# ARMSTRONG'S INDUSTRIAL INSULATIONS


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This copy of

# ARMSTRONG'S INDUSTRIAL INSULATIONS

presented to

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ARMSTRONG CORK COMPANY
Building Materials Division
Lancaster, Pennsylvania


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# ARMSTRONG'S INDUSTRIAL INSULATIONS

ARMSTRONG CORK COMPANY

LANCASTER PENNSYLVANIA

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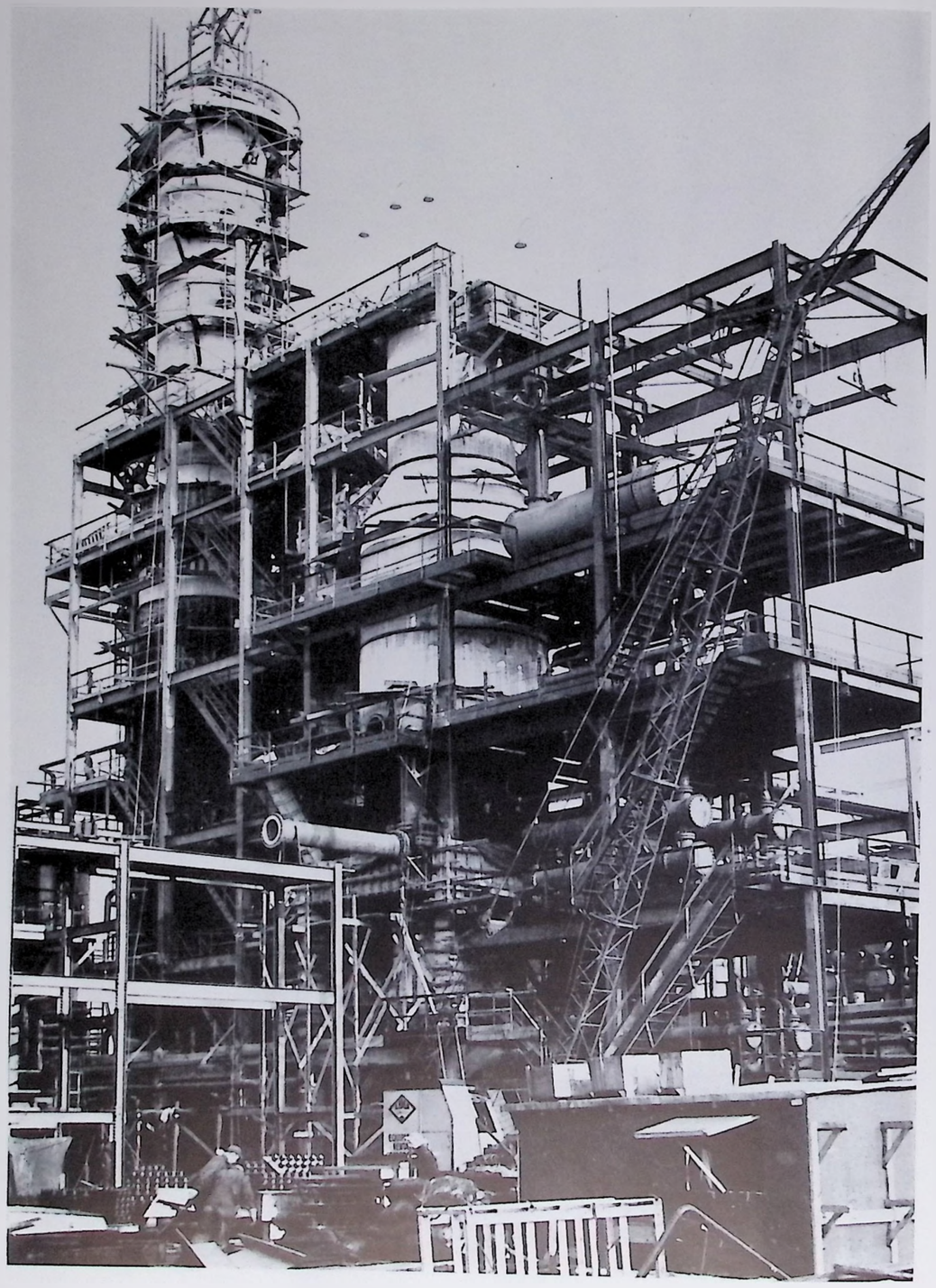
# FOREWORD

The purpose of the book is to give those who design, specify, and purchase industrial insulations sufficient facts to enable them to make the correct decisions when confronted with most insulation problems. While the information in this book does not completely cover the available knowledge of industrial insulations, it is an attempt to organize the essential data on these materials and make them available in one place.

Much of the information you will find in the following pages is the result of more than a half century's experience on the part of Armstrong engineers, construction superintendents, and foremen. Many of the insulation uses and installation methods they have developed through the years have become standard procedure in the industry.



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# Buying Industrial Insulations

Most industrial insulations, like other building materials, are bought on contract, either on a fixed sum or cost plus basis.

Therefore, by its very nature, in the insulation business as in the entire building industry, the buyer cannot see what he is getting until after he has agreed to pay for it. He can look at samples of the insulation and the sundry materials that will be used on the job, but he can't see what the workmen will actually do with those materials until they have been applied and the job is finished, ready for operation.

Although a contract is a legal binding document it cannot guarantee that the purchaser will get an insulation job installed with the best quality materials and in accordance with the best insulation construction practice. It is impractical, if not impossible, to draw up a contract so wide in scope and so accurate in detail that it cannot be interpreted to the contractor's advantage if he really wants to do so. Naturally, too, some contractors know more about insulation design, construction, and workmanship than others. For these reasons, the major factors determining whether or not you get the quality that you have agreed to pay for in an insulation job are the integrity and ability of the insulation contractor you select. In the final analysis your wisest move in purchasing an industrial insulation job is to choose a contractor in whom you can have complete confidence.

Except for firms who buy insulation frequently it is not easy to select a contractor in whom you can have full confidence. Even the steady buyer has difficulty selecting the best contractor because, for example, in low-temperature work it often takes years for the true quality of design, materials, and workmanship to prove itself. We hope it may aid your selection of a contractor to know the following brief facts about the Armstrong Cork Company and its policies and practices in the industrial insulation business.

The Armstrong Cork Company is an average-sized corporation and has enjoyed a steady growth since its founding in 1860. It is engaged in a variety of fields as diversified as flooring, glass packaging, and textile mill specialties. Its approach is generally conservative, and it takes a long-term viewpoint in its business relationships in all fields. What is most important to the insulation buyer is the Company's general attitude toward its customers and its ability to perform industrial insulation work.

The interest of the Armstrong Cork Company toward any insulation work it performs has always extended beyond the one year guarantee period customarily used in contracts. In cold storage construction work this is of particular importance because many faulty construction practices do not come to light until after the usual guarantee period has expired. It can probably be said that in a typical installation the difference between good and poor design and workmanship makes itself obvious near the end of the normal life or usage of the insulation rather than at the start. The purchaser's bonus for selecting an able contractor may well be several extra years of efficient and trouble-free service from the insulation job.

The ability of Armstrong's Contracting Organization to perform insulation work is described briefly in the chapter that follows, and the remainder of the book is largely devoted to the facts about the insulation products the Company manufactures and supplies and to the methods used in applying those products.



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# Armstrong's District and Branch Offices






# Armstrong's Contracting Organization

Armstrong is not only a manufacturer of industrial insulations but is also a contractor for the application of these products. Consequently, the Armstrong Cork Company not only installs its own products but will install the products of other manufacturers when they logically should be included with insulation work, or when they supplement the products that Armstrong manufactures. The installation of cold storage doors, shelving, and tracking are typical examples of materials or equipment in this category.

The contracting operations of the Armstrong Cork Company are unique in at least one respect. There are very few companies, including building contractors, who operate year in and year out on such a large scale and maintain a comparable organization. Armstrong operates through 44 district and branch offices, covering most all of the important trading areas in the country.

Each district office operation is directed by a manager who is responsible for all work in his territory. The functions of billing, credit, research, and general policy are handled in the home offices in Lancaster, Pennsylvania. This enables the district manager to devote a large part of his time to direct supervision of field activities and the solution of insulation problems.

This integrated system can offer unusually efficient service to all types of insulation buyers. Take, for example, a large engineering company having home offices on the Atlantic Seaboard, and buying insulation work along the Gulf Coast, or in the Far West. Armstrong's well-knit organization can help the home office engineers develop plans and specifications. Then the actual installation can be carried out with complete understanding by another Armstrong office in the territory where the work is being done. Thus the engineering firm has the advantage of being able to work all over the country with a familiar organization. Paper work is handled in the same manner on every job so that misunderstandings are eliminated, communications are simplified.

Not only the large engineering company but also every other insulation buyer may feel free at any time to call upon the services of the trained engineers who staff each Armstrong office. Many of our customers like to consult with these men while plans are on the drawing board. They have found that qualified advice during early stages of planning avoids problems, saves money, and makes the job a better one.

In addition to the engineering advice available through Armstrong's district offices, the company maintains at the home offices a staff of engineers and research scientists whose job it is to work on the solution of especially difficult problems involving industrial insulations.

Also in Lancaster is a staff department where all contracts are checked to insure complete accuracy of price and specifications before being signed by the contracting officer.

Out in the district offices again, trained construction superintendents schedule delivery of materials, arrange job-labor schedules, and generally supervise all contract installation in their areas. Working directly under these men are construction foremen whose responsibility it is to get the job properly done.

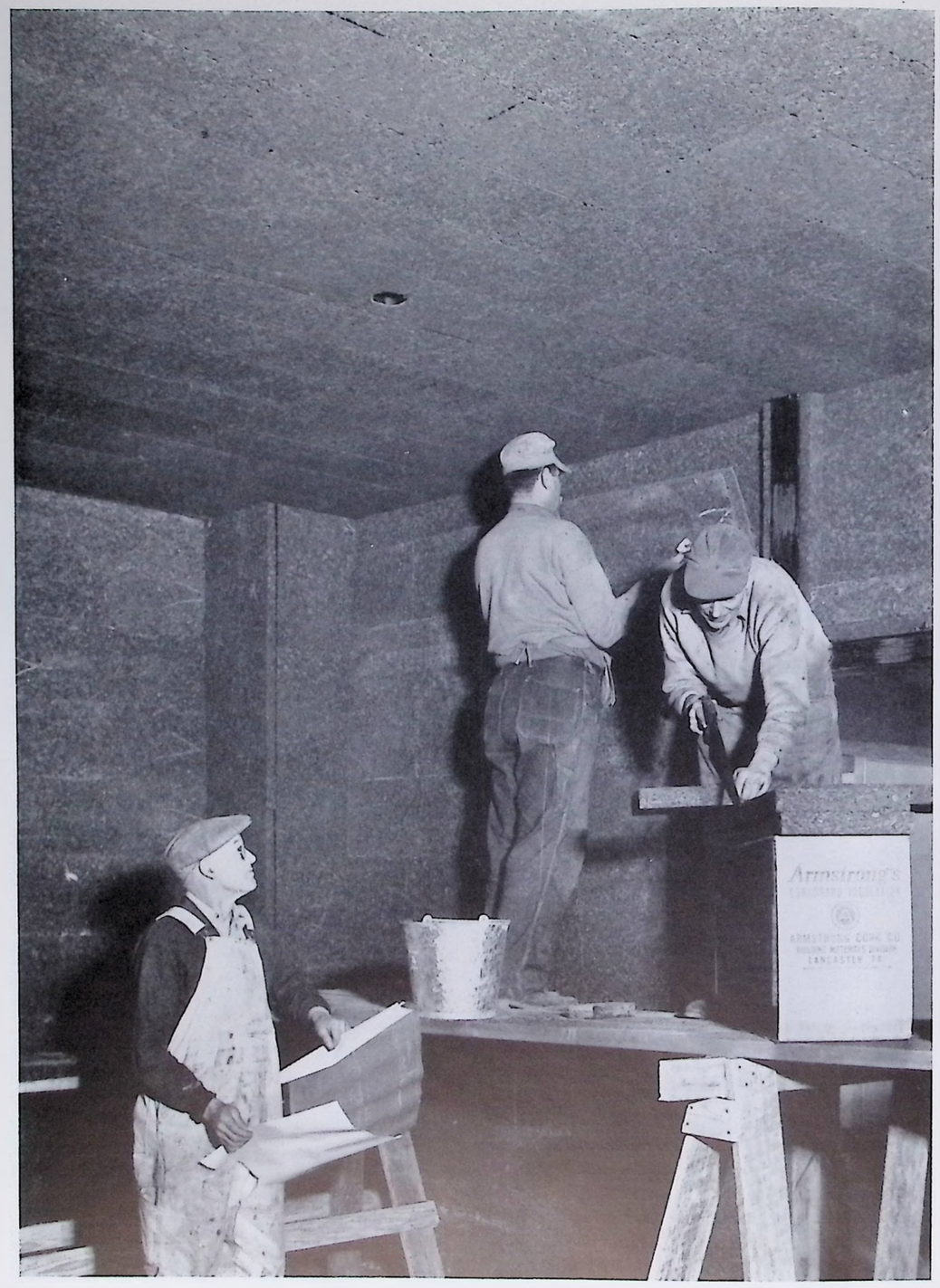
All of the people in the Armstrong Contracting Organization have been trained in the tradition of good workmanship. Our long experience in the insulation business has convinced us that even the best materials cannot perform at a high degree of efficiency year after year unless they are properly installed.

While this is true of all insulating materials, it is particularly important in the low-temperature insulation field. Because of the moisture problem, workmen who install low-temperature insulations must understand the importance of proper application methods and of sealing moisture out of insulation construction.

A discussion of moisture and how it must be reckoned with in all low-temperature work is included in Section I, beginning on Page 12.



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Section I

# COLD ROOMS

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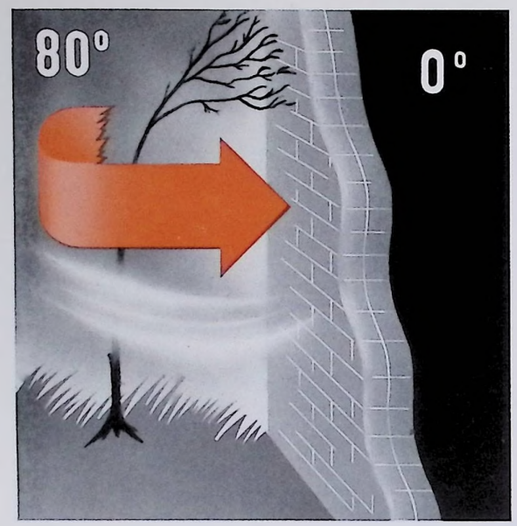
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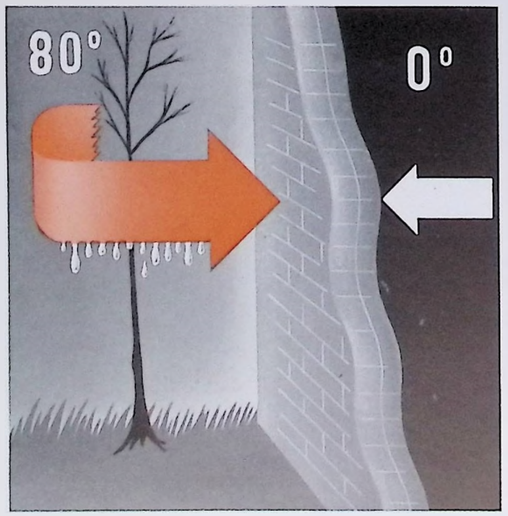


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# The Moisture Problem in Low-Temperature Insulation




Wind Pressure




Vapor Pressure

One of the problems faced by the designer of low-temperature facilities arises from the fact that available data on insulating materials, particularly the figures on heat transmission, are based on new materials, unaffected by service conditions. Actually, the most important single fact that must be taken into account is that, from the very day any insulated construction is put into service, the insulating material is subjected to the deteriorating effect of moisture, the great natural enemy of all low-temperature insulation. The most important factor in determining how well any insulation is going to retard heat flow over a period of time is how well that material will resist the penetration of moisture and withstand its damaging effects.

The moisture that plays havoc with insulated construction is the unseen moisture that is always present in the atmosphere. There is a surprising amount of moisture in air. On the average day, for example, if all the moisture in the air above Manhattan Island were to fall to the earth in the form of water, it would amount to a deluge of 543 million gallons. Because moisture in air is actually part of the air, it can go anywhere that air can go. No building material in common use today is absolutely impervious to this flow of air and the moisture that it contains.

Airborne moisture is driven through a wall by three forces, wind pressure, vapor pressure, and stack effect. How these forces operate can be shown with a 13″ thick brick wall as an example.

### Wind Pressure

A 30-mile an hour wind blowing against the 13″ thick brick wall will drive 21 cu. ft. of air an hour through every square foot of wall surface. With an outside temperature of 80° and a relative humidity of 70%, three quarts of water would be driven through 200 sq. ft. of wall surface in one hour. In 24 hours those three quarts of water would grow to a total of 18 gallons.

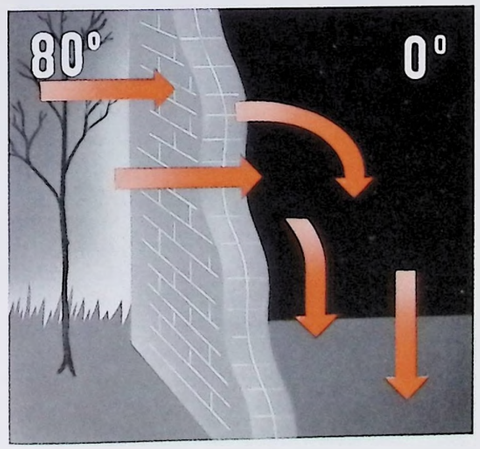


### Vapor Pressure

Even when the wind isn't blowing, moisture will force its way through building construction. Here's how it happens. When temperature within an insulated area is lowered, the air is chilled and gives up its moisture and an unbalanced condition exists. The warm outside air then contains far more moisture than the cold air inside the refrigerated space. This difference in moisture content of the air sets up a force called vapor pressure. Nature, in trying to equalize both temperature and moisture content of inside and outside air, forces heat as well as vapor right through the construction. With the temperature of the outside air at 80° and the relative humidity 70%, and the temperature in the cold room held at 0°, vapor pressure will force about one quart of water a week through every 200 sq. ft. of 13″ thick common brick building wall surface.

### Stack Effect

The third driving force that pushes moisture through building constructions is called stack effect. It works like this. The natural movement of warm air toward cold air sets up a pressure on the outside of the building wall. When the warm air has forced its way through the wall, it cools off as it reaches the refrigerated interior and then settles to the floor, as its temperature drops. Cooling actually shrinks the air, and this shrinkage, combined with falling of the cold air toward the floor creates a partial vacuum at the top of the room. More warm air rushes in to overcome this vacuum and a constant current develops. This current of inflowing warm air brings still more moisture with it. These three natural forces, wind pressure, vapor pressure, and stack effect, all working together will drive unbelievably large amounts of moisture through a brick wall or any other building construction.




Stack Effect

### Dew Point

When the inside of the wall is lined with an insulating material and low temperatures are held within the room, the natural phenomenon of dew point also enters the picture. Dew point temperature is that temperature at which the moisture in the air condenses and is deposited in the form of water. Of course, dew point temperatures will vary with the temperature outside the insulated wall and the temperature within the refrigerated space, but almost invariably the place where the vapor in the air turns to water occurs somewhere within the insulating material itself. If the insulation is of a type that absorbs water, it soon loses much of its ability to stop heat flow, for water is a good conductor of heat.

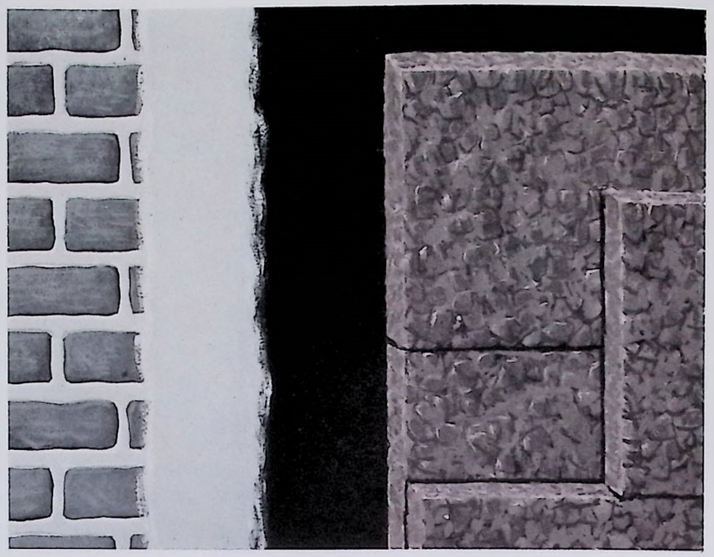
To make matters worse, if temperatures within the insulation are low enough, all the accumulated water turns to ice. The pressures set up by the expansion of ice forming in the insulation can actually lift up a concrete wearing floor or buckle an insulated wall. When this happens, the entire job must be torn out and re-insulated.

### Wall Must Be Sealed Against Moisture

The first step in preventing this costly damage is to seal the building wall against vapor infiltration. The most practical way of doing this yet discovered is known as "The Asphalt Specification," a sealing method developed by Armstrong back in 1924. It consists of eliminating hollows in the wall and at the same time cutting down air flow with a coat of portland cement plaster. Then a coat of asphalt priming paint is applied to seal the pores in the plaster and to provide a



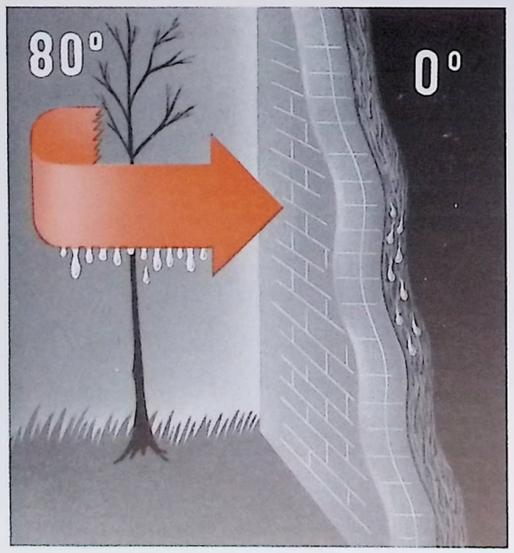
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This cut-away drawing shows recommended method of erecting Armstrong's Corkboard over a brick wall. The wall is first back plastered to make it true and even. Asphaltic priming paint over the plaster seals vapor out. The corkboard is then applied in hot asphalt, which reinforces the vapor seal and is a strong adhesive, holding the insulation firmly in place.

good bond with the hot asphalt in which the insulation is dipped before application. After the insulation has been erected, a finish of portland cement plaster or asphalt emulsion is applied to the interior wall surfaces.

Both these finishes protect the insulation from bumps and abrasion, but they don't offer absolute protection against moisture. For moisture can get into insulation from the inside of the room as well as the outside.




Dew Point

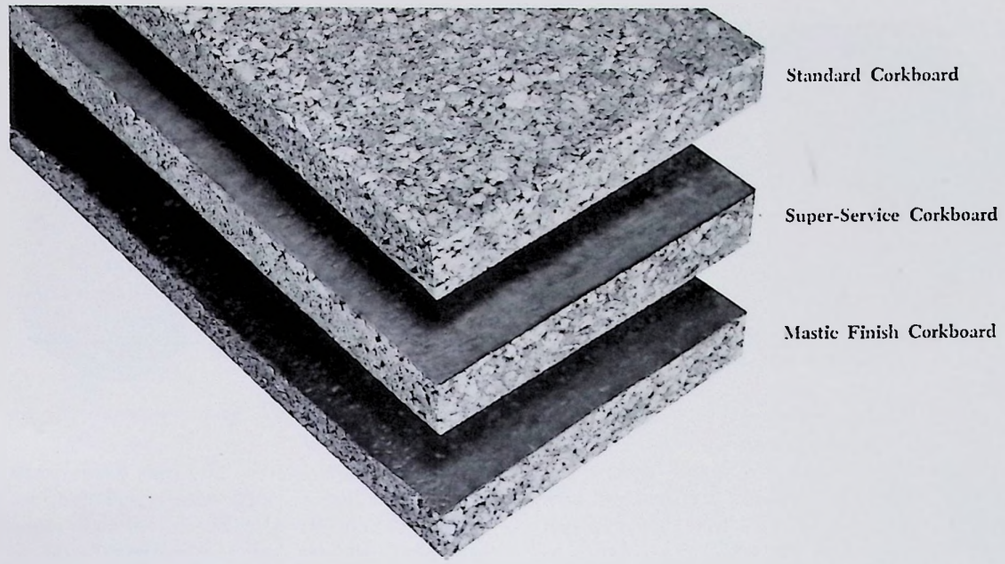
### Moisture Flow Reversed

During the winter months in rooms that operate at above freezing temperatures, temperature differentials are often reversed. Then the flow of air and moisture is reversed, too. The moisture from within the room will work through the finish and deposit itself in the insulating material. In addition, washing down of cooler rooms, or wet produce being brought in adds to the moisture on the inside. If a break occurs in the finish because of a blow, settling of the building, or even vibration from machinery, moisture will build up in some insulations very rapidly.

Not only are breaks liable to occur in the interior finish, but the vapor seal on the outside of the insulation may be broken by the same causes. When a break occurs in either the interior finish or outer vapor seal, the amount of moisture damage depends on the character of the insulating material. That's why it pays to use insulation that has good moisture resistance.

A moisture-resistant insulation will resist the efficiency-robbing effects of moisture that may get through the seal. It will pay its cost many times over in longer insulation life, lower refrigeration costs, and elimination of repair bills.






# Armstrong's Corkboard Insulation For Cold Rooms

### The Properties of Cork

Cork is truly an unusual product of nature. It is actually the outer bark of an oak tree that flourishes commercially only in the area surrounding the western Mediterranean Sea. Instead of being fibrous in structure, as is the bark of most other trees, the bark of the cork oak is composed of tiny cells, so small that there are 200 million of them to every cubic inch of cork bark. These tiny cells give to cork a high resistance to the passage of heat. Each cell is filled with still air, and next to a vacuum, still air is the best insulation known. The smaller the space in which the still air is confined, the less opportunity there is for the air to circulate and transfer heat. The air filled cells in cork are so small they can be seen only through a microscope.

### High Moisture Resistance

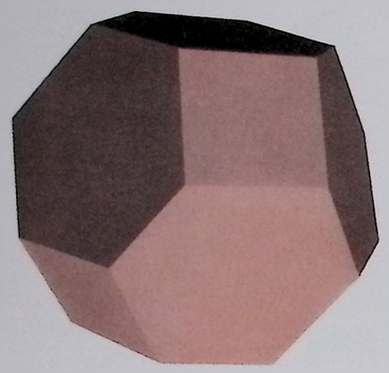
This remarkable cellular structure also gives the material its high degree of natural moisture resistance. Each tiny cork cell is a perfect geometric shape, having 14 sides. These 14 sided cells fit together so closely that there is no space between them where moisture can accumulate. In addition, the walls of each cell are made of a resinous material, so tough that moisture cannot break through to the still air space within.

But even the high moisture resistance of corkboard and the use of the vapor sealing methods described on Pages 15 and 16 will not alone assure a trouble-free, low-temperature insulation job. How well moisture will be kept out depends, in the final analysis, on the craftsmanship of the men who actually install the job.

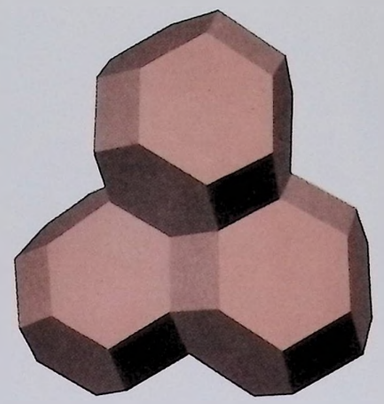
If these workmen fail to appreciate the dangers of moisture infiltration, if they are careless or ignore instructions, moisture will find the weak spots in the construction. Then the job will become a continuing source of unnecessary operating and repair expense, and will deteriorate rapidly, calling for costly replacement of the insulation in a relatively short time.



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Cork is composed of millions of 14-sided cells which fit together perfectly, with no air spaces between the individual cell walls. Each tiny cell is filled with still air.



An insulation buyer can guard against the moisture infiltration problem by making sure that the work is properly planned. Then he can select insulation that has inherent resistance to moisture. Finally he can deal with a contractor who has workmen trained to do everything practical to seal moisture out of the construction.

### Armstrong's Corkboard

Through its many years of proved and dependable service, corkboard has become the recognized standard of comparison for all low-temperature insulating materials. Corkboard's low thermal conductivity, combined with its natural resistance to moisture and its other desirable physical characteristics, makes it a most practical and efficient insulating material for every low-temperature installation.

Armstrong's Corkboard is made of carefully sized granules of pure cork. These granules are compressed and baked at very high temperatures into large blocks. In the baking process the natural resins of cork are released and serve as an adhesive, firmly bonding the granules together. After the large, homogeneous cork block is removed from the mold, it is cut into the various accurately sized pieces of Armstrong's Corkboard Insulation.

Actually more than 75% of the volume of a piece of corkboard is air. This still air gives to cork insulation its low thermal conductivity of 0.27 Btu. per square foot per hour per degree temperature difference at 60° F. mean temperature. (See Conductivity Curve on Page 19.)

The tough walls of the tiny cells which make up each cork granule effectively seal moisture out of the material. Also, because of the unique cellular structure of cork, water cannot be drawn through the material by capillary action. Thus it does not have the blotting paper effect which causes materials of fibrous composition to become water soaked rapidly when exposed to the moisture conditions of cold room work.

In addition to its high insulating efficiency and great natural moisture resistance, Armstrong's Corkboard offers the following advantages:

**Resistance to Decay**—Armstrong's Corkboard has outstanding resistance to decay, mold, or other structural change.

**Structural Strength**—The structural strength of corkboard is good. Solid corkboard walls can be erected to a height of 14′ without being held in place by expensive supporting construction.

**Light Weight**—The weight of Armstrong's Corkboard averages from 0.55 to 0.65 lb. per board foot. It is easily and quickly handled and erected in any kind of low-temperature construction.

**Good Key for Finishes**—Armstrong's Corkboard provides a good key for finishing materials. There is no need to use metal lath or hexagonal wire mesh to hold finishes in place over corkboard surfaces.

**Fire Resistance**—Corkboard is classified as a fire-retardant material. It will not take fire from sparks or embers. It can be ignited only by flame and then burns very slowly and only as long as it is in direct contact with the flame. When the flame is removed, combustion ceases immediately. Corkboard will not smolder or carry fire. In fact, the fire-retardant properties of corkboard have served to check the spread of fire.

**Structural Stability**—Corkboard insulation does not buckle or swell, shrink or warp, either while being erected or afterward. It lies flat and stays flat, providing smooth, even surfaces, free from humps and waves.

**Resistance to Settling**—Rigid corkboard insulation will not settle and pack down, even under the most severe conditions of vibration. It stays permanently in place, leaving no empty spaces where heat and moisture can work their way through the insulated construction.

**Free from Odor**—Armstrong's Corkboard is sanitary and free from any objectionable or contaminating odor. It does not provide a harboring place for vermin.

**Federal Specification**—This material equals or exceeds Federal Specification HH-C-561b for corkboard insulation.



### Types of Armstrong's Corkboard

Armstrong's Corkboard is supplied in three types:

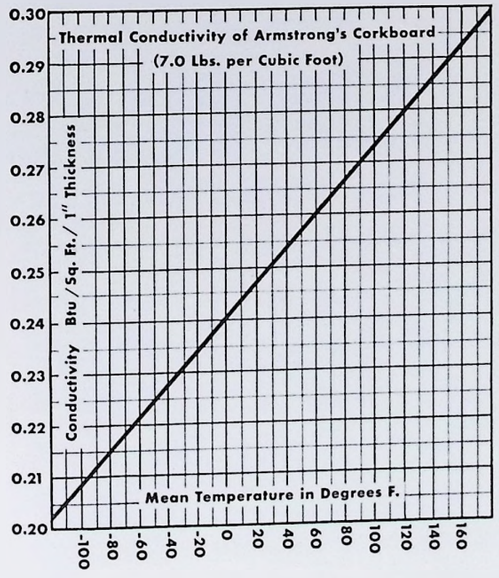
1. Standard Corkboard, which is accurately sized boards of pure cork insulation ready for application.

2. Super-Service Corkboard, which is factory sealed on both sides with a special ironed-on asphalt mastic coating. This coating is firmly keyed to the surface and is entirely free from breaks and "pinholes." It is used where extremely severe moisture conditions make the special protection afforded by the extra asphaltic coating desirable for longer insulation life.

3. Armstrong's Mastic Finish Corkboard, which has a ⅛″ asphalt mastic coating on one face. This coating serves as a finish and provides extra protection against moisture from within the insulated room.

### Sizes of Armstrong's Corkboard

Armstrong's Corkboard insulation is manufactured in 12″ x 36″, 18″ x 36″, 24″ x 36″, and 36″ x 36″ sizes. Thicknesses of the product are 1″, 1½″, 2″, 3″, 4″, and 6″.




### Packaging and Shipping Information

Quantities less than 30,000 board feet of Armstrong's Corkboard are shipped in bulk, tubes, or cartons, at the customer's option, subject only to the regulations of the carrier.

Larger quantities are ordinarily shipped in bulk or in tubes, but can be shipped in cartons at slight additional charge.

### Container Contents

Armstrong's Corkboard

Cartons (all sizes).....72 bd. ft.
Tubes (1″, 1½″, 2″, 3″).....54 bd. ft.
Tubes (4″).....48 bd. ft.

### Approx. Weights

| Bulk or tubes | Cartons |
|---|---|
| .60 lb. | .65 lb. |



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# Sundry Materials for Use in Cold Room Construction

The importance of using correct sundry materials to erect, finish, and maintain Armstrong's Corkboard insulations cannot be overemphasized. For satisfactory results only sundry materials formulated to withstand conditions found in low-temperature construction should be used.

Armstrong's insulation sundries are the result of years of experiment and research in the most effective methods of installing insulation. Each product described on the following pages has been developed specifically for the phase of the job where its use is recommended.

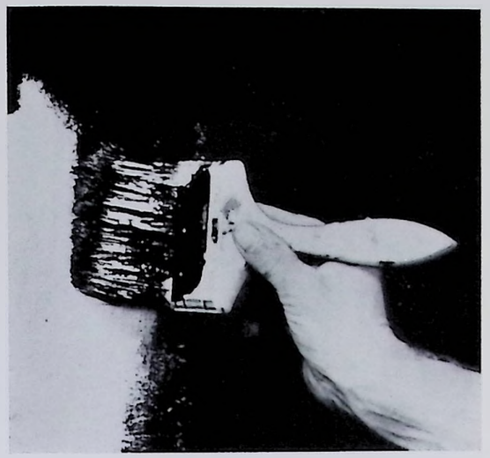


**Armstrong's No. 4 Asphaltic Paint**—This asphaltic primer is non-corrosive and rust preventing. It should be used on steel or other metal surfaces before application of low-temperature insulation in either hot asphalt or adhesives. No. 4 Asphaltic Paint forms a strong and long-lasting film which is extremely resistant to moisture, as well as acids, alkalis, and chemical fumes.

**Coverage**—Approximately 150 sq. ft. per gallon of No. 4 Paint.

**Packaging**—1- and 5-gallon cans and 30- and 55-gallon drums. Weight is 9 lbs. per gallon.





**Armstrong's No. 3 Asphaltic Paint**—This asphaltic paint has been especially developed for priming masonry, concrete, or portland cement plaster surfaces prior to erecting insulation in hot asphalt or cold erection plastic. It penetrates the pores and forms a tough film which helps seal the surface against air and vapor penetration and provides a strong bond with the hot asphalt or cold plastic. Armstrong's No. 3 Asphaltic Paint is unaffected by temperature change and becomes stronger with age.

**Coverage**—100 sq. ft. per gallon sprayed on in two coats, 75 sq. ft. per gallon brushed on in one coat.

**Packaging**—1- and 5-gallon pails and 30- and 55-gallon drums. Weight is 8½ lbs. per gallon.



**Armstrong's Erection Asphalt**—This is a 180° to 200° F. melting point odorless asphalt specially formulated for erecting Armstrong's Corkboard. For wall, floor, and ceiling insulation, as well as ducts, columns, and in other applications, Armstrong's Erection Asphalt furnishes a tough, lasting bond and a tight seal against air.

This asphalt handles well with today's hot erection methods. It is not subject to chemical change, resists cracking or softening under extreme temperature variations, and maintains these qualities for many years.

**Coverage**—Four-tenths of a pound of Armstrong's Erection Asphalt will cover approximately one square foot.

**Packaging**—450-lb. drums displacing about 8.6 cubic feet, and in 100-lb. paper wrapped rolls.



**Cold Erection Plastic**—This material is used in erecting Armstrong's Corkboard Insulation where the use of hot asphalt is impractical or hazardous. The material possesses virtually the same properties as Armstrong's Erection Asphalt.

The basic ingredient of cold erection plastic is erection asphalt, dissolved in a solvent and mixed with an inert filler. The solvent odor disappears when the material is thoroughly dry. Cold erection plastic can be used in rooms designed to operate in any temperature range. It is not recommended as a cold room finish.



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**Armstrong's No. 340 Waterproof Cement**—This medium body cement is recommended for the erection of corkboard insulation against metal surfaces. It also adheres tightly to concrete and plaster. Armstrong's No. 340 Cement should be spread with a special square notched trowel over one entire surface of the insulation board before it is put in place.

No. 340 Cement is easy to work and possesses the high initial strength necessary to support the weight of the insulation without reinforcing. It remains plastic after drying and shrinks only slightly during the setting and drying period.

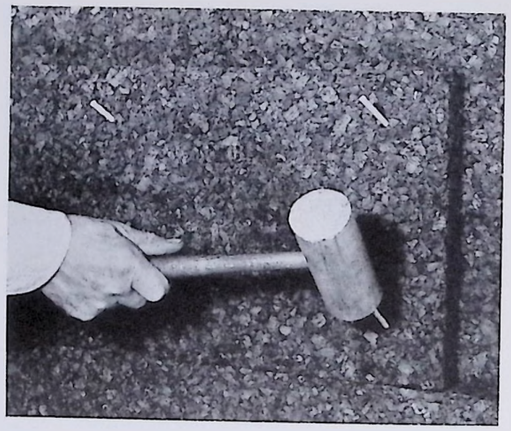
**Coverage**—30 sq. feet per gallon, applied with a notched trowel.

