	9 7/8 9 3/8	10 3/8 10 1/8
12	3/8 1/2	14 14		8 1/8 8 1/8	9 8 3/4	9 1/2 9 1/8	10 9 7/8
14	3/8 1/2	15 15		8 7/8 8 1/8	9 3/8 9 1/4	9 7/8 9 3/8	10 3/8 10 1/8
16	3/8 1/2	17 17		9 7/8 9 3/8	10 3/8 10 1/8	10 7/8 10 3/8	11 3/8 11 1/8
18	3/8 1/2	19 19		10 3/8 10 3/8	11 1/8 11 1/8	11 3/8 11 3/8	12 1/8 12 1/8
20	3/8 1/2	21 21		11 7/8 11 3/8	12 3/8 12 1/8	12 7/8 11 3/8	13 3/8 13 1/8
24	3/8 1/2	25 25		13 7/8 13 3/8	14 3/8 14 1/8	14 7/8 14 3/8	15 3/8 15 1/8

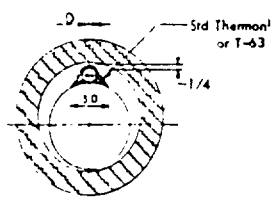
INSULATION SIZE DATA FOR ELECTRICALLY TRACED PIPELINES

TABLE IV - MINERAL INSULATED ELECTRIC TRACING CABLE

Conductors	2 #18	2 #18	3 #18	2 #16	3 #16	2 #14	3 #14	2 #12	3 #12	2 #10	3 #10	2 #8	3 #8
Cable OD-in.	.230	.246	.246	.340	.355	.371	.387	.402	.434	.449	.480	.512	.543
T-80 or T-85	Table I (¾-in. Tracers)							Table I (1-in. Tracers)					
Std or T-63	Table III (¾-in. Tracers)							Table III (1-in. Tracers)					

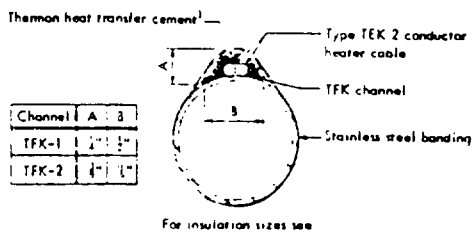


For comparable tracer size see Table IV, then select insulation size from Table I



For comparable tracer size see Table IV, then select insulation size from Table III

ELECTRIC TRACER MI CABLE CEMENTED TO PROCESS LINE



Channel	A	B
TEK-1	1/4"	1/2"
TEK-2	1/2"	1"

For insulation sizes see Table I for ¾-in. tracers

ELECTRIC TRACER THERMON TYPE "TEK" CABLE CEMENTED WITH STEEL CHANNEL TO PROCESS LINE

[1] Heat Transfer Cement by Thermon Mfg. Co., Houston 19, Texas, or approved equal.

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THERMAL INSULATION MATERIAL SPECIFICATIONS

SCOPE

These specifications describe the essential requirements for the purchase of thermal insulation, including block, pipe covering, preformed shapes, and accessory materials.

Materials and accessories as listed in individual specifications shall be of quality, type, or identification as called for in these Material Specification

I. MATERIAL - GENERAL

A. Types and Dimensions

1. Material furnished under these specifications shall be of type and thickness listed on Insulation Design Schedules, Insulation Equipm and/or Line Lists, or as otherwise prescribed by the Purchaser.

2. Pipe insulation shall be furnished in conventional lengths, plus or minus not more than 3/32 inch, with ends cut square. Inside diam shall fit firmly on specified pipe size and outside diameter shall correspond to a Nominal Pipe Size, with the exception of Specification No. 14, Preformed Flexible Plastic Foam.

B. Sampling for Testing. Where vendor is unable to provide acceptable test or performance data, to meet the requirements of these specific tions, representative samples of insulating and accessory materials shall be submitted to the Purchaser in sizes and amounts required for testing. all instances these samples, which shall be supplied without cost to Purchaser, shall be shipped by Vendor within seven days following receipt written request.

C. Packaging. Unless otherwise agreed, material shall be packed in substantial containers, so constructed as to ensure safe delivery of mat by common and other approved carrier in a condition satisfactory to the Purchaser.

D. Marking and Identification. Unless otherwise specified, shipping containers shall be legibly marked with name of material, size, type, quantity contained therein; name of Insulation Contractor, if any, and purchase order number under which shipment is made. In addition, whe required, container shall bear the work order number, the Item or line Number for which material is intended, and its relative position and sec of application.