**Packaging**—1- and 5-gallon cans. This cement weighs 12½ lbs. per gallon.



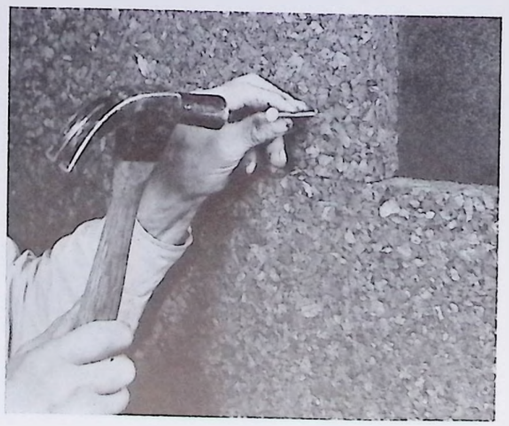
**Hardwood Skewers**—These hardwood skewers are especially treated with an odorless preservative to prevent mold growth and dry rot. They are used to secure the second and succeeding layers of corkboard insulation to the preceding layer. Two skewers should be used per square foot for wall insulation and partitions of solid insulation, three per sq. ft. for ceilings. Treated hardwood skewers are available in the following lengths and diameters:

| Length | Diameter | Weight per M |
|---|---|---|
| 4″ | ¼″ | 3 lbs. |
| 5½″ | ¼″ | 6½ lbs. |
| 7″ | ¼″ | 10 lbs. |



**Galvanized Nails**—These specially hot-galvanized nails, with ½″ diameter heads and thin shanks, are used for the erection of Armstrong's Corkboard. They are recommended to secure the first layer of insulation against wood surfaces and for toenailing the first layer in partitions of solid corkboard insulation. Two nails should be used per square foot of wall, three per square foot of ceilings. Available in the following sizes:

| Length and Sizes | No. per 100-lb. Keg |
|---|---|
| 3″ x No. 9 | 6,000 |
| 4″ x No. 9 | 4,500 |
| 5½″ x No. 8 | 2,900 |
| 7½″ x No. 8 | 2,000 |







**Armstrong's Asphalt Emulsion**—This material is the basic ingredient for Armstrong's Plastic Emulsion and S. P. Emulsion Finishes. Asphalt Emulsion is a clay emulsion of high grade, finely dispersed asphalt which when mixed on the job according to the following formula, can be trowelled directly to the surface of the insulating material. For plastic emulsion (sand-finish) mix according to the following:

50 gallons Armstrong's Asphalt Emulsion
112 lbs. asbestos fibers
275 lbs. (2¾ cu. ft.) dry, screened sand
15 gallons clean water

For S. P. Emulsion (smooth finish) mix as follows:

50 gallons Armstrong's Asphalt Emulsion
115 lbs. asbestos floats
15 gallons clean water

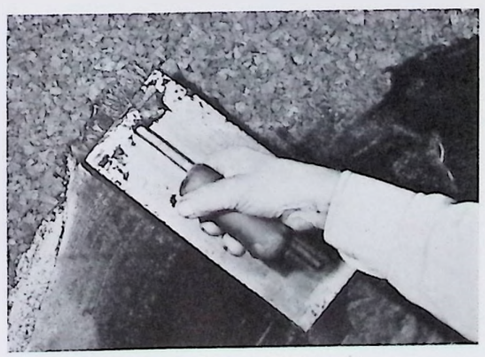
**Packaging**—Armstrong's Asphalt Emulsion is packed in 1- and 5-gallon cans and in 30- and 55-gallon drums. It weighs 9½ lbs. per gallon. (See Footnote 1 on Page 24.)



**Armstrong's Plastic Emulsion**—This product is a complete asphalt plastic finish ready for application as received. It is a mixture of Armstrong's Asphalt Emulsion, asbestos fibers, sand, and water. Plastic Emulsion is trowelled directly to the insulation surface in two coats.

**Coverage**—8 sq. ft. per gallon of Armstrong's Plastic Emulsion for a two-coat surface.

**Packaging**—1- and 5-gallon cans and 30- and 55-gallon drums. Armstrong's Plastic Emulsion weighs 11 lbs. per gallon. (See Footnote 1 on Page 24.)



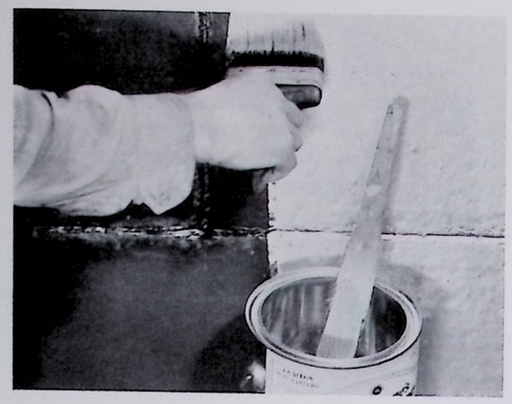
**Armstrong's S. P. Emulsion**—This is a factory mixed combination of Armstrong's Asphalt Emulsion and asbestos fibers, ready for application to insulation surfaces. It is used when a smooth, plastic finish is desired. The emulsion is trowelled on directly in two coats to a final thickness of approximately ⅛″ when dry.

**Coverage**—9 sq. ft. of two coat surface for each gallon of Armstrong's S. P. Emulsion.

**Packaging**—1- and 5-gallon cans and 30- and 55-gallon drums. Weight is 10 lbs. per gallon. (See Footnote 1 on Page 24.)



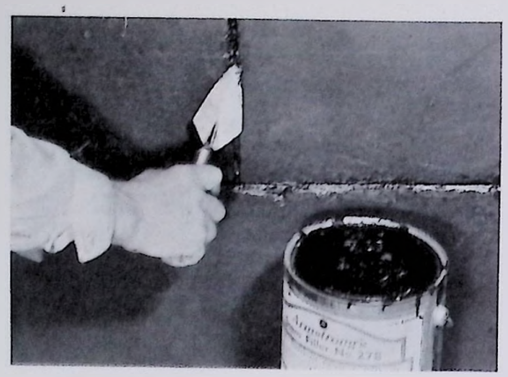
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**Armstrong's Aluminum Cold Storage Paint**—This paint provides a light-reflective finish for asphaltic surfaces. It does not discolor due to bleeding through of the asphalt, is odorless when dry, and does not crack at low temperatures. This Aluminum Cold Storage Paint should not be used on wood, metal, or any surfaces other than asphaltic ones. It is shipped as liquid and powder, packaged separately, which must be thoroughly mixed just prior to using.

**Coverage**—one gallon will cover 250 square feet in two coats.

**Packaging**—½-, 1-, and 5-gallon cans. It weighs 9 lbs. per gallon.



**Armstrong's No. 27-B Seam Filler**—This is an asphalt mastic compound designed to fill and seal the joints between pieces of Armstrong's Mastic Finish Corkboard. It has been specially developed to withstand the low temperatures used in refrigerated construction, and will not shrink out of joints in the insulation.

**Coverage**—One gallon of No. 27-B Seam Filler is shipped as a sundry with every 150 square feet of Armstrong's Mastic Finish Corkboard.

**Packaging**—½-, 1-, and 5-gallon cans. Weight is 13½ lbs. per gallon.



**Insulating Paper**—This is a black paper saturated and coated with pure asphalt. It is used as a vapor seal when erecting Armstrong's Corkboard insulation against wood and frame construction. In application, joints of insulating paper should be lapped not less than 3".

**Packaging**—36" wide rolls, each containing 500 sq. ft. Weight is 38 lbs. per roll.



**Asbestos Floats**—These floats are a special grade of asbestos fiber used for mixing with asphalt emulsion. They give a dense, tough, hard quality to the final asphalt plastic finish applied to walls or ceilings of low-temperature rooms.

**Packaging**—100-lb. bags.

I. Armstrong's S. P., Plastic, and Asphalt Emulsions should not be applied when the temperature is below 40° F. Heat and fans should be provided if necessary to maintain this temperature until the finish is thoroughly dry. When dry the finish can be used in rooms operating at temperatures as low as 25° below zero.

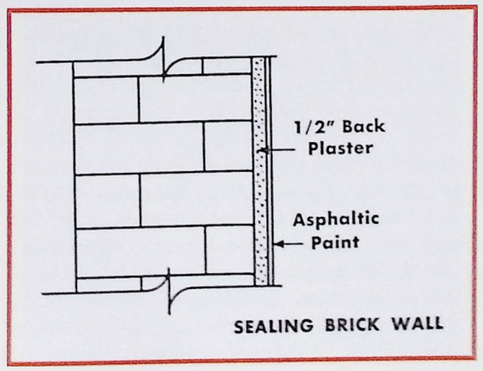


# General Recommendations For Construction of Cold Rooms

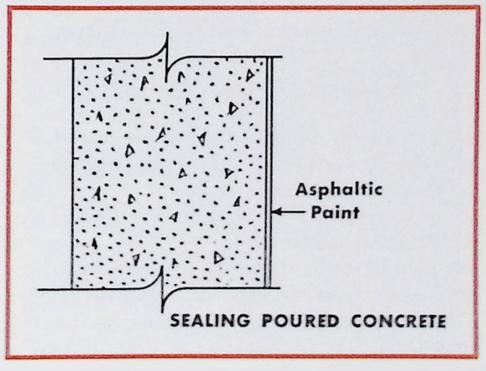
Not so many years ago the majority of all refrigerated space operated at temperatures above the freezing point. Today that situation is completely reversed. Frozen foods, and lower processing temperatures, have brought about a tremendous expansion of freezing and storage facilities that operate at temperatures well below freezing. Widespread use of low-temperature test facilities in manufacturing industries, the steady increase in the demand for ice cream, and many other factors have all contributed toward this change. These lower temperatures not only call for greater thicknesses of insulation to reduce refrigeration costs, but they also increase the severity of the service conditions imposed on insulation. The greater the difference in temperature between the refrigerated space and the outside air, the stronger are the natural forces driving moisture into insulated construction. The very fact that temperatures are low also adds an additional hazard to cold room construction. That hazard is ice, which will form wherever moisture collects in an insulating material under below-freezing conditions. The pressure exerted by freezing can bulge the walls of a cold room or heave up a concrete wearing floor. Under these conditions, sealing moisture out of the insulation becomes of paramount importance. (See Section I, The Moisture Problem in Low-Temperature Insulation, Page 14.)

### Building Construction Important

Keeping moisture out of insulation begins with the building itself. Wherever possible, walls, floors, and ceilings should be of solid brick or poured concrete construction. Air spaces that occur in hollow tile, or sheathed studs, or joists should be avoided. Air in these spaces contains moisture, which is likely to condense on the colder surfaces. This condensation will not only rot wooden construction, or drip down through the ceiling insulation, but will also freeze and build up into large ice formations when extremely low temperatures are used. When this construction cannot be avoided, as in existing buildings, hollow spaces must be ventilated so that the air can circulate and carry off moisture. When porous construction, such as concrete block or cinder block, or a porous type stone is used, coat the outer surface of the wall with Gunite Cement to reduce the air infiltration.



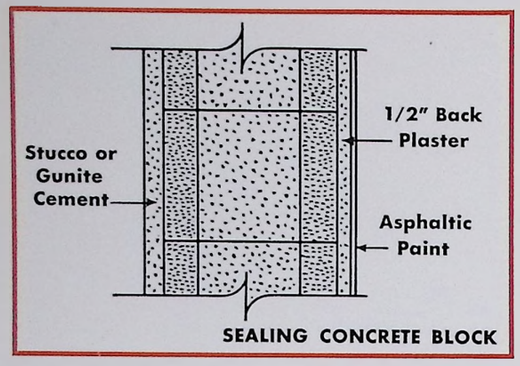
SEALING BRICK WALL

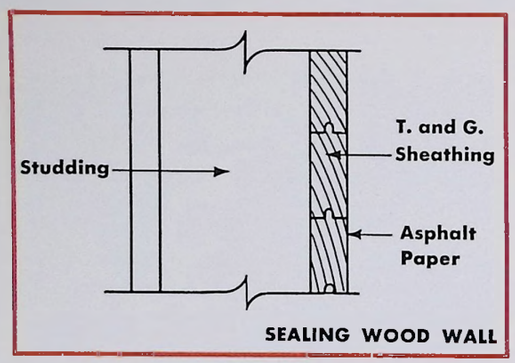


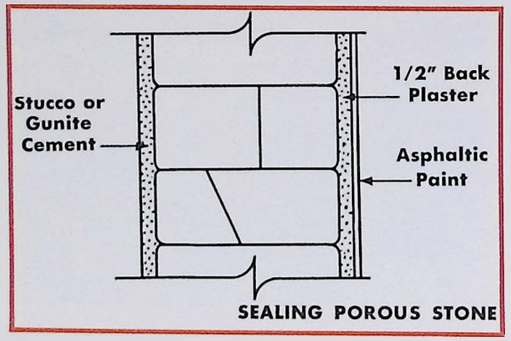
SEALING POURED CONCRETE



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### Apply Insulation to Even Surface

Next step in the fight to keep moisture out is to make the surface to which the insulation is to be applied even and true. In the case of brick, concrete or cinder block, or hollow tile or stone construction, this can be done with a coat of portland cement plaster in one or more coats, depending upon the irregularities of the surface. The plaster should be thick enough so that it is at least ¼″ in thickness at all high points. In the case of smooth poured concrete surfaces, the back plaster may be omitted. In addition to greatly reducing air infiltration, back plaster seals the masonry joints in the wall, and provides a tight, smooth surface for application of the priming paint which follows. It also provides a smooth surface against which to erect the insulation, thereby reducing voids between the insulation and the wall.

### Priming the Wall

Then Armstrong's No. 3 Asphaltic Priming Paint should be applied to the dry plaster surface. The solvent in this priming paint decreases its viscosity, and the low viscosity allows the paint to penetrate the pores of the wall. When the solvent evaporates, the asphalt remains in the pores as a vapor and air seal.

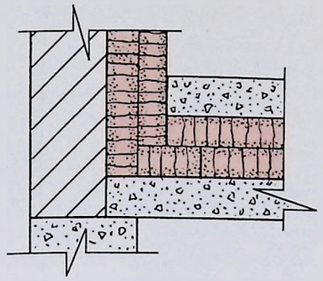
In addition to sealing the wall, the priming paint used must not soften under the temperatures produced when the sun is shining on the wall. In some cases these temperatures are as high as 150° F. on the outside of the wall, and it is possible that this can produce a temperature of 105° F. at the paint film. Obviously, an ordinary priming paint cannot be relied upon under these conditions. The paint used must have high film strength, as well as resistance to flow at maximum wall temperatures, and must withstand cracking or deterioration as it ages.

For best results, corkboard insulation should then be applied in hot asphalt. Since the bond between the priming paint and the asphalt is only as good as the asphalt used, the selection of the proper asphalt is a matter of prime importance. Armstrong's Erection Asphalt, for example, is tough and strong, has a minimum susceptibility to temperature changes, is not subject in itself to further chemical change, and maintains these qualities for many years.

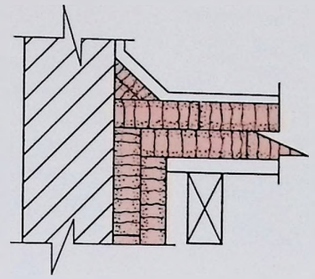
### Full Thickness Required at All Points

Building construction should take into account the fact that greater efficiency and longer life can be attained when space is allowed for full insulation thickness at all points. Foundation walls of low-temperature rooms should be poured short so that when the depressed subfloor of the room is poured it will overlap the top of the foundation wall. This permits application of full

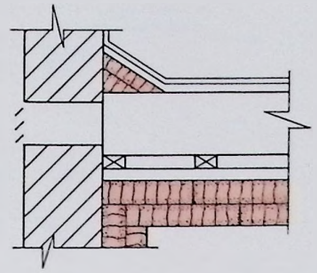




Foundation wall poured short with subfloor lapping over it allows full insulation thickness.



Clearance between building wall and first ceiling joist should allow for full insulation.



Stringers between joists and sheathing to which insulation is applied permit air flow.

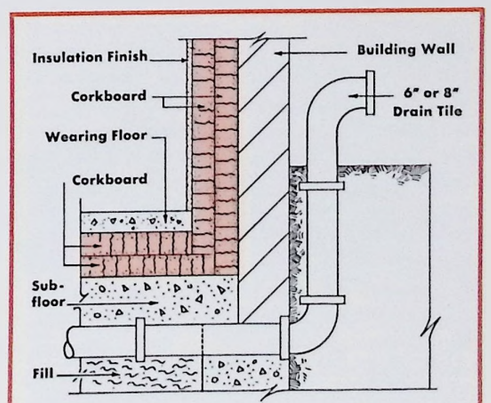
thickness of insulation at the point where wall and floor meet. In envelope construction, care should be taken to obtain sufficient clearance between the masonry wall and the adjacent ceiling joists, so that full insulation thickness may be applied at that point. The same precaution should be taken where a slot is required for a concrete ceiling slab in curtain wall construction.

Insulation should not be applied to wood sheathing placed directly on the underside of ceiling joists forming a roof deck. This sheathing boxes in the air space between joists, cutting down circulation and allowing damaging condensation to form in these spaces. The sheathing should be placed on 2″ x 3″ stringers, on 18″ centers, running at right angles to the direction of the joists. Louvers should then be planned for opposite outside walls. The stringers will permit the free circulation of air over the entire ceiling.

### Freezing Under Subfloors

One of the great danger points in freezer construction is ice formation in the ground under the floor of on-grade or below-grade freezer rooms. Over long periods of time, particularly with larger freezers, refrigeration in the room draws heat from the ground through the floor slab faster than it can be replaced by natural forces. No amount of insulation will prevent this flow of heat from the sub-soil, as insulation retards but does not eliminate heat flow. As the ground becomes colder, frost forms first under the center of the room, and then gradually works its way toward the edges until the ground is frozen solid in the form of a huge cone. After a while, cracks appear in the subfloor, then the walls. As the pressure grows, the walls and floor buckle and heave, and the space becomes unusable. The best way to guard against this trouble is to ventilate the sub-soil underneath on-grade or below-grade freezers with a system of air ducts. They can introduce sufficient warm air to keep the ground above the freezing point and prevent the formation of frost. Terra cotta tile ducts 6′ on centers or 2′ x 3′ concrete tunnels 16′ on centers can be used. They should be laid across the short dimension of the room.

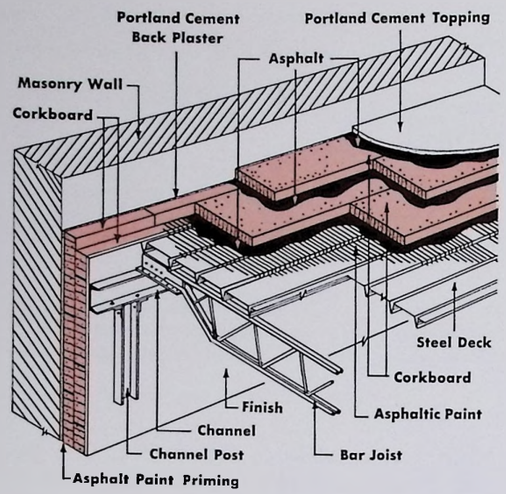
Soil composition, drainage, climatic locale, and floor dimensions all should be considered. Maximum dimensions of unventilated floors should not exceed 20′ x 20′. Under average conditions, natural heat from sun and earth will penetrate under the floor 10′ from the outside walls.

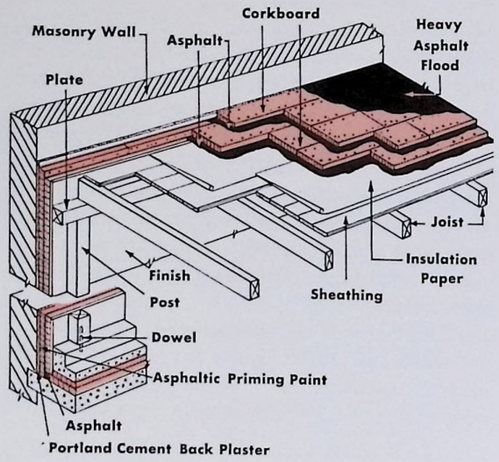


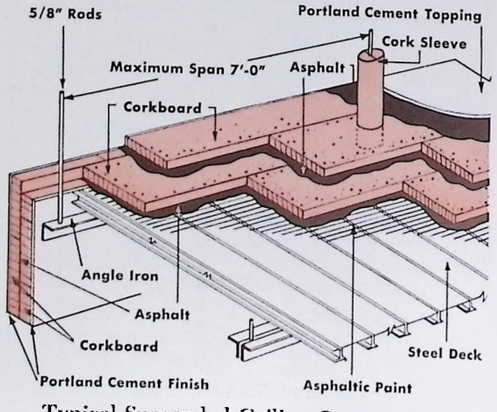

Detail of Subfloor Vent



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Typical Suspended Ceiling Constructions

## Cooler Rooms

Freezer rooms should never be located under cooler rooms operating at above freezing temperatures. In spite of the insulation between, floor temperatures may become so low in the cooler that products on the floor will freeze.

Coolers are usually insulated with 4" or 5" of Armstrong's Corkboard, depending on temperatures being held. Since temperatures are above 32°, moisture is not so serious a problem in cooler construction as in building freezers. However, avoidance of hollows in construction, and the use of back plaster and priming paint on the wall will pay their cost many times in increased efficiency and longer life for cooler rooms.

## Free Standing Walls

Many freezers and coolers are built on the side of the building or in the corner of a larger room. The partition walls of these rooms can be built without wood or masonry. Self-supporting or solid corkboard walls are strong and substantial, have no air spaces, and take up much less space than an insulated partition built of ordinary construction materials.

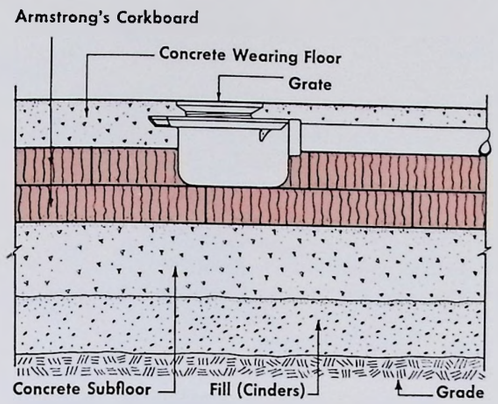
## False Ceilings

When the height of the room is greater than necessary for the cold room, a false ceiling is recommended to conserve refrigeration. This ceiling can be of tee-iron construction, or the cork can be laid in fabricated sheet metal pans or on wood sheathing. When it is necessary to suspend the ceiling from the construction above, hanger rods should be insulated with cork covering for a distance of about three feet above the ceiling to prevent frost formation on them.

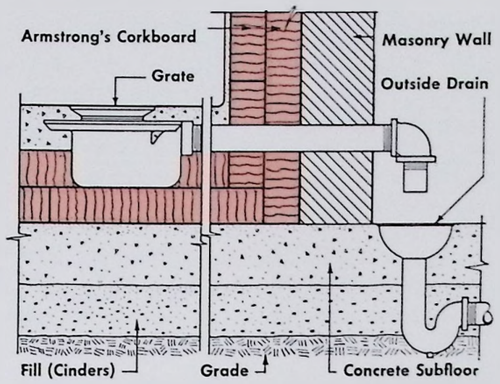
## Single or Double Layer Construction

In cooler rooms double layer construction is almost invariably used. It has the advantage of being more airproof than single layer construction due to the lapping of joints and the additional layer of asphalt between the layers of corkboard. Single layer work is somewhat less expensive to erect and for this reason is sometimes used in coolers. For freezer rooms double layer construction is always recommended.






A properly designed cold storage room drain can be installed without breaking through the floor insulation.




Well designed drain installed in converted cold room. Drip drain outside wall meets health code requirements.

## Floor Drains

Floor drains in cooler and freezer rooms also require special attention. A drain especially designed for cold storage room installation should be used. The significant feature of these drains is their short, squat dimensions. The vertical space between the outlet and the base is much shorter than that in a common drain fixture. This means that the trap can be placed on top of at least several inches of floor insulation in the refrigerated room. Thus the drain and its piping can be installed without puncturing and weakening the insulating envelope.

To avoid contaminating odors, most metropolitan areas have strict sanitary codes which forbid the direct connection of cooler room drains to sewer systems. Coolers in these localities must be drained into sewer lines through an open drip drain, located outside the walls of the low-temperature room.

Floor drains are included in the specifications for freezer rooms, when the freezer is designed to serve also as a cooler during certain seasons of the year. Freezer rooms which might be subsequently converted into coolers should also be equipped with properly designed floor drains.

Drains for freezer rooms are installed in the same manner as the cooler room drains. After a freezer has been cleaned and scrubbed down, glycerine should be poured into the drain to clear the trap of water before the room is put under refrigeration again. This glycerine must be replaced after every subsequent cleaning.

## Electrical Wiring

Electrical wiring of low-temperature rooms also should be given special consideration. Too many times, when the electrician arrives on the job, everything is complete except for the final insulation finish and sometimes that is already applied. No provision has been made for the wiring. Faced with this problem, the electrician can do nothing but wire the room from the outside, dropping outlets from the ceiling at those points where lights are required in the freezer.

Metal conduits are good conductors of warm air and heat and each conduit reduces the efficiency of the room. Moisture and warm air flowing into the room through the break made by the conduit will condense, turning to ice on the surrounding insulation and on the outer surfaces of electrical fixtures. The moisture and the warm air inside the conduit will do the same thing, forming more ice inside the conduits and fixtures. This condensation and freezing will damage the insulation and the electrical work.

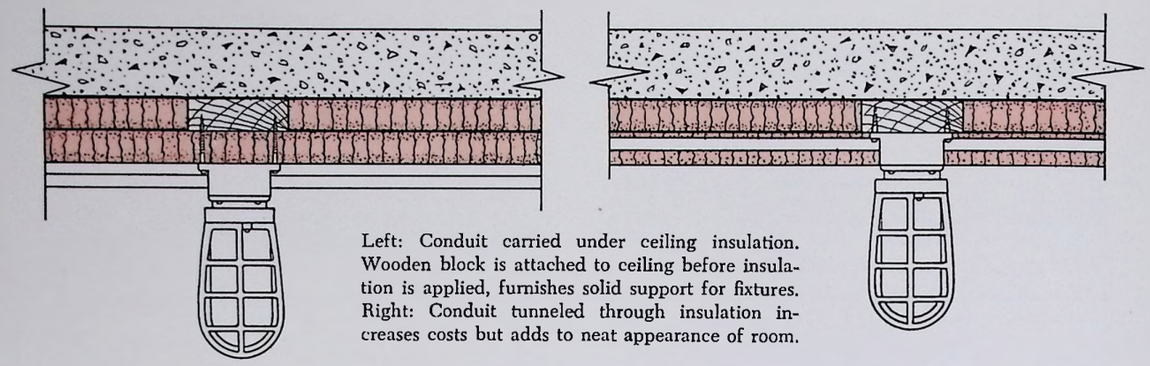
The best recommended practice is to bring the electrical wiring into the freezer through one conduit, piercing the wall insulation only once, just under the ceiling insulation.

It is good practice to seal the inside of the conduit at the point where it goes through the wall. Special sealing condulets, which can be poured with wax, will prevent the infiltration of air through the conduit into the room.

Suspending light fixtures and electrical conduits on the underside of the ceiling often pre-



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Left: Conduit carried under ceiling insulation. Wooden block is attached to ceiling before insulation is applied, furnishes solid support for fixtures. Right: Conduit tunneled through insulation increases costs but adds to neat appearance of room.

sents a problem. The insulation does not provide firm support for the weight of the fixtures and conduits, and it is hardly feasible to drill 6 or 8 inches through this ceiling insulation to obtain solid support in the concrete or wood ceiling.

This problem is solved by the use of wood blocks placed at predetermined locations on the ceiling in the first layer of insulation. Conduits and fixtures can then be hung to these blocks.

All wiring in a low-temperature room should be moistureproof, although it is not necessary to use lead cables. Conduits may be thin wall or threaded pipe, galvanized to prevent rusting. Fixtures and light switches should be vaporproof.

### Cold Room Tracking

Overhead tracking is a vital accessory for cold storage rooms built for the storage of heavy and cumbersome foodstuffs such as meat. Strong structural ceiling supports are needed to carry overhead tram-rail loads. Wooden beams are most commonly used because they are less expensive and do not require the special tools and skill required for handling structural steel. However, steel is more durable and is recommended for rooms where moisture is a problem. In the hands of competent mechanics, fabricated steel beams are installed more rapidly than wooden supports, and the labor costs saved will help make up the difference in original price.

Wherever possible, the tracking supports should be erected within the insulated room, entirely independent of the building structure. This places all the weight on the cold room floor, rather than from the roof structure, or overhead members, and maintenance is simplified.

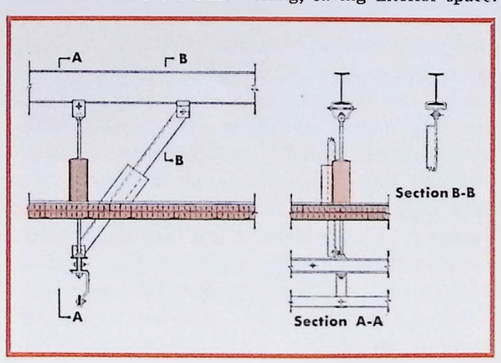
When external supporting framework is used, they are in the form of adequate beams built into the ceiling construction, ceiling beams supported at each end by the wall construction, or a separate supporting construction. In most cases, external supporting methods necessitate piercing the insulation at numerous points. This reduces the thermal efficiency of the job and opens up places where frost and moisture can accumulate.

False ceilings can often be used to good advantage when installing tram-rail equipment. In these cases, the overhead tracking must be installed before the insulation is erected.

### Interior Finishes

There are three types of interior finishes generally used in low-temperature room construction. These include Armstrong's Mastic Finish, which is a ⅛″ asphalt-coating ironed on the insulation at the factory; asphalt emulsion type finishes, which include Armstrong's S. P. and

Detail of cold room tracking under a false ceiling. Note that structural supports and bracing for the tracking are closed off above the false ceiling, saving interior space.





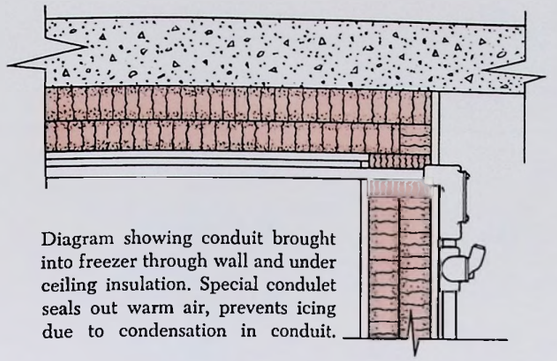



Diagram showing conduit brought into freezer through wall and under ceiling insulation. Special condulet seals out warm air, prevents icing due to condensation in conduit.

Armstrong's Plastic Emulsions; and portland cement plaster interior finish.

The desired finished appearance of the low-temperature space, and the service conditions to be encountered in the room will determine which of these finishes should be used.

All three finishes provide good protection for the insulation from moisture within the refrigerated space. When unusually high humidity conditions prevail, the factory mastic finish on corkboard provides extremely high resistance.

Plastic and S. P. Emulsion finishes may be used on walls and ceilings in rooms operating to 25° F. below zero. These black finishes can be brightened by the application of aluminum cold storage paint if brighter room interiors are desired. When asphaltic finishes are subjected to bumping or abrasion, they should be protected with bump rails or wainscoting.

Portland cement plaster is a durable, hard, light colored finish for cold room walls. Because of its weight, this finish should not be used on ceilings, unless temperatures lower than 25° below zero are held. Then, the portland cement should be reinforced with metal lath. For temperatures above –25° F. emulsion finishes are easier and less expensive to apply to ceilings.

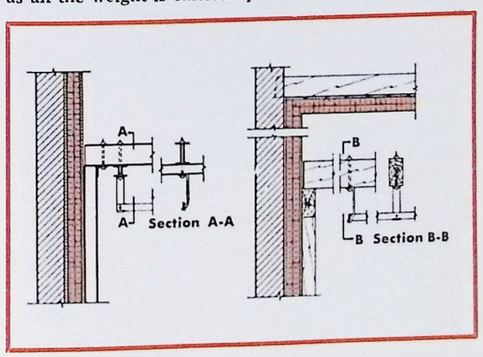
Portland cement plaster on walls will withstand moderate bumping and abrasion without damage. When unusually severe service conditions prevail, the portland cement should also be protected with bump rails or wainscoting.

### Thickness of Insulation

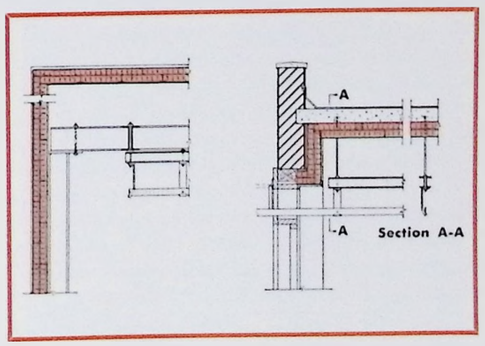
The thickness of insulation will vary with the temperatures held within the refrigerated space. Generally speaking, freezer storages operating at temperatures from 5° below to 5° above zero should be insulated with 7″ of corkboard. Sharp freezers and hardening rooms operating from 5° below to 20° below zero, the insulation thickness should be increased to 8″. Ten inches are usually recommended for temperatures from minus 20° to minus 35°. At temperatures below 35° below zero, the thickness should be increased as the temperature drops. These same recommendations apply to hardening and freezing tunnels.

In some cases, greater thicknesses than those outlined above may be necessary. For example, in the South outside temperatures may run high, requiring more insulation, particularly on the sunny side of the building. Where the ceiling of the cold room is also the building roof, insulation thicknesses must also be calculated to offset the effects of direct exposure to the sun's rays.

Tracking can be carried within the room by either wood or steel members. At no point is the insulation punctured, as all the weight is carried by the concrete wearing floor.




Two methods of hanging tracking within the cold room are detailed here. Note in the drawing at right that the tracking is bolted directly to the concrete ceiling slab.






*Armstrong's Industrial Insulations (1951)*
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## Recommended Storage Temperatures and Humidities

| Commodity | Storage temperature, °F. | Relative humidity, per cent | Approximate storage life |
|---|---|---|---|
| Apples | 30–32 | 85–88 | —* |
| Asparagus | 32 | 85–90 | 3– 4 weeks |
| Bananas (Holding) | 56 | —* | 7–10 days |
| Beans | | | |
| Green or snap | 32–40 | 85–90 | 2– 4 weeks |
| Lima | 32–40 | 85–90 | 2– 4 weeks |
| Beets | | | |
| Topped | 32–35 | 95–98 | 1– 3 months |
| Bunch | 32 | 95–98 | 10–14 days |
| Blackberries | 31–32 | 80–85 | 7–10 days |
| Broccoli (Italian) | 32–35 | 90–95 | 7–10 days |
| Brussels Sprouts | 32–35 | 90–95 | 3– 4 weeks |
| Cabbage | 32 | 90–95 | 3– 4 months |
| Carrots | | | |
| Topped | 32 | 95–98 | 4– 5 months |
| Bunch | 32 | 85–90 | 10–14 days |
| Cauliflower | 32 | 85–90 | 2– 3 weeks |
| Celery | 31–32 | 90–95 | 2– 4 months |
| Cherries | 31–32 | 80–85 | 10–14 days |
| Corn (sweet) | 31–32 | 85–90 | —* |
| Cranberries | 36–40 | 85–90 | 1– 3 months |
| Cucumbers | 45–50 | 80–85 | 10–14 days |
| Dried fruits | 32–50 | 70–75 | 9–12 months |
| Eggplants | 45–50 | 85–90 | 10 days |
| Endive | 32 | 90–95 | 2– 3 weeks |
| Frozen-pack fruits | –10– 0 | — | 6–12 months |
| Frozen-pack vegetables | –10– 0 | — | 6–12 months |
| Garlic | 32 | 70–75 | 6– 8 months |
| Grapefruit | 45–55 | 85–90 | 6– 8 weeks |
| Grapes | | | |
| European type | 30–31 | 80–85 | 3– 6 months |
| American type | 31–32 | 80–85 | 3– 8 weeks |
| Horseradish | 32 | 95–98 | 10–12 months |
| Leeks | 32 | 90–95 | 1– 3 months |
| Lemons | 55–58 | 90–95 | 1– 4 months |
| Lettuce | 32 | 90–95 | 2– 3 weeks |
| Limes | 45–48 | 85–90 | 6– 8 weeks |
| Melons | | | |
| Watermelons | 36–40 | 75–85 | 2– 3 weeks |
| Muskmelons | 32–34 | 75–78 | 7–10 days |
| Honey Dew and Honey Ball | 36–38 | 75–85 | 2– 4 weeks |
| Casaba and Persian | 36–40 | 75–85 | 4– 6 weeks |
| Mushrooms (cultivated) | 32–35 | 80–85 | 2– 3 days |
| Onions and onion sets | 32 | 70–75 | 6– 8 months |
| Oranges | 32–34 | 85–90 | 8–10 weeks |
| Parsnips | 32 | 90–95 | 2– 4 months |
| Peaches | 31–32 | 85–90 | 2– 4 weeks |
| Pears | | | |
| Bartlett | 29–30 | 85–90 | 45–90 days |
| Fall and winter varieties | 30–31 | 85–90 | —* |
| Peas (green) | 32 | 85–90 | 1– 2 weeks |
| Pineapples | | | |
| Mature green | 50–60 | 85–90 | 3– 4 weeks |
| Ripe | 40–45 | 85–90 | 2– 4 weeks |
| Plums (including prunes) | 31–32 | 80–85 | 3– 8 weeks |
| Potatoes | 36–50 | 85–90 | —* |
| Raspberries | | | |
| Black | 31–32 | 80–85 | 7–10 days |
| Red | 31–32 | 80–85 | 7–10 days |
| Rhubarb | 32 | 90–95 | 2– 3 weeks |
| Squash (winter) | 50–55 | 70–75 | 2– 6 months |
| Strawberries | 31–32 | 80–85 | 7–10 days |
| Sweet potatoes | 55–60 | 75–80 | 4– 6 months |
| Tomatoes | | | |
| Ripe | 40–50 | 85–90 | 7–10 days |
| Mature green | 55–70 | 85–90 | 3– 5 weeks |
| Turnips (including rutabagas) | 32 | 95–98 | 4– 5 months |

* Variety and handling during storage so affect storage life that no figures can be given.

Courtesy The American Society of Refrigerating Engineers, 1950 Data Book, Applications Volume.



# Specifications for the Erection of Armstrong's Corkboard

These specifications are included for the convenience of architects, engineers, and owners who desire to write specifications for low-temperature work.

### 1. General

The following applications are the ones most generally used in the construction of cold storage rooms. Cooperation in the engineering of special problems is freely offered by the Armstrong Cork Company. Call any Armstrong Office.

**a. Single and Multiple Layer Construction**

The following sections make reference to two layer construction. When more than two layers of corkboard are specified, the additional layers shall be applied as described for the second layer, unless otherwise noted. When only one layer of corkboard is specified, it shall be erected as described for the first layer. Though two layer construction is preferred to eliminate through joints, single layer construction may be used.

**b. Back Plaster**

Where corkboard insulation is to be applied against masonry walls in asphalt, the walls must be made true and even, if necessary, with portland cement mortar, mixed:

1 part portland cement
3 parts clean, sharp sand
(Use no lime in back plaster)

Immediately preceding the application of plaster, wet the walls evenly with clean water. Apply the plaster in one or more coats to ¼" minimum thickness on all high points, straighten with a straightedge, and float smooth. Where necessary to insure a good bond, the existing wall surfaces must be roughened or hacked before applying the portland cement back plaster.

**c. Asphaltic Priming Paint**

All brick, concrete, or plastered surfaces to which corkboard is to be applied in hot asphalt must be primed with Armstrong's No. 3 Asphaltic Paint, applied with either brush or spray. The surfaces must be thoroughly dry before the priming paint is applied. This paint must be allowed to dry before erection of the insulation.

**d. Temperature of Asphalt**

The hot asphalt in which corkboard is dipped shall be held between 350° and 375° F. Do not heat asphalt to temperatures higher than these.

**e. Broken Joints**

In the following specifications, the method of application of corkboard provides that vertical joints in the first layer and all joints in the successive layers shall be broken with respect to each other and that all joints shall be tight.

**f. Nails and Skewers**

Drive nails and skewers obliquely at different angles to provide maximum holding power. Use nails for the attachment of the first layer of corkboard to wood and frame construction, or for the attachment of the second layer to wood stripped concrete ceiling, or for toenailing first layer of solid cork walls. Galvanized nails should always be used and should be about 1" longer than the thickness of insulation being nailed in place.

Treated hardwood skewers are used for the attachment of the second and subsequent layers of corkboard and are approximately equal in length to the combined thickness of two layers.