E. Attachments

1. Standard lacquered or brass bands, customarily furnished by the manufacturer of pipe insulation, will not be required.

2. Canvas or other factory-applied surfacing, where required with insulating material, shall be as called for on bills of material or purc requisitions.

F. Approved Equals. Other insulating and/or accessory materials may be approved by the Purchaser, but only where clearly shown that prop ties involved conform to these specifications.

II. PROPERTIES

A. Properties of insulation shall be in accordance with the applicable standard ASTM Test Methods, latest revision.

B. Test values for a given insulating material shall be in accordance with limits called for in properties listed for that material within these specifications.

C. ASTM Test Methods for the following properties are:

Breaking Load - Calculated Flexural Strength - Block Insulation	C 203
Breaking Load - Calculated Flexural Strength - Pipe Insulation	C 446
Compressive Strength	C 165
Deflection Strength	C 209 - 14 through 16
Density - Block Insulation	C 303
Density - Pipe Insulation	C 302
Density - Blanket Insulation	C 167
Fire Resistance - Combustibility	E 136
Fire Resistance - Flammability of Plastic Foams and Sheeting	D 1692
Fire Resistance - Flame Spread	C 209 - Part 32
Hardness	C 569
Hot Surface Performance	C 411
Maximum Use Temperature	C 447
Resistance to Abrasion	C 421
Resistance to Dropping	C 487
Shrinkage after Heat Soaking	C 356
Specific Heat	C 351
Tensile Strength	C 209 - 18 through 24; C 446
Thermal Conductivity (Depending on Material and Temperature)	C 177, C 335, C 420, or C 518
Water Absorption	C 209 - 26 through 28
Water Vapor Transmission	C 355

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III. DIMENSIONS OF CURVED SEGMENTS, LAGGING, AND PIPE INSULATION

A. Dimensions of NPS pipe insulation shall be in accordance with ASTM C 312 and C 521, latest revisions.

B. Unless otherwise specified, curved side wall segments of insulation for hot equipment, and pipe insulation, with the exception of cellular glass, shall be installed in single layer up to and including 3-inch thickness. Thickness 3½-inch and greater shall be in layers as shown below.

Total Scheduled Nominal Thickness, Inches	Inner Layer Nominal Thickness, Inches	Middle Layer Nominal Thickness, Inches	Outer Layer Nominal Thickness, Inches
3-1/2	1-1/2	None	2
4	2	None	2
4-1/2	2	None	2-1/2
5	2-1/2	None	2-1/2
5-1/2	2-1/2	None	3
6	3	None	3
6-1/2	2	2	2-1/2
7	2	2-1/2	2-1/2
7-1/2	2-1/2	2-1/2	2-1/2
8	2-1/2	2-1/2	3
8-1/2	2-1/2	3	3
9	3	3	3

C. On cylindrical side walls of hot vessels up to 12 ft 0 in. OD, and for all multiple layer applications, insulation shall be molded or preformed curved side wall segments in accordance with ASTM Recommended Practice C 450, latest revision.

D. On cylindrical side walls of block insulated hot vessels over 12 ft 0 in. OD single layer insulation up to 3-inch thickness shall be mitered lagging in accordance with ASTM Recommended Practice C 450, latest revision.

E. Unless otherwise specified, cellular glass insulation on low temperature equipment and piping and all other applications shall be installed in single layer up to and including 2-1/2-inch thickness. Insulation in excess of 2-1/2 inches total thickness shall be applied in multi-layer construction in accordance with the following table.

Total Scheduled Thickness, Inches	Inner Layer Thickness, Inches	Outer Layer Thickness, Inches
3	1-1/2	1-1/2
3-1/2	1-1/2	2
4	2	2
4-1/2	2	2-1/2
5	2-1/2	2-1/2
5-1/2	2-1/2	3
6	3	3
6-1/2	3	3-1/2
7	3-1/2	3-1/2
7-1/2	3-1/2	4
8	4	4
8-1/2	4	4-1/2
9	4-1/2	4-1/2

IV. CONDITION OF MATERIAL

Insulating materials, other than cements and mastics, shall be dry when applied.

V. PREFORMED VALVE, FITTING, AND FLANGE COVERS

A. All fittings, such as valve, flange, ell and tee covers, and shapes such as curved segments and head covers specified to be molded, shaped, or fabricated shall have dimensions in accordance with ASTM Recommended Practice C 450, latest revision.

B. Parts of such fittings shall fit tightly together and shall be cemented together with fabrication cement as called for in individual specifications and as designated in these specifications.

VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS

Individual insulation materials, as identified by Specification Numbers, shall be of composition and shall have properties as listed.

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS – contd

SPECIFICATION NO. 10: CELLULAR GLASS INSULATION

Composition

Material shall be composed of glass, completely inorganic, processed and cellulated at temperatures sufficient to produce a rigid, cellular thermal insulation.

Properties

Alkalinity	pH shall be between 6.9 and 7.5.
Capillarity	After 7 days on wet surface, gain in weight shall be 0%.
Coefficient of Expansion	Shall average 4.6×10^{-6} per degree F.
Combustibility	Shall be incombustible.
Compressive Strength	Shall be not less than 100 psi.
Density	Shall be not less than 8 lb per cu ft, nor more than 11 lb per cu ft.
Flexural Strength	Shall be not less than 75 psi.
Hygroscopicity	Two-inch cubes dried at 220 F to constant weight, then exposed to air at 70 F and 90% relative humidity for 14 days, shall not gain any weight.
Maximum Use Temperature	Maximum temperature without mechanical, thermal, or chemical failure shall be not less than 800 F.
Resistance to Acids	Shall be impervious to common acids and fumes except hydrofluoric and hot phosphoric.
Shear Strength	Shall be not less than 40 psi.
Specific Heat	Shall average 0.20 Btu per lb per degree F.
Tensile Strength	Shall be not less than 40 psi.
Thermal Conductivity	The thermal conductivity at the given mean temperatures shall not exceed the following values:

Mean Temp, °F	Btu/inch, hr, sq ft, °F
0	0.36
100	0.42
200	0.48
300	0.56
400	0.63
600	0.74

Thermal Diffusivity at 75 F	Shall average 0.42 sq ft per day.
Water Absorption	After 24-hour submersion, shall not exceed 0.2% by volume (surface only).
Water Vapor Transmission	Shall have a WVT of zero grains per sq ft per hour.

Do not feel that this is necessary

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 12: RIGID URETHANE FOAM

Composition

Material shall be composed of polyurethane foamed into a closed cell rigid thermal insulation.

Properties

Closed Cell Content . . . . . Shall be not less than 90%, as determined on sample 2" x 2" x 2" in accordance with ASTM D 1940.

Coefficient of Expansion . . . . . Shall not exceed the following:

Temperature Range, °F	Coefficient of Expansion, per °F
75 to 200	8.0×10^{-5}

When tested in accordance with ASTM D 696.

Combustibility . . . . . Shall not have burning extent over 2 inches when tested in accordance with ASTM D 1692.

Compressive Strength . . . . . Shall be not less than 15 psi at yield point in any direction when tested in accordance with ASTM D 1621.

Density . . . . . Shall be not less than 2.1 lb per cu ft, nor more than 4.5 lb per cu ft when tested in accordance with ASTM D 1622.

Flexural Strength . . . . . Shall be not less than 20 psi in any direction in accordance with ASTM D 790.

Maximum Use Temperature . . . . . Maximum temperature without mechanical, thermal, or chemical failure shall be not less than 200 F.

Resistance to Acids, Caustics and Solvents . . . . . Shall be resistant to common hydrocarbon solvents, mild acids and caustics provided that they do not exceed 10% concentrations. (Not resistant to ketones)

Shear Strength . . . . . Shall be not less than 20 psi in any direction when tested in accordance with ASTM C 273.

Specific Heat . . . . . Shall average 0.25 Btu per lb per degree F.

Thermal Conductivity . . . . . The thermal conductivity at the given mean temperatures shall not exceed the following values: (Sample to be aged at 70 F for 30 days before test)

Mean Temp, °F	Btu/inch, hr, sq ft, °F
0	0.16
100	0.17

Thermal Shock Resistance . . . . . Shall not spall, chip, crack, or otherwise fail when heated to 200 F and then quenched with water.

Water Absorption . . . . . After 24-hour submersion, increase in weight shall not exceed 0.15 lb per sq ft of exposed surface.

Water Vapor Transmission . . . . . Shall have water vapor transmission of less than 3.5 perm inches when tested by wet cup method (ASTM C 355).

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS – contd

SPECIFICATION NO. 14: PREFORMED FLEXIBLE PLASTIC FOAM

Composition

Material shall be preformed flexible foamed plastic, having a closed cell structure.