Use two nails or skewers per square foot for securing corkboard to walls and 3 per square foot for ceilings and solid cork walls.

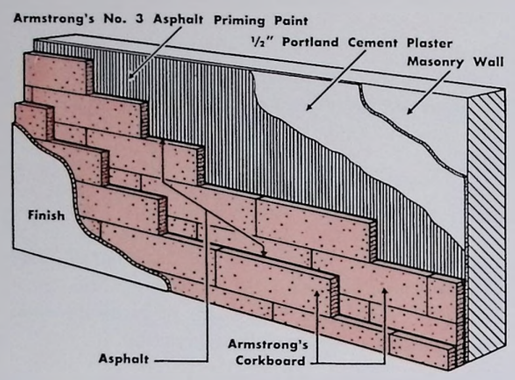
In order not to indent the surface of the corkboard, avoid setting nails or skewers with heavy hammer blows—light blows are more effective. It is preferable to use a mallet or large headed hammer to drive skewers.



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## 2. Walls

### 2a. Masonry Walls—Two Layers of Corkboard—Both in Hot Asphalt




All masonry wall surfaces shall be thoroughly cleaned of dirt, dust, loose mortar, etc., and, where necessary, the wall surfaces shall be made true and even as described under Item 1b.

After the plaster is dry, prime the wall as described under Item 1c.

Apply the first layer of corkboard directly to this surface in hot asphalt.

Apply the second layer in hot asphalt and additionally secure it to the first layer with treated hardwood skewers of proper length.

Finish the exposed corkboard surfaces (as specified under FINISHES).

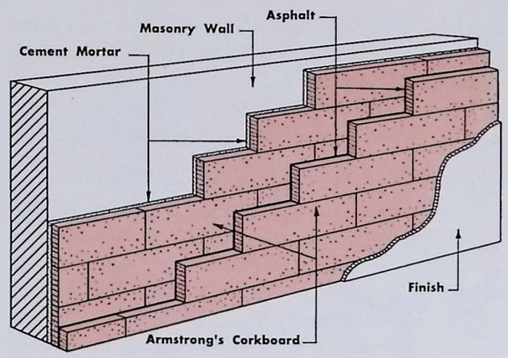
#### Wall Heights Over 14′

**Vertical sleepers**—Reinforce insulation on masonry walls with treated vertical wood sleepers 1⅝″ x (thickness of the first layer of corkboard) 3′ apart and embedded in the first layer. Fasten to the masonry wall with suitable anchors on 5′ centers. Bolt heads or nuts and washers shall be countersunk into the wood sleepers and covered with a cork plug.

**Horizontal girths**—Reinforce insulation on masonry walls with treated horizontal wood girths 1⅝″ x (thickness of the first layer of corkboard) or steel angle irons, 6′ to 7′ apart, embedded in the first layer and fastened to the masonry walls with suitable anchors on 5′0″ centers. Bolt heads or nuts and washers shall be countersunk into the wood sleepers and covered with a cork plug.

**Buckstays**—Reinforce insulation on masonry walls with 3″ wood buckstays erected on 4′0″ centers. Buckstays shall be bolted on not over 8′0″ centers with ⅝″ bolts anchored in the masonry walls. Bolt heads or nuts and washers shall be countersunk into the buckstays and covered with a cork plug.

### 2b. Masonry Walls—Two Layers of Corkboard—First Layer in Cement Mortar; Second Layer in Hot Asphalt




All masonry walls must be thoroughly cleaned of dirt, dust, loose mortar, etc., and, where necessary, roughened or hacked to ensure a bond.

Erect the first layer of corkboard, applying ½″ of portland cement mortar to the board, mixed:

1 part portland cement
3 parts clean, sharp sand

Apply the second layer of corkboard in hot asphalt and additionally secure it to the first layer with treated hardwood skewers of proper length.

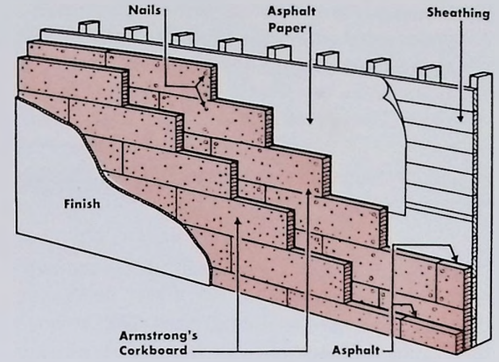
Finish the exposed corkboard surfaces (as specified under FINISHES).

Wall heights over 14′ (see Specification 2a).

### 2c. Wood Walls—Two Layers of Corkboard—Both in Hot Asphalt

Directly against the sheathing of the wood walls apply one layer of heavy asphalt paper securely tacked in place with edges lapped not less than 3″.

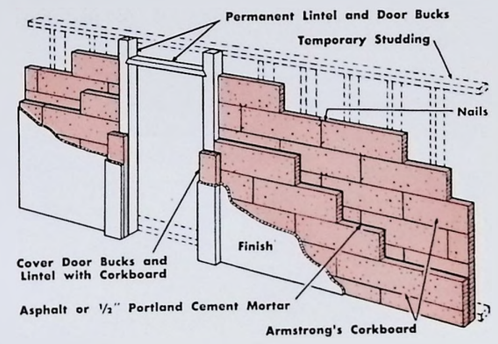





Apply the first layer of corkboard directly to this paper in hot asphalt and secure it to the wood wall with special galvanized nails of proper length. Apply the second layer in hot asphalt and additionally secure it to the first layer with treated hardwood skewers of proper length.

Finish the exposed corkboard surfaces (as specified under FINISHES).

### 2d. Solid Corkboard Walls—Two Layers of Corkboard—Asphalt or Cement Core




Erect temporary 2″ x 4″ studs on 18″ centers in alignment as a guide for self-supporting, solid corkboard walls. Erect first layer of corkboard against temporary studs. Toenail each piece of corkboard to abutting ones, and where possible to walls, floor, and ceiling with special galvanized nails of the proper length.

Erect the second layer against the first in hot asphalt and additionally secure it to the first layer with treated hardwood skewers of proper length.

Finish the exposed cork surfaces (as specified under FINISHES).

Do not remove the temporary studs until the finish on the opposite face of the wall has set.

### 2e. Solid Corkboard Walls—Two Layers of Corkboard—Cement Core (See illustration under Paragraph 2d).

Erect temporary 2 x 4 studs on 18″ centers in alignment as a guide for the self-supporting solid corkboard walls. Erect the first layer of corkboard against the temporary studs, securely toenailing each sheet of corkboard to the abutting one, and wherever possible, to walls, floor, and ceiling with special galvanized nails of proper length.

Erect the second layer against the first one, applying ½″ of portland cement mortar to the board, mixed

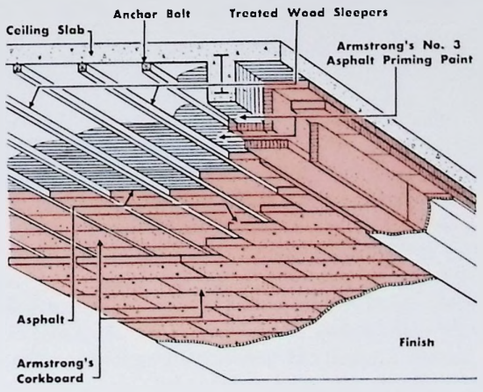
1 part portland cement
3 parts clean, sharp sand

and additionally secure it to the first layer with treated hardwood skewers of proper length.

Finish the exposed corkboard surfaces (as specified under FINISHES).

## 3. Ceilings, Roofs, and Beams

### 3a. Concrete Slab—Two Layers of Corkboard—Both in Hot Asphalt




Before any insulation is applied, fasten to the underside of the concrete ceiling 1⅝″ x (thick-



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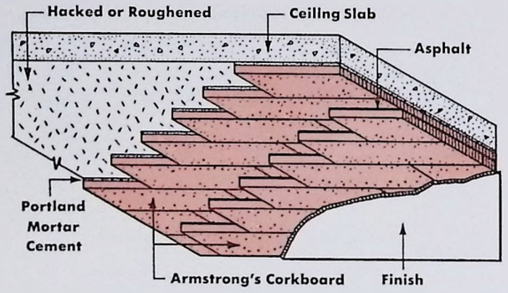
ness of first layer of corkboard) sleepers with suitable anchors. The sleepers must be spaced with 12″ or 18″ between so that the corkboard will fit tightly between them.

The concrete ceiling slab and sleepers must be thoroughly cleaned of all dirt, dust, loose plaster, etc., and primed (as described under Item 1c).

Apply the first layer of corkboard in hot asphalt between the sleepers and toenail it to the sleepers with special galvanized nails. Apply the second layer in hot asphalt and additionally secure it to the first layer with treated hardwood skewers of proper length. Where the second layer crosses the sleepers, nail it with special galvanized nails of proper length.

Finish the exposed corkboard surfaces (as described under FINISHES).

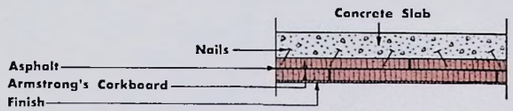
### 3b. Concrete Slab—Two Layers of Corkboard—First Layer Applied in Portland Cement Mortar; Second Layer in Hot Asphalt




The concrete ceiling must be thoroughly cleaned of dirt, dust, loose mortar, etc., and be roughened or hacked to ensure a good bond. Wet the concrete and erect the first layer of corkboard, applying ½″ of portland cement mortar to the board, mixed with 1 part portland cement, 2 parts clean, sharp sand and prop in place until securely bonded to the concrete ceiling slab. Apply the second layer of corkboard in hot asphalt and additionally secure it to the first layer with treated hardwood skewers of proper length.

Finish the exposed corkboard surfaces (as specified under FINISHES).

### 3c. Concrete Slab—Two Layers of Corkboard—First Layer in Forms; Second Layer in Hot Asphalt After Forms Are Removed

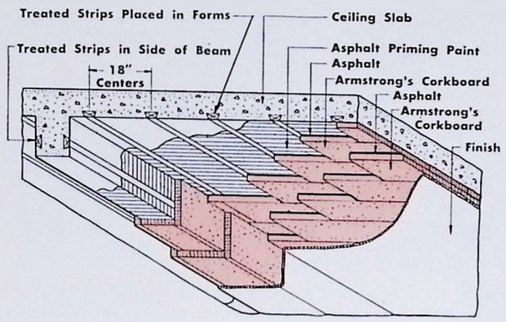



The building contractor shall depress the concrete forms to the proper elevations to receive the first layer of corkboard and shall remove them after the concrete slab has set, care being taken that the corkboard is left undamaged.

Set the first layer of corkboard directly in the forms with all joints tight. Three nails per square foot shall be driven obliquely into the top surface with heads protruding. After the forms have been removed, apply the second layer of corkboard in hot asphalt against the underside of the first layer and additionally secure it with treated hardwood skewers of proper length.

Finish the exposed corkboard surfaces (as specified under FINISHES).

### 3d. Concrete Slab—Two Layers of Corkboard—Both in Hot Asphalt; Beveled Wood Strips in Concrete




Treated beveled wood strips shall be placed in the concrete forms on 18″ (or otherwise specified) centers.

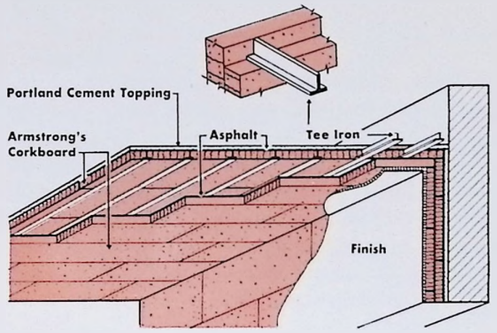
After the forms have been removed and the concrete has seasoned, the surface to receive the insulation shall be thoroughly cleaned of dirt, loose concrete, etc. The concrete surface shall be primed (as described under Item 1c).



Apply the first layer of corkboard in hot asphalt and secure it to the wood strips with special galvanized nails of proper length. Apply the second layer in hot asphalt and additionally secure it to the first layer with treated hardwood skewers of proper length.

Finish the exposed corkboard surfaces (as described under FINISHES).

### 3e. Tee-Iron Ceilings—Two Layers of Corkboard—First Layer Fitted Between Tees; Second Layer Beneath in Hot Asphalt




Tee-irons shall be spaced 12″ (or 18″) apart. Place the first layer of corkboard between the tee-irons, notching the edges to fit snugly between the flanges.

Flood the top surface with a heavy coat of hot asphalt and apply approximately 1″ of portland cement topping, mixed with 1 part portland cement, 3 parts clean, sharp sand.

Apply the second layer in hot asphalt against the underside of the first layer and additionally secure it to the first layer with treated hardwood skewers of proper length.

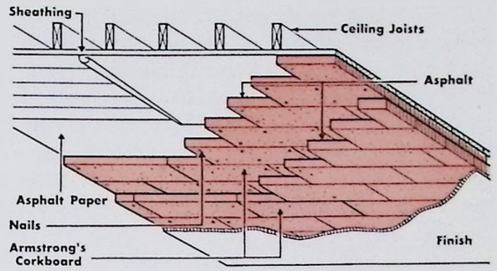
When more than two layers are used, apply the additional layers above the first one in hot asphalt, finishing with cement topping.

**NOTE:** This specification is not recommended for one-layer work.

Finish the exposed corkboard surfaces (as specified under FINISHES).

### 3f. Wood Ceilings — (Insulation Underneath) — Two Layers of Corkboard—Both Layers in Hot Asphalt

Directly against the underside of the wood ceiling apply one layer of heavy asphalt paper

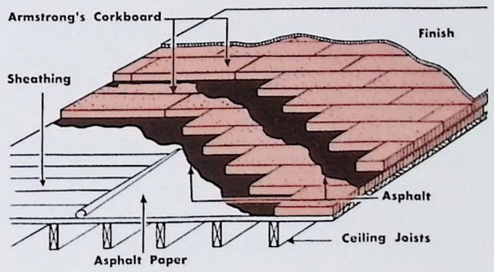



securely tacked in place with edges lapped not less than 3″.

Apply first layer of corkboard to this paper in hot asphalt and secure it to the wood ceiling with special galvanized nails of proper length. Apply the second layer in hot asphalt and additionally secure it to the first layer with treated hardwood skewers of proper length.

Finish the exposed corkboard surfaces (as specified under FINISHES).

### 3g. Wood Ceiling or Roof Deck—(Insulation on Top)—Two Layers of Corkboard—Both in Hot Asphalt*




Provide a slot one inch (1″) wider than the thickness of the wall insulation along all walls so that the wall and ceiling (roof) insulation will join without a break.

On top of the wood ceiling structure tack one layer of heavy asphalt paper with the edges lapped at least 3″ and sealed with hot asphalt.

Over this apply corkboard, each layer being laid in and flooded with hot asphalt.

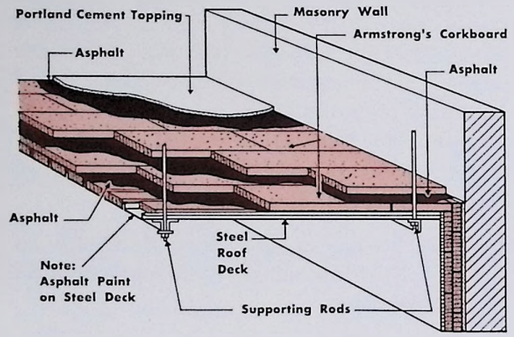
Alternate Finish—Mop over the corkboard with hot asphalt, one layer of 15-pound saturated roofing felt. Lap and seal all edges of the felt (and flash wherever possible).



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*NOTE: When this specification applies to a roof deck, it is understood that the owner or another contractor shall protect the insulation immediately as it is laid, with at least one layer of roofing felt thoroughly mopped on with hot asphalt or pitch. Unless adequate protection is provided, the insulation contractor cannot accept responsibility for any failure that may develop.

### 3h. Steel Ceiling or Roof Deck—(Insulation on Top)—Two Layers of Corkboard—Both in Hot Asphalt*




Provide a slot 1 inch (1″) wider than the thickness of the wall insulation along all walls so that the wall and ceiling (roof) insulation will join without a break.

Set steel roof deck with flanges up and prime with #3 or #4 Asphaltic Paint. Set special corkboard fillers between flanges.

Over this apply corkboard, each layer being laid in and flooded with hot asphalt.

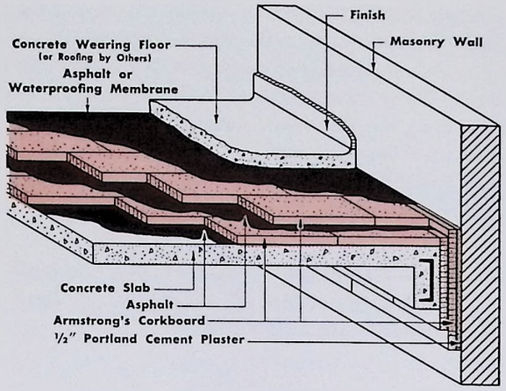
**Alternate finishes**

(a) Apply ¾″ coat of portland cement mortar, mixed with 1 part portland cement and 3 parts clean, sharp sand.

(b) Mop over corkboard with hot asphalt, one layer of 15-pound saturated roofing felt. Lap and seal all edges (and flash where possible).

### 3i. Concrete Ceiling or Roof Slab—Two Layers of Corkboard—Both in Hot Asphalt*

Provide in the concrete slab a slot 1″ wider

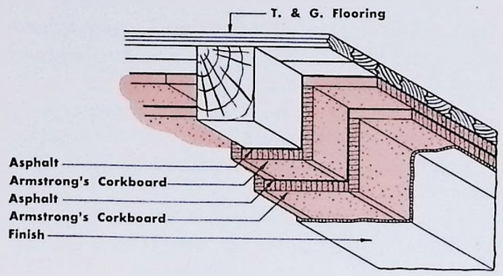



than the thickness of the wall insulation along all walls so that wall and ceiling insulation will join without a break.

Apply the corkboard directly to the concrete slab, each layer of insulation being laid in and flooded with hot asphalt.

Mop over the corkboard with hot asphalt, one layer of 15-pound saturated roofing felt. Lap and seal all edges (and flash where possible).

### 3j. Wood Beams—Two Layers of Corkboard—Both in Hot Asphalt

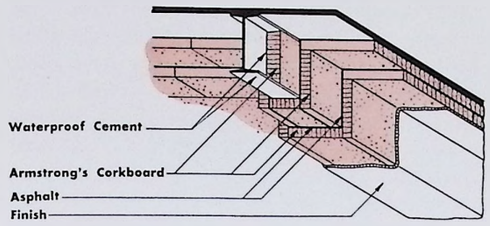



Prime the wood beams with Armstrong's No. 3 Asphaltic Paint. Apply the first layer of corkboard in hot asphalt and secure it to the beams with special galvanized nails of proper length, three per square foot. Apply the second layer in hot asphalt and additionally secure it to the first layer with treated wood skewers of proper length three per square foot.

Finish the exposed corkboard surfaces with an asphalt finish (as specified under FINISHES).



### 3k. Steel Beams—Two Layers of Corkboard—First Layer in Waterproof Cement—Second Layer in Hot Asphalt




Steel beams shall be cleaned of all dirt or rust where the insulation is to be applied.

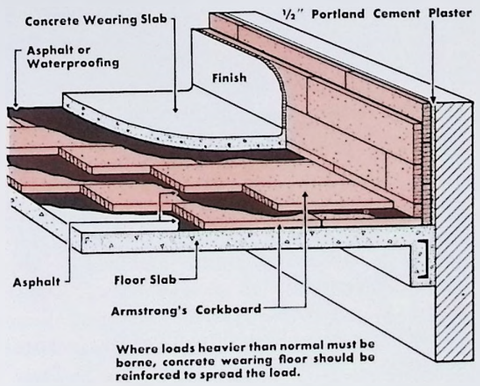
Apply the corkboard against the steel beams in waterproof cement, filling all web spaces, and prop in place until the cement has set. Apply subsequent layers in hot asphalt and additionally secure them with treated wood skewers of proper length, three per square foot.

Finish the exposed corkboard surfaces with an asphalt finish (as specified under FINISHES).

## 4. Floors

**NOTE:** Where extreme moisture conditions prevail, apply over the corkboard a waterproofing membrane consisting of two layers of 15-pound saturated roofing felt, each layer being mopped in hot asphalt, flashed nine inches (9″), and sealed along all walls and around all columns.

### 4a. Concrete Floor—Two Layers of Corkboard—Both in Hot Asphalt

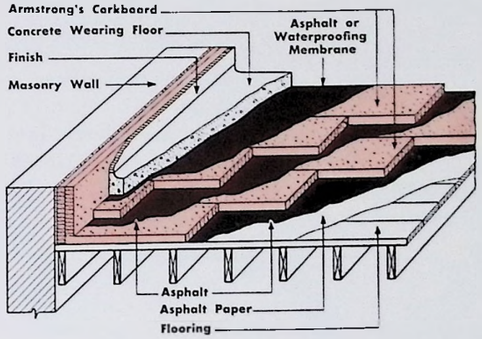



The concrete base or floor on which the insulation is to be laid shall be dry and reasonably smooth and level.

Over this apply corkboard, each layer being laid in and flooded with hot asphalt.

Install a concrete wearing floor on top of the insulation or membrane. (As specified under CONCRETE WEARING FLOORS).

### 4b. Wood Floor—Two Layers of Corkboard—Both in Hot Asphalt




Directly on top of the wood floor apply one layer of heavy asphalt paper with all edges lapped not less than 3″ and sealed with hot asphalt.

Over this apply corkboard, each layer being laid in and flooded with hot asphalt.

Install a concrete wearing floor on top of the insulation or membrane (as specified under CONCRETE WEARING FLOORS).

## 5. Columns

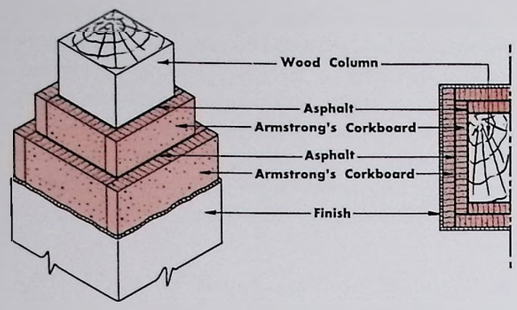
**NOTE:** All vertical corners shall be protected with suitable angle corner guards, securely fastened to the column before the finish is applied. Round columns shall have sheet metal guards.

### 5a. Square Wood Columns—Two Layers of Corkboard—Both in Hot Asphalt

Prime the wood column with Armstrong's No. 3 Asphaltic Paint. Apply the first layer of corkboard in hot asphalt and secure it to the wood columns with special galvanized nails of proper length, three per square foot. Apply the second layer in hot asphalt and additionally secure it



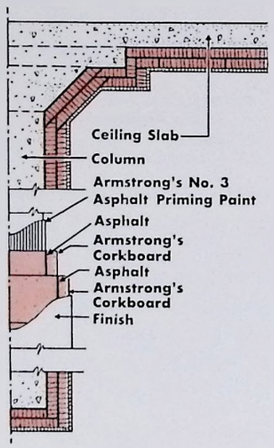
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to the first layer with treated hardwood skewers of proper length, three per square foot.

Finish the exposed corkboard surfaces (as specified under FINISHES).

**5b. Square Concrete Columns and Flares—Two Layers of Corkboard—Both in Hot Asphalt**



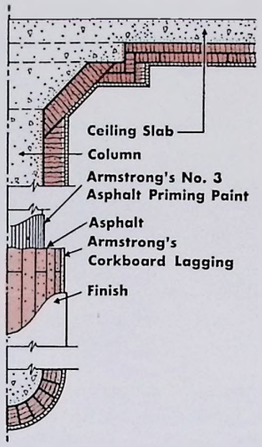

The concrete columns shall be primed (as described under Item 1c).

Apply the first layer of corkboard in hot asphalt.

Apply the second layer in hot asphalt and additionally secure it to the first layer with treated hardwood skewers of proper length, using three skewers per square foot.

Finish the exposed corkboard surfaces (as specified under FINISHES).

**5c. Round Concrete Columns and Flares—One Layer of Cork Lagging Applied in Hot Asphalt**

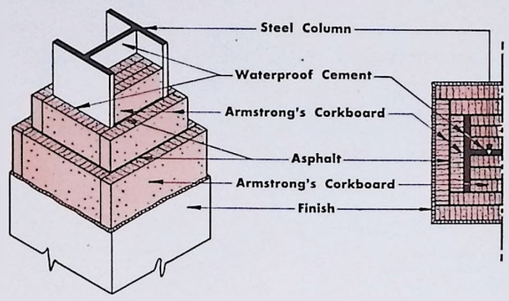



The concrete surfaces shall be primed as described under Item 1c.

Apply the cork lagging, properly beveled to fit the column, in hot asphalt, and toenail each cork lagging to the abutting one with treated wood skewers of proper length.

Finish the exposed corkboard surfaces (as specified under FINISHES).

**5d. Steel Columns—Two Layers of Corkboard—First Layer in Waterproof Cement—Second Layer in Hot Asphalt**




The steel columns shall be clean of all dirt or rust where the insulation is to be applied.

Apply the corkboard against the column in waterproof cement, filling all web spaces, and prop in place until the cement has set. Apply subsequent layers in hot asphalt and additionally secure them with treated wood skewers of proper length, two per square foot.

Finish the exposed corkboard surfaces (as specified under FINISHES).



## 6. Finishes

**6a. Asphalt Emulsion Finishes**

These finishes shall be applied directly to the corkboard in two coats, each ⅛″ thick. Before applying the first coat, all voids, open joints, or broken corners must be pointed with emulsion finish. The first coat must be hand dry before the second coat is applied. Trowel the second coat smooth. The final thickness of the finish shall be approximately ⅛″ when dry. Finish all corners true and clean. Do not use where operating temperatures will be lower than 25° below zero.

**NOTE:** Do not apply asphalt emulsion finish when the temperature is below 40° F. In cold weather, provide heat to warm the spaces where the finish is being applied.

**(1) Armstrong's Asphalt Emulsion Finish**

Finish the exposed corkboard surfaces with Armstrong's Asphalt Emulsion, mixed:

50 gallons Armstrong's Asphalt Emulsion
115 pounds asbestos floats
275 pounds (2¾ cu. ft.) dry, screened sand
15 gallons clean water

Apply as described under Item 6a.

**(2) Armstrong's S. P. Emulsion Finish**

(Smooth finish): Finish the exposed corkboard surface with Armstrong's S. P. Emulsion in accordance with Item 6a.

(Sand Finish): Finish the exposed corkboard with Armstrong's S. P. Emulsion, mixed:

50 gallons Armstrong's S. P. Emulsion
175 lbs. (1¾ cu. ft.) dry, screened sand
a small amount of clean water for tempering

This mixture shall be applied in accordance with Item 6a.

**(3) Armstrong's Plastic Emulsion**

Finish the exposed corkboard with Armstrong's Plastic Emulsion, which is a complete asphalt plastic finish ready for application as received from the factory. This mixture shall be used as supplied and shall be troweled on in two coats to a final thickness of ⅛″, as described under Item 6a.

**6b. Armstrong's Mastic Finish**

The exposed corkboard surfaces shall have a mastic finish approximately ⅛″ thick ironed on the corkboard at the factory. After the boards are in place, the joints and the holes made by nails or skewers shall be sealed with mastic seam filler in a neat and workmanlike manner.

The convex corners may be finished with Armstrong's Mastic Finish Quarter Round.

**6c. Portland Cement Finish**

Portland cement finish shall be applied to corkboard walls in two coats, each approximately ¼″ thick. First coat shall be keyed to corkboard and thoroughly scratched. Second coat shall be brought to a float or trowel finish. When applied to corkboard ceilings, portland cement finish shall be reinforced with expanded metal lath.

Portland cement finish shall be mixed:

1 part portland cement
3 parts clean, screened sand
5% hydrated lime

Corner beads. All outside corners shall be protected with metal corner beads, fastened securely in place, before the finish is applied.

**NOTE:** Portland cement finish contracts in setting, causing shrinkage cracks, a condition that cannot be avoided but which will not impair the insulation efficiency. To reduce cracking to a minimum, finish coat of plaster shall be scored each way approximately on 4′0″ centers.

## 7. Painting

**7a. Armstrong's Aluminum Paint**—Over asphaltic surfaces only, apply the paint in two coats, flowing on each coat. Allow the first coat to dry before the second coat is applied. The aluminum paint shall not be mixed until just before application.

## 8. Concrete Wearing Floors

8a. Over the insulation install a monolithic concrete wearing floor 3″ thick at the low point (unless otherwise specified) sloped 1″ in 10′0″.

(Slope shall be increased for floors subject to extreme moisture conditions.)

The concrete shall be mixed:

1 part portland cement
2 parts clean, sharp sand
3 parts crushed stone

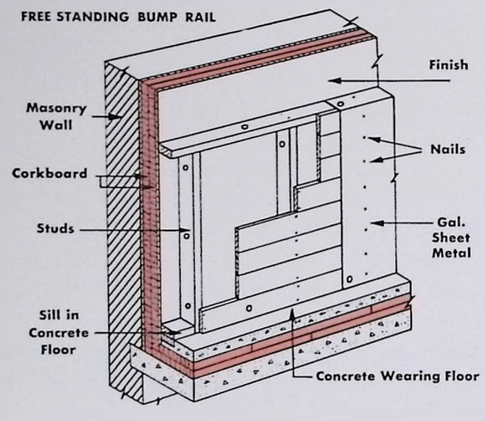
The concrete shall be floated and troweled to a smooth surface and slightly coved at all vertical surfaces.



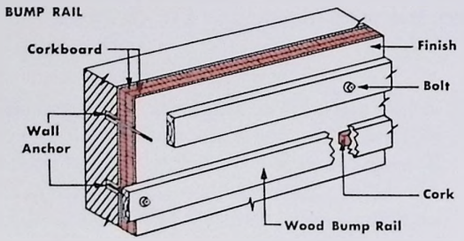
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# Preventing Damage to Cold Room Insulation

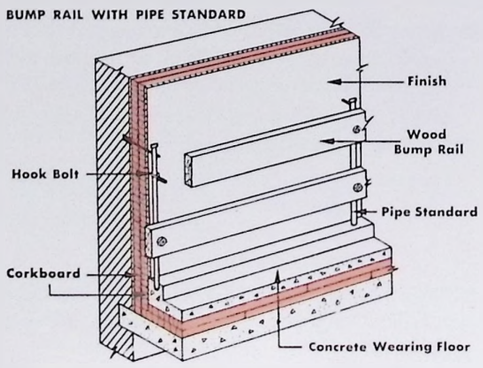
FREE STANDING BUMP RAIL




BUMP RAIL




BUMP RAIL WITH PIPE STANDARD




Damage to insulation from wheeled trucks, abrasions by stored goods and ordinary wear and tear can be more costly than the relatively little expense entailed in preventing it in the first place. Punctures in insulation finish allow moisture penetration, with a resulting drop in insulating efficiency and rise in refrigeration costs. Freezing of the collected moisture will eventually destroy the insulation structure.

Prevention of this damage is comparatively easy and relatively inexpensive if the work is done at the time of original construction. The diagrams on these pages show the construction details of many of the protective devices used today. Most of them can be readily added to existing installations at any time.

The illustration at the top left shows a free standing bump rail covered with galvanized sheet metal. The 2 x 4 studs rest on a 2 x 4 sill imbedded in the concrete wearing floor. The studs are anchored at the bottom by a 2 x 4 blocking cut to length and wedged between each stud. Another 2 x 4 runs across the top of the studs to add rigidity to the construction. Tongue-and-groove sheathing is nailed on this framework and covered with metal sheeting. Holes should be drilled through the metal and the sheathing to provide for air circulation between the studs.

Next is shown a bump rail construction for a moderate temperature room. Here horizontal rails are anchored by bolts through the insulation into the masonry walls. A 2″ piece of corkboard coated with asphalt or emulsion is slipped over each bolt and is installed between the finish on the wall and the rail. This not only acts as a shock absorber, but the insulating efficiency of the cork minimizes frosting on the bolt.

Lower illustration is also a type of bump rail for moderate temperature rooms. The horizontal wooden rails here are fastened to pipe standards sunk into the concrete curb. The bolts at the top



of the pipe standards are anchored into the masonry wall and the bump rails are fastened to the upright standards with hook bolts.

At the top of this page is shown a protective wainscoting of portland cement plaster in a low-temperature room which has been finished with asphalt emulsion. As a key to hold the portland cement plaster, expanded metal lath is stapled to the insulation over the emulsion finish and is topped with a cap strip. The plaster is then trowelled on in two coats to a ¾″ thickness.

Columns are particularly exposed to damage. Round columns are usually protected with sheet steel as shown at the right. The steel may be either riveted or welded around the column. If the welding method is used, asbestos pads should be applied over the insulation finish before the steel guards are put in place to prevent heat damage to the finish on the insulation.

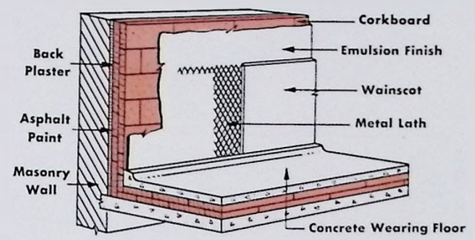
The corners of square metal columns are usually protected with iron angle guards approximately 3 feet high, with expansion corner beads above the guards as high as desired. The angle irons are embedded into the concrete wearing floor and are bolted together at the top with a tie-strap, usually ¼″ thick.

An expansion corner bead is shown on the square column at left. These corner beads are installed in the same manner, whether they are used on square columns or on the outside corner of a wall. They are firmly anchored to the cork insulation with staples and then the plaster is applied to the beading.

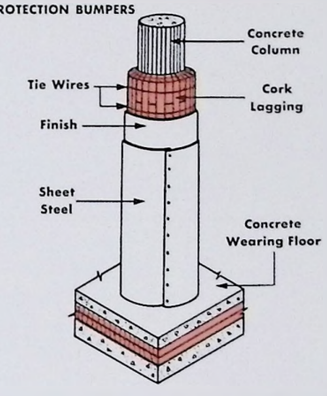
Concrete wearing floors in all cold rooms should be slightly coved to the side walls to prevent moisture which may collect on the floor from seeping into the insulation at the junction of the wall and the floor. The cove is easy to install when the floor is poured. A relatively shallow coving is all that is necessary, unless damage by bumping is likely to occur.

A concrete curb, illustrated at left, poured at the same time as the concrete wearing floor will protect the insulation finish and the insulation beneath it from many damaging blows from wheeled trucks. At the same time, it protects the insulation from water seepage at the floor level. These concrete curbs are usually 4″ x 4″, unless unusual operating conditions prevail. Then they can be poured larger or smaller to meet the special requirements of a particular job.

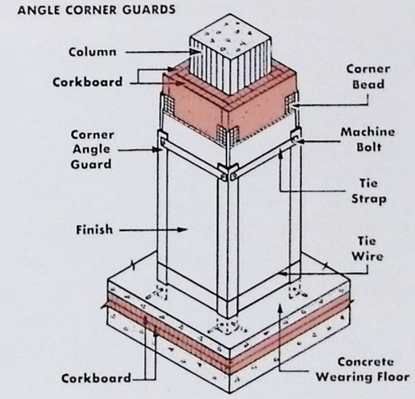
PORTLAND CEMENT WAINSCOT



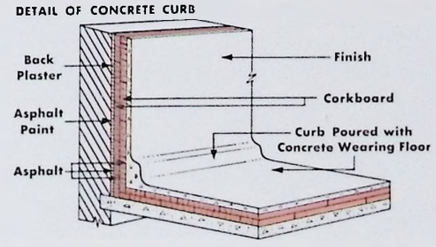

STEEL PROTECTION BUMPERS




ANGLE CORNER GUARDS




DETAIL OF CONCRETE CURB






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# Maintenance and Care of Cold Room Insulation



After low-temperature insulation is properly installed, following the simple maintenance procedures outlined below will result in long-lasting and efficient operating conditions. Excessive power consumption and costly shutdowns for expensive repairs will be avoided.

Proper maintenance is relatively simple and very inexpensive. Actually only two things have to be done. One is to inspect regularly all surfaces for breaks, cracks, or openings that would permit infiltration of moisture-laden warm air. The second is to patch any breaks before appreciable moisture or frost damage is done. In following out this formula, the following points should be checked:

### Exterior Walls

Exterior walls should be checked regularly for any cracks or flaws. Wall joints should be pointed when necessary. Under ordinary circumstances, masonry walls require some pointing almost every year to keep them in top condition.

### Interior Walls

Patch all cracked or chipped places in the wall finish as soon as they develop. Armstrong's Asphalt Emulsion or Armstrong's Seam Filler or both can be used to treat such spots. Generally, the asphalt emulsion is used for relatively small breaks, while large gouges or breaks are filled first with seam filler and then finished with a coat of asphalt emulsion.

When the interior finish is of portland cement plaster, all loose plaster should be removed and new plaster, mixed one part portland cement, two parts clean screened sand, and no more than 8% hydrated lime, should be applied.

### Roof Surfaces

Examine roof surfaces above top floor cold rooms at frequent intervals. Repair the roofing immediately if any leaks develop. Give special attention to all flashings at parapets and at junctions with other vertical walls. Flashings should be free from breaks and tight to parapets or walls to prevent storm-water seepage.

### Wood Fixtures

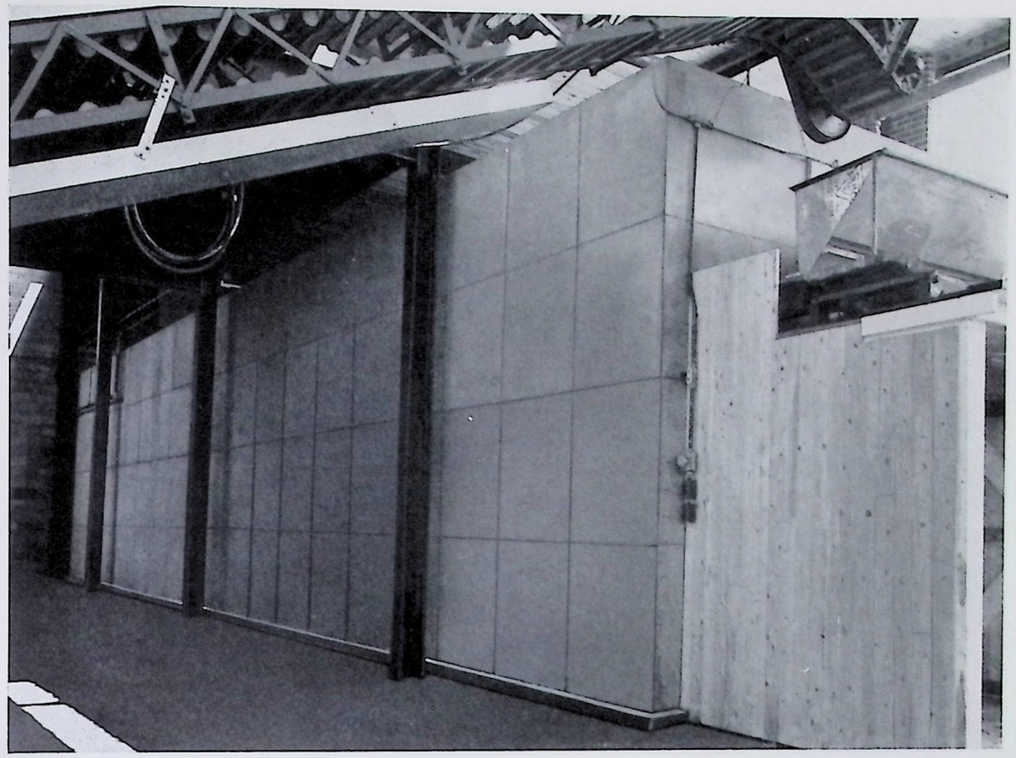
Paint all wood fixtures, such as door frames, racks, shelves, false ceilings, supports, bunkers, and catwalks, at least once a year to prevent rotting and deterioration. Use an odorless paint and brush on one good covering coat.