Properties

Alkalinity	pH shall be 5 to 9.
Combustibility	Shall be self-extinguishing.
Density	Shall be not less than 5 nor more than 8 lb per cu ft.
Maximum Use Temperature	Shall not fail mechanically, thermally or chemically when subjected to continuous temperature of 180 F (sheet insulation) or 200 F (pipe insulation).
Resistance to Acids	Shall have good resistance to most common acids.
Resistance to Caustics	Shall have good resistance to most common caustics.
Specific Heat	Shall average 0.42 Btu per lb per degree F.
Thermal Conductivity	The thermal conductivity at the given mean temperatures shall not exceed the following values:

Mean Temp, °F	Btu/inch, hr, sq ft, °F
75	0.26
120	0.27

Water Absorption (by immersion)	Shall not exceed 2.5% gain, by volume.
Water Vapor Transmission	Shall not exceed 0.15 perm, inch, by wet cup test.

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 15: PREFORMED FIBROUS GLASS - HIGH DENSITY (Over 10 lb per cu ft)

Composition

Material shall be composed of fibrous glass molded into pipe and block insulation with an inorganic non-punking binder. Insulation for low temperature service up to and including 1-1/2-inch thickness for 6-inch NPS and smaller pipe, and 2-inch thickness for 4-inch NPS and smaller pipe, shall have factory applied fire-retardant vapor-barrier jackets consisting of aluminum foil laminated with a special embossed white kraft paper reinforced with glass fiber yarn for puncture resistance, and having self-sealing longitudinal lap joints with a self-extinguishing pressure-sensitive adhesive protected by release paper.

Properties

Alkalinity . . . . . pH shall be 8.

Capillarity . . . . . After 7 days on wet surface, gain in weight shall be 0%.

Compressive Strength . . . . . 7.38 psi at 10% deformation.

Density:
Pipe . . . . . Shall be not less than 10 nor more than 13 lb per cu ft.

Block . . . . . Shall be not less than 10 nor more than 11 lb per cu ft.

Dimensional Stability . . . . . Linear shrinkage after heating for 24 hours at 1,000 F: 1.67%.

Hygroscopicity . . . . . When exposed to air at 120 F and 95% relative humidity for 96 hours, shall be less than 0.2% by volume.

Maximum Use Temperature . . . . . Shall be suitable for use from minus 120 F to plus 1,000 F without mechanical, thermal, or chemical failure.

Resistance to Acids . . . . . Good, except to hydrofluoric and phosphoric.

Resistance to Alkalies . . . . . Poor.

Specific Gravity . . . . . Shall average 2.6 true, 0.17 apparent.

Specific Heat . . . . . Shall average 0.20 Btu per lb per degree F.

Thermal Conductivity . . . . . The thermal conductivity at the given mean temperatures shall not exceed the following values:

Mean Temp, °F	Btu/inch, hr sq ft, °F
0	0.28
70	0.29
100	0.31
200	0.35
300	0.39
400	0.44
500	0.47

Thermal Diffusivity at 75 F . . . . . 0.4 sq ft per day.

Water Absorption (by immersion) . . . . . 2.22%.

Sizes Available:
Pipe . . . . . Dimensional standard sizes, 1-inch, 1-1/2-inch, and 2-inch thick up to 12-inch NPS in sectional form and 33-inch NPS in segmental form.

Block . . . . . 1-inch, 1-1/2-inch, and 2-inch thick by 24 inches by 48 inches.

Water Vapor Transmission (through jacket) . . Shall not exceed 0.01 perm.

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS – contd

SPECIFICATION NO. 16: PREFORMED FIBROUS GLASS – LOW DENSITY (3 to 5 lb per cu ft)

Composition

Material shall be composed of fibrous glass molded into pipe insulation with a modified phenolic type binder. Insulation up to and including 1-1/2-inch thickness for 14-inch OD and smaller pipe, and 2-inch thickness for insulation sizes up to but not including 11-inch NPS, shall have factory-applied, fire-retardant vapor-barrier jackets consisting of aluminum foil laminated with a special embossed white kraft paper reinforced with glass fiber yarn for puncture resistance, and having self-sealing longitudinal lap joints with a self-extinguishing pressure-sensitive adhesive protected by release paper.

Properties

Alkalinity . . . . . pH shall be between 7 and 10.

Capillarity . . . . . After 7 days on wet surface, gain in weight shall be 0%.

Density . . . . . Shall be greater than 3 and less than 5 lb per cu ft.

Hygroscopicity . . . . . When exposed to air at 120 F and 95% relative humidity for 96 hours, shall be less than 0.2% by volume.

Loss on Ignition . . . . . Shall be between 8 and 19% by weight.

Maximum Use Temperature . . . . . Shall be suitable for use from minus 120 F to plus 375 F without mechanical, thermal, or chemical failure.

Thermal Conductivity . . . . . The thermal conductivity at the given mean temperatures shall not exceed the following values:

Mean Temp, °F	Btu/inch, hr, sq ft, °F
0	0.20
50	0.22
75	0.23
100	0.24
200	0.31

Thermal Diffusivity at 75 F . . . . . 0.46 sq ft per day (5 lb)
0.77 sq ft per day (3 lb)

Water Absorption (by immersion) . . . . . Percentage of volume is very high, due to open fibrous structure, but does not retain if water can run out.

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS – contd

SPECIFICATION NO. 17-RX: PREFORMED FIBROUS GLASS VAPOR SEAL RIGID-FACED INSULATION – for use on the exterior surfaces of heating, ventilating, and air conditioning ducts.

Composition

Material shall be composed of fibrous glass with a modified phenolic resin binder, formed into a rigid board and faced with a factory-applied vapor barrier of 0.0025-inch aluminum foil, having and Underwriters' Laboratory label with Flame Spread 15 to 20, Smoke Developed 0 to 1(

Properties

Alkalinity	pH shall be between 7 and 10.
Capillarity	After 7 days on wet surface, gain in weight shall be 0%.
Density (average of 10 samples)	Shall be not less than 5.0 nor more than 9.0 lb per cu ft.
Hygroscopicity	When oven-dried to constant weight, then exposed to air at 70 F and 90% relative humidity for 14 days, gain in weight shall be less than 2%.
Resistance to Abrasion	Weight loss shall be less than the following: After first 10-minute run: 35% After second 10-minute run: 55%
Thermal Diffusivity at 75 F	Shall average not more than 0.77 sq ft per day.
Water Absorption (by immersion)	Percentage of volume is very high due to open fibrous structure, but does not retain if water can run out.

SPECIFICATION NO. 17-RY: PREFORMED FIBROUS GLASS COATED RIGID INSULATION – for use on the interior surfaces of heating, ventilating, and air conditioning ducts.

Composition

Material shall be composed of fibrous glass with a modified phenolic resin binder, formed into a rigid board, and coated on one side with neoprene compound.

Properties

Alkalinity	pH shall be between 7 and 10.
Capillarity	After 7 days on wet surface, gain in weight shall be 0%.
Density (average of 10 samples)	Shall be not less than 6.0 nor more than 6.5 lb per cu ft.
Maximum Use Temperature	Shall be suitable for use from minus 120 F to plus 250 F without mechanical, thermal, or chemical failure.
Resistance to Acids	Fairly good, except to hydrofluoric.
Resistance to Alkalies	Poor.
Specific Heat	Shall average 0.20 Btu per lb per cu ft.
Tensile Strength (Parting Strength, Average)	Shall be greater than 1.2 lb per gram of weight.
Thermal Conductivity	The thermal conductivity at the given mean temperatures shall not exceed the following values:

Mean Temp, °F	Btu/inch, hr, sq ft, °F
75	0.26
100	0.27

Thermal Diffusivity at 75 F	0.8 sq ft per day.
Water Absorption (by immersion)	Percentage of volume is very high, due to open fibrous structure, but does not retain if water can run out.

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 18-FX: FIBROUS GLASS FLEXIBLE DUCT INSULATION - for use on the exterior surfaces of heating, ventilating, and air conditioning ducts that are in concealed spaces.

Composition

Material shall be composed of fibrous glass with a modified phenolic resin binder, formed into a flexible blanket and faced with a factory-applied fire-retardant vapor barrier of foil-reinforced kraft paper having a perm rating of not more than 0.05. Non-permanent fire-retardant treatments such as salts will not be allowed.

Properties

Alkalinity . . . . . pH shall be between 7 and 10.

Capillarity . . . . . After 7 days on wet surface, gain in weight shall be 0%.

Density (average of 10 samples) . . . . . Shall be not less than 0.9 lb per cu ft.

Hygroscopicity . . . . . When oven-dried to constant weight, then exposed to air at 70 F and 90% relative humidity for 14 days, gain in-weight shall be not more than 2%.

Maximum Use Temperature (glass core) . . . . Shall be suitable for use from minus 120 F to plus 375 F without mechanical, thermal, or chemical failure.

Resistance to Acids . . . . . Fairly good, except to hydrofluoric.

Resistance to Alkalies . . . . . Poor.

Specific Heat . . . . . Shall average 0.20 Btu per lb per degree F.