### Doors

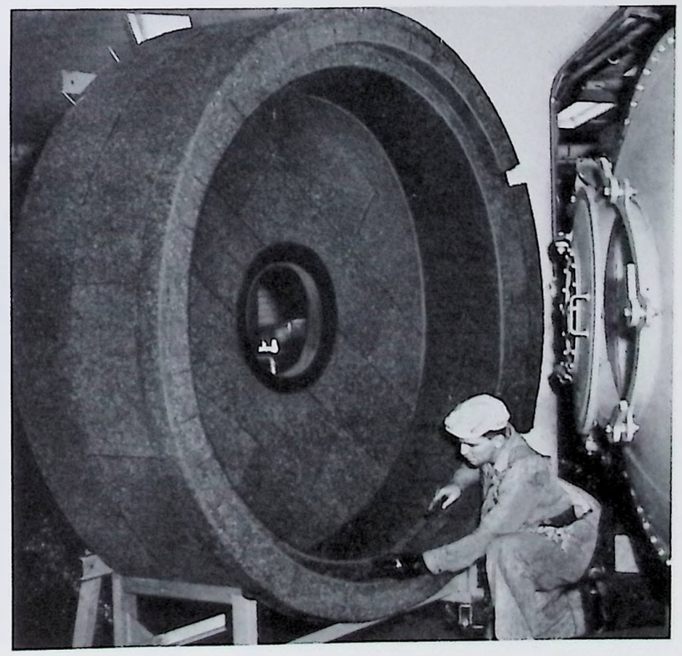
Check alignment of doors. Be sure they fit snugly and evenly. Replace hard or flat gaskets in order to get a true seal when the door is shut.

Tighten all hardware, including hinges, latches, and springs. Replace promptly any damaged or worn hardware. Also check door sills, casings, and other wooden fixtures for rotting, and if they are either rotted or worn excessively they should be replaced without delay.





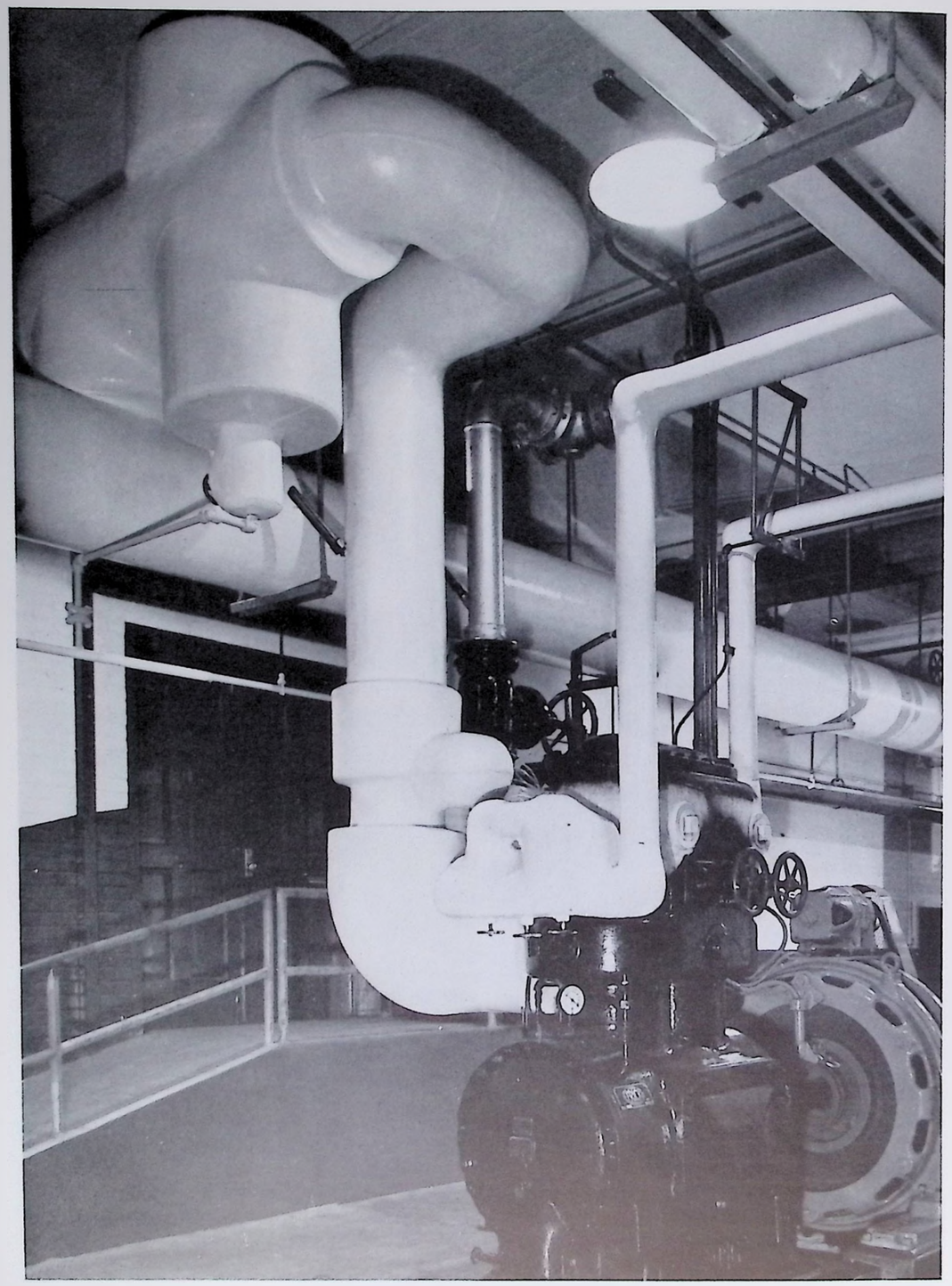
Above: This ten-foot-high food freezing tunnel is built entirely of Armstrong's Corkboard. The walls are self-supporting, and carry the weight of the ceiling, which is of Tee-iron construction. The tunnel is sixty feet long and operates at 30° F. below zero.



At right: The ease with which corkboard can be bent and handled to fit curved or unusual contours is demonstrated by this illustration. Here a workman is building a cork-insulated door for a stratosphere test chamber.



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Section II

# COLD LINES

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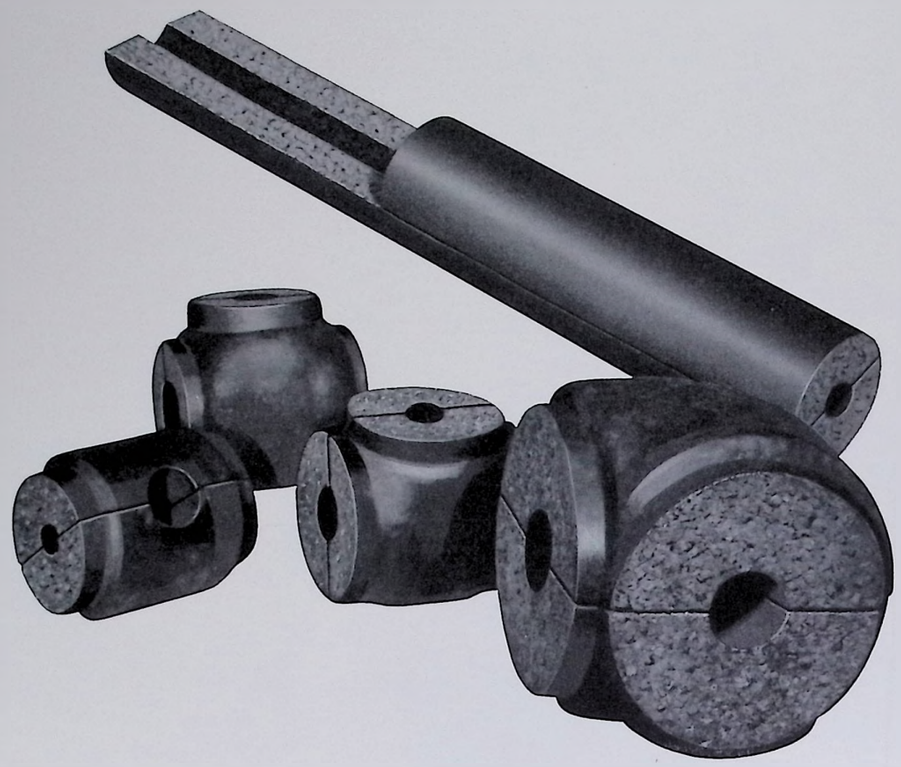
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# Armstrong's Cork Covering For All Cold Lines

Armstrong's Cork Covering is made from clean granules of pure cork, compressed in molds of the proper shape for various sizes of pipe and fittings, and then baked into strong and homogeneous shapes. The sections then are machined to accurate size and factory finished inside and out with a moistureproof, airtight asphalt mastic finish. Armstrong's Cork Covering possesses virtually the same physical properties as Armstrong's Corkboard, Page 17. This covering equals or exceeds Federal Specification HH-P-381 for pipe-covering; cork, molded.

High natural resistance to moisture and heat flow are as essential to cold line insulation as to the insulation of cold rooms. (See "Moisture Problem in Low-Temperature Insulation," Page 14.) Unless a moisture-resistant insulation is used on cold lines, moisture from the surrounding air will be forced into any break or opening and work its way into the insulating material. Moisture is a good conductor of heat, and the heat retarding properties of the insulation will decrease in direct proportion to the moisture present. If the insulation on the line is of fibrous material, as moisture is absorbed capillary attraction will carry that moisture far from the original point of contact, and in time the whole length of the insulation will become saturated.

If the lines are cold enough, the moisture will turn to frost, and in due time the formation of ice will break up the insulation and cause it to lose its efficiency entirely.



High resistance to damaging moisture is one of the outstanding characteristics of Armstrong's Cork Covering. This is due to the natural cellular structure of cork. (See "The Properties of Cork" on Page 17.) The factory-applied asphalt mastic finish on the covering is a further protection against moisture infiltration.

On all cold lines, highly efficient Armstrong's Cork Covering, when applied in proper thicknesses, reduces refrigeration loss by 80 to 90 percent. High efficiency is maintained through long years of service because of cork's unusual ability to withstand the damaging effects of moisture. The savings that can be realized through the use of cork covering on low-temperature lines can be quickly calculated from the "Comparative Heat Loss Data" on Page 60.

### Thicknesses

Armstrong's Cork Covering is manufactured in three regular thicknesses and in special thicknesses to meet various service conditions. As shown below, the actual thickness varies with the pipe size between the minimum and maximum given in each case.

**Light-Duty Thickness**—1.20 to 1.93 inches thick, depending on pipe size, for use on refrigerated drinking water or other cold lines, and generally where temperatures of 35° F. and above are maintained.

**Standard Thickness**—1.70 to 3.50 inches thick, depending on pipe size, for brine, ammonia, carbon dioxide, or other gas or liquid lines operating at temperatures from 0° to 35° F. This thickness should also be used where the maximum temperature difference between the refrigerant and surrounding air is less than 100° F.

**Heavy-Duty Thickness**—2.63 to 4.19 inches thick, depending on pipe size, for cold lines operating at temperatures from 0° to 25° F. below zero. This thickness should also be used where temperatures surrounding the cold lines are unusually high, as in boiler rooms or adjacent to steam lines, or in tunnels or pipe shafts.

**Special Thickness**—3.89 inches or more in thickness, as required for special process cold lines where extremely low temperatures are specified. Chart on Page 61 gives special recommended wall thicknesses of cork covering for different refrigerant line temperatures.

### Pipe Coverings

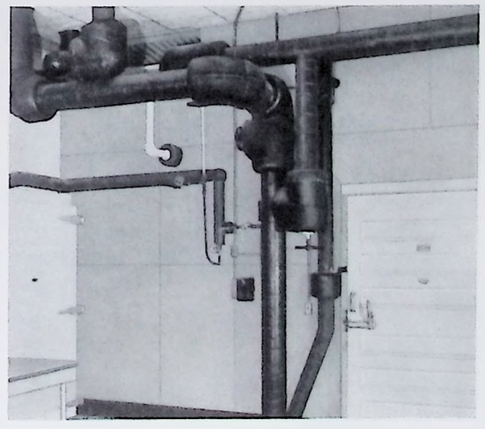
All pipe covering thicknesses are made to fit exactly any size of standard pipe and tubing from ¼" up and are furnished in 36" long molded sections. For larger pipe sizes, Armstrong's Cork Covering is supplied in 36" long sections built up at the factory from beveled lagging, ready to apply on the job.

The pipe sizes for which built-up lagged covering is furnished are as follows:

Light-Duty Thickness —all pipe sizes above 12"
Standard Thickness —all pipe sizes above 14"
Heavy-Duty Thickness—all pipe sizes above 12"

### Fitting Covers

Fitting covers are made in the same thicknesses as are pipe coverings and are designed for all types of standard fittings, such as ells, tees, valves, flanges, unions, weld and sweat fittings, etc. Fitting covers are rigid and will not sag. They are made to join accurately with the pipe covering, thus providing the same dependable protection for fittings that straight lengths of covering provide for all other parts of the line. For the most generally used sizes, cork fitting covers are furnished in two molded sections designed to fit the exact contour of the fitting and ready to apply in the same manner as pipe covering. For the larger sizes, fitting covers are furnished in sections built up at the factory and ready to apply when received on the job.



Cork covering accurately fits all size pipe and fittings.



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## Armstrong's Cork Covering Dimensions

### Nominal Pipe Size Covering

The dimensions of Armstrong's Cork Covering for nominal pipe sizes from ¼" to 36" and for tubing sizes from ⅜" O. D. to 6⅛" O. D. are as shown in the tables below. For sizes above single heavy lines, molded cork covering is furnished. For sizes below single heavy lines, assembled cork lagging sections are furnished in half sections. For sizes below double heavy lines, quarter sections of assembled cork lagging are furnished.

| Nominal Pipe Size, Inches | O. D. Pipe, Inches | Light-Duty Thickness | | Standard Thickness | | Heavy-Duty Thickness | | Nominal 4" Wall Thickness | | Nominal 5" Wall Thickness | | Nominal 6" Wall Thickness | | Nominal 7" Wall Thickness | | Nominal 8" Wall Thickness | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Thickness Inches | O. D. Covering Inches | Thickness Inches | O. D. Covering Inches | Thickness Inches | O. D. Covering Inches | Thickness Inches | O. D. Covering Inches | Thickness Inches | O. D. Covering Inches | Thickness Inches | O. D. Covering Inches | Thickness Inches | O. D. Covering Inches | Thickness Inches | O. D. Covering Inches |
| ¼ | .540 | 1.35 | 3.25 | 1.85 | 4.25 | 2.88 | 6.31 | 4.16 | 8.87 | 5.29 | 11.12 | 5.82 | 12.19 | 7.04 | 14.62 | 8.41 | 17.37 |
| ⅜ | .675 | 1.28 | 3.25 | 1.78 | 4.25 | 2.82 | 6.31 | 4.10 | 8.87 | 5.22 | 11.12 | 6.22 | 13.12 | 6.97 | 14.62 | 8.34 | 17.37 |
| ½ | .840 | 1.20 | 3.25 | 1.70 | 4.25 | 2.73 | 6.31 | 4.01 | 8.87 | 5.14 | 11.12 | 6.14 | 13.12 | 6.89 | 14.62 | 8.26 | 17.37 |
| ¾ | 1.050 | 1.35 | 3.75 | 1.82 | 4.69 | 2.63 | 6.31 | 3.91 | 8.87 | 5.03 | 11.12 | 6.03 | 13.12 | 6.78 | 14.62 | 8.16 | 17.37 |
| 1 | 1.315 | 1.47 | 4.25 | 2.00 | 5.31 | 2.97 | 7.25 | 4.16 | 9.62 | 4.90 | 11.12 | 5.90 | 13.12 | 7.47 | 16.25 | 8.03 | 17.37 |
| 1¼ | 1.660 | 1.51 | 4.69 | 2.32 | 6.31 | 3.10 | 7.87 | 3.98 | 9.62 | 5.26 | 12.19 | 6.48 | 14.62 | 7.29 | 16.25 | 7.86 | 17.37 |
| 1½ | 1.900 | 1.39 | 4.69 | 2.42 | 6.75 | 2.99 | 7.87 | 3.86 | 9.62 | 5.14 | 12.19 | 6.36 | 14.62 | 7.17 | 16.25 | 7.73 | 17.37 |
| 2 | 2.375 | 1.47 | 5.31 | 2.44 | 7.25 | 3.25 | 8.87 | 3.94 | 10.25 | 4.90 | 12.19 | 6.12 | 14.62 | 6.94 | 16.25 | 8.38 | 19.12 |
| 2½ | 2.875 | 1.37 | 5.62 | 2.50 | 7.87 | 3.00 | 8.87 | 4.12 | 11.12 | 5.12 | 13.12 | 5.87 | 14.62 | 7.25 | 17.37 | 8.13 | 19.12 |
| 3 | 3.500 | 1.62 | 6.75 | 2.68 | 8.87 | 3.06 | 9.62 | 4.34 | 12.19 | 4.81 | 13.12 | 6.37 | 16.25 | 6.94 | 17.37 | 7.81 | 19.12 |
| 3½ | 4.000 | 1.62 | 7.25 | 2.81 | 9.62 | 3.56 | 11.12 | 4.09 | 12.19 | 5.31 | 14.62 | 6.12 | 16.25 | 7.56 | 19.12 | 8.50 | 21.00 |
| 4 | 4.500 | 1.68 | 7.87 | 2.56 | 9.62 | 3.31 | 11.12 | 4.31 | 13.12 | 5.06 | 14.62 | 6.43 | 17.37 | 7.31 | 19.12 | 8.25 | 21.00 |
| 5 | 5.563 | 1.65 | 8.87 | 2.78 | 11.12 | 3.78 | 13.12 | 4.53 | 14.62 | 5.34 | 16.25 | 5.90 | 17.37 | 6.77 | 19.12 | 7.72 | 21.00 |
| 6 | 6.625 | 1.81 | 10.25 | 2.78 | 12.19 | 4.00 | 14.62 | 4.00 | 14.62 | 5.37 | 17.37 | 6.25 | 19.12 | 7.18 | 21.00 | 8.00 | 22.63 |
| 8 | 8.625 | 1.78 | 12.19 | 3.00 | 14.62 | 3.81 | 16.25 | 4.37 | 17.37 | 5.25 | 19.12 | 6.19 | 21.00 | 7.00 | 22.63 | 8.00 | 24.63 |
| 10 | 10.750 | 1.93 | 14.62 | 3.31 | 17.37 | 4.19 | 19.12 | — | — | 5.12 | 21.00 | 6.00 | 22.75 | 7.00 | 24.75 | 8.00 | 26.75 |
| 12 | 12.750 | 1.75 | 16.25 | 3.18 | 19.12 | 4.12 | 21.00 | — | — | 5.00 | 22.75 | 6.00 | 24.75 | 7.00 | 26.75 | 8.00 | 28.75 |
| 14 | 14.00 | 1.50 | 17.00 | 3.50 | 21.00 | 4.00 | 22.00 | — | — | 5.00 | 24.00 | 6.00 | 26.00 | 7.00 | 28.00 | 8.00 | 30.00 |
| 16 | 16.00 | 1.50 | 19.00 | 3.00 | 22.00 | 4.00 | 24.00 | — | — | 5.00 | 26.00 | 6.00 | 28.00 | 7.00 | 30.00 | 8.00 | 32.00 |
| 18 | 18.00 | 1.50 | 21.00 | 3.00 | 24.00 | 4.00 | 26.00 | — | — | 5.00 | 28.00 | 6.00 | 30.00 | 7.00 | 32.00 | 8.00 | 34.00 |
| 20 | 20.00 | 1.50 | 23.00 | 3.00 | 26.00 | 4.00 | 28.00 | — | — | 5.00 | 30.00 | 6.00 | 32.00 | 7.00 | 34.00 | 8.00 | 36.00 |
| 22 | 22.00 | 1.50 | 25.00 | 3.00 | 28.00 | 4.00 | 30.00 | — | — | 5.00 | 32.00 | 6.00 | 34.00 | 7.00 | 36.00 | 8.00 | 38.00 |
| 24 | 24.00 | 1.50 | 27.00 | 3.00 | 30.00 | 4.00 | 32.00 | — | — | 5.00 | 34.00 | 6.00 | 36.00 | 7.00 | 38.00 | 8.00 | 40.00 |
| 26 | 26.00 | 1.50 | 29.00 | 3.00 | 32.00 | 4.00 | 34.00 | — | — | 5.00 | 36.00 | 6.00 | 38.00 | 7.00 | 40.00 | 8.00 | 42.00 |
| 28 | 28.00 | 1.50 | 31.00 | 3.00 | 34.00 | 4.00 | 36.00 | — | — | 5.00 | 38.00 | 6.00 | 40.00 | 7.00 | 42.00 | 8.00 | 44.00 |
| 30 | 30.00 | 1.50 | 33.00 | 3.00 | 36.00 | 4.00 | 38.00 | — | — | 5.00 | 40.00 | 6.00 | 42.00 | 7.00 | 44.00 | 8.00 | 46.00 |
| 32 | 32.00 | 1.50 | 35.00 | 3.00 | 38.00 | 4.00 | 40.00 | — | — | 5.00 | 42.00 | 6.00 | 44.00 | 7.00 | 46.00 | 8.00 | 48.00 |
| 34 | 34.00 | 1.50 | 37.00 | 3.00 | 40.00 | 4.00 | 42.00 | — | — | 5.00 | 44.00 | 6.00 | 46.00 | 7.00 | 48.00 | 8.00 | 50.00 |
| 36 | 36.00 | 1.50 | 39.00 | 3.00 | 42.00 | 4.00 | 44.00 | — | — | 5.00 | 46.00 | 6.00 | 48.00 | 7.00 | 50.00 | 8.00 | 52.00 |



### Tubing Covering

| Tubing O. D. Pipe Inches | Light-Duty Thickness | | Standard Thickness | | Heavy-Duty Thickness | |
|---|---|---|---|---|---|---|
| | Thickness Inches | O. D. Covering Inches | Thickness Inches | O. D. Covering Inches | Thickness Inches | O. D. Covering Inches |
| ⅜ | 1.43 | 3.25 | 1.93 | 4.25 | 2.96 | 6.31 |
| ½ | 1.37 | 3.25 | 1.87 | 4.25 | 2.90 | 6.31 |
| ⅝ | 1.31 | 3.25 | 1.81 | 4.25 | 2.84 | 6.31 |
| ⅞ | 1.43 | 3.75 | 1.90 | 4.69 | 2.71 | 6.31 |
| 1⅛ | 1.56 | 4.25 | 2.09 | 5.31 | 3.06 | 7.25 |
| 1⅜ | 1.65 | 4.69 | 2.46 | 6.31 | 3.24 | 7.87 |
| 1⅝ | 1.53 | 4.69 | 2.56 | 6.75 | 3.12 | 7.87 |
| 2⅛ | 1.59 | 5.31 | 2.56 | 7.25 | 3.37 | 8.87 |
| 2⅝ | 1.34 | 5.31 | 2.62 | 7.87 | 3.12 | 8.87 |
| 3⅛ | 1.81 | 6.75 | 2.87 | 8.87 | 3.24 | 9.62 |
| 3⅝ | 1.81 | 7.25 | 2.99 | 9.62 | 3.74 | 11.12 |
| 4⅛ | 1.87 | 7.87 | 2.74 | 9.62 | 3.49 | 11.12 |
| 5⅛ | 1.87 | 8.87 | 3.00 | 11.12 | 3.99 | 13.12 |
| 6⅛ | 2.06 | 10.25 | 3.02 | 12.19 | 4.24 | 14.62 |

## How to Order Armstrong's Cork Covering

To insure the correct listing of materials, orders for Armstrong's Cork Covering should be specific with regard to the following points:

### Thickness of Covering

Light-Duty Thickness
Standard Thickness
Heavy-Duty Thickness
Special Wall Thickness (refer to minimum thickness table on Page 61)

### Quantity

List number of lineal feet of each thickness of covering and number of fittings by types.

### Pipe Size

Pipe sizes should be carefully measured and accurately determined. Sizes are assumed to be "nominal inside pipe diameter" *unless otherwise specified*, i.e., as "Size O.D.," copper and steel tubing, etc.

### Size and Type of Fitting or Valve

Specify if screwed or flanged. *Unless otherwise specified*, all fittings are assumed to be screwed.

Specify if Standard, Extra Heavy (250#), Ammonia, Sweat, Weld. *Unless otherwise specified*, all fittings are assumed to be 125# standard. Unless maker's name and catalog number are specified, 150# fittings are considered the same as standard. 300# fittings are considered same as Extra Heavy, with the exception of 300# valves, which are considered as "Special Fittings."

Specify type fitting, i.e., 90° ell, 45° ell, union, tee, etc. *Unless otherwise specified*, all ells are assumed to be 90°, standard radius. Composite fitting covers designed to fit all makes of weld and sweat ells and tees are furnished for pipe sizes up to and including 6". For weld and sweat ells and tees over 6", Special Fitting Covers are furnished and maker's name and catalog number are required with orders.

Specify type of valve—gate, angle, globe, and whether screwed or bolted bonnet. *Unless otherwise specified*, standard valves under 2" are assumed to be screwed bonnet; 2" and over are assumed to be bolted bonnet. Ammonia valves under 1" are assumed to be screwed bonnet; 1" and over are assumed to be bolted bonnet.

"Special Fittings." Specify manufacturer's name and catalog number of fitting. Where this information is not available, include dimensioned prints with the cork covering order.



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# Sundry Materials for Use With Cork Covering

To air and vaporproof cold lines thoroughly and to apply finishes that are neat and long lasting, it is essential that sundry materials specifically designed for these purposes be used. The sundries described below were developed by the Armstrong Cork Company for the specific phase of the installation where their use is recommended. The necessary sundries are furnished with each order in right quantities to install the cork covering properly.

**Armstrong's No. 299 Waterproof Cement**—This is a waterproof, alkali- and acid-resistant cement that is quick setting and strong. It should be applied only to the surface that will be immediately placed in contact with an adjoining surface. It is necessary to coat only one of two adjoining cork surfaces with No. 299 Cement.

**Coverage**—35 sq. ft. of joint areas per gallon.

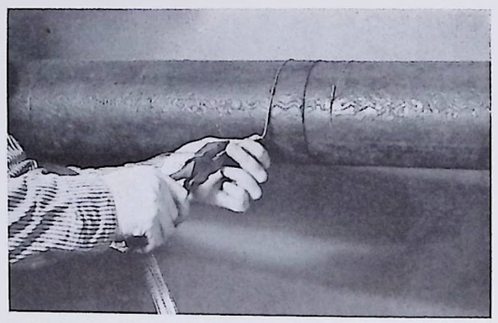
**Packaging**—1- and 5-gallon cans. No. 299 Waterproof Cement weighs 12 lbs. per gallon.



**Copper Clad Steel Wire**—This wire is used to hold the covering firmly in place on the line or fitting. It is a special copper jacketed steel wire, drawn from a steel-cored copper billet, and combines the strength of steel with the corrosion resistance of copper.

It is available in these gauges and weights:

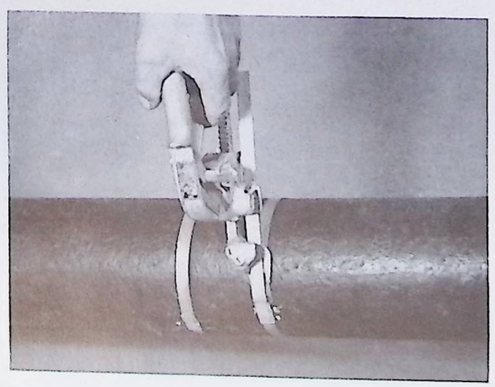
| B and S Wire Gauge | Lbs. per Ft. |
|---|---|
| No. 14 | .0015 |
| No. 12 | .0183 |
| No. 10 | .0291 |



**Galvanized Bands and Seals**—Galvanized bands and seals are substituted for wire at no extra cost for use in applying cork lagging and the larger sizes of cork covering.

| Size of Bands | Gauge | Lbs. per Ft. |
|---|---|---|
| ½ x .015 | 28 | .0256 |
| ½ x .020 | 25 | .034 |
| ¾ x .020 | 25 | .0526 |
| ¾ x .035 | 20 | .0891 |

For applications where corrosive or special atmospheric conditions exist, stainless steel or monel metal strapping and seals should be used.



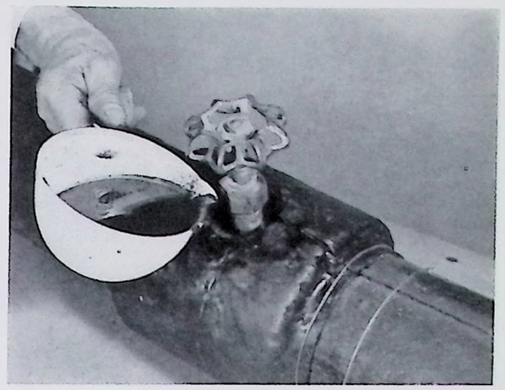


**Fitting Filler**—Armstrong offers two materials for use in sealing off joints and filling voids between fittings on cold lines and the cork fitting covers.

Armstrong's Fitting Filler is made by mixing molten paraffin wax and cork particles. This mixture is poured into fitting covers to eliminate all voids between fitting and cork cover. The necessary amount is shipped as a sundry with every shipment of cork covering.

Brine Putty is a mixture of cork particles and special asphalts primarily used for filling voids and large joints before the application of Armstrong's No. 27-B Seam Filler.

**Weight**—Both weigh 56 lbs. per cu. ft.



**Armstrong's No. 27-B Seam Filler**—This asphalt mastic compound is designed to fill and seal the joints between sections of pipe covering or fitting covers. It has been specially developed to withstand low temperatures. The proper quantity is supplied with all orders for cork covering.

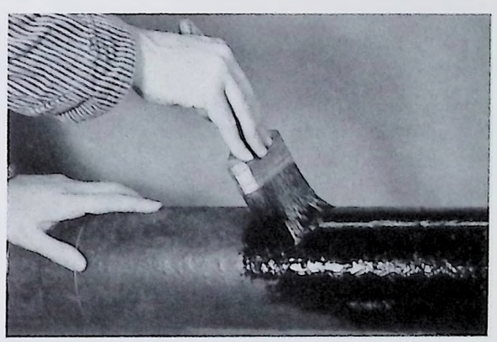
**Packaging**—1- and 5-gallon cans. No. 27-B Seam Filler weighs 13½ lbs. per gallon.



**Armstrong's No. 1 Cork Covering Paint**—After covering has been applied, this paint is used to provide a glossy black finish for the installation. Where any asphaltic surface is not exposed to weather, Armstrong's No. 1 Cork Covering Paint furnishes long lasting protection against vapor infiltration. All cork pipe covering and all insulated tanks and equipment located indoors should receive a coat of this paint annually.

**Coverage**—180 sq. ft. per gallon of brush coat.

**Packaging**—1- and 5-gallon cans. No. 1 Cork Covering Paint weighs 8½ lbs. per gallon.



**Armstrong's Solvopruf®**—This is a solvent proof finishing and adhesive material for use with Armstrong's Corkboard or Cork Covering. Solvopruf resists the deteriorating effects of toluol, methylethylketone, gasoline, kerosene, and benzol. When Solvopruf is to be used, the cork covering is shipped without the asphalt mastic finish on the outer surfaces, as Solvopruf must be applied to bare cork.

Solvopruf is applied with a brush or trowel. When set, it retains its plasticity at temperatures from 35° below zero to 125° Fahrenheit.

**Coverage**—50 sq. ft. per gallon over uncoated cork, as a finish. 100 sq. ft. per gallon as a primer or an adhesive.

**Packaging**—Furnished in a unit consisting of a separate 5-gallon container of Mix A and five 6-oz. bottles of Mix B. One bottle of B is combined with one gallon of Mix A before application.

In addition to the sundries listed above, Armstrong's Insulmastic, described on Page 70, is used as a finish for cork covering out of doors.



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# General Recommendations for Insulation of Cold Lines

Although cork covering is subjected to more severe service conditions than other types of pipe insulation, it can be depended upon for long and efficient life if applied in strict accordance with the recommendations in this section.

### Application of Covering

It is essential that all lines be completely dry. If Armstrong's Cork Covering is applied to wet or frosted pipe, the moisture on the pipe will eventually work its way into the insulation and reduce the efficiency of the job.

Pipe lines must be made tight and carefully tested before any cork covering is applied. Any leaks occurring after application of the covering cause damage which must be immediately repaired. Also, so that the covering fits snugly, all foreign matter such as rust or plaster must be removed from the pipe surface before applying insulation. Care should also be taken to see that the inside surfaces of the cork covering are clean and free from foreign matter.

All wires must be straight and drawn tight. Crooked wires are useless, as they loosen and allow the joints of the covering to open up. This condition permits moisture condensation and frost formation which eventually destroys the insulating efficiency of the material.

End joints must be tight and true if cork covering is to perform efficiently.

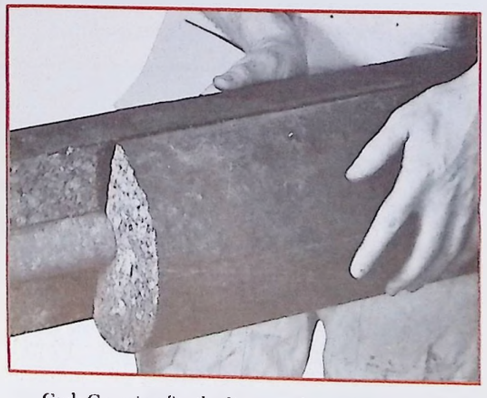
### Sectional Pipe Covering

Sectional covering is applied to the straight runs of pipe with all end joints broken. To start, one 36″ length should be cut in half and one half section and one full length section should then be applied to the pipe. The installation is continued with 36″ half sections until completed.

All dust should be removed from contract surfaces of the covering with a stiff brush before it is applied. Armstrong's Waterproof Cement should be applied to all longitudinal and end joints and the covering should be wired in place with not less than 6 wires to a section, of the size shown in the table on the opposite page.



Applying Armstrong's Waterproof Cement to joints.



Cork Covering fits the line snugly, without voids.





Copper clad steel wire holds the covering in place.



All joints are carefully pointed with seam filler.



Final step is application of cork covering paint.

**Wire Sizes for Cork Covering and Cork Fitting Covers**

| Sectional Covering | | Screwed Fitting Covers | | Flanged Fitting Covers | |
|---|---|---|---|---|---|
| Size | Gauge | Size | Gauge | Size | Gauge |
| **Light-Duty Thickness** | | | | | |
| ¼″–3″ | 14 | ¼″–3″ | 14 | ¼″–¾″ | 14 |
| 3½″–10″ | 12 | 3½″–6″ | 12 | 1″–4″ | 12 |
| 12″–20″ | 10 | 8″–16″ | 10 | 5″–12″ | 10 |
| **Standard Thickness** | | | | | |
| ¼″–1½″ | 14 | ¼″–1½″ | 14 | ¼″–6″ | 12 |
| 2″–8″ | 12 | 2″–6″ | 12 | 8″–20″ | 10 |
| 10″–20″ | 10 | 8″–16″ | 10 | | |
| **Heavy-Duty Thickness** | | | | | |
| ¼″–¾″ | 14 | ¼″–¾″ | 14 | ¼″–4″ | 12 |
| 1″–6″ | 12 | 1″–5″ | 12 | 5″–8″ | 10 |
| 8″–20″ | 10 | 6″–10″ | 10 | | |

The wires should be drawn tight all around and not just at the point where the twist is made. Longitudinal joints of the covering should be along the top and bottom of the pipe rather than along the side. Particular care should be taken to see that all joints are tight. This can be done by wedging the covering tightly between the fitting covers and pulling all wires tight enough so that they are embedded in the asphalt mastic finish around the whole circumference of the covering, without breaking the finish.

### Molded Covers for Screwed Fittings

When screwed fittings are to be insulated, the fitting covers should be applied before the sectional covering. This is done because the fitting covers extend beyond the bead of the fitting and the straight line covering is then wedged into place between the fitting covers to secure tight fit at all the end joints.

### Molded Covers for Flanged Fittings

Molded cork covers for flanged fittings are designed to rest on the outside of the sectional covering. The sectional pipe covering should be applied first and butted against the flanges of the fitting and wedged slightly between them.

Covers for large flanged fittings are assembled

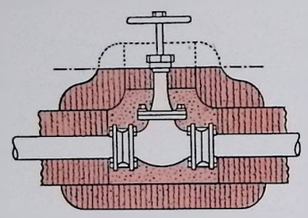


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at the factory from beveled cork lags. These covers are designed to rest on the outside of the sectional covering also, in the same manner as the molded coverings for flanged fittings.

### Covers for Valves

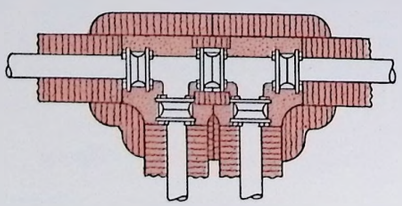
The insulation on valves should not cover the stuffing box. If the valve cover does extend above the stuffing box, cut away the bonnet insulation just enough to leave the stuffing box accessible for adjustment and packing.



In the case of bolted bonnet valves, be sure that the bonnet disc is carefully fitted and sealed. Screwed bonnet valves should be packed with a plastic mixture of crude paraffin and cork particles below the stuffing box and sealed off with Armstrong's Seam Filler.

### Close Fittings

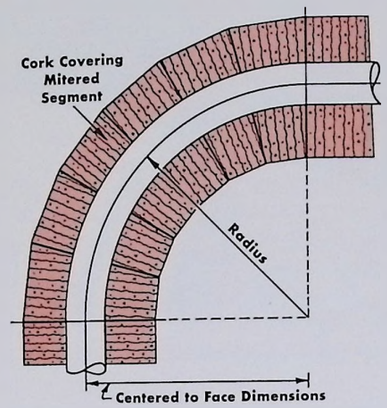
Fittings are frequently installed with short nipples, or even flange to flange. This makes it necessary to cut the fitting covers. When this condition occurs, the entire cut should not be made on one fitting cover but the covers should be cut equally as shown in the illustration.



In the case of flanged fittings, it is advisable to place a ring of covering over the flanges at the joints between the two fitting covers. This provides a bearing for the two cut ends.

### Pipe Bends

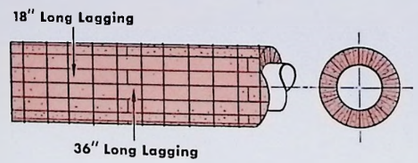
Pipe bends are covered by mitering regular section covering to fit the bend. After the angle of the miter has been determined, pieces should




be cut small enough so that practically straight line contact between the pipe and the covering is obtained. The miters should be applied starting at either end, and the last piece should be carefully measured for full tight fit.

### Cork Lagging on Pipes

For pipes larger than those for which sectional molded covering is made, lagging is supplied in 36″ lengths properly beveled for the pipe size and is built up on the pipes. (See "Cork Lagging" on Page 70 for description of this material.) The lag covering is built up on the pipes before any fitting covers, either screwed or




flanged, are applied. To start the application of the lagging, alternate 18″ and 36″ lengths should be used. The covering job can then be continued with full 36″ lengths until it is complete. Wires should be spaced on 6″ centers and must be pulled straight and tight and slightly embedded in the asphalt mastic finish. If galvanized bands are used, they may be spaced on 8″ centers and drawn tight with the take-up bolts.