Tensile Strength (average parting strength) . . Shall be more than 1.2 lb per gram of weight.

Thermal Conductivity . . . . . The thermal conductivity at the given mean temperatures shall not exceed the following values:

Mean Temp, °F	Btu/inch, hr, sq ft, °F
75	0.26
100	0.27

Thermal Diffusivity . . . . . 2.5 sq ft per day.

Water Absorption (by immersion) . . . . . Percentage of volume is very high, due to open fibrous structure, but does not retain if water can run out.

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 18-FY: FIBROUS GLASS FLEXIBLE DUCT INSULATION - acoustical and thermal insulation for use on the interior surface of supply and return air ducts carrying conditioned and warm air respectively.

Composition

Material shall be composed of fibrous glass with a modified phenolic resin binder, formed into a flexible blanket, and coated on one side with neoprene compound.

Properties

Alkalinity	pH shall be between 7 and 10.
Capillarity	After 7 days on wet surface, gain in weight shall be 0%.
Density (average of 10 samples)	Shall be not less than 2 lb per cu ft.
Erosion Resistance	Shall withstand air velocities up to and including 7,500 feet per minute with no erosion.
Flame Spread	Shall be less than 25.
Friction Coefficient	Shall not exceed 0.020.
Loss on Ignition	Shall be not less than 12 nor more than 20% by weight.
Maximum Use Temperature	Shall be suitable for use from minus 120 F to plus 250 F without mechanical, thermal, or chemical failure.
Noise Reduction Coefficient	Shall be 0.75 or above - No. 6 mounting.
Odor	Shall be essentially odorless.
Resistance to Acids	Fairly good, except to hydrofluoric.
Resistance to Alkalies	Poor.
Smoke Developed	Shall be less than 50.
Specific Gravity	Shall average 2.5 true, 0.030 apparent.
Specific Heat	Shall average 0.20 Btu per lb per degree F.
Thermal Conductivity	The thermal conductivity at the given mean temperatures shall not exceed the following values:

Mean Temp, °F	Btu/inch, hr, sq ft, °F
50	0.22
75	0.23
100	0.25

Thermal Diffusivity at 75 F	1.2 sq ft per day.
Water Absorption	Percentage of volume is very high, due to open fibrous structure, but does not retain if water can run out.

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 19-H: MINERAL WOOL WITH INTEGRAL ALUMINUM FACING FOR VESSEL SIDE WALLS AND EXPANDED SILICA FOR VESSEL ROOFS OR HEADS

Composition

Material shall be composed of curly mineral wool preformed and bonded to 3/4 hard, 0.016-inch thick, ribbed 3003 alloy aluminum to form panels 50.3-inches wide by 100-inches long. Panels shall be factory drilled for studs when they are to be secured to vessel by stud welding. Panels shall not be drilled when they are to be secured to vessel by strapping.

Properties - Mineral Wool (Attached to Aluminum Facing)

Alkalinity . . . . . pH shall be not less than 6.0 nor more than 8.6.

Combustibility . . . . . Shall be incombustible.

Compressive Strength . . . . . Shall be not less than 0.28 psi at 10% deformation.

Density . . . . . Shall be not less than 4 nor more than 4.5 lb per cu ft.

Hygroscopicity . . . . . Shall be not more than 17% by weight.

Maximum Use Temperature . . . . . Shall not fail mechanically, thermally, or chemically when subjected to surface or soaking temperature of 450 F.

Thermal Conductivity . . . . . The thermal conductivity at the given mean temperatures shall not exceed the following values:

Mean Temp, °F	Btu/inch, hr, sq ft, °F
50	0.24
100	0.26
200	0.33
300	0.43

Thermal Diffusivity at 75 F . . . . . Shall average 0.02 sq ft per hr.

EXPANDED SILICA . . . . . As specified in SPECIFICATION NO. 22.

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 19-J: ALUMINUM-FACED FIBROUS GLASS PANELS AND FIBROUS GLASS ROOF INSULATION

Composition

For Side Walls. Material shall be composed of fibrous glass with a modified phenolic binder, with an integral 0.016-inch-thick embossed aluminum facing on one side, formed into panels 48 inches wide by 96 inches long.

For Roof or Heads. Material shall be composed of fibrous glass with resin binder, formed into a semi-rigid board and faced with factory-applied glass reinforced asphalt with a kraft finish.