### Pipe Spacing

For maximum efficiency and neat finished appearance, pipes and fittings must be spaced to allow full thickness of insulation to be applied without cutting. The table below lists the minimum distances between pipes or between pipes and adjacent surfaces that permit the application of Armstrong's Cork Covering in the full three regular thicknesses.

All openings in the walls and floors should be large enough to allow full thickness of covering to pass through. This insures a tight job and eliminates frost and drip that always occur when covering is butted to the wall or floor. The table on Page 50 lists the outside diameters of Armstrong's Cork Covering for all pipe and tubing sizes from ¼″ up to 36″.

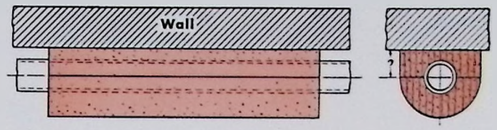
### Pipe Spacing Table

| Coverings<br>Fitting Pipes<br>Pipe Sizes | Space required between parallel pipes | Space required between pipes and adjacent surfaces |
|---|---|---|
| **Light-Duty Thickness** | | |
| Screwed fittings uup to and including 6″ | 6″ | 4″ |
| Screwed fittings larger than 6″ | 10″ | 5″ |
| Flanged fittings | 10″ | 5″ |
| **Standard Thickness** | | |
| Screwed fittings up to and including 6″ | 8″ | 6″ |
| Screwed fittings larger than 6″ | 14″ | 8″ |
| Flanged fittings | 14″ | 8″ |
| **Heavy-Duty Thickness** | | |
| Screwed fittings up to and including 3″ | 10″ | 8″ |
| Screwed fittings larger than 3″ | 18″ | 12″ |
| Flanged fittings | 18″ | 12″ |

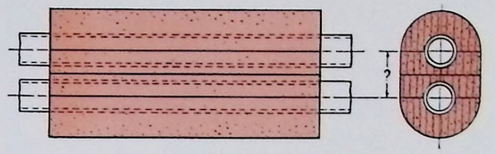
### Armstrong's Cork Centers

Armstrong's Cork Centers should be used on pipes that are too close to each other or to adjacent wall or ceiling surfaces to use the regular covering. Centers are used in combination with sectional covering as shown in the illustrations at top of the next column.

**NOTE:** When ordering molded Armstrong's Cork Centers, specify sizes of pipes and distance between center of pipes or between center of pipes and adjacent surface.



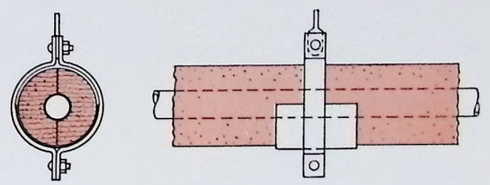

Pipe Close to Wall



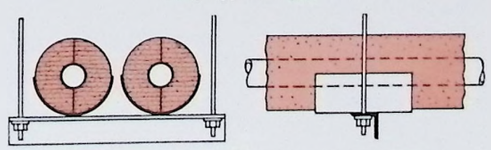

Pipes Close Together

### Pipe Hangers

To distribute the weight of the line and to prevent damage to the covering, all cork-covered lines must be supported by hangers on the outside of the covering. Hangers attached directly to the pipe complicate the installation of the covering. If the hangers are left uninsulated, frost will form on them and eventually work its way into the pipe covering itself and cause failure at those points. The only way to prevent this condition, if hangers are attached directly to the pipe, is to insulate the hanger rods for a distance of several feet above the covering. This is time consuming and expensive, and it is far more practical to use strap or trapeze type hangers as shown below to support the line and covering from the outside.



Strap Type Hanger



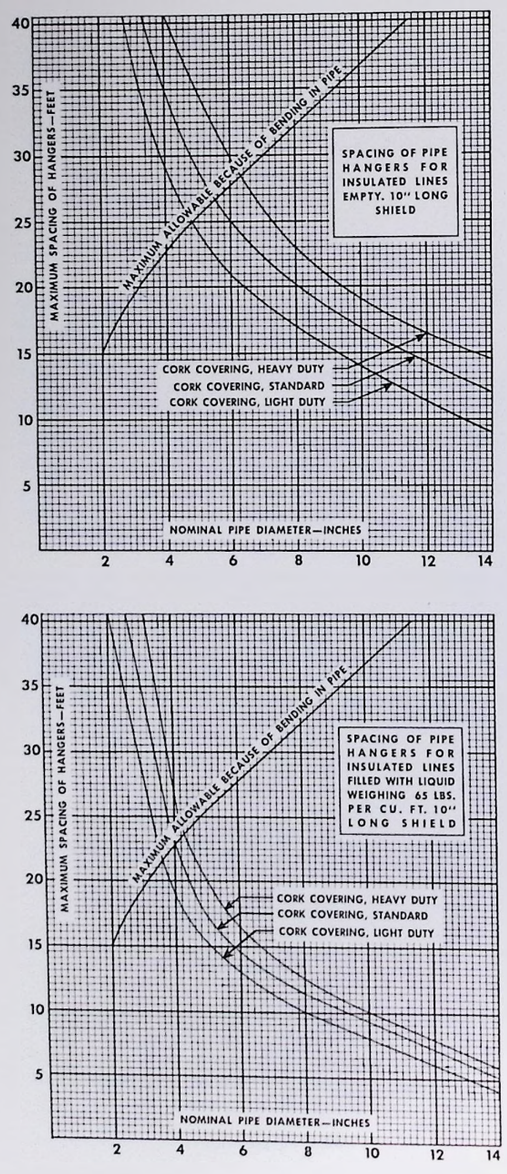
Trapeze Type Hanger

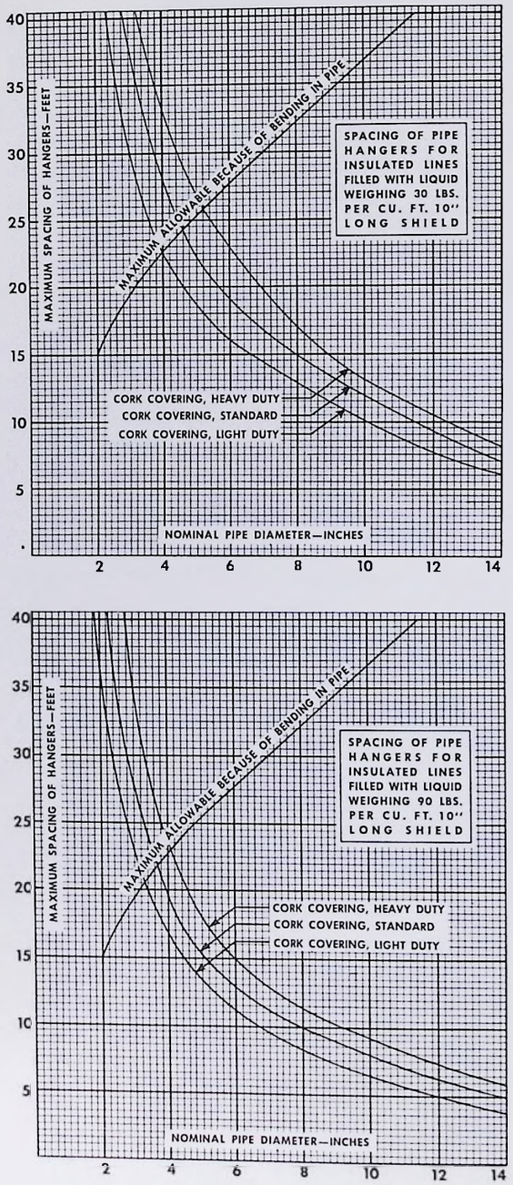


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To prevent the weight of the line and the cork covering from compressing the insulation and breaking through the finish at the hangers, careful attention should be given to the spacing of the hangers. The four graphs on this page can be used to determine proper distances between hangers on the outside of the covering. The curves on these graphs are based on lines filled with refrigerants of various weights and supported by 10" long shields of 16-gauge metal.

To find pipe hanger spacing, draw a line vertically from the pipe diameter figure at the bottom of the chart. At the point where this line meets the curve representing the thickness of covering being used, proceed horizontally to the left, and read proper hanger spacing figure.












### Armstrong's Cork Covering Paint

When rooms through which the insulated, refrigerated piping runs are dry, Armstrong's Cork Covering Paint is the most widely used finish. This is an asphaltic paint and is applied with a brush. It reinforces the asphalt mastic finish on the cork covering and provides a neat, shiny black finish for the line. It also arrests corrosion of the wires which hold the covering in place. Cork Covering Paint should be applied when the installation is completed, and for proper maintenance a good coat should be applied every year thereafter.

### Canvas Finish

When a de luxe finish that can be painted any desired color is required, a canvas finish should be applied. So that the canvas will be neat and smooth, one layer of rosin-sized paper, with edges lapped 1", should be wrapped around the covering and stapled securely in place. 8-oz. canvas should then be stretched tightly over the paper and sewn or pasted in place. If possible, all seams should be on top of the line. Sewn seams should be blind stitched where exposed. After application of the canvas, it should be sized with a good cold water sizing, then painted with two coats of lead and oil paint.

### Tape Finish

For extra reinforcement of the finish and protection of the wires, membrane tape should be used on cork covering. The tape is applied to the fitting covers using a combination of wrapping and stripping to cover all surfaces. After application, a good coat of Armstrong's Cork Covering Paint should be applied.

### Outdoor Weatherproof Finishes

The following finishes are recommended for lines exposed to the weather, wet or humid atmospheres, or running through refrigerated rooms or pipe shafts.

### Straight Pipe Runs

On sectional pipe covering, roofing paper should be applied in one layer, lapping edges at least 2" and butting the body of flange fitting covers and extending over shoulders of screw fitting covers. The lap should be made to form a watershed and should be sealed with an asphaltic weatherproofing material. All longitudinal laps should be on the side. The weatherproofing should then be wired in place with copper-clad wire or galvanized bands. The roofing paper should then be finished with a good coat of Armstrong's No. 1 Cork Covering Paint.

### Fitting Covers

Armstrong's Insulmastic should be used on fitting covers. Insulmastic is trowelled on in two coats over hexagonal wire mesh that has been firmly wired and stapled in place. It should be brought over the edge of the fittings to form a seal with the straight pipe covering.

### Solvent Proof Finish

For cork covering installations exposed to solvents and solvent fumes, Armstrong's Solvopruf finish should be used. This finish is brushed or trowelled on to the cork covering. When this finish is to be used, cork covering and fitting covers should be ordered without the factory applied asphalt plastic exterior finish. The Solvopruf finish must be applied directly to the uncoated surfaces of the cork covering.

### Fire-Resistant Finish

Where a fire-resistant finish is specified for cork insulated lines, Armstrong's CC Navy Sealer No. 44 is recommended. Cork covering should be ordered unfinished, as this sealer is applied to bare cork surfaces. This specially developed, fire-resistant vapor barrier coating is shipped in proper amounts as a sundry and is used to coat both inner and outer faces of the covering and as an adhesive at all joints. CC Navy Sealer should be applied with a brush to curved surfaces and with a trowel to flat surfaces. When this sealer is used, and the covering is applied with copper clad steel wire, the installation meets all requirements of Military Specification MIL-P-876A.

Navy Sealer can be ordered separately. Its coverage is 35 sq. ft. per gallon in a $\frac{1}{16}$" thick coat. Shipped in 1- and 5-gallon containers.



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## Armstrong's Cork Covering—Comparative Heat Loss Data

| Pipe size inches | Light-Duty Thickness: Transmission in Btu per lin. ft. per deg. F. dif. in temp. for 1 hour | Light-Duty Thickness: 24 hours | Standard Thickness: 1 hour | Standard Thickness: 24 hours | Heavy-Duty Thickness: 1 hour | Heavy-Duty Thickness: 24 hours | Bare Pipes: 1 hour | Bare Pipes: 24 hours |
|---|---|---|---|---|---|---|---|---|
| ¼ | .0802 | 1.92 | .0713 | 1.71 | .0611 | 1.47 | 0.452 | 10.8 |
| ⅜ | .0906 | 2.17 | .0976 | 1.91 | .0670 | 1.60 | 0.494 | 11.9 |
| ½ | .104 | 2.50 | .0895 | 2.15 | .0742 | 1.78 | 0.565 | 13.6 |
| ¾ | .111 | 2.66 | .0973 | 2.34 | .0829 | 1.98 | 0.670 | 16.0 |
| 1 | .121 | 2.90 | .105 | 2.52 | .0873 | 2.09 | 0.817 | 19.5 |
| 1¼ | .135 | 3.24 | .110 | 2.64 | .959 | 2.30 | 1.005 | 24.1 |
| 1½ | .155 | 3.73 | .116 | 2.78 | .104 | 2.50 | 1.130 | 27.2 |
| 2 | .175 | 4.20 | .131 | 3.14 | .113 | 2.71 | 1.383 | 33.2 |
| 2½ | .207 | 4.98 | .145 | 3.48 | .132 | 3.17 | 1.650 | 39.6 |
| 3 | .215 | 5.16 | .157 | 3.77 | .147 | 3.52 | 1.948 | 46.7 |
| 3½ | .236 | 5.67 | .167 | 4.00 | .146 | 3.51 | 2.20 | 52.8 |
| 4 | .254 | 6.11 | .192 | 4.61 | .163 | 3.92 | 2.44 | 58.5 |
| 5 | .300 | 7.20 | .211 | 5.06 | .173 | 4.15 | 2.97 | 71.3 |
| 6 | .326 | 7.86 | .238 | 5.70 | .187 | 4.49 | 3.50 | 84.0 |
| 8 | .400 | 9.60 | .276 | 6.61 | .227 | 5.45 | 4.45 | 107.0 |
| 10 | .457 | 11.0 | .329 | 7.90 | .268 | 6.43 | 5.48 | 132.0 |
| 12 | .658 | 15.8 | .377 | 9.04 | .303 | 7.27 | 6.48 | 155.0 |
| 14 | .712 | 17.1 | .415 | 9.96 | .327 | 7.86 | 7.09 | 170.0 |
| 16 | .819 | 19.6 | .462 | 11.1 | .363 | 8.71 | 8.15 | 196.0 |
| 18 | .867 | 20.7 | .509 | 12.2 | .405 | 9.72 | 9.11 | 219.0 |
| 20 | .972 | 23.3 | .553 | 13.2 | .438 | 10.5 | 10.1 | 242.0 |

## Savings Effected by Armstrong's Cork Covering

The above data simplify the calculation of refrigeration losses in covered and bare cold lines and readily prove that Armstrong's Cork Covering can pay for itself within a few months. The saving of refrigeration resulting from use of Armstrong's Cork Covering continues as long as it remains in use and is properly maintained.

The following example illustrates the use of the table and describes the simple calculation necessary to determine annual cold line refrigeration losses. Assume a 1½" line 200 ft. long including fittings carrying 15° F. brine and with surrounding air at an average of 85° F. The temperature difference is 70° F. The lineal foot loss of bare 1½" pipe is 27.2 Btu's per 24 hours per degree difference in temperature. Hence the annual loss is $27.2 \times 200 \times 70 \times 365 = 138{,}992{,}000$ Btu's. This figure divided by 288,000 (Btu's per ton of refrigeration) = 482 tons, the annual refrigeration loss through uninsulated pipe under the conditions stated. Now assuming the cold line to be covered with Armstrong's Cork Covering, Brine Thickness, the 24-hour loss for the conditions is 2.78 Btu's. The annual loss is $2.78 \times 200 \times 70 \times 365 \div 288{,}000 = 49$ tons.

The annual saving under the two conditions is, then 482 — 49 or 433 tons. Evaluating this loss at a fair average cost of $1.75 per ton, the annual saving is $757.75. As the fair average cost of 200 ft. of Brine Thickness Armstrong's Cork Covering is $337.50, the insulation cost is recovered within the first six months of operation.



## Recommended Minimum Cork Covering Thicknesses

For line temperatures lower than 25° F. below zero, special wall thicknesses of Armstrong's Cork Covering as listed in the following table are recommended. Particular attention should be given to the design conditions outlined in Notes 1–5, upon which the thickness recommendations below are based.

1. Figures in table are degrees Fahrenheit and are *minimum* temperatures for use with the thickness stated. Table is based on covering used in spaces at normal temperatures and humidities, in this case an air temperature of 70° F. and with relative humidities up to 70% at 70° F. air temperature.
2. For air temperatures in excess of 70° F., base thickness on a line temperature proportionately lower.
3. For relative humidities of 70%–90% at 70° F., base thickness on a line temperature of 20° F. lower.
4. For relative humidities of 90% and above at 70° F., base thickness on a line temperature of 30° F. lower.
5. For relative humidities at temperatures above 70° F., base thickness on relative humidity at 70° F. having equal moisture.

| Pipe Diam. Inches | THICKNESS OF CORK COVERING 4" | 5" | 6" | 7" | 8" | 9" | 10" | 11" | 12" | 13" | 14" | 15" | 16" |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ¼ | −200 | | | | | | | | | | | | |
| ⅜ | −200 | | | | | | | | | | | | |
| ½ | −200 | | | | | | | | | | | | |
| ¾ | −120 | −200 | | | | | | | | | | | |
| 1 | −110 | −180 | | −280 | | | | | | | | | |
| 1¼ | −95 | −150 | | −250 | | | | | | | | | |
| 1½ | −90 | −145 | −200 | −245 | −285 | | | | | | | | |
| 2 | −80 | −130 | −185 | −240 | −270 | | | | | | | | |
| 2½ | −70 | −120 | −170 | −225 | −265 | | | | | | | | |
| 3 | −65 | −110 | −155 | −200 | −240 | −275 | | | | | | | |
| 3½ | −60 | −100 | −145 | −195 | −240 | −270 | | | | | | | |
| 4 | −55 | −95 | −140 | −190 | −235 | −270 | | | | | | | |
| 5 | −50 | −85 | −125 | −170 | −215 | −250 | | | | | | | |
| 6 | −40 | −80 | −120 | −160 | −200 | −235 | −265 | | | | | | |
| 8 | −35 | −70 | −105 | −140 | −180 | −215 | −250 | | | | | | |
| 10 | −30 | −60 | −95 | −130 | −165 | −200 | −235 | −270 | | | | | |
| 12 | −30 | −60 | −90 | −120 | −160 | −200 | −235 | −270 | | | | | |
| 14 | −30 | −60 | −85 | −120 | −155 | −190 | −225 | −260 | | | | | |
| 16 | −30 | −55 | −85 | −115 | −145 | −180 | −215 | −250 | | | | | |
| 18 | −30 | −50 | −80 | −110 | −140 | −170 | −200 | −240 | −280 | | | | |
| 20 | −25 | −50 | −75 | −105 | −135 | −165 | −195 | −225 | −255 | | | | |
| 22 | −25 | −50 | −75 | −105 | −135 | −165 | −195 | −225 | −255 | | | | |
| 24 | −25 | −50 | −75 | −105 | −135 | −160 | −190 | −220 | −250 | | | | |
| 27 | −25 | −50 | −75 | −100 | −130 | −160 | −190 | −220 | −250 | | | | |
| 30 | −25 | −50 | −70 | −100 | −130 | −160 | −185 | −210 | −240 | −265 | | | |
| 33 | −25 | −50 | −70 | −100 | −130 | −155 | −185 | −210 | −235 | −260 | | | |
| 36 | −25 | −45 | −70 | −100 | −125 | −155 | −180 | −205 | −230 | −255 | | | |
| 42 | −20 | −45 | −70 | −100 | −125 | −150 | −175 | −200 | −225 | −250 | | | |
| 48 | −20 | −45 | −70 | −95 | −120 | −150 | −175 | −195 | −220 | −240 | −260 | | |
| 54 | −20 | −45 | −65 | −95 | −120 | −145 | −170 | −190 | −215 | −235 | −255 | | |
| 60 | −20 | −45 | −65 | −95 | −115 | −145 | −170 | −190 | −210 | −230 | −250 | −270 | |
| 66 | −20 | −40 | −65 | −90 | −115 | −140 | −165 | −185 | −205 | −225 | −245 | −270 | |
| 72 | −20 | −40 | −65 | −90 | −110 | −135 | −160 | −180 | −200 | −220 | −240 | −260 | |
| 78 | −20 | −40 | −60 | −85 | −110 | −135 | −155 | −175 | −200 | −220 | −240 | −260 | |
| 84 | −15 | −40 | −60 | −85 | −105 | −130 | −150 | −170 | −195 | −215 | −235 | −255 | |
| 96 | −15 | −35 | −55 | −80 | −100 | −125 | −145 | −165 | −190 | −210 | −230 | −250 | |
| 106 | −15 | −35 | −55 | −75 | −95 | −120 | −140 | −160 | −185 | −200 | −220 | −240 | −260 |
| 120" & over | −15 | −35 | −50 | −70 | −90 | −115 | −135 | −155 | −175 | −195 | −215 | −240 | −260 |

**Example:**—Given a refrigerant line whose nominal pipe size is 16" and is specified to operate at a temperature of —105° F., what thickness of cork covering should be specified? Assuming normal conditions surrounding the line (reference Note 1), select the *minimum temperature* for this pipe size which corresponds closest to that specified. In this case —115° F. is the closest minimum and requires 7" thickness cork covering. Should temperature or humidity vary from the assumed normal, adjust the given line temperature as indicated in Notes 2–5.



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# Specifications for Application Of Armstrong's Cork Covering

These specifications are included for the convenience of architects, engineers, and owners who desire to specify Armstrong's Cork Covering.

### 1. General

**1a. Insulation Thickness**

After all the pipe lines have been tested and made tight, they shall be covered with Armstrong's Cork Covering and Fitting Covers of proper thickness as outlined below:

For line temperatures above 35° F.—Light-Duty Thickness

For line temperatures from 0° F. to 35° F.—Standard Thickness

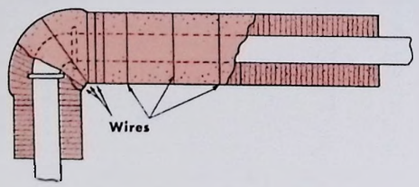
For line temperatures from 0° F. to minus 25° F.—Heavy-Duty Thickness

**1b. Condition of Cold Line**

All foreign matter such as plaster shall be removed from all pipe surfaces before covering is applied. Under no circumstances shall pipes be covered while wet or in a frosted condition.

### 2. Sectional Covering

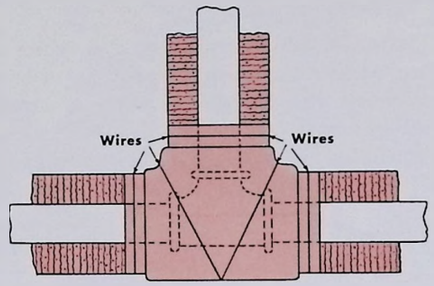
**2a. Method of Application**




Sectional covering shall be applied with all end joints broken by making one-half of the first section 18 inches long and leaving the other half 36 inches in length. All longitudinal joints shall be on the top and the bottom of the pipe and not along the sides. The covering shall be applied with Armstrong's Waterproof Cement on all joints and wired in place with not less than six copper-clad steel wires to a section.

### 3. Molded Fitting Covers

**3a. Method of Application**




Molded fitting covers shall be applied with Armstrong's Waterproof Cement on all joints and wired in place with copper-clad steel wire using not less than four wires on screwed fittings and six wires on flanged fittings. All spaces between covers and fittings shall be carefully filled with Armstrong's Fitting Filler.

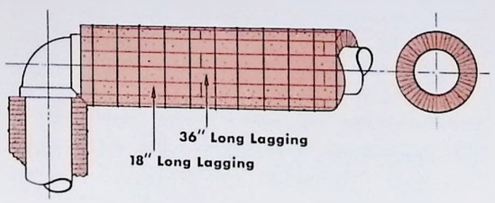
**Note:** With screwed fittings, the fitting covers are applied before the straight pipe covering; with flanged fittings, the straight pipe covering is applied before the fitting covers.

### 4. Use of Seam Filler

After the covering is applied, all seams and chipped edges shall be filled with Armstrong's Seam Filler so as to seal all breaks and openings and leave a smooth and even surface.

### 5. Cork Lagging

**5a. Method of Application**




Lagging may be factory assembled into half sectional form in which case the assembly shall proceed as with sectional covering. With lagging



assembled on the job, all joints shall be broken by starting with alternate 18- and 36-inch long lags. Armstrong's Waterproof Cement shall be used on all joints, and the lags shall be wired in place with copper-clad steel wire using not less than six wires to every three feet of lagging.

**Note 1:** In all cases where a pipe passes through an insulated wall into a refrigerated room the covering shall extend one inch beyond the wall inside the room.

**Note 2:** Wall and floor openings for insulated pipes must be large enough to allow the full thickness of the covering to be used.

### 6. Finishes—Indoor Piping

**6a. Cork Covering Paint**

After cork covering has been applied and seams filled and all edges smoothed, apply a good coat of Armstrong's No. 1 Cork Covering Paint over the installation in dry inside rooms.

**6b. Canvas Finish**

After cork covering has been applied and seams filled and all edges smoothed, but not painted, one layer of 25-lb. rosin-sized paper, with edges lapped 1" shall be wrapped around the covering and stapled securely in place. Over the paper, 8-oz. canvas shall be stretched tightly and pasted or sewn in place. All seams shall be on top of the lines. Sewn seams should be blind stitched where exposed.

Fittings shall be finished with a coat of asbestos cement applied over hexagonal mesh wire firmly laced in place. After the cement is dry, 8-oz. canvas shall be carefully cut to fit smoothly over the fittings, and pasted or sewn.

Canvas finish on fittings and pipe covering shall be sized with cold water sizing. When dry, the canvas shall be painted with two coats of lead and oil paint of the color specified.

**6c. Membrane Tape Finish**

After cork covering has been applied and seams filled and all edges smoothed (but not painted), membrane tape shall be applied to the covering and fitting covers as follows:

The tape shall be applied to the fitting covers to conform to the curvature of the cover using a combination of wrapping and stripping, so as to cover all surfaces. The tape shall crimp over the shoulders of the fitting covers, and the loose ends shall be tied at the junction of the fitting cover and the straight pipe covering by wrapping the tape on the straight covering. All loose ends of tape strips shall be fastened on fitting covers with one wrap of tape around the covers where the ends occur.

The tape shall be wrapped spirally around the straight covering, lapping the edges ½" after establishing the angle of the wrap.

The exterior surface of the tape shall be finished with a good coat of Armstrong's No. 1 Cork Covering Paint.

### 7. Finishes—Outdoor Piping

**7a. Weatherproof Paper (On Sectional Covering)**

Weatherproof paper shall be applied over the Armstrong's Cork Covering on all refrigerated piping in the following locations:

1. Located outdoors or otherwise exposed to weather conditions
2. In refrigerated rooms
3. Exposed to wet or steamy atmosphere
4. Run in tunnels or underground trenches. (If tunnel or trench is well drained and ventilated, Cork Covering Paint may be used.)

Sectional Covering—After covering has been completely applied, one layer of two-ply roofing paper shall be applied on the straight pipe runs with at least a 2" lap at all joints. The lap shall be made in every instance so as to form a watershed. All laps shall be sealed and the longitudinal laps shall be additionally secured at intervals with coppered staples. The weatherproofing shall be wired in place with No. 14 copper-clad wire on approximately 9" centers. It shall be finished with Armstrong's No. 1 Cork Covering Paint.

The weatherproofing shall butt the body of fitting covers and extend over the shoulders of screwed fitting covers.

**7b. Armstrong's Insulmastic (On Fitting Covers)**

The weatherproofing on fitting covers shall be two coats of Armstrong's Insulmastic, each ⅛" thick, which dry to a final thickness of approximately 3/16". The Insulmastic shall be applied evenly and neatly and shall be brought over the edges of the fitting covers so as to seal the joints where the roofing paper on the straight line covering butts the fitting covers.



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# Maintenance of Cold Line Insulation

It is not reasonable to expect any equipment to give long and economical service unless it is kept in good condition. As outlined in the preceding pages, the insulation of low-temperature lines is subjected to unusually severe attack by moisture. If applied correctly and given proper care Armstrong's Cork Covering or Lagging installations do not wear out. There are jobs on record that are 25 and 30 years old which are still giving excellent service because they have been kept in good operating condition by routine care and maintenance every year. If cork covered lines are not properly maintained it is possible that condensation will form wherever a break in the exterior vapor seal occurs. It will then work into and under the good insulation causing failure. This condensation always rusts piping, often making replacement necessary.

On lines and equipment the first step in maintenance is to inspect the wires and bands to make sure that they are all tight and in place. Loose wires can be tightened and missing wires should be replaced. Only copper-clad steel wire should be used because it alone has the strength and corrosion resistance that is necessary.

As the bands or wires are being replaced, the covering should be closely inspected. Covering that has badly deteriorated should be replaced with new covering. Dents, gouges, and deep scars can be repaired by pointing with Armstrong's No. 27-B Seam Filler.

Next, the entire installation should be given a good coat of Armstrong's No. 1 Cork Covering Paint. This paint will fill up small cracks and crazes in the old finish and keep them from getting larger. It also cuts down moisture and air leaks into the insulation.

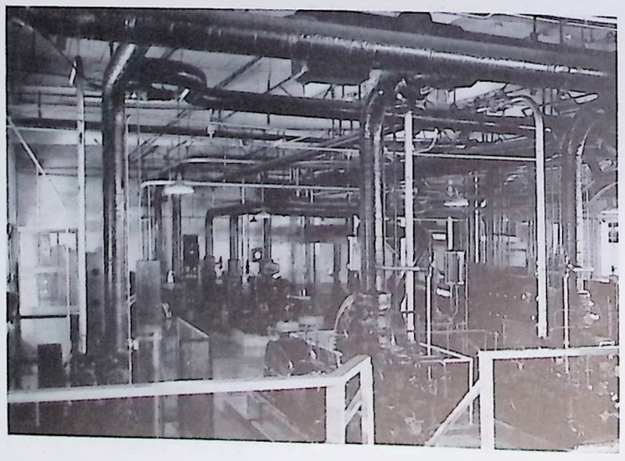
On indoor lines finished with canvas and paint the only maintenance generally required is repainting as often as necessary. Every three to five years is the usual schedule.

In the case of bad dents that have broken through the canvas jacket, the covering underneath should be either replaced or repaired with No. 27-B Seam Filler, depending on the damage, and then a patch of new rosin sized paper, canvas and paint should be applied.

On outdoor covering, wires and bands must be inspected and repaired the same as for indoor covering. A yearly painting of the weatherproof paper with Armstrong's No. 1 Cork Covering Paint is recommended.

On fitting covers, if breaks have occurred in the finish, they should be repaired with the finishing material originally used.

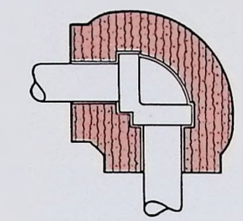
Fitting covers finished with Armstrong's Insulmastic should be painted periodically with Armstrong's No. 1 Cork Covering Paint.



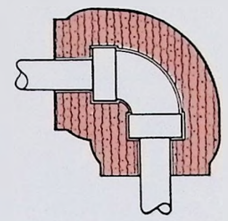
This photograph is dramatic evidence of the value of properly maintaining cork covering. Installed twenty years ago, this covering has been kept in perfect condition by a program of periodic inspection, painting, and minor repair.



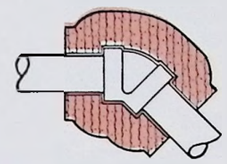
# Types of Cork Fitting Covers



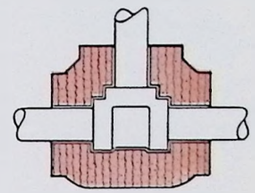
Ell
(Molded Cork Jacket)



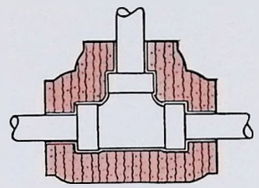
Long Turn Ell
(Molded Cork Jacket)



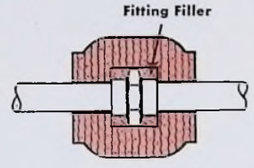
45° Ell
(Molded Cork Jacket)



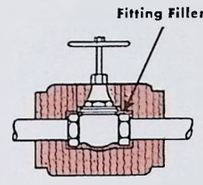
Tee
(Molded Cork Jacket)



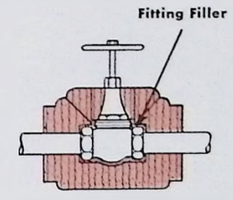
Long Turn Tee
(Molded Cork Jacket)



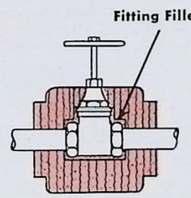

Union
(Molded Cork Jacket)



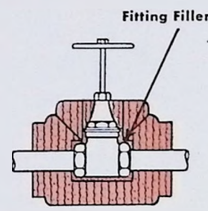

Screwed End, Screwed Bonnet
Globe Valve (Muff Type)



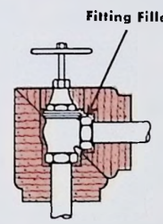

Screwed End, Screwed Bonnet
Globe Valve (With Bonnet)



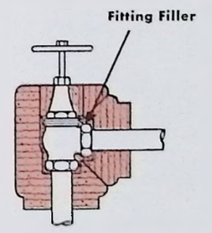

Screwed End, Screwed Bonnet
Gate Valve (Muff Type)



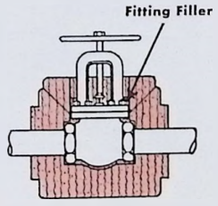

Screwed End, Screwed Bonnet
Gate Valve (With Bonnet)



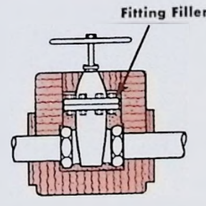

Screwed End, Screwed Bonnet
Angle Valve (Muff Type)



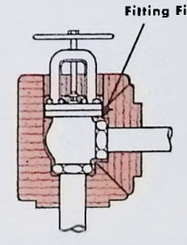

Screwed End, Screwed Bonnet
Angle Valve (With Bonnet)



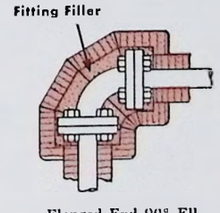

Screwed End, Bolted Bonnet
Globe Valve



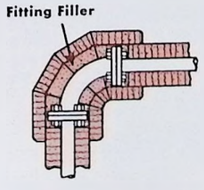

Screwed End, Bolted Bonnet
Gate Valve



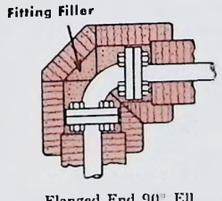

Screwed End, Bolted Bonnet
Angle Valve



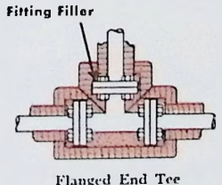

Flanged End 90° Ell
Recessed for Flanges



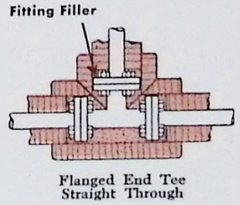

Flanged End 90° Ell
Straight Through




Flanged End 90° Ell
Recessed for Pipe Covering



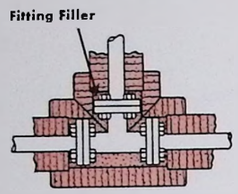

Flanged End Tee
Recessed for Flanges



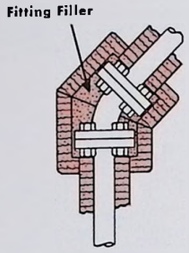

Flanged End Tee
Straight Through



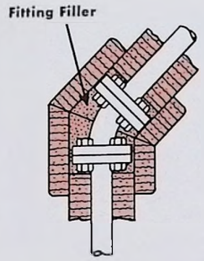

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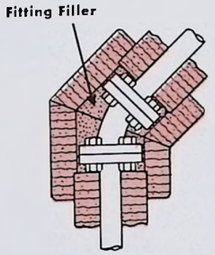

Flanged End Tee
Recessed for Pipe Covering



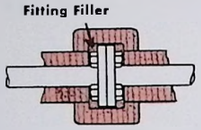

Flanged End 45° Ell
Recessed for Flanges



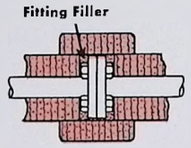

Flanged End 45° Ell
Straight Through



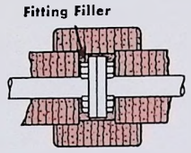

Flanged End 45° Ell
Recessed for Pipe Covering



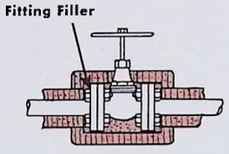

Flange Cover
Recessed for Flanges



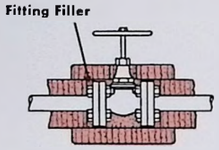

Flange Cover
Straight Through



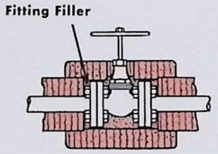

Flange Cover
Recessed for Pipe Covering



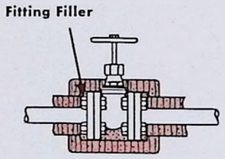

Flanged End
Screwed Bonnet Globe Valve
Recessed for Flanges



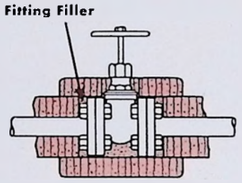

Flanged End
Screwed Bonnet Globe Valve
Straight Through



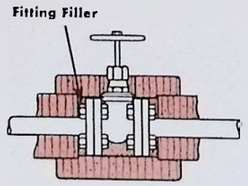

Flanged End
Screwed Bonnet Globe Valve
Recessed for Pipe Covering



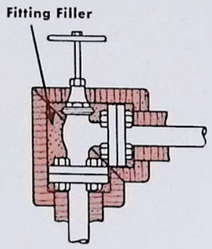

Flanged End
Screwed Bonnet Gate Valve
Recessed for Flanges



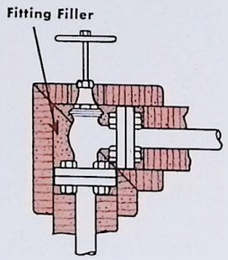

Flanged End
Screwed Bonnet Gate Valve
Straight Through



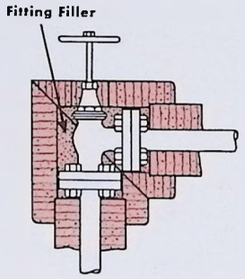

Flanged End
Screwed Bonnet Gate Valve
Recessed for Pipe Covering



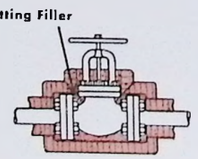

Flanged End
Screwed Bonnet Angle Valve
Recessed for Flanges



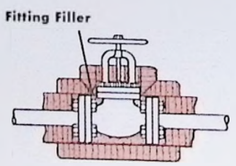

Flanged End
Screwed Bonnet Angle Valve
Straight Through



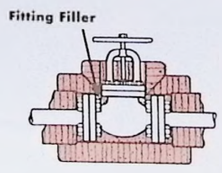

Flanged End
Screwed Bonnet Angle Valve
Recessed for Pipe Covering



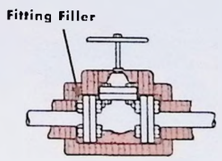

Flanged End
Bolted Bonnet Globe Valve
Recessed for Flanges




Flanged End
Bolted Bonnet Globe Valve
Straight Through

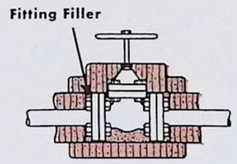



Flanged End
Bolted Bonnet Globe Valve
Recessed for Pipe Covering

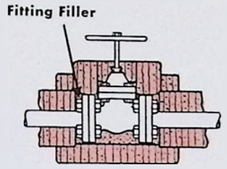



Flanged End
Bolted Bonnet Gate Valve
Recessed for Flanges

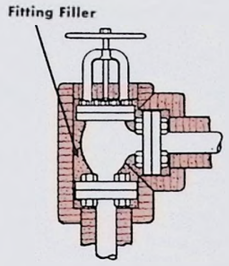




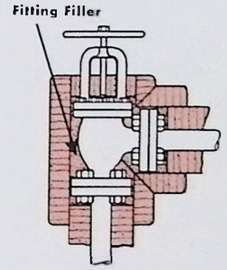

Flanged End
Bolted Bonnet Gate Valve
Straight Through



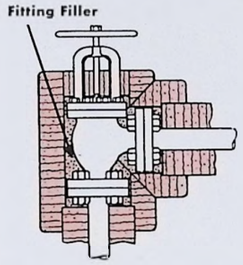

Flanged End
Bolted Bonnet Gate Valve
Recessed for Pipe Covering



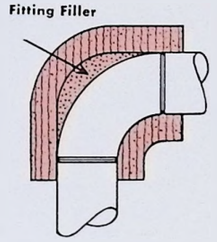

Flanged End
Bolted Bonnet Angle Valve
Recessed for Flanges



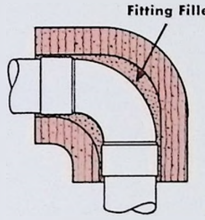

Flanged End
Bolted Bonnet Angle Valve
Straight Through



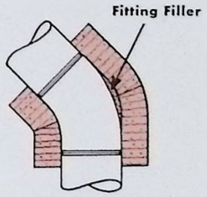

Flanged End
Bolted Bonnet Angle Valve
Recessed for Pipe Covering



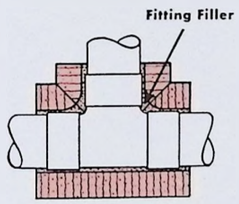

90° Weld Ell in a Composite
Weld and Sweat Jacket



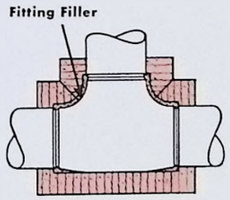

90° Sweat Ell in a Composite
Weld and Sweat Jacket



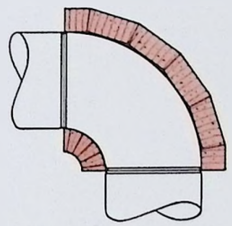

45° Weld Ell in a Composite
Weld and Sweat Jacket



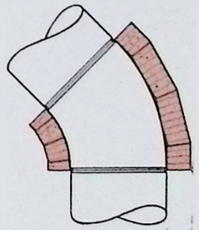

Sweat Tee



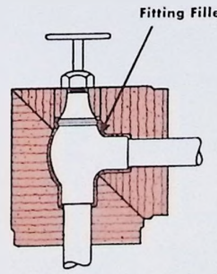

Weld Tee



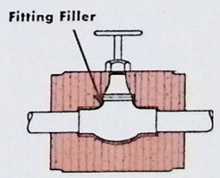
90° Weld Ell
8″ or over Pipe Size



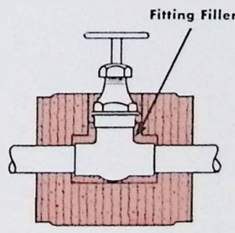
45° Weld Ell
8″ or over Pipe Size




Sweat Angle Valve



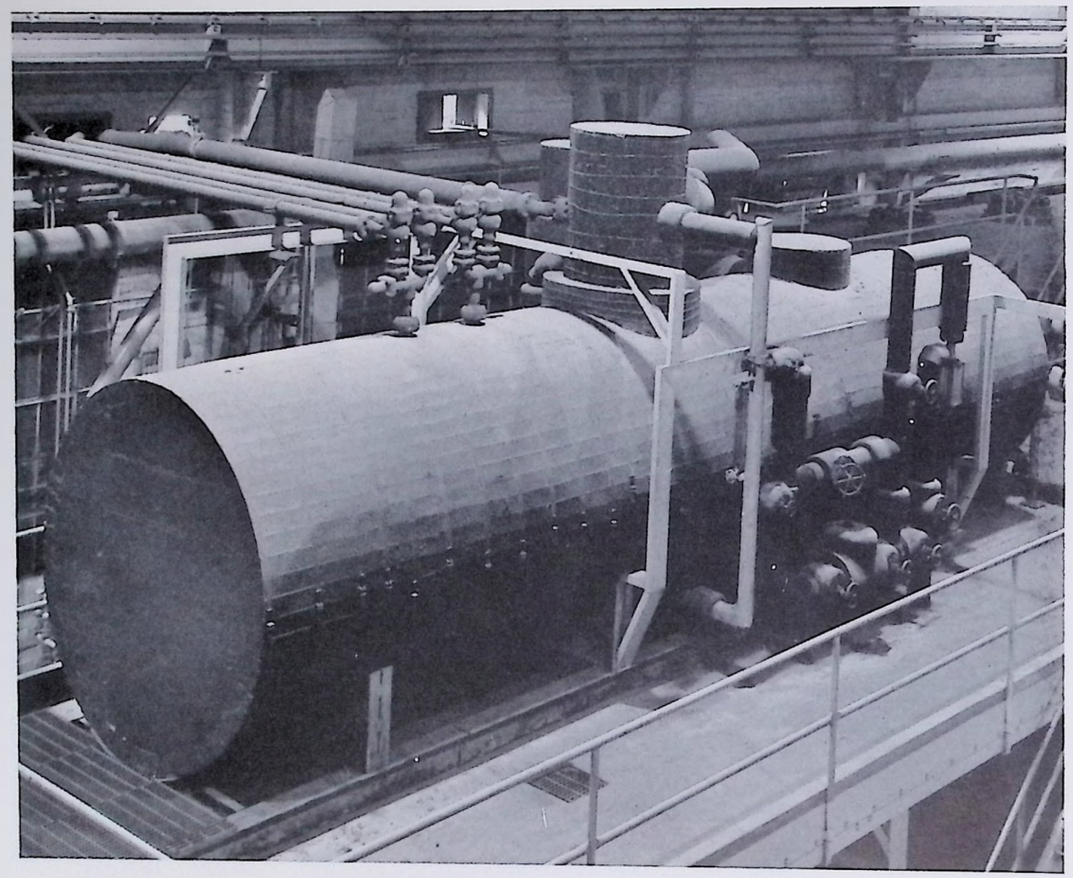

Sweat Globe Valve




Sweat Gate Valve



*Armstrong's Industrial Insulations (1951)*
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Section III

# LOW-TEMPERATURE TANKS AND VESSELS

Armstrong's Corkboard and Cork Lagging..... 70

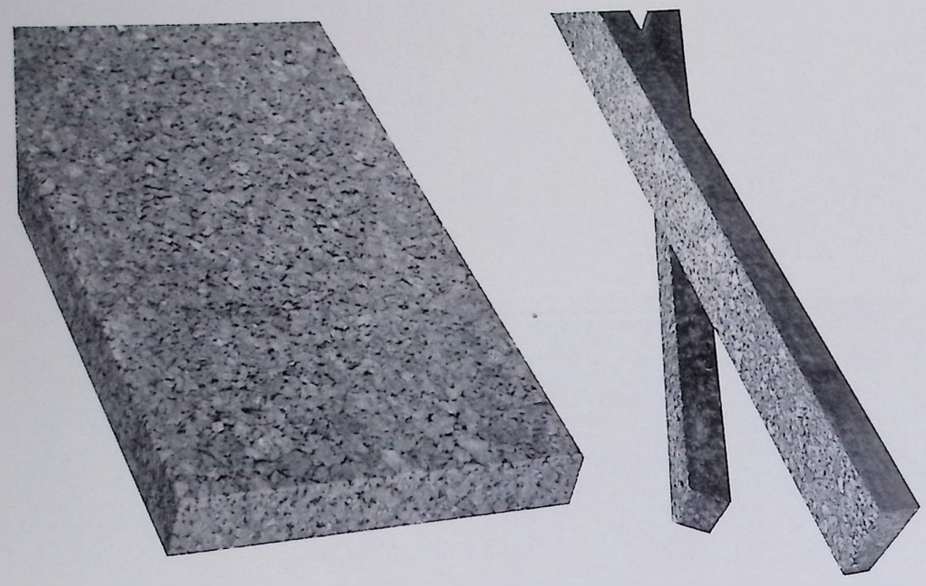
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# Armstrong's Corkboard and Cork Lagging

### Armstrong's Corkboard

Corkboard's high insulating efficiency and natural moisture resistance make it an effective and long lasting insulation for low-temperature equipment, regardless of the severity of the service conditions encountered. (See Section I, "The Moisture Problem In Low-Temperature Insulation," Page 14.)

Armstrong's Corkboard is used for the insulation of rectangular brine and freezing tanks and other flat surfaced equipment. It is also used to insulate large cylindrical equipment over 54" in diameter. In these applications, standard size pieces of corkboard are easy to score and fit to the contour of the vessel.

For additional information on physical properties of corkboard, see Pages 17, 18, 19.

### Armstrong's Cork Lagging

Cylindrical coolers, tanks, and other low-temperature equipment under 54" in diameter are insulated with Armstrong's Cork Lagging and Discs in various thicknesses. Lagging and discs are cut from Armstrong's Corkboard and are coated on the inside and outside surfaces with a moistureproof asphaltic finish. They are made in thicknesses of from 1" to 10". These products possess the same physical characteristics as Armstrong's Corkboard, described on Pages 18, 19.

Low-temperature equipment is made in many and varied sizes, shapes, and types. In order that lagging may be supplied in the proper lengths and beveled to fit exactly, it is necessary when ordering to send sketches or blueprints marked with accurate measurements.

### Sundry Materials

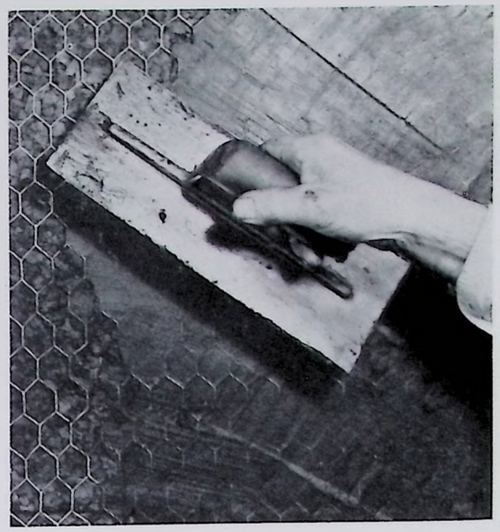
**Armstrong's Insulmastic**—Insulmastic is a factory-mixed combination of Armstrong's Asphalt Emulsion with special fibers and fillers. It is recommended for use where a fire-resistant finish is required. Applied in two coats, each approximately ⅛" thick, Insulmastic is an excellent finishing material for low-temperature insulation exposed to the weather. On high towers, spherical and cylindrical vessels, elevated lines, etc., galvanized wire mesh should be applied directly to the insulation before Armstrong's Insulmastic is trowelled on.

Armstrong's Insulmastic possesses the tensile strength necessary to withstand normal movement without cracking or rupturing, is not affected by temperature changes, does not slip or sag at high temperatures, and bonds well with the corkboard insulation surface.

When Insulmastic is applied in two coats, each about ⅛" thick, it will dry to a final thickness of 3/16". Final finish is gray in color.

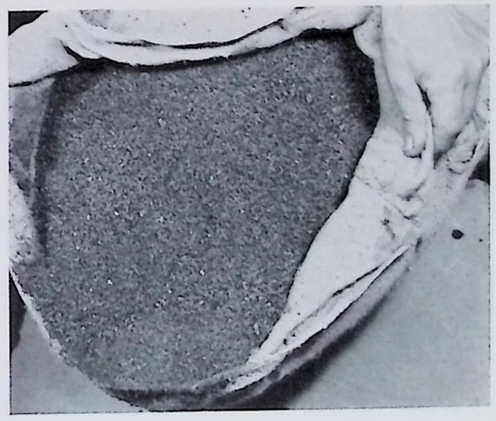
**Coverage**—In a two-coat finish, two pounds of Insulmastic will cover approximately one square foot of insulation surface.

**Packaging**—45-, 270-, and 500-lb. drums. Weight is 10 lbs. per gallon.



**Armstrong's Fine Regranulated Cork**—This product consists of fine particles of Armstrong's Corkboard and is used wherever the application of cork in board form is impractical. Regranulated cork is principally used as a filler around tanks and vessels and in small and irregularly shaped spaces. Fine regranulated cork has good insulating qualities, possesses the high natural moisture resistance inherent in all cork, and resists packing and settling. This material includes all baked cork particles that will pass through an 8-mesh screen.

**Packaging**—Fine regranulated cork is packed in bags containing approximately 7 cu. ft. Weight is about 5 lbs. per cubic foot.



**Armstrong's Asphalt Emulsion**—Used for pointing up joints in cork insulation and as a base for job mixed emulsion finishes. (See Page 23 for description of this product.)

**Armstrong's S. P. Emulsion**—Used for pointing up joints in cork insulation and as a smooth, black finish for indoor equipment. (See Page 23 for description of this product.)

**Solvopruf®**—Used as a finish where resistance to deterioration by solvents or solvent fumes is needed. This finish must be applied to bare cork surfaces. (See Page 53 for description.)

**Galvanized Bands and Seals**—These bands and seals are used in the application of Armstrong's Cork Lagging to tanks and vessels.

| Size of Bands | Gauge | Lbs. per Ft. |
|---|---|---|
| ½ x .015 | 23 | .0256 |
| ½ x .020 | 25 | .034 |
| ¾ x .020 | 25 | .0526 |
| ¾ x .035 | 20 | .0891 |
| 1¼ x .050 | 18 | .212 |

For applications where corrosive or special atmospheric conditions exist, stainless steel or monel metal strapping and seals should be substituted for galvanized.





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# General Recommendations for the Insulation of Low-Temperature Tanks and Vessels

Tanks and vessels operating at moderate or low temperatures require insulation to minimize refrigeration costs, to permit accurate control of processing temperatures, to prevent condensation of moisture on the outside or inside tank surfaces, or as is usually the case, for a combination of these reasons.

### Rectangular Equipment

Before the insulation is applied, the tank or vessel should be tested and made tight. Armstrong's Corkboard in standard sizes is used for insulation of rectangular equipment and for freezing and brine storage tanks. Sometimes space does not permit use of corkboard throughout freezing tanks. In these cases corkboard should be applied wherever possible, with granulated cork used in the inaccessible points. Where more than one thickness of insulation is used, corner joints should be staggered, and courses should be applied with all joints staggered in relation to the joints in the preceding layer.

### Equipment Over 54″ in Diameter

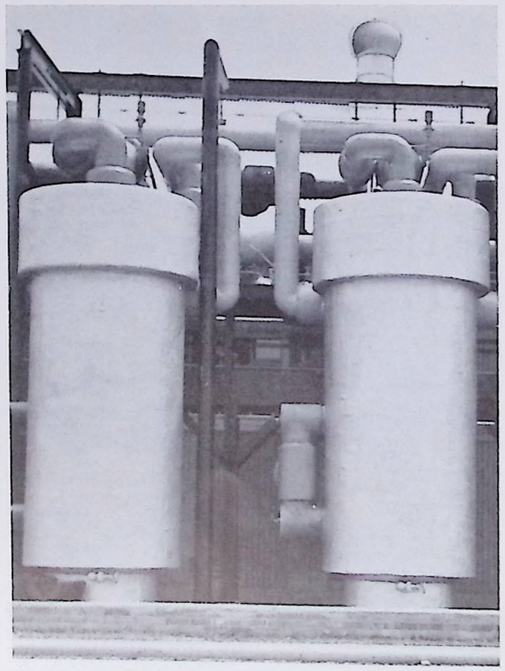
For the insulation of cylindrical equipment over 54″ in diameter, standard size pieces of corkboard, scored with a saw and then bent to fit the contour of the vessel, are used. On equipment of this size, convex heads are also insulated with scored corkboard. If more than one course is applied, the joints in each course should be staggered, and interlocking joints should be used at the point where the insulation on the tank head meets the body insulation.

Scored corkboard is applied in adhesive or hot asphalt. When the hot asphalt method is used, tank surface should be first coated with Armstrong's No. 4 Asphaltic Priming Paint. The first layer, and all succeeding layers, should be banded on with galvanized bands on 12″ centers drawn up tight and securely locked.

### Equipment Under 54″ in Diameter

On equipment under 54″ in diameter, Armstrong's Cork Lagging, ordered from the factory cut to fit the exact contour of the vessel, is applied. Ends are insulated with circular cork discs. On convex heads, the lagging on the tank body should be extended out to enclose the disc. The space betwen the disc and the head of the tank or vessel is then filled with Fitting Filler.

For the application of cork lagging, some method of holding the material in place until the supporting metal bands can be applied must be provided. A rope and coil spring usually is adequate for this purpose.



Low-temperature tanks and vessels located out-of-doors can be efficiently insulated with Armstrong's Corkboard or Cork Lagging. Finishes key firmly to the cork surfaces.



The insulation of both horizontal and vertical tanks should be started at the bottom by slipping the lags under the retaining belt and alternating long and short lengths. Armstrong's Waterproof Cement should be used on joints, coating only the surfaces that will be placed immediately in contact with the joining surfaces. When the first course of lagging has circled the vessel, galvanized bands should be applied beginning close to the end of the lagging and spaced every 12″ as far as the course is complete. Bands should be pulled up tightly and lags pounded with a wooden mallet to even the joints. This procedure should be carried on the same way with the next and subsequent courses, using all full length lags. The short lags are to be used only in the first and last course. All lagging for tanks more than 3 feet long should be applied with broken end joints.

After the insulation has been applied, all rough edges should be rounded off with a rasp, making a neat and workmanlike job. Any exposed cork surfaces should be smoothed off and all joints and chipped edges filled with an asphaltic filler, using a pointing trowel or a broad bladed knife to make a smooth and even surface.

### Tank Supports

When it is possible to do so, horizontal tanks should be supported on saddles outside the insulation; that is, the cork lagging or corkboard on the body of the tank should run straight through between the saddles and the tank. The tank can be supported on blocks until the lagging or corkboard is in place. The bearing surface of the saddle should be large enough to carry the load without compressing the cork.

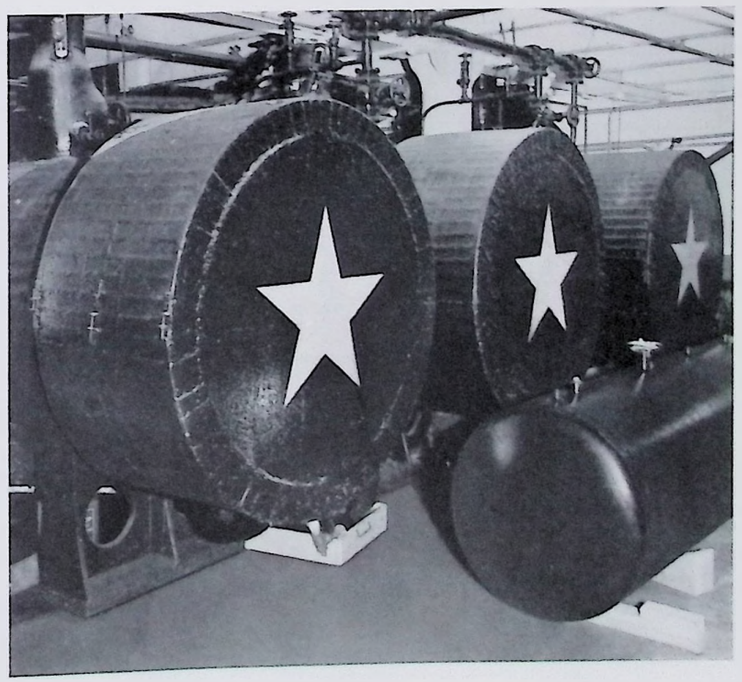
For heavy loads, Armstrong's Vibracork will provide good insulating efficiency between the tank and the saddle. Another alternative is to insert strips of wood at intervals.

Any brackets, supports, or attachments on low-temperature vessels should be insulated, whenever possible, for a minimum of 3′ from the insulation on the outside of the vessel. This prevents condensation and frost formation at the points where the insulation is pierced.

### Removable Manhole Covers

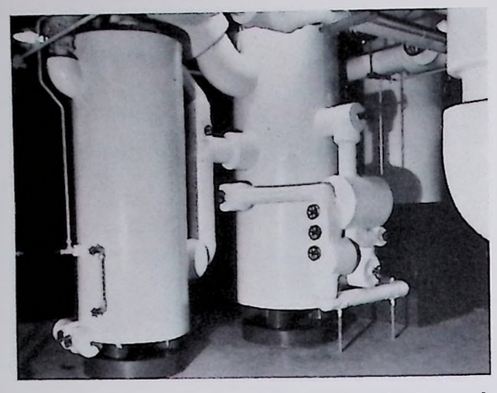
Manholes in equipment that must be inspected or cleaned can be insulated as thoroughly as the body of the equipment and yet be readily

The two brine coolers in the foreground were insulated in 1912 with six inches of Armstrong's Cork Lagging. The third cooler was covered in 1917. The cork on all three is still in excellent condition, and will give many more years of service, as evidenced by this recent photograph.

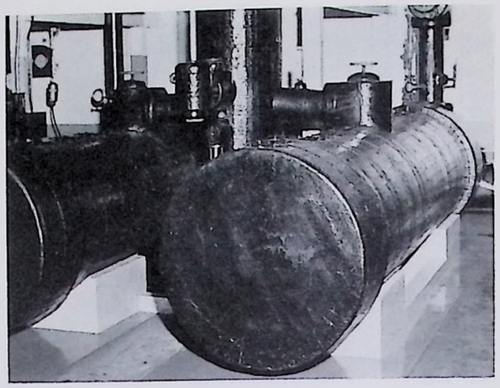




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Canvas neatly sewed or pasted over a plaster finish on cork insulated equipment can be painted in any desired color.



Cork covering paint finish is inexpensive and easy to apply, helps protect the insulation from moisture penetration.

accessible. Removable covers are assembled in two sections. This is done with a collar of cork lagging in two equal sections built up around the manhole. Into the top of each section is fitted half of a corkboard disc. Each half section is then covered with sheet metal for protection in handling and secured by bolts to wooden blocks set in the insulation on the tank body.

### Removable Flange Covers

The problem of accessible, insulated flanges can be solved by removable flange covers made of curved segments of Armstrong's Corkboard built up and fitted around the flange. Each segment is covered with sheet metal for protection during handling. The sections are bolted to wooden rings set in the insulation on the body and the head of the tank or vessel.

### Armstrong's Cork Covering Paint

For indoor equipment under 54″ in diameter, insulated with cork lagging, Armstrong's Cork Covering Paint is a highly satisfactory finish. It reinforces the vapor resistance of the asphalt mastic finish on the outer surface of the lagging and prevents corrosion of the metal bands that are used to hold the lagging in place.

### Armstrong's Asphalt Emulsion Finishes

Asphalt emulsion provides durable, moisture-proof finishes for indoor equipment over 54″ in diameter and for flat surfaced equipment. Armstrong's Plastic Emulsion is used when a sand finish is desired. For a smooth finish, Armstrong's S. P. Emulsion is recommended. Both are trowelled on in two coats, each ⅛″ thick, after all joints have first been pointed up with the same emulsion. The dull black surface resists cracking and crazing and gives a smooth, neat appearance.

### Plaster Finish

This finish may be used on all types of insulated tanks and vessels located indoors, where a light colored finish, or one that may be painted to harmonize with the surroundings, is desired. After all joints have been pointed up with asphalt emulsion, 1″ hexagonal mesh wire is drawn tight over the equipment, with all laps tightly laced. Then asbestos cement plaster, mixed ⅓ portland cement and ⅔ asbestos cement is applied in two coats. If the surface is to be painted, 8-oz. canvas should be sewn or pasted over the plaster, sized with a cold water sizing, and then painted in two coats with a good lead and oil paint in the desired color.

### Armstrong's Insulmastic Finish

Where a weatherproof finish is desired, Armstrong's Insulmastic should be trowelled on in two coats. On high towers, spherical and cylindrical vessels, hexagonal mesh wire should be firmly fastened to the insulation to provide a strong key for the Insulmastic finish.



# Specifications for Insulation of Low-Temperature Tanks and Vessels

These specifications are included for the convenience of architects, engineers, and owners who wish to specify Armstrong's Corkboard or Cork Lagging.

## 1. General

### 1a. Insulation Thickness

After the tank, vessel, or piece of equipment has been tested and made tight, it shall be covered with Armstrong's Corkboard or Cork Lagging according to the following thickness schedule:

| Temperature | Insulation Thickness |
|---|---|
| −40° to −25° F. | 9″ |
| −25° to −10° F. | 8″ |
| −10° to + 5° F. | 6″ |
| 5° to 20° F. | 5″ |
| 20° to 35° F. | 4″ |
| 35° to 50° F. | 3″ |
| 50° to 65° F. | 2″ |

### 1b. Condition of Surfaces

All foreign matter such as plaster, grease, or dirt shall be removed from all surfaces before insulation is applied. In no case shall equipment be covered while wet or in a frosted condition.

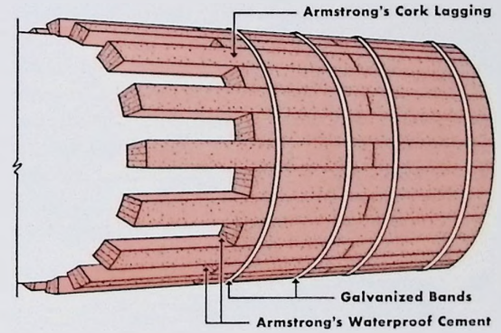
## 2. Equipment Under 54″ in Diameter

### 2a. Insulating Material

Cylindrical coolers, accumulators, and other tanks and vessels operating at moderate or low temperatures shall be insulated with a single thickness of Armstrong's Cork Lagging and Discs cut to fit the diameter of the vessel. The lagging shall be beveled to the proper diameter and shall have an asphaltic finish ironed-on at the factory to both inner and outer surfaces.

### 2b. Application of Lagging

Lagging shall be applied with Armstrong's No. 299 Waterproof Cement on all joints and secured with galvanized iron bands drawn tight and securely fastened. The bands shall be spaced not more than 12″ on centers. All lagging shall



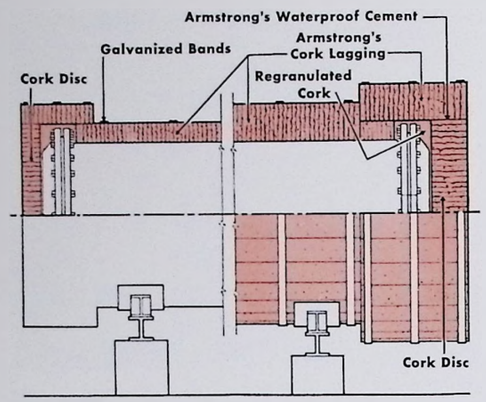

be applied with broken transverse joints. All spaces between the tank or vessel and the lagging shall be filled with Armstrong's Fitting Filler, or Regranulated Cork.

### 2c. Application of Cork Discs (equipment with flanged heads)

On equipment having flanged heads, the ends shall be insulated with a disc of Armstrong's Corkboard equal in thickness to the insulation specified for the body of the vessel. Flanges shall



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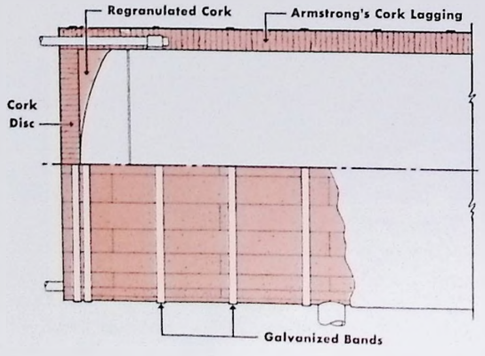



be insulated with cork lagging also equal in thickness to the insulation on the body. The flange lagging shall project beyond the apex of the head a distance equal to the thickness of the cork disc and shall have a bearing on the lagging on the tank body of not less than the thickness of the insulation on the body.

The flange lagging shall be applied with Armstrong's No. 299 Waterproof Cement on all joints and secured with not less than three galvanized iron bands. The space between the bolt heads and the body lagging shall be filled with Armstrong's Fitting Filler, or Regranulated Cork.

The cork disc shall be cemented in place with Armstrong's No. 299 Waterproof Cement and held firmly when the bands around the flanges are drawn up tight. The space between the disc and tank head shall be filled with fine regranulated cork, or fitting filler, to eliminate all voids.

### 2d. Application of Cork Discs (equipment without flanges)




On equipment having convex heads, the ends of the vessel shall be insulated with a disc of Armstrong's Corkboard equal in thickness to the insulation specified for the body of the vessel. The lagging on the body shall extend beyond the apex of the head a distance equal to the thickness of the disc. The disc shall then be cemented inside the extended lagging and held in place with a galvanized iron band drawn up tight and securely locked around the extended insulation.

Voids between the tank end and the cork disc shall be filled with Armstrong's Fitting Filler, or Fine Regranulated Cork.

On equipment having flat heads, the lagging on the body shall be extended a distance equal to the thickness of the disc, and the disc shall be applied as specified above.

### 2e. Insulation of Removable Heads

Where heads must be removed for inspection or cleaning, the insulation shall be applied as specified under 2c., Application of Cork Discs (equipment with flanged heads), except that the flange lagging shall be assembled in two equal sections bonded together with Armstrong's No. 299 Waterproof Cement. One half a cork disc shall then be bonded to the lagging with waterproof cement and the completed half section shall be covered with sheet metal. Metal angles shall be welded to the half sections along the joint where they meet, and the half sections shall be applied to the end of the vessel and be held tightly in place by machine bolts drawn up tight through the angles. A felt gasket shall be inserted between the half sections before the bolts are tightened to provide a tight seal.

### 2f. Use of Seam Filler

After the insulation has been applied, all joints and chipped places in the asphalt mastic shall be filled with Armstrong's Seam Filler to provide a smooth, even surface.

## 3. Equipment Over 54″ in Diameter

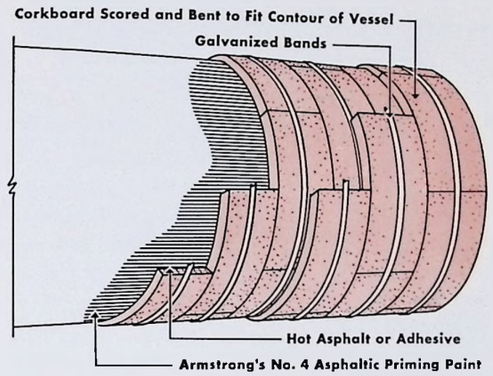
### 3a. Insulating Material

Cylindrical tanks, towers, vessels, and other equipment over 54″ in diameter shall be insulated with single or multiple layers of Armstrong's Corkboard scored and bent to fit the contour of the equipment.



### 3b. Application of Corkboard

The surface of the equipment shall first be primed with a good coat of Armstrong's No. 4 Asphaltic Priming Paint. The first layer of Armstrong's Corkboard shall be applied in hot

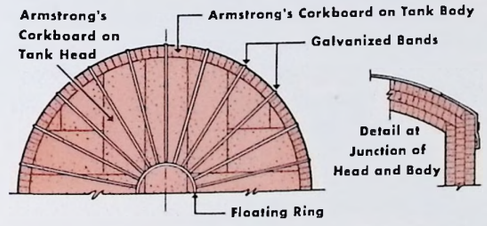



asphalt or waterproof adhesive. Conditions of the job will determine which of these two methods should be used.

The first layer of corkboard shall be banded on immediately after application with galvanized bands spaced on 12″ centers, drawn tight, and securely fastened in place.

Successive layers of insulation shall be applied as specified for the first layer, and held in place with treated hardwood skewers. Each layer shall be banded as described for the first layer.

### 3c. Insulation of Heads (without flanges)

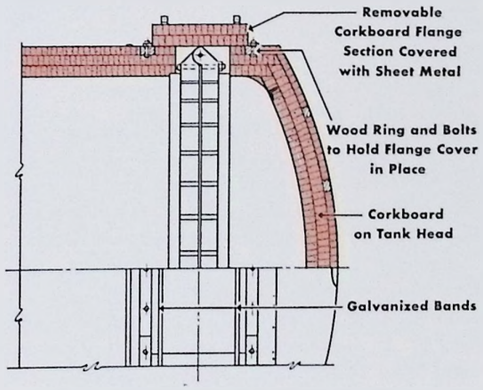



On equipment without flanges, the insulation shall conform to the contour of the heads. The insulation shall be applied in the same manner as described under 3b., except that the galvanized bands holding each course in place shall be fastened to floating rings or stranded cable at the center of the head. The other ends of the bands shall be attached on 12″ centers to extra galvanized bands on the body insulation, or to metal angle clips welded to the body.

At the intersection of the heads and the body, the joints in the insulation shall be interlocking and shall be cut to form neat rounded corners, with thickness equal to that on the body.

### 3d. Insulation of Heads (with flanges–removable)

Where heads must be removed for inspection or cleaning, a wooden ring shall be inset into the final layer of insulation on the body. The ring shall be inset back from the end of the body insulation a distance equal to the total thickness of the body insulation. A similar ring shall be inset into the final layer of insulation on the head.



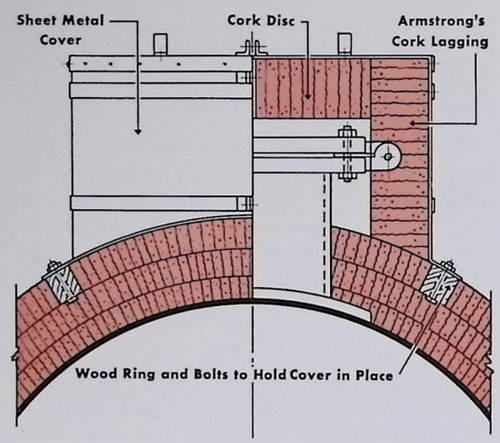

Curved segments of Armstrong's Corkboard equal in thickness to the insulation on the body shall then be built up around the flange. Each segment shall be covered with sheet metal for easy removal and prevention of damage. The curved segments shall be held firmly in place with ⅜″ carriage bolts with nuts and washers installed in the wooden rings on tank head and body. They shall be additionally secured with galvanized metal bands with clips and bolts, applied and drawn tight after the removable segments have been bolted into position.



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### 3e. Insulation of Manholes (removable)

Removable manhole covers shall be built up from cork lagging and discs. A collar of cork lagging shall be built up around the manhole in two sections, projecting beyond the manhole a distance equal to the thickness of the cork disc. The lagging shall be bonded together with




Armstrong's No. 299 Waterproof Cement. One half a cork disc shall then be bonded to the lagging with waterproof cement and the completed half section shall be covered with sheet metal for easy removal and prevention of damage. Metal angles shall be welded to each half section along the joint where they meet, and the sections shall be applied to the manhole and held tightly together by machine bolts drawn up tight through the angles. A felt gasket shall be inserted between the half sections before the bolts are tightened to provide a tight seal.

## 4. Freezing and Brine Storage Tanks

### 4a. Insulating Materials

Wherever possible, Armstrong's Corkboard shall be used for the insulation of freezing and brine storage tanks. Where space limitations make the use of corkboard impractical, Armstrong's Granulated Cork shall be used.

### 4b. Insulation of Tank Bottoms

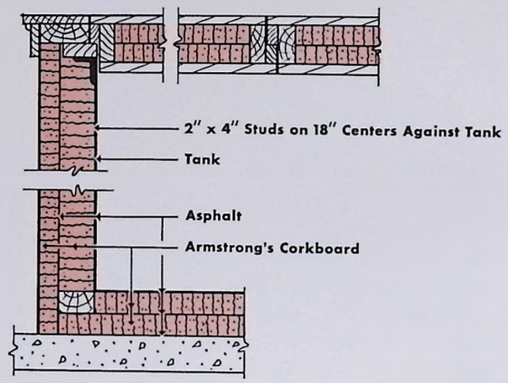
**Two Courses of Armstrong's Corkboard**

The first layer of Armstrong's Corkboard shall be applied to the concrete or wooden base in a mopping of hot asphalt. Apply the second layer in a mopping of hot asphalt. All joints shall be tight, and broken with respect to preceding layers. The top of the second layer shall be flooded with a coat of hot asphalt.

### 4c. Insulation of Tank Sides

**Two Courses of Armstrong's Corkboard**

Studding equal in thickness to the first layer of insulation shall be erected 24" apart against

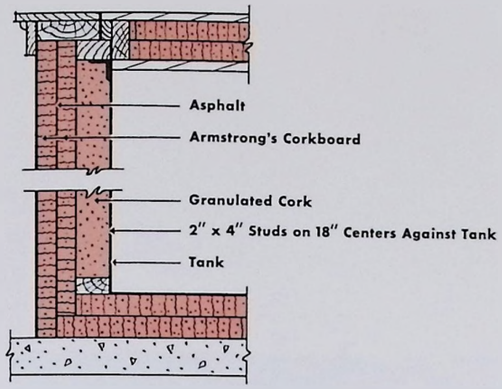



the sides of the tank. The studs shall be firmly anchored to the top of the tank and to a wooden plate at the bottom. The first layer of Armstrong's Corkboard shall be applied in hot asphalt against the tank sides and between the studs and shall be toenailed to the studs with galvanized nails. The second layer of Armstrong's Corkboard shall be applied in hot asphalt and additionally secured to the first layer with treated hardwood skewers. Where the second layer crosses the studs, it shall be additionally nailed with galvanized nails of proper length. All joints shall be tight, and broken in relation to the joints in the preceding layer.

### 4d. Insulation of Tank Sides

**One Course of Corkboard and One Course of Granulated Cork**



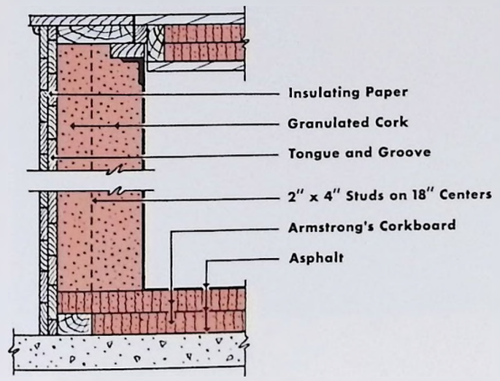



2" x 4" studs shall be erected against the sides of the tank on 18" centers, well secured to the top of the tank, and to a 2" x 4" plate at the bottom. A layer of Armstrong's Corkboard of specified thickness shall be erected against the studs and secured in place with galvanized nails.

The space between the studs shall then be filled with Armstrong's Granulated Cork well packed in place.

### 4e. Insulation of Tank Sides

**Granulated Cork**




Retaining walls shall be constructed 10" to 12" away from the tank sides, consisting of 2" x 4" studs on 18" centers, and sheathed on the outside with two layers of tongue and groove boards, one erected vertically and the other horizontally. A layer of insulating paper shall be tacked between the two layers of tongue and groove boards. The studs shall be secured to a 2" x 4" plate at the bottom of the tank, and to suitable framing at the top. The space between the retaining wall and the side of the tank shall be filled with Armstrong's Granulated Cork well packed in place.

## 5. Finishes—Indoor Equipment

### 5a. Cork Covering Paint (for equipment under 54" in diameter only)

After the cork lagging has been applied and all seams, edges, and chipped places in the factory finish filled, a good coat of Armstrong's Cork Covering Paint shall be applied.

### 5b. Asphalt Emulsion Finishes

After the insulation has been erected, all joints and cracks shall be pointed up with the finishing material used. Then apply a coat of S. P. Emulsion (smooth finish) or Plastic Emulsion (sand finish) ⅛" thick directly to the insulation surface and allow to dry. Apply the second coat approximately ⅛" thick and trowel to a smooth and even surface.