Properties

		Aluminum Faced Fibrous Glass	Fibrous Glass Roof Insulation
Alkalinity	pH shall be	8.0 (min.), 10.0 (max.)	8.0 (min.), 10.0 (max.)
Capillarity	After 7 days on wet surface, gain in weight shall be	0	0
Coefficient of Expansion	Shall be	0	8.0×10^{-5} (Ave.)
Combustibility	Flash Point Melting Point " "	700 F (Resin) 1,200 F (Glass)	425 F (Asphalt) 150 F (Asphalt) 1,200 F (Glass)
Compressive Strength		0.7 psi at 10% deformation	10 psi at 10% deformation
Density		3.25 ± 10%	11 (min.), 18 (max.)
Hygroscopicity	Two-inch cubes dried at 220 F to constant weight, then exposed to air at 70 F, 90% R.H. for 14 days shall gain not more than	1% by weight	1% by weight
Maximum Use Temperature	Shall not fail mechanically, thermally, or chemically within temperature limits of	60 to 450 F	Atmospheric to 350 F
Resistance to Acids	Impervious to common acids and acid fumes except hydrofluoric and hot phosphoric	Yes	Yes
Resistance to Alkalies		Poor	Poor
Specific Heat	Shall average	0.2 Btu/lb	0.2 Btu/lb
Thermal Conductivity	When tested in accordance with ASTM C 177, latest revision, the thermal conductivity shall not exceed the following values at the given mean temperatures	Mean Temp, °F / Conductivity Btu/inch, hr, sq ft, °F 0 / 0.20 100 / 0.24 200 / 0.29 300 / 0.35	Mean Temp, °F / Conductivity Btu/inch, hr, sq ft, °F 0 / 0.24 100 / 0.28 200 / 0.34
Thermal Diffusivity	Shall average, sq ft/hr	0.033	0.004 at 70 F (12 lb density)
Water Absorption	After 24-hour submersion weight gain shall not exceed	400%	400%

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS – contd

SPECIFICATION NO. 21: ASBESTOS FIBER

Composition

Material shall be composed of asbestos fibers blended with suitable inorganic binder, processed and molded at sufficient temperatures to produce a rigid, homogeneous thermal insulation.

Properties

Absorptivity . . . . . Not over 85% of volume after 24 hours submersion.

Alkalinity . . . . . pH shall be 10.5.

Coefficient of Expansion (or Volume and Linear Shrinkage) . . . . . Shrinkage shall be less than 0.7% when heated to 750 F.

Combustibility . . . . . Shall be incombustible.

Compressive Strength . . . . . When tested in accordance with ASTM C 165, latest revision, the percentage of deformation produced by loading shall not exceed the following:

Deformation, %	Load, psi
2	5.5
5	11.0
10	17.0

Corrosiveness to Stainless Steel . . . . . Shall not contribute to stress corrosion of austenitic stainless steel.

Density . . . . . Shall be not less than 14 nor more than 18 lb per cu ft.

Flexural Strength . . . . . Shall be not less than 100 psi when tested in accordance with ASTM C 203, latest revision.

Hardness . . . . . A 1/8-inch ball point under a 1-kg load shall produce a maximum penetration of 0.40 mm.

Hygroscopicity . . . . . Two-inch cubes oven-dried to constant weight, then exposed to air at 70 F, and 90% relative humidity for 14 days, shall gain a maximum of 12.1% of the original weight.

Maximum Use Temperature . . . . . Maximum temperature without mechanical, thermal, or chemical failure shall be not less than 1,200 F.

Resistance to Acids and Caustics . . . . . Solutions or vapors of those commonly used in industry have negligible effect on physical characteristics.

Shrinkage . . . . . Shall be not more than 0.25% when tested at 1,200 F.

Specific Heat . . . . . Shall be not less than 0.22, nor more than 0.24, Btu per lb per degree F.

Thermal Conductivity . . . . . The thermal conductivity at the given mean temperatures shall not exceed the following values:

Mean Temp, °F	Btu/inch, hr, sq ft, °F
100	0.32
200	0.37
300	0.42
400	0.47
600	0.57

Thermal Diffusivity . . . . . Shall be approximately 0.197 sq ft per day.

Thermal Shock Resistance . . . . . Material shall not spall, chip, crack, or otherwise fail when heated to 750 F and then quenched with water.

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 22: BONDED EXPANDED SILICA

Composition

Material shall be composed of expanded silica (perlite), reinforced with asbestos and glass fibers in suitable proportion, and with other bindi fillers added to provide proper structural strength.

Properties

Alkalinity	pH shall be not below 8.0 and not above 9.8.
Capillarity	After 7 days on wet surface, gain in weight shall be less than 1%.
Combustibility	Shall be incombustible.
Compressive Strength	Strength at 5% deformation shall be not less than 80 psi.
Corrosiveness to Stainless Steel	Shall not contribute to stress corrosion of austenitic stainless steel.
Density	Shall be not less than 9.5 lb per cu ft, nor more than 11.5 lb per cu ft.
Dusting	Fabrication and erection dusting shall be within the allowable criteria established by the Plant Medical Department.
Flexural Strength	Shall be not less than 80 psi.
Hygroscopicity	Two-inch cubes, oven-dried to constant weight, then exposed to air at 70 F and 90% relati humidity for 30 days shall gain less than 1% of the original weight.
Resistance to Abrasion	Sample shall lose not more than 40% of original weight after first 10-minute run, and not mo than 70% after second 10-minute run.
Maximum Use Temperature	Material shall be suitable for temperatures up to 1,600 F.
Resistance to Acids	Excellent; when immersed in 25% concentration of sulfuric acid, hydrochloric acid, or aqua regia, shall show no damage in 100 hours.
Resistance to Caustics	Good for most common caustics.
Shrinkage	0.47% at 1,000 F and 1.25% at 1,500 F soaking heat.
Specific Heat	Will be furnished later.
Thermal Conductivity	Shall not exceed the following values at the given mean temperatures:

Mean Temp, °F	Btu/inch, hr, sq ft, °F
100	0.34
200	0.40
300	0.45
400	0.50
600	0.58
1,000	0.78

Tensile Strength	25 psi.
Thermal Diffusivity	Shall not exceed 0.33 sq ft per day at 100 F mean temperature.
Thermal Shock Resistance	Shall not be damaged by rapid change in temperature.
Water Absorption	After 24-hour submersion, gain shall not exceed 4% by volume of water.

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VI. SPECIFICATIONS FOR INDIVIDUAL INSULATION MATERIALS - contd

SPECIFICATION NO. 23: INHIBITED CALCIUM SILICATE

Composition

Material shall be composed of hydrous calcium silicate blended with asbestos fibers in suitable proportion, with or without inorganic filler, and with an inhibitor added to prevent stress corrosion of stainless steel.

Properties

Alkalinity . . . . . pH shall be not below 8 nor above 10.

Breaking Load . . . . . Not less than 20 lbs when testing a specimen 6 inches wide by 1 inch thick over a 10-inch span.

Coefficient of Expansion . . . . . Not less than 1.9×10^{-6} average on reheat to 1,200 F.

Combustibility . . . . . Shall be incombustible.

Compressive Strength . . . . . The percentage of deformation produced by loading shall not exceed the following:

Load, Psi	Deformation, %
70	2
150	5
200	10

Corrosiveness to Stainless Steel . . . . . Shall not cause stress corrosion cracking of stainless steel after six months when tested by A. W. Dana method reported in October 1957 issue of ASTM Bulletin.

Density . . . . . Shall be not less than 10 lbs per cu ft, or more than 13 lbs per cu ft.

Dusting . . . . . Fabrication and erection dusting shall be within the allowable criteria established by the Plant Medical Department.

Flexural Strength . . . . . Shall be not less than 50 psi.

Hardness . . . . . A 1/8-inch ball point under a 1-kg load shall produce a maximum penetration of 0.50 mm.

Hygroscopicity . . . . . When oven-dried to constant weight, then exposed to air at 70 F and 90% relative humidity for 14 days, shall gain a maximum of 26% of the original weight.

Maximum Use Temperature . . . . . Maximum temperature without mechanical, thermal, or chemical failure shall be not less than 1,200 F.

Resistance to Acids and Caustics . . . . . Shall be resistant to most common caustics (not considered an acid-resisting material).

Shrinkage . . . . . Shall be not more than 1.6% at 1,200 F.

Specific Heat . . . . . 0.21 to .28 Btu per lb per degree F at 400 F.

Tensile Strength . . . . . Shall be not less than 20 psi.

Thermal Conductivity . . . . . The thermal conductivity at the given mean temperatures shall not exceed the following values:

Mean Temp, °F	Btu/inch, hr, sq ft, °F
100	.33
200	.37
300	.41
400	.46
600	.57

Thermal Diffusivity . . . . . Shall average 0.013 to 0.016 sq ft per hour.

Thermal Shock Resistance . . . . . Shall not spall, chip, crack, or otherwise fail when heated to 1,200 F and then quenched with water.

Water Absorption . . . . . After 24-hour submersion, shall gain not more than 480% of the original weight.

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