### 5c. Plaster Finish

After the insulation has been applied, all joints and cracks shall be pointed up with Armstrong's S. P. Emulsion. Hexagonal wire mesh shall then be drawn tight over the insulation and laced at all laps. A ½" layer of plaster, mixed ⅓ portland cement and ⅔ asbestos cement shall be trowelled to a smooth finish.

If a canvas finish is desired, 8-oz. canvas shall be sewn or pasted over the plaster. For painting, the canvas shall be sized with a cold water sizing, then painted with two coats of a good lead and oil paint in the color specified.

## 6. Finishes—Outdoor Equipment

### 6a. Armstrong's Insulmastic Finish

Where a weatherproof finish is desired, Armstrong's Insulmastic shall be applied in two coats, each approximately ⅛" thick. The first coat shall be thoroughly dry before the second coat is applied. This finish will dry to a final thickness of approximately 3/16".

On high towers, large spherical and cylindrical vessels, and other elevated or large sized equipment, 1" galvanized mesh shall be securely fastened to the equipment before Armstrong's Insulmastic is applied in two coats.



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Section IV

# AIR-CONDITIONING DUCTS

Materials for Insulation of Air-Conditioning Ducts..... 82

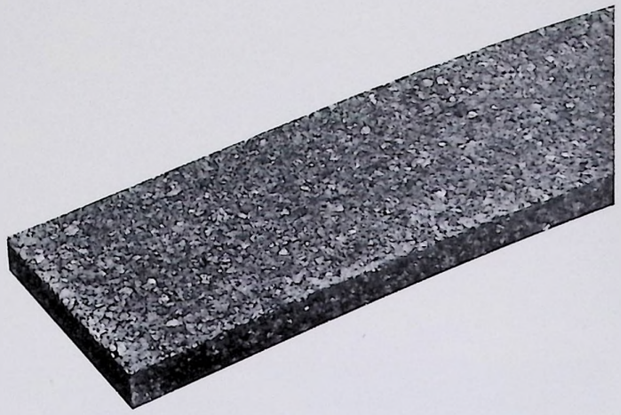
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# Materials for the Insulation Of Air-Conditioning Ducts

Armstrong's Corkboard is recommended for the insulation of air-conditioning ducts and equipment. This strong, rigid insulation is easy to handle on the job. It can be applied quickly and neatly and will stay dry and efficient throughout many years of even the most severe service. Corkboard also provides a base to which finishing materials firmly key. Armstrong's contracting organization will install other duct insulation materials when their use is practical and when cost is an important consideration.

### Armstrong's Corkboard

Corkboard is made entirely of granules of pure cork baked into board form. Cork is cellular in structure, and its minute air-filled cells are separated by tough, resinous walls. This unique structure effectively resists the passage of both heat and moisture. (See Section I, "The Moisture Problem in Low-Temperature Insulation," Page 14.)

The most commonly used sizes of corkboard in the insulation of air-conditioning ducts are 12″ x 36″ and 18″ x 36″. 1″, 1½″, and 2″ thicknesses meet most duct insulation requirements. (For full information on Armstrong's Corkboard, including physical properties, shipping and packaging data, see Pages 17, 18, and 19.)

### Sundry Materials

**Armstrong's No. 340 Waterproof Cement**—This waterproof adhesive is recommended for the application of corkboard against metal ducts. It is easy to apply and will support the weight of the insulation without reinforcing. Coverage is 30 sq. ft. per gallon, applied with a special square-notched trowel. (See Page 22 for complete information on this product.)

**Armstrong's Asphalt Emulsion**—A clay emulsion of finely dispersed asphalt used as the basic ingredient in job-mixed asphalt emulsion finishes and for pointing up joints in corkboard duct insulation. (See Page 23 for full description of asphalt emulsion.)

**Armstrong's S. P. Emulsion**—A durable factory-mixed smooth finish for indoor ducts. (See Page 23 for full information.)

**Armstrong's Plastic Emulsion**—This is a durable, moisture-resistant, factory-mixed, sand finish for air-conditioning ducts. (See Page 23 for full information.)

**Armstrong's Insulmastic**—Insulmastic finish is recommended for outdoor ducts. This sundry material bonds well to corkboard surfaces, does not slip or sag at high temperatures. (See Page 70 for full information.)



# General Recommendations for Insulation Of Air-Conditioning Ducts

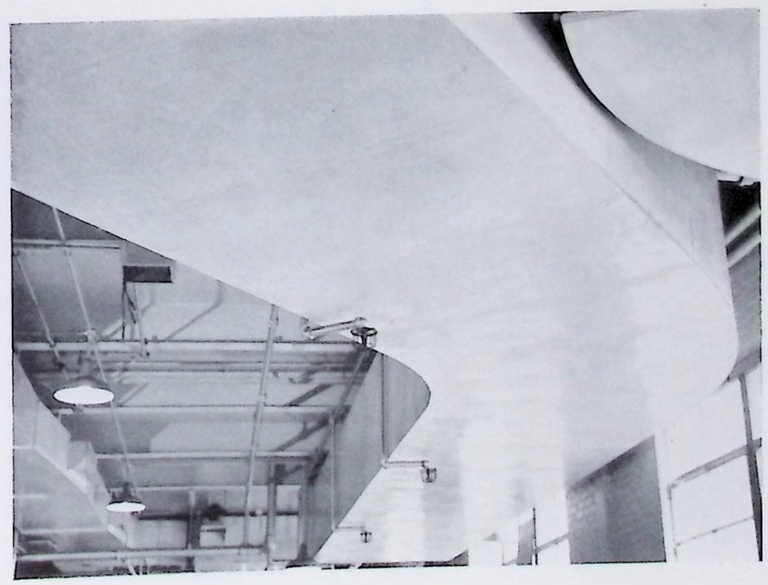
If air-conditioning systems are to operate satisfactorily, they must be able to deliver conditioned air to all points in the system with a minimum of heat or refrigeration loss through the duct walls. The conditioned air in uninsulated ducts, particularly on long runs, will either pick up or lose heat, depending upon the outside temperature in the area through which the duct passes. The result will be a variance in the delivered temperature of the air at different points of the system. Proper insulation of air-conditioning ducts can control this variance, generally improving the over-all operating performance of the air-conditioning installation.

Insulation is also necessary to prevent moisture condensation and consequent drip from air-conditioning duct and equipment surfaces. During hot humid weather, or where air-conditioning ducts run through high humidity areas, moisture condensation on duct surfaces is ruinous to the finish, and the resultant drip may damage manufactured goods or processing equipment or make working conditions unpleasant for personnel. When ducts are concealed, drip going unnoticed can rot or rust building construction and damage paint and plaster, too.

Any recommendations for thickness of insulation for air-conditioning ducts must be determined by the operating and efficiency requirements of the individual system. Generally speaking, for moderate temperature differentials between air in the room and conditioned air in the duct, and on short runs of duct work, a 1″ thickness of Armstrong's Corkboard is recommended on supply ducts and equipment, leaving the return ducts bare.

Where temperature differentials are severe and on long runs of duct work, 1½″ or 2″ thickness of corkboard is recommended on supply ducts and equipment with 1″ corkboard thickness used on return ducts.

Corkboard duct insulation is applied in one layer. Various application methods are described on Page 84. Where ducts are constructed with standing seams, a corkboard thickness should be selected which will cover the seams.



Asbestos cement plaster provides a neat, light reflective finish for this main supply duct. The duct was insulated with 1″ thick corkboard, then a coat of portland cement plaster was trowelled on. The asbestos cement plaster finish coat was applied over hexagonal mesh wire laced securely in place.



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# Specifications for Applying Insulation to Air-Conditioning Ducts

These specifications are included for the convenience of architects, engineers, and owners who desire to write specifications for air-conditioning ducts.

## 1. General

### 1a. Condition of Duct Work

Before duct insulation is applied, the surface shall be clean and free from dust, dirt, grease, and moisture.

## 2. Application of Corkboard

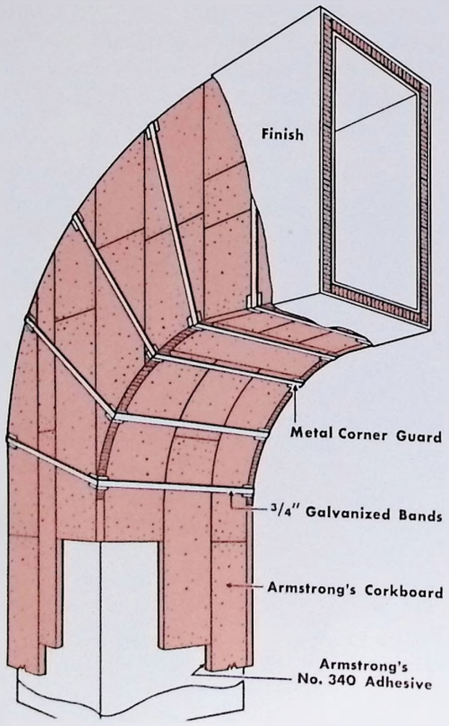
### 2a. Adhesive Method

Spread Armstrong's No. 340 Adhesive over the entire surface of the corkboard with a square notched trowel and apply the corkboard to the duct surface. Additionally secure the corkboard with copper-clad wire ties or metal bands spaced evenly on 12″ centers.

On ducts greater than 3′ in any one dimension, use metal bands only.

Metal bands on the bottom of ducts wider than 6′ shall be additionally secured to metal fasteners attached to the ducts with a suitable adhesive. Sheet metal screws or other mechanical fasteners also may be used for this purpose.

For concealed ducts and ducts requiring no finish, all joints in the insulation shall be pointed with Armstrong's Asphalt Emulsion or other suitable seam filler.




### 2b. Mechanical Method

#### 1. Insulation Hangers

Apply suitable metal fasteners directly to the ducts using proper erection adhesive. Distribution of fasteners on duct surface shall be determined by duct dimension and shape. Apply Armstrong's Corkboard directly to ducts and secure fasteners through corkboard. For concealed ducts and ducts requiring no finish, all joints shall be pointed with Armstrong's Asphalt Emulsion or other suitable seam filler.

#### 2. Sheet Metal Screw Method

Apply Armstrong's Corkboard directly to duct, using suitable sheet metal screws and roofing caps to hold the corkboard firmly in place. When sheet metal screws are used, no additional supports are required.

For concealed ducts and ducts requiring no finish, all joints shall be pointed with Armstrong's Asphalt Emulsion or other suitable seam filler.



### 2c. Asphalt Method

Duct surfaces shall be first primed with Armstrong's No. 4 Asphaltic Paint. Dip corkboard in hot asphalt and apply to metal ducts. Corkboard shall be additionally secured with copper-clad wire ties or metal bands 12″ on center. On ducts greater than 3′ in any one dimension, metal bands only shall be used.

Bands on the bottom of ducts wider than 6′ shall be additionally secured to metal fasteners attached to the duct with a suitable adhesive. Sheet metal screws may also be used for this purpose.

For concealed ducts and ducts requiring no finish, all joints shall be pointed with Armstrong's Asphalt Emulsion or other suitable seam filler.

## 3. Finishes for Corkboard

### 3a. Brush Coat of Armstrong's Asphalt Emulsion

The surfaces of the corkboard shall be painted with two brush coats of Asphalt Emulsion.

### 3b. Armstrong's S. P. Emulsion (smooth finish)

Apply two coats of S. P. Emulsion directly to the corkboard surfaces. The first coat shall be thoroughly dry before the second coat is applied. This finish can be painted, where specified, with Armstrong's Aluminum Paint.

### 3c. Asbestos Cement Plaster Finish

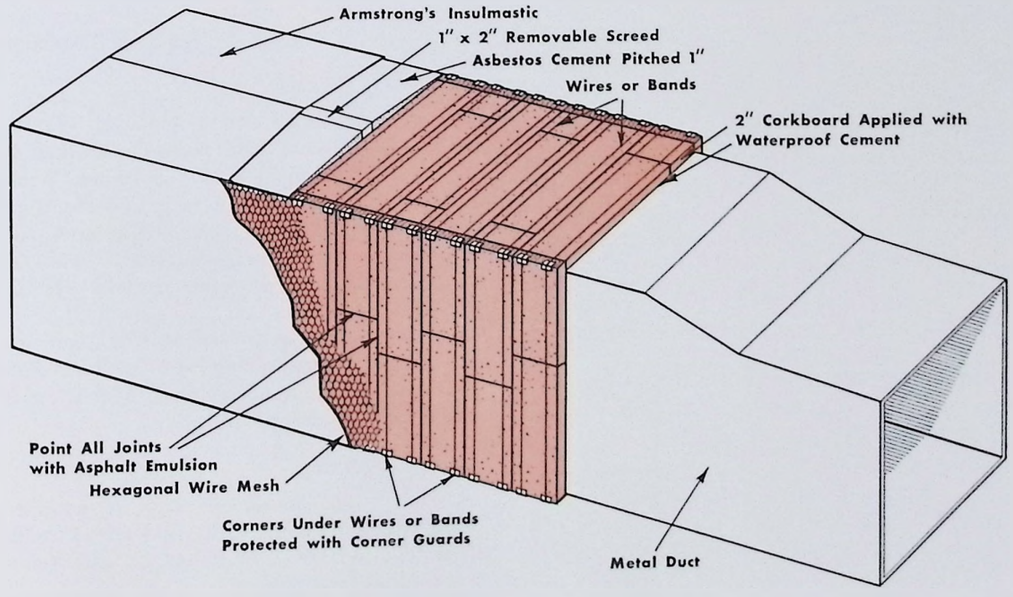
The corkboard surfaces shall be covered with 2″ galvanized wire mesh stapled and laced in place. All exposed corners shall be fitted with corner beads. Asbestos Cement Plaster shall be mixed one part portland cement and three parts asbestos cement by volume and shall be applied in two coats. The first coat shall be thoroughly dry before the second coat is applied. When dry, this finish may be painted where specified.

### 3d. Canvas Finish

Apply rosin-sized paper directly over the corkboard insulation, with edges lapped at least 3″ and fastened in place. Apply 8-oz. canvas stretched tightly in place and secure with either blind seams or pasted seams. To paint, size canvas with cold water sizing and after the sizing is thoroughly dry, paint with lead and oil or water base paint.

### 3e. Weatherproof Finish—Outdoor Ducts

Where a weatherproof finish is desired, Armstrong's Insulmastic shall be applied in two coats.






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each approximately ⅛″ thick. The first coat shall be thoroughly dry before the second coat is applied. This finish will dry to a final thickness of approximately 3/16″.

On high towers, large spherical and cylindrical vessels, and other elevated or large-sized equipment, 1″ galvanized mesh shall be securely fastened to the equipment before Armstrong's Insulmastic is applied in two coats.

### 4. Application of Semi-Rigid Insulation

#### 4a. Adhesive Method

The insulation shall be fastened to the duct with Armstrong's No. 340 Cement applied directly to the insulation in spots approximately 1/16″ thick on every sq. ft. of duct surface, or by strips of adhesive approximately at 4″ intervals, applied with a notched trowel. The insulation shall be placed against the duct surfaces with joints butted tightly together and shall be pressed firmly in place to insure a good bond with the metal surface.

For application to curved surfaces, the insulation shall be scored at 1″ intervals for short bends and 2″ intervals for gradual bends.

Soft iron banding wire or copper-clad steel wire on 12″ centers shall then be looped around the insulation on the ducts, drawn tight and twisted in place.

#### 4b. Mechanical Method

Suitable metal fasteners shall be applied to the duct using a proper erection adhesive. Apply the insulation directly to the duct and secure the fasteners through the insulating material. Insulation to be applied against curved surfaces shall be scored at 1″ intervals for short bends and at 2″ intervals for gradual bends.

### 5. Finishes for Semi-Rigid Type Insulation

#### 5a. Asbestos Cement Plaster Finish

Directly over the insulation apply 1″ hexagonal wire mesh around the entire duct and lace tightly in place. For ducts greater than 3′ in any one dimension, additional reinforcement must be provided so that the hexagonal mesh will remain snug against the insulation. In these cases, provide mechanical fasteners installed on the duct prior to the erection of insulation, or additionally secure the wire mesh in place by bands or wires. All exposed corners of the insulation shall be fitted with metal corner beads securely fastened in place.

Apply Asbestos Cement Plaster in two coats, not to exceed ½″ in thickness. The cement plaster shall be mixed one part portland cement and three parts asbestos cement. When dry, this finish may be painted where specified.

#### 5b. Asbestos Cement Plaster Finish—Alternate Method

All exposed corners in the insulation shall be fitted with metal corner beads securely fastened in place. Apply expanded metal lath and firmly attach to duct stiffener ribs or standing seams. To prevent sagging of metal lath over large duct areas, additional supports in the form of metal fasteners, applied to the ducts before the insulation is put in place, shall be provided and the lath securely attached. Metal bands or wires secured around the entire duct or between stiffeners may be applied as an alternate method of support for the metal lath.

Apply Asbestos Cement Plaster in two coats, mixed one part portland cement and three parts asbestos cement by volume. When dry, this finish may be painted where specified.

### 6. Application of Blanket Type Duct Insulation

#### 6a. Cylindrical Ducts

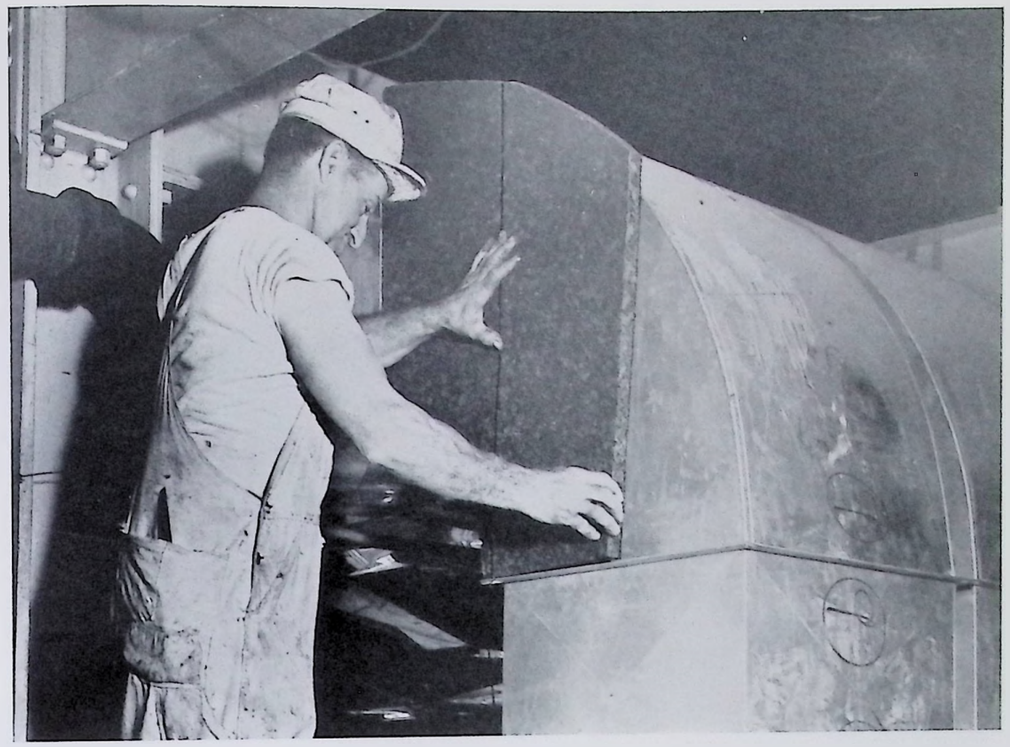
Apply Armstrong's No. 4 Asphaltic Priming Paint around the circumference of the duct in 4″ strips, approximately 27″ on center. While this priming paint is still tacky, blanket type insulation shall be applied to the duct and additionally secured in place with 2″ wide industrial tape over all joints or with spirally wrapped twine cord.

Where additional layers of insulation are specified, apply succeeding layers with all joints overlapped, then secure in place with 2″ wide industrial tape or twine cord.

#### 6b. Square Ducts

Blanket type insulation shall be wrapped around the duct and held in place with 2″ wide industrial tape over all joints or with twine cord spirally wrapped.

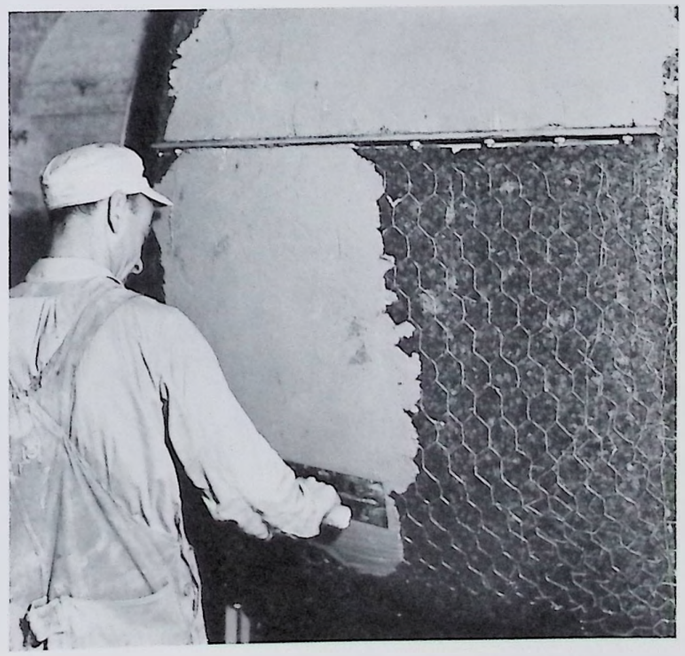






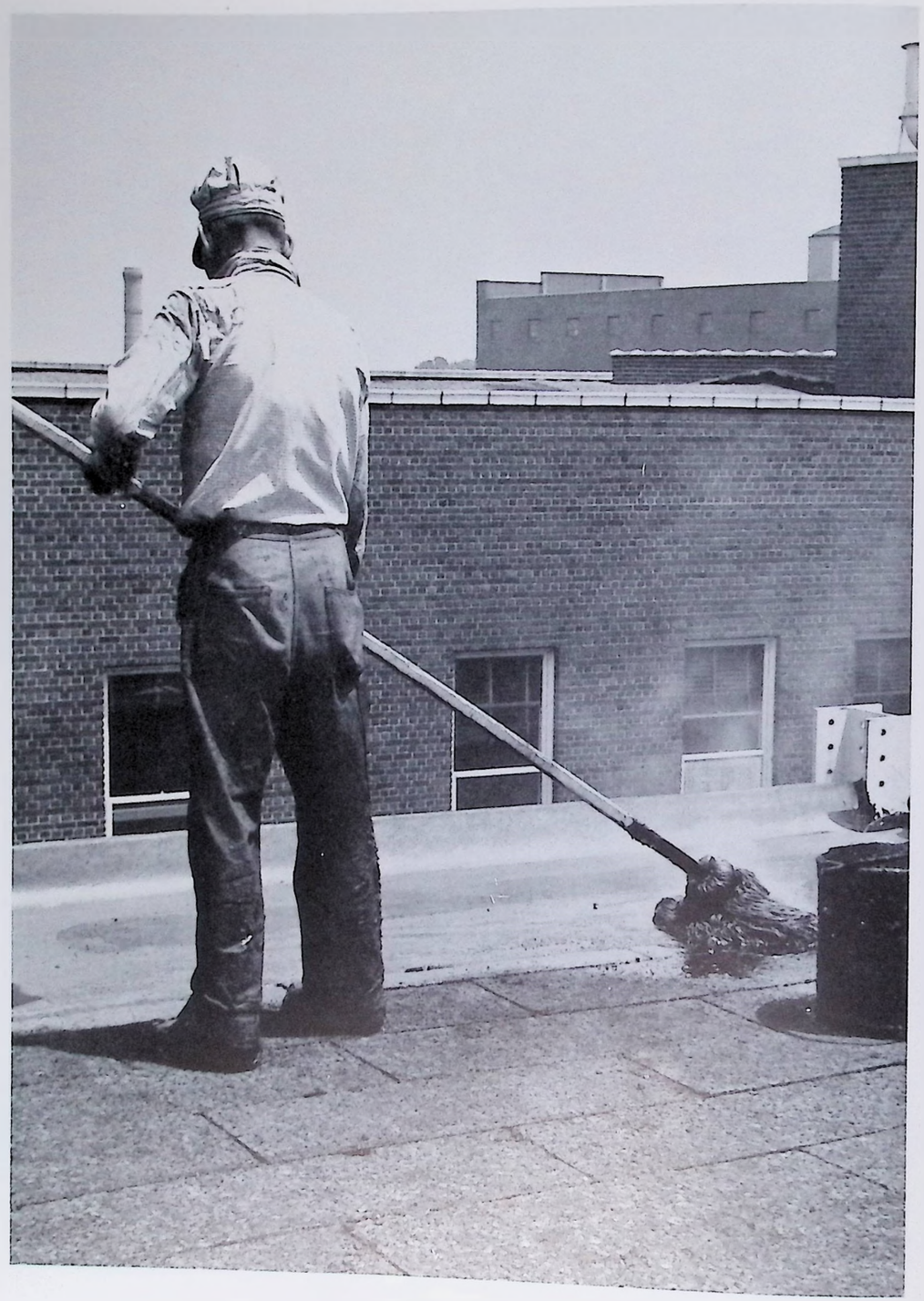
This workman is applying Armstrong's Corkboard with No. 340 Adhesive. This method is fast and efficient, and the job is simplified by the fact that corkboard can be easily cut to fit the curves and contours of the duct.

When large areas are to be finished with asbestos cement plaster, hexagonal mesh wire is used to provide additional support for the finish. On most surfaces, however, the surface of the corkboard furnishes a good key for finishes.





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Section V

# ROOF INSULATIONS


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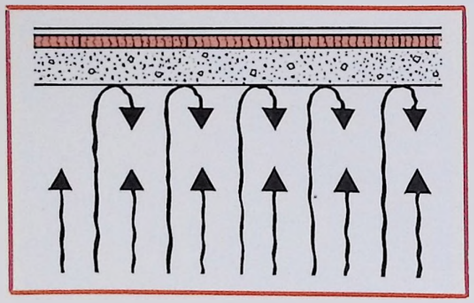

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# The Reasons for Roof Insulation

### Insulation Reduces Heat Loss

The most universally recognized function of roof insulation is to reduce heat loss. Of the heat escaping from a building, by far the greater portion travels through the roof, because the natural movement of warm air is upward. The following example illustrates the effectiveness of roof insulation in reducing heat transmission.

An uninsulated roof consisting of 4″ of concrete plus standard roofing will transmit 50.4 Btu. of heat per hour through every square foot of the



roof area when a temperature difference of 70° F. exists between inside and outside surfaces.

The same roof, when insulated with 2″ of Armstrong's Corkboard Roof Insulation, will transmit only 7.70 Btu. per square foot per hour, for a 70° temperature differential.

In other words, the addition of 2 inches of Armstrong's Corkboard reduces heat flow through the roof by 84.8% under the conditions above.

No matter what the type of building, this reduction of heat loss means an appreciable cut in fuel cost. Because roof insulation reduces the amount of heat required to maintain comfortable inside temperatures, smaller, less expensive heating systems can be used in insulated buildings. This can mean a substantial saving in the cost of new construction. Roof insulation also acts as a barrier to heat in the summer. With air conditioning being used to maintain comfortable inside temperatures during hot summer months the expense of operating cooling systems is greatly increased if a building roof readily permits summer heat to enter. Here again, roof insulation can decrease the load which equipment must carry and will often permit the use of smaller units.

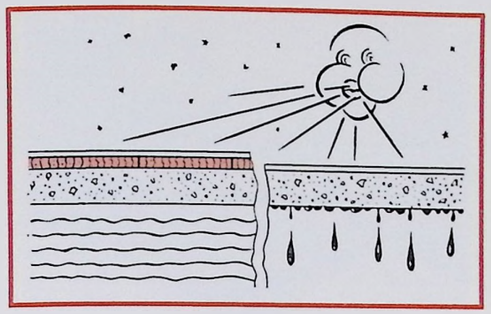
Thus roof insulation does a year round job in making building operations more economical. The savings in fuel and refrigeration costs alone will usually pay the entire cost of the insulation job within a very few years.

### Insulation Prevents Condensation

A second important function of roof insulation is to prevent moisture from condensing on the ceilings of heated buildings. This condition requires the insulation of buildings in which a high relative humidity is maintained as a feature of the manufacturing process. Textile mills and tobacco plants are outstanding examples. The same thing is true in industries where so much steam and water are used that the humidity is almost constantly near the saturation point, as it is in paper mills and laundries. Condensation affects these industries in varying degrees, from a troublesome film of moisture to an actual dripping of water from ceilings and walls.

This condensation, or sweating, results from the contact of humid air with a surface whose temperature is below the dewpoint of the air. The capacity of air to absorb and hold moisture (water vapor) in suspension varies with its temperature. When warm air is cooled, its moisture capacity is lowered and a point is approached at which the air can no longer hold all of its moisture in suspension. This is known as the point of saturation or dewpoint. Any lowering of temperature to or below this point causes the moisture in the air to condense.





A familiar example is the "sweating" of a water pitcher. When the air in contact with the colder surface of the pitcher is cooled to the dewpoint, the moisture in the air condenses and is deposited as water on the surface of the pitcher.

A similar situation exists when warm moist air strikes the surface of a cold ceiling. Even though the air temperature in a room may be 70° F. or above, the temperature of an uninsulated ceiling surface will be considerably lower if it is cold outside. When ceiling temperature is at or below the dewpoint temperature of the air, condensation is the result.

### Effects of Condensation

Industries that require maintained humidity, and plants in which the method of manufacture or the nature of the work causes high process humidity, can suffer the following expensive and annoying effects of condensation:

1. Dripping of water from the ceiling discolors and sometimes injures the quality of goods being manufactured, handled, or stored. This dripping may also rust or otherwise damage machinery and creates a condition which is extremely unpleasant and unhealthful for employees.

2. Wooden roof structures are weakened and




Armstrong's Temlok Roof Insulation effectively checks heat flow through roof structures, improving the efficiency of heating and air-conditioning systems. It is strong and easy to handle.



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may eventually be destroyed by continued condensation. Moisture soaks into the timber and promotes decay of the structural members. Interior finish materials become moisture soaked and hard to maintain.

3. Moisture absorbed by the roof structure increases its thermal conductivity, which causes heat to pass through it even faster. Increases in both fuel expenditures and the rate of moisture condensation are the results.

Condensation can be prevented by (1) reducing the relative humidity of the air, or (2) lowering the heat transmission of the roof structure to a point where ceiling surfaces will not become cooled to or below the dewpoint.

While it may be possible, in some cases, to alter relative humidity artificially, this remedy is never practical. The mechanical equipment required represents not only a substantial initial outlay but also means additional operating and maintenance cost. And in many industries a maintained humidity in the atmosphere is an essential feature of the manufacturing process.

Thus it is far more practical to employ the second method—that of lowering the heat transmission of the roof. This is easily accomplished by installing the right thickness of insulation.

### Selecting the Right Roof Insulation

When selecting a roof insulation the following factors should be considered:

**Thermal Conductivity**—Obviously, the material chosen must have a high resistance to heat flow. The higher this resistance, or the lower the material's thermal conductivity, the greater will be the savings afforded by its use. By choosing a material of low conductivity, you can often use less insulation to provide adequate protection under a given set of conditions. (To calculate insulation thicknesses required to prevent condensation and to determine how various thicknesses of insulation will reduce heat flow through most types of roof construction, see Pages 96 and 97.)

**Moisture Resistance**—The effectiveness of any roof insulation in service is determined largely by the material's ability to resist moisture. Roof insulations that absorb moisture lose their thermal efficiency rapidly and eventually they deteriorate and weaken the whole roof structure. This problem is most acute under severe service conditions where high relative humidities or large temperature differences exist.

**Structural Strength**—The speed and efficiency with which roof insulation can be installed depends mainly on how well the material will stand up under normal job conditions. A tough, sturdy insulation makes work go faster, reduces waste and results in a better finished job. It also provides a firmer base for built-up roofing and is better able to support roof traffic.

**Weight**—A lightweight material is easier to handle on the job and puts less strain on load-bearing structural members. This is particularly important when insulation is being applied to a building which is not new.

**Cost**—Any insulation which meets its need efficiently will repay its cost in service. Thus the best way to choose an insulation is to consider the other factors first, decide what materials will satisfy your specific requirements, and then investigate the costs of each. A factor which should not be overlooked is the length of service which you can expect from the material you choose. Especially on heavy-duty jobs, it pays to be sure that the insulation will provide many years of efficient, trouble-free service.



Corkboard's high insulating efficiency and natural moisture resistance make it an unsurpassed roof insulation material for applications where service conditions are severe.





# Armstrong's Corkboard Roof Insulation

Armstrong's Corkboard Roof Insulation is made entirely of pure cork granules, compressed and baked into board form. The physical characteristics of this product, which have made it the standard low-temperature insulation, also make it a highly satisfactory material for all types of roof insulation applications.

Cork's structure is cellular, consisting of millions of minute isolated air spaces. This unique structure gives Armstrong's Corkboard Roof Insulation its great resistance to moisture as well as its unusually low thermal conductivity of 0.27 Btu's. (See Page 17.)

These two characteristics of corkboard have established it as an unsurpassed material for the insulation of roofs where severe moisture conditions prevail. On the roofs of textile and paper mills, laundries, and tobacco plants, and other places requiring heavy-duty applications, Armstrong's Corkboard has established records of long and satisfactory service that have not been equalled by any other roof insulating material.

In fact, thousands of roofs that were insulated with Armstrong's Corkboard as long as twenty or even thirty years ago are still giving dependable, trouble-free service. Armstrong's Corkboard Roof Insulation is recommended for all types of industrial buildings and for any building located in areas where below-freezing temperatures are regularly experienced during the heating season.

On the job, corkboard's other qualities contribute to the efficiency and economy of the finished roof. Armstrong's Corkboard Roof Insulation is light in weight—averaging from 0.55 to 0.65 lb. per board foot. It is strong and tough and has no tendency to shrink, swell, or warp. Corkboard provides an unexcelled bond between insulation and roof deck and absorbs very little asphalt or pitch. Corkboard's natural resiliency and firm, square edges assure tight, trouble-free joints. It is a clean homogeneous material, and is readily cut and shaped with ordinary tools. Armstrong's Corkboard Roof Insulation conforms to Federal Specification HH-C-561b.

Armstrong's Corkboard Roof Insulation is supplied in 12″ x 36″, 18″ x 36″, 24″ x 36″, and 36″ x 36″ sizes, 1″, 1½″, 2″, 3″, and 4″ thick.

### Packaging and Shipping Information

Quantities less than 30,000 board feet are shipped in bulk, tubes or cartons, at the customer's option, subject only to the regulations of the carrier.

Larger quantities are ordinarily shipped in bulk or in tubes but can be shipped in cartons at a slight additional charge.

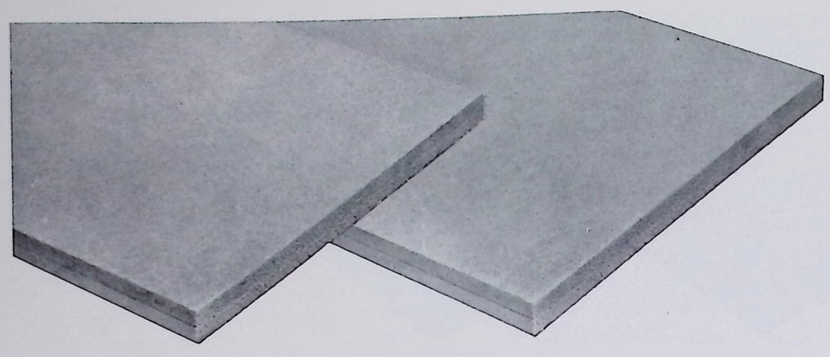
| | Approx. Weights | |
|---|---|---|
| | Bulk or Tubes | Cartons |
| Armstrong's Corkboard Roof Insulation, per bd. ft. | .60 lb. | .65 lb. |

Container Contents

| | |
|---|---|
| Cartons (all sizes) | 72 bd. ft. |
| Tubes (1″, 1½″, 2″, 3″) | 54 bd. ft. |
| Tubes (4″) | 48 bd. ft. |



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# Armstrong's Temlok Roof Insulation

Armstrong's Temlok® Roof Insulation provides low-cost thermal efficiency for applications where service conditions do not demand the use of a heavy-duty material like corkboard.

Temlok is made of sturdy pine fibers, processed to form a strong, homogeneous board. The tiny enclosed air spaces which occur between the fibers give Temlok its high insulating efficiency. In thicknesses of 1" and up Temlok Roof Insulation has a thermal conductivity of 0.33 Btu. per square foot per inch thickness per degree F. temperature difference at 60° mean temperature.

While Temlok does not possess the natural moisture resistance of corkboard, a sizing solution introduced in the manufacturing process gives each fiber a water-resistant jacket. Temlok absorbs less than half the amount of water allowed under Commercial Standard CS-42-48, Federal Specification LLL-F-321b (as amended) and A. S. T. M. Specification C208-48.

The strength of Temlok's individual fibers permits the manufacture of a low-density product. This results not only in low thermal conductivity but also keeps the weight of Temlok down to an average of 1.27 lbs. per board foot.

Armstrong's Temlok Roof Insulation is strong and durable, exceeding U. S. Commercial Standard CS-42-48, Federal Specification LLL-F-321b, and A. S. T. M. Specification C208-48, as they apply to strength. This strength makes Temlok easy to handle on the job. No special handling techniques are required. Temlok Roof Insulation has accurately cut square edges and provides a sturdy base for built-up roofing.

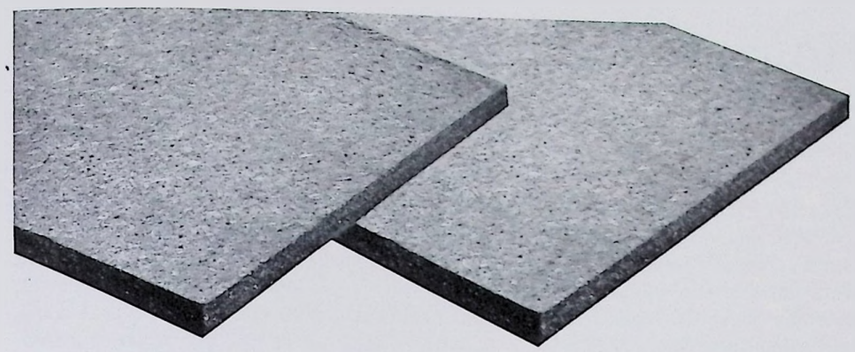
| Thickness | Over-all Size | Coverage of Net Size | Edge Treatment | Homogeneous or Laminated | Depth of Shiplap |
|---|---|---|---|---|---|
| ½" | 24" x 48" | 24" x 48" | Square | Homogeneous | None |
| 1" | 24" x 48" | 24" x 48" | Square | Homogeneous or Laminated | None |
| 1" | 23⅞" x 47⅞" | 23¼" x 47¼" | Shiplapped | Homogeneous or Laminated | ⅝" |
| 1½" | 24" x 48" | 24" x 48" | Square | Laminated | None |
| 1½" | 24¾" x 48¾" | 24" x 48" | Shiplapped | Laminated | ¾" |
| 2" | 24" x 48" | 24" x 48" | Square | Laminated | None |
| 2" | 25" x 49" | 24" x 48" | Shiplapped | Laminated | 1" |

**Packaging and Shipping Information**

| Size | Thickness | Approx. Sq. Ft. Per Bundle | No. of Pcs. per Bundle |
|---|---|---|---|
| 24" x 48" | ½" | 112 | 14 |
| 24" x 48" | 1" | 56 | 7 |
| 24" x 48" | 1½" | 40 | 5 |
| 24" x 48" | 2" | 32 | 4 |

One inch and greater thicknesses can be furnished square edged or shiplapped. Depth of shiplap on 1" thickness is ⅝", on 1½" thickness is ¾", on 2" thickness is 1". All bundles are wrapped in heavy kraft paper. ½" thick roof insulation is furnished in a solid homogeneous board. 1" thickness will be furnished either laminated or homogeneous. 1½" and 2" thicknesses are furnished in laminated form. Laminated roof insulation is bonded firmly together by staples or with a strong adhesive.





# Asphalt-Impregnated Temlok

Armstrong's Asphalt-Impregnated Temlok Roof Insulation meets the need for a product which offers some of the desirable characteristics of both regular Temlok and Armstrong's Corkboard.

A waterproof asphaltic compound is substituted for the regular Temlok sizing solution. This increases Temlok's strength by approximately 20% and gives Asphalt-Impregnated Temlok a higher resistance to moisture. Although the thermal conductivity (0.36 Btu.) of the finished board is slightly higher than that of regular Temlok, Asphalt-Impregnated Temlok can be used in the same thickness for all applications.

Asphalt-Impregnation means that the waterproofing quality of asphalt is present throughout the board, and not just on the surface, as is the case with asphalt-coated products. Thus Asphalt-Impregnated Temlok loses none of its moisture resistance when the material is cut or when the surface is scuffed or indented.

The presence of asphalt throughout the board gives it lower pitch absorption and also increases edge strength and resistance to breakage.

Asphalt-Impregnated Temlok weighs approximately 1.30 lbs. per board foot.

Armstrong's Asphalt-Impregnated Temlok is slightly higher in price than regular Temlok. On jobs which fully utilize its properties, however, this extra initial cost of the impregnated material is more than justified in service.

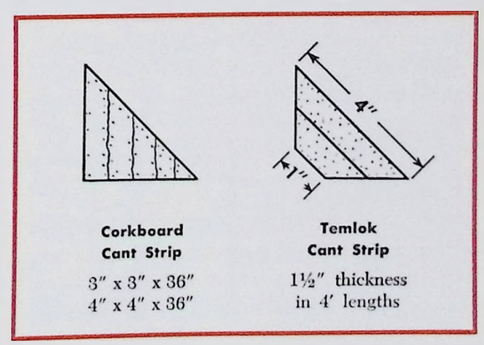
This material is handled and applied according to the specifications for application of Armstrong's Temlok, as outlined on Page 98.

Armstrong's Asphalt-Impregnated Temlok Roof Insulation is supplied in the same sizes and thicknesses as Temlok. (See table giving Temlok sizes on Page 94.)

## Cant Strips

Armstrong's Temlok and Corkboard Cant Strips have the same insulating efficiency and general characteristics as the materials from which they are made. They are made to fit into the 90° junctions of roof decks with parapet walls, penthouses, and other vertical surfaces. The gentle incline formed adjacent to vertical surfaces prevents water from collecting against them and provides a sturdy insulated base for flashing. (See drawings below.)

Corkboard Cant Strips are supplied 3" x 3" x 36" and 4" x 4" x 36", cut on the diagonal. Temlok Cant Strips are fabricated to the design shown below and are supplied in 4' lengths.




**Corkboard Cant Strip**
3" x 3" x 36"
4" x 4" x 36"

**Temlok Cant Strip**
1½" thickness
in 4' lengths



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# How to Determine Adequate Insulation Thickness

Once a roof insulation has been selected that will meet your service requirements, the next step is to determine an adequate thickness. There is an economical thickness of roof insulation for every job. A lesser thickness will result in excessive fuel and air-conditioning losses. A greater thickness will not save enough extra to justify its greater cost. The accompanying chart and table enable you to approach this problem in two ways.

If condensation is a definite factor (and it is in all but the very mildest of climates) you should first determine the thickness of insulation that is required to prevent it. To do this you must know four things:

1. The highest inside temperature which will be normally maintained within the building.
2. The highest relative humidity which will be normally maintained within the building.
3. The lowest outside temperature which will prevail.
4. The type of roof construction to be used.

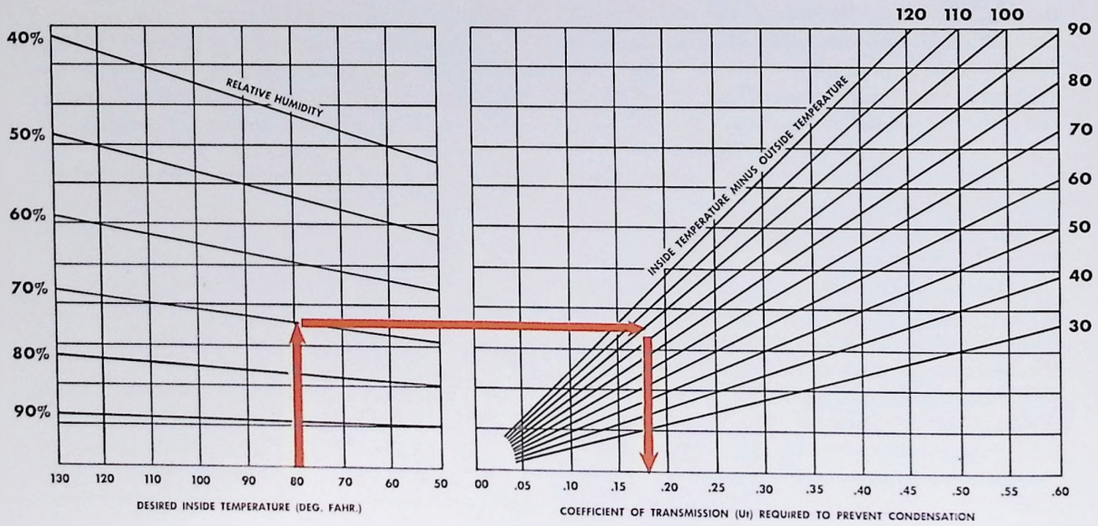
With this information you can quickly determine the coefficient of heat transmission (Ut) your roof must have to prevent condensation. The coefficient of heat transmission (Ut) combines the thermal conductivities of the materials in a given roof, allowing for their thicknesses, and thus expresses as one value the heat transmission of the roof in Btu. per square foot per degree F. temperature difference per hour.

When this value is known, it is a simple matter to find it in the Roof Resistance Table and learn what thickness of the material selected is needed for a given roof construction.

The following example will illustrate how the chart and table may be used:

Assume that the maximum inside temperature will be 80° F., the relative humidity 70%, and the minimum outside temperature 20° below zero. Roof is to be a flat metal roof deck.

Starting at the bottom of the chart below, find the point which indicates an inside temperature of 80° F. Move upward vertically from this point until the 70% relative humidity curve is intersected. Then move horizontally into the right section of the chart to an intersection with diagonal marked 100. (Since the minimum outside temperature is 20 degrees below zero and the maximum inside temperature is 80 degrees above, the maximum temperature difference is 100.) From this intersection, move downward vertically to the horizontal scale at the bottom of the right chart. On this scale may be read the coefficient of heat transmission required to prevent condensation. In this instance, Ut is .18.






Referring now to the Roof Resistance Table below, it may be seen that, for a flat metal roof deck, 1½" of Armstrong's Corkboard provides a Ut of .15 and 2" of Armstrong's Temlok provides a Ut of .14. In either case the insulation will prevent condensation and provide an adequate margin of safety as well.

**Roof Resistance Table—Corkboard and Temlok***

| Type of Roof | Armstrong's Corkboard | Ut | Armstrong's Temlok | Ut |
|---|---|---|---|---|
| Flat Metal Roof Deck | No Insulation | 1.06 | No Insulation | 1.06 |
| | 1" Corkboard | .22 | ½" Temlok | .43 |
| | 1½" Corkboard | .15 | 1" Temlok | .25 |
| | 2" Corkboard | .12 | 1½" Temlok | .18 |
| | 3" Corkboard | .083 | 2" Temlok | .14 |
| | 4" Corkboard | .063 | | |
| 2" Concrete Slab and Roofing | No Insulation | .82 | No Insulation | .82 |
| | 1" Corkboard | .20 | ½" Temlok | .38 |
| | 1½" Corkboard | .15 | 1" Temlok | .24 |
| | 2" Corkboard | .12 | 1½" Temlok | .17 |
| | 3" Corkboard | .081 | 2" Temlok | .14 |
| | 4" Corkboard | .062 | | |
| 4" Concrete Slab and Roofing | No Insulation | .72 | No Insulation | .72 |
| | 1" Corkboard | .20 | ½" Temlok | .36 |
| | 1½" Corkboard | .14 | 1" Temlok | .23 |
| | 2" Corkboard | .11 | 1½" Temlok | .17 |
| | 3" Corkboard | .080 | 2" Temlok | .13 |
| | 4" Corkboard | .062 | | |
| 6" Concrete Slab and Roofing | No Insulation | .65 | No Insulation | .65 |
| | 1" Corkboard | .19 | ½" Temlok | .34 |
| | 1½" Corkboard | .14 | 1" Temlok | .22 |
| | 2" Corkboard | .11 | 1½" Temlok | .16 |
| | 3" Corkboard | .079 | 2" Temlok | .13 |
| | 4" Corkboard | .061 | | |
| 2" Wood** and Roofing | No Insulation | .32 | No Insulation | .32 |
| | 1" Corkboard | .15 | ½" Temlok | .22 |
| | 1½" Corkboard | .12 | 1" Temlok | .16 |
| | 2" Corkboard | .095 | 1½" Temlok | .13 |
| | 3" Corkboard | .070 | 2" Temlok | .11 |
| | 4" Corkboard | .056 | | |
| 3" Wood** and Roofing | No Insulation | .23 | No Insulation | .23 |
| | 1" Corkboard | .12 | ½" Temlok | .17 |
| | 1½" Corkboard | .10 | 1" Temlok | .14 |
| | 2" Corkboard | .085 | 1½" Temlok | .11 |
| | 3" Corkboard | .065 | 2" Temlok | .096 |
| | 4" Corkboard | .052 | | |

* The insulating efficiency of Asphalt-Impregnated Temlok is such that it may be used in the same thicknesses as regular Temlok.
** Nominal thickness specified—actual thickness used in calculations.
Ut—Transmission in Btu. per square foot per degree F. temperature difference per hour.

If you wish to base your selection on heat savings, the following procedure may be used:

First, calculate the amount of heat that will escape through your roof if it is not insulated. You can do this by multiplying Ut for the uninsulated roof by the difference between inside and outside temperatures. This will give you heat loss in Btu.'s per square foot per hour.

Then, following the same procedure, figure the heat loss through the roof if insulated, substituting Ut for the insulation thickness selected. By comparing the two results, it may be readily seen that roof insulation is a sound investment.

Using the conditions assumed for the example above, it works out this way:
Temperature difference equals 100° F.
Ut for uninsulated metal roof deck equals 1.06

Thus, heat loss per hour per square foot equals 1.06 x 100 or 106 Btu. Ut for metal roof deck plus 1½" of Armstrong's Corkboard equals .15. Thus, heat loss per square foot per hour equals .15 x 100 or 15 Btu. Ut for metal roof deck plus 2" of Armstrong's Temlok equals .14. Thus, heat loss per square foot per hour in this case equals .14 x 100 or 14 Btu.

The thickness of either material required to prevent condensation also cuts heat loss by about 85% under the given conditions.

It is only fair to add that in most cases the extremes used as a basis for calculation may exist for relatively short periods. To calculate heat savings for a year's time the temperature difference should be based not on the minimum outside temperature but on the average temperature for the annual period of time during which heat is required.

This is not the case where condensation is involved, however, because condensation will occur any time the ceiling temperature drops below the dewpoint of the inside air.

Therefore, in the great majority of cases, the thickness required to prevent condensation under extreme conditions, allowing for some margin of safety, will be the economical thickness of roof insulation to use.

An exception is in the case of refrigerated interiors where roof insulation also serves as a part of the cold storage insulation envelope. Then insulation thickness must be based on inside temperature limits and other factors which enter into cold storage design. (See Section I.)



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# Specifications for Applying Armstrong's Roof Insulations

The specifications which follow reflect knowledge and experience which have been gained from many years in the manufacture and sale of roof insulation materials. They have been developed by Armstrong's Research Laboratories to provide efficient, long-lasting service from Armstrong's Roof Insulations. They are consistent with the best practices in the industry.

## 1. General

### 1a. Condition of Roof Deck

The roof deck shall be thoroughly dry, firm, and smooth and shall be swept clean of any loose materials or dirt before applying felts or insulations. In fireproof construction, where a poured cant strip is provided, a vertical butt edge, equal in height to the thickness of insulations, shall be provided at the base of the cant.

### 1b. Bitumen

Either asphalt or pitch may be used as the waterproofing agent for applying the vapor seal and embedding the insulation, except that pitch shall not be used to apply these courses over a steel deck. To assure strong bonding and proper thickness of moppings, asphalt shall be applied at working temperature between 375° F. and 400° F., and pitch shall be applied at working temperatures between 350° F. and 375° F.

For the application of felts, asphalt shall be mopped at the average rate of 30 lbs. per 100 sq. ft. for each mopping, and pitch shall be mopped at the average rate of 25 lbs. per 100 sq. ft. for each mopping. Insulation, where bitumen application is specified, shall be embedded in a heavy flood mopping, sealing all edges by sliding each board into place while the bitumen is hot and butting against adjacent boards.

### 1c. Insulation

Insulation shall be stored so that it is protected from the weather during the course of the work. No insulated areas shall be left exposed at the end of the day. Where work is stopped or weather threatens, all exposed edges of insulation shall be sealed by felt cutoff flashings extending 6″ onto the roof deck or base course and 4″ onto the protective roofing courses over the insulation. This flashing shall be mopped tightly over the edge of the insulation. Where this flashing is to remain as a water cutoff, it shall be laid in two plies as specified under Paragraph 1f. below.

Units shall be laid with all transverse joints broken, and additional layers shall break joints with first layer. Where nailing is required, it shall be done through the full thickness of insulation. Nails shall penetrate roof deck ¾″ but shall not protrude through deck.

### 1d. Edges and Vertical Surfaces

Insulation shall be cut and fitted closely around penthouses, parapets, firewalls, pipes, ventilators, skylights, etc. At all edges or intersections of vertical surfaces, base membrane shall be extended at least 4″ over top of insulation and be mopped back over insulation to seal edges. At all exposed edges or eaves a 4″ wide wood nailing strip equal in thickness to the insulation to be used shall be provided to terminate the insulation and allow nailing of edging, etc.

### 1e. Vapor Seal

A vapor seal shall be applied under insulation on all heated buildings north of the latitude of the Ohio River, or where the average January temperature is below 35°, and on all buildings anywhere in which excessive moisture conditions prevail due to processes within the building, as in textile mills, laundries, breweries, etc.

### 1f. Water Cutoffs

(1) Corkboard Roof Insulation shall be isolated by felt cutoff strips every 25 feet in one direction only, or

(2) Temlok Roof Insulation shall be isolated in areas of not more than 30 square feet over the entire roof.

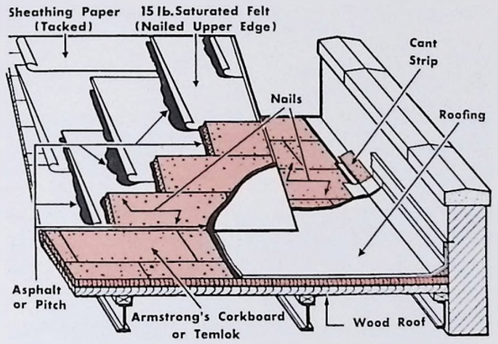


(3) (In both cases) additional strips shall be placed 2 feet back from all vertical surfaces. Strips shall be applied in two layers and mopped to the roof deck or membrane and to the top surface of the insulation. The first strip shall extend 4″ over the top of the insulation and 4″ onto the adjacent roof deck or membrane, and the second strip shall overlap the first in each direction at least 2″.

### 1g. Cant Strips

Cant strips shall be provided at all vertical surfaces of the same material as the roof insulation and as manufactured by Armstrong Cork Co.

## 2. Wood and Pre-Cast Gypsum Plank or Slab Deck




### 2a. No Vapor Seal Required*

Dry Application (inclines up to 9″ per foot). Over roof deck, a layer of sheathing paper weighing not less than 5 lbs. per 100 sq. ft. shall be applied, each sheet lapped 6″ over the preceding sheet and nailed to hold in place.

Apply Armstrong's (Temlok, Asphalt-Impregnated Temlok, Corkboard) Insulation ( ) inches thick in ( ) layers. Joints shall be (shiplapped, butted), and all transverse joints shall be broken, with additional layers breaking joints with first layers. Insulation shall be secured by nailing through top layer of insulation, using galvanized roofing nails of sufficient length to penetrate roof deck ¾″, placed on not less than 12″ centers over the area of the board and along all edges.

Apply roof covering in accordance with manufacturer's instructions, following closely upon application of insulation, so no insulation is exposed to showers or unprotected at night.

### 2b. Vapor Seal Required*

Asphalt Base (inclines up to 3″ per foot).
Coal Tar Pitch Base (inclines to 1″ per ft.).

Over roof deck, a layer of sheathing paper weighing not less than 5 lbs. per 100 sq. ft. shall be applied, each sheet lapped 2″ over the preceding sheet and nailed to hold in place.

Two layers of 15-lb. (asphalt, tarred) felt shall be laid over the sheathing paper, lapping each sheet 19″ over the preceding sheet, and nailing on 18″ centers, 2″ from the top edge. Nails shall be 1″ barbed roofing nails driven through flat roofing tins. The felt shall then be mopped back 17″ on each, or up to but not beyond the nail course, with hot (asphalt, pitch).

Apply Armstrong's (Temlok, Asphalt-Impregnated Temlok, Corkboard) Insulation ( ) inches thick in ( ) layers, embedding boards in a heavy mopping of hot (asphalt, pitch) applied to base felt. Joints shall be (shiplapped, butted). Additional layers of insulation shall be similarly mopped parallel to and breaking joints with the first. No nailing shall penetrate the vapor barrier.

Apply roof covering in accordance with manufacturer's instructions following closely upon application of the insulation, so no insulation remains exposed to sudden showers or unprotected at the close of the day.

### 2c. Steep Roofs

Asphalt Base (inclines from 3″ per foot to 6″ per foot). Use specification 2b. above except that:

(1) All felts shall be nailed on 12″ centers instead of 18″ centers.

(2) All insulation shall be nailed on not less than 12″ centers over the area of the boards above all edges.

Asphalt Base (inclines from 6″ per foot to 9″ per foot). Use specification 2b. above except that:

(1) Additional nailing requirements specified in 2c.—Asphalt Base above shall apply.

(2) Steep asphalt shall be used.

Coal Tar Pitch Base (inclines from 1″ per foot to 4″ per foot). Use 2b. above except that:

(1) Additional nailing requirements specified in Asphalt Base (inclines from 3″ per foot to 6″ per foot) above shall apply.

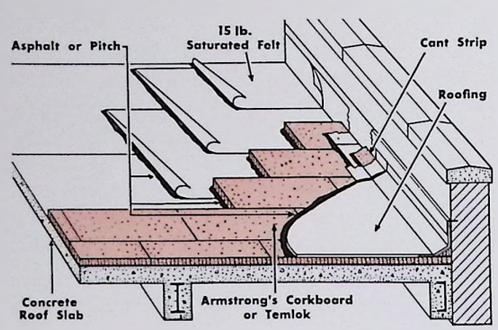
(2) Steep pitch shall be used.



* See Paragraph 1c.

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### 3. Poured Concrete or Gypsum and Precast Concrete Deck




**3a. No Vapor Seal Required***

Asphalt Base (inclines up to 3″ per foot);
Coal Tar Pitch Base (inclines to 1″ per ft.).

Where asphalt is used, roof deck shall be primed, using Armstrong's No. 3 Asphaltic Paint or other suitable primer. Poured concrete or gypsum decks shall be primed over the entire surface, using a second application of primer in the latter case if necessary. Pre-cast concrete units shall be adequately grouted at all joints and the priming applied to the face of the units only, keeping back 4″ from the edges of the units. Where pitch is used, omit priming.

(Asphalt, pitch) shall be mopped on the entire surface of the poured concrete deck, in 2′ wide strips spaced 6″ apart in the case of a poured gypsum deck, and in spots or strips in the case of pre-cast concrete units, keeping back 4″ from the edges of the units. Into this mopping, while hot, shall be applied one layer of 15-lb. (asphalt, tarred) felt, lapping each sheet, 2″ over the preceding sheet and sealing all laps with a mopping of hot (asphalt, pitch). When the deck provides nailing, all sheets shall be nailed at the upper edge, under the lap, on 18″ centers, using 1″ barbed roofing nails driven through flat roofing tins.

Apply Armstrong's (Temlok, Asphalt-Impregnated Temlok, Corkboard) Insulation ( ) inches thick in ( ) layers, embedding boards in a heavy mopping of hot (asphalt, pitch) applied to the base felt. Joints shall be (shiplapped, butted). Additional layers shall be similarly mopped parallel to and breaking joints with the first.

Apply roof covering in accordance with manufacturer's instructions, following closely upon application of insulation, so no insulation remains exposed to sudden showers or unprotected at the close of the day.

**3b. Vapor Seal Required***

Asphalt Base (inclines up to 3″ per foot).
Coal Tar Pitch Base (inclines to 1″ per ft.).

Specification A above shall be followed, except that specification for felt shall be changed to:

"Into this mopping, while hot, shall be applied two layers of 15-lb. (asphalt, tarred) felt, lapping each sheet 19″ over the preceding sheet and nailing where possible on 18″ centers 2″ from top edge of each sheet. The felt shall then be mopped back the full 19″ width of the sheet in the case of the poured concrete or gypsum deck and 17″ in the case of pre-cast concrete units. Nails shall be 1″ barbed roofing nails driven through flat roofing tins." No nailing shall penetrate the vapor barrier.

**3c. Steep Roofs**

Asphalt Base (inclines from 3″ per foot to 6″ per foot). Use Specifications 3a. and 3b. above, except that:

(1) All felts shall be laid perpendicular to the incline of the roof and shall be nailed on 12″ centers instead of 18″ centers where roof deck permits nailing.

(2) When the deck does not permit nailing, as in the case of dense poured or pre-cast concrete, nailing strips shall be provided. Nailing strips shall be of treated wood laid flush with the roof deck and parallel to the incline. On pre-cast concrete decks, nailing strips shall be placed between each vertical row of units. All nailing shall penetrate strips at least ¾″.

On poured concrete decks, nailing strips shall be provided on 24″ centers where 24″ x 48″ insulation boards are used, and on 18″ centers where 12″ x 36″ insulation boards are used. Where nailing strips are located on more than 12″ centers, felts shall be fastened with two nails at each nailing strip, located 2″ and 6″ respectively from the top edge of the sheet.

(3) Where roof deck permits nailing, all insulation shall be nailed on not less than 12″ centers over the area of the boards and along all edges. Where nailing strips are provided all insulation shall be fastened at each strip by nailing on 12″ centers parallel to the incline of the roof. Nails shall not penetrate roof deck or nailing strips.

Asphalt Base (inclines from 6″ per foot to 9″ per foot). Use specifications 2a. and 2b. above except that:

(1) Additional nailing requirements specified in 3c.—Asphalt Base above shall apply except that nailing of insulation over nailing strips shall be increased to 6″ centers.

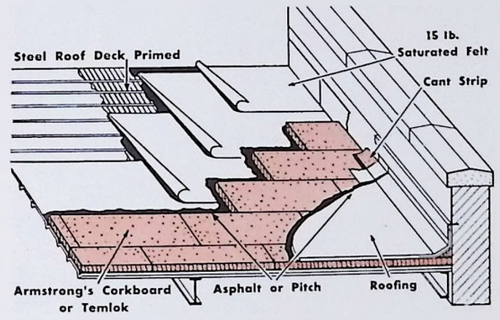
(2) Steep asphalt shall be used.

Coal Tar Pitch Base (inclines from 1″ per foot to 4″ per foot). Specifications 3a. and 3b. above shall be followed except that:

(1) Additional nailing requirements specified in 3c.—Asphalt Base above shall apply.

(2) Steep pitch shall be used.

### 4. Steel Deck




**4a. No Vapor Seal Required***

Asphalt Base Only (inclines up to 1″ per foot).

Where units have not been shop coated, roof deck shall be primed, using Armstrong's No. 4 Asphaltic Paint or other suitable primer.

Apply Armstrong's (Temlok, Asphalt-Impregnated Temlok, Corkboard) Insulation ( ) inches thick in ( ) layers. The first layer shall be applied into a mopping of hot steep asphalt applied to the roof deck. Each board shall be given an additional uniform mopping of steep asphalt on the back, prior to embedding in the mopping applied to the deck. Additional layers of insulation shall be mopped to the first, laid parallel to and breaking joints with the same.

Apply roof covering in accordance with manufacturer's instructions, following closely upon the application of insulation, so no insulation remains exposed to sudden showers or unprotected at the close of the day.

**4b. Vapor Seal Required***

Asphalt Base Only (inclines up to 1″ per foot).

Where units have not been shop coated, roof deck shall be primed using Armstrong's No. 4 Asphaltic Paint or other suitable primer.

A uniform mopping of steep asphalt shall be applied after the primer has dried, into which while hot, shall be applied two layers of 15-lb. asphalt felt, lapping each sheet 19″ over the preceding sheet and mopping back the full 19″ width of the sheet with hot steep asphalt.

Apply Armstrong's (Temlok, Asphalt-Impregnated Temlok, Corkboard) Insulation ( ) inches thick in ( ) layers, embedding boards in a heavy mopping of hot steep asphalt applied to the base felt. Joints shall be (shiplapped, butted). Additional layers shall be similarly mopped parallel to and breaking joints with the first.

Apply roof covering in accordance with manufacturer's instructions, following closely upon application of insulation, so no insulation is exposed to sudden showers or unprotected at night.

**4c. Steep Roofs**

Asphalt Base Only (inclines from 1″ per foot to 6″ per foot). Use specifications 4a. and 4b. above except that:

(1) Insulation shall be additionally secured to the roof deck by means of self-tapping screws, expanding nails or cleats, using not less than five such fasteners for boards 24″ x 48″ or three for boards 12″ x 36″. If more than one layer of insulation is applied, fastening shall be done through the top layer, and the fastener shall be of a type that will adequately support each layer.

(2) Under conditions of unusual humidity under the roof deck, fasteners shall be designed to penetrate the steel deck.

**Application of Roofing**

Application of roofing over Armstrong's Roof Insulation shall be done in accordance with recommendations of the manufacturer of the roofing materials. In all cases where the manufacturer's guarantee bond is required, his instructions as to the adequacy of the insulation base for given conditions shall be followed.

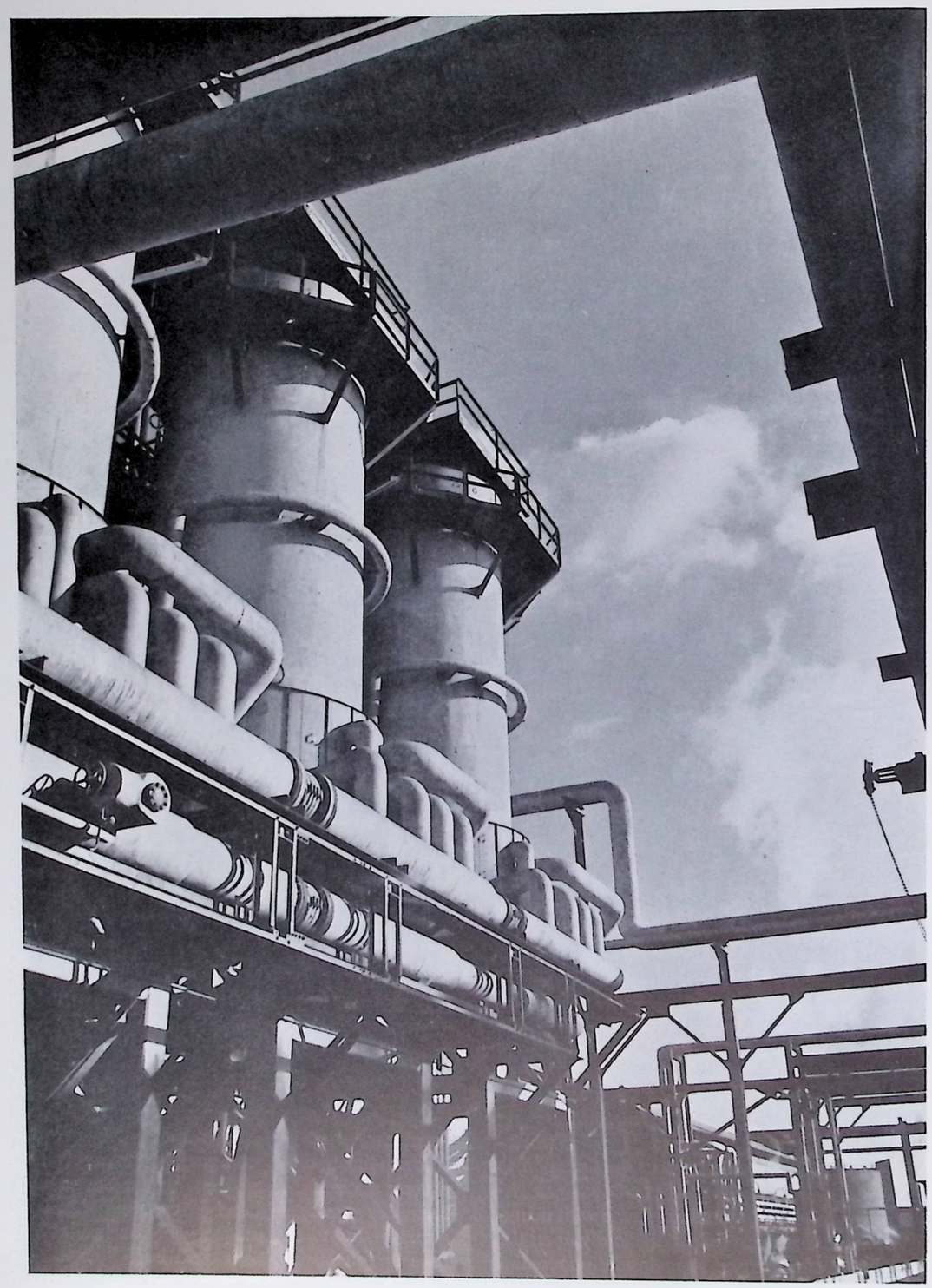
* See Paragraph 1c.





*See Paragraph 1c.

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Section VI

# HEAT INSULATIONS


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# How Insulations Reduce Heat Losses

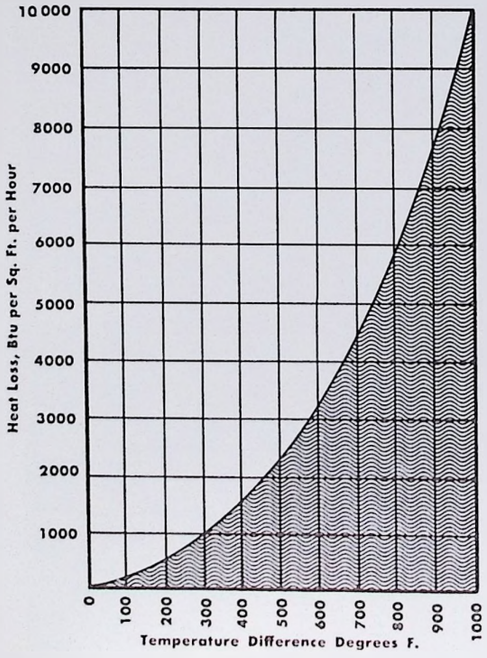
Heat losses come from the three methods of heat transfer: radiation, convection and conduction. In high-temperature pipe covering the principal factors are convection and conduction.

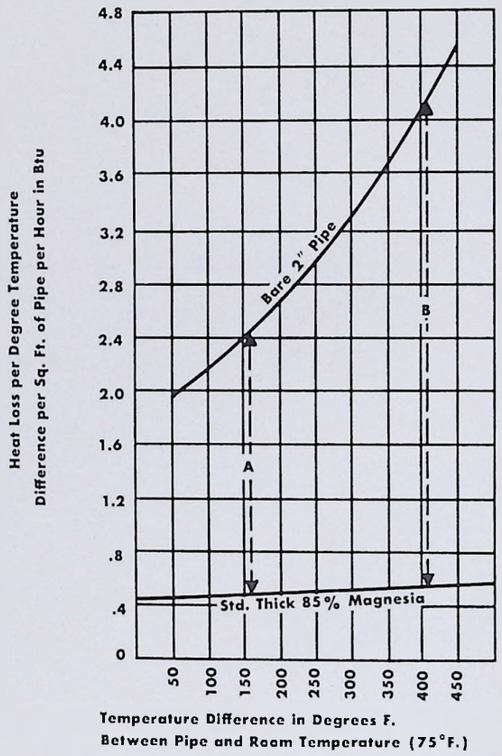
When any heated surface, such as a hot water or steam pipe, or a boiler wall, is surrounded by air at a lower temperature, the film of air which is adjacent to the surface is quickly heated. This heated air rises and more air is drawn in to take its place. This results in convection currents which rapidly carry away heat and thus produce excessive heat losses.

The amount of heat lost increases rapidly as temperature differences increase. This fact is illustrated by the accompanying chart. For example, the heat lost from one square foot of surface per hour is about 2300 Btu. at a temperature difference of 500° F. but is 10,000 Btu. at a temperature difference of 1000° F.

The function of heat insulation is to lower the temperature of exposed surfaces to a point where heat losses will be minimized.

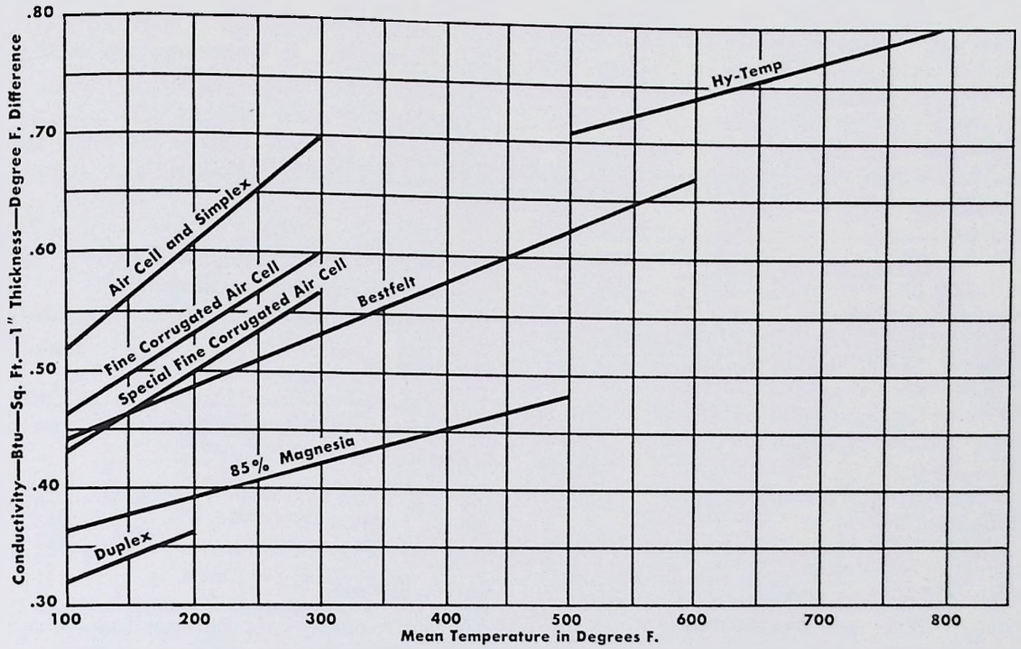
This is accomplished by covering the heated surface with a material that retards the flow of heat. A material which performs this function is an insulator and theoretically the perfect insulation is a vacuum because it contains nothing to conduct or convect heat. In industrial applications, a vacuum is impractical to obtain. The next best insulator is still air, and an insulation material is composed of tiny pockets of still air entrapped in its fibers, crystals, or cells.




This chart shows the effect of insulation in reducing heat loss from bare pipe. It should be noted that, while the loss from bare pipe goes up rapidly as temperature difference increases, the loss from insulated pipe remains nearly constant. By comparison of line "A" and "B" it also can be seen that the saving per degree of temperature difference is far greater at high than at low steam temperatures.






Heat losses due to convection are further increased if the surrounding air is being moved by external force (i. e. wind). The effect of air velocity varies with the shape of the heated surface, the temperature difference and other factors. Under an average set of conditions, however, heat loss from a bare surface, with a 10 mile an hour wind, will be approximately 150% to 200% greater than the loss in still air.

By the same token, insulation reduces the loss due to air velocity. For example, with a 30 mile an hour wind, one inch of insulation reduces heat loss to only 15%. With 2" of insulation the loss increase due to wind is about 10% and with 3" the increase is further reduced to about 5%.

The characteristic which enables heat insulations to reduce heat loss is low thermal conductivity. Thermal conductivity, like density, is a specific physical property, and is expressed as the quantity of heat—in British thermal units—that will pass in one hour through one sq. ft. of a given material 1" thick when a temperature difference of one degree Fahrenheit exists between the two sides. Thermal conductivity is often designated as the "K" factor. Insulation may be broadly defined as a material having a low "K" factor. "K" values vary with mean temperature so the thermal conductivities of heat insulation are normally expressed in relationship to mean temperature.

While low thermal conductivity is of primary importance in the selection of heat insulation, other factors must be considered.

To perform efficiently, insulation must have the ability to withstand the temperatures to which it will be subjected without warping, shrinking or deteriorating. Therefore, careful attention should be given not only to the temperature ratings of various insulations but also to their physical and chemical properties.

Insulation is often subjected to considerable stress and mechanical vibration. Be sure the material used on your job is sturdy enough to give lasting service without costly maintenance and repair. Strong materials also can be installed quicker and with less breakage and waste.

The lighter your insulation is, the less structural strain will be placed on piping and equipment. In addition, light weight frequently means a more efficient insulation.

The cost of an insulation is a matter of economics. It is largely a comparison of dollars spent to achieve dollars saved. The factors to be weighed are the amount of fuel an insulation will save each year compared with the job cost and probable expense of maintenance.



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# Heat Loss Calculations

### Heat Loss Formulae

The transmission of heat through an insulation material varies directly as the difference in temperature between the inner and outer surfaces of the material, and inversely as the resistance of the insulation to the transfer of heat. This resistance is a function of the thermal conductivity of the material, and its applied thickness. That is—

(1) $R = \frac{X}{k}$

R = Resistance
X = Thickness of the material
k = Thermal Conductivity of the material

The amount of heat transmitted through a given insulation, of given thickness, in a given period of time, will vary with the shape and position of the insulated surfaces as well as with exposure to moving air conditions. Normal insulation practice bases heat loss calculations on still, dry air conditions. If actual conditions vary appreciably from the assumed conditions, the necessary corrections as outlined on Pages 108 and 109 should be considered in the final calculations that follow.

These terms are used:

U = Heat loss in B.T.U.'s per square foot of *outer surface* per hour.
(For total temperature difference between heated metal and air.
If U is desired in terms of "per degree difference in temperature" divide result by the number of degrees difference in temperature).
$t_1$ = Temperature of inner surface in degrees Fahrenheit
$t_2$ = Temperature of *outer surface* in degrees Fahrenheit
$t_a$ = Temperature of surrounding air in degrees Fahrenheit
x = Thickness (actual) of material in inches
k = Thermal conductivity of material
$r_1$ = Radius of inner surface in inches
$r_2$ = Radius of outer surface in inches
D = Diameter (outside) of insulation in inches

### Flat Surfaces

To calculate the heat losses from insulated flat surfaces the following formulae will serve in nearly all cases.

(2) $U = \frac{t_1 - t_2}{\frac{x}{k}}$ or if more than one material (3) $U = \frac{t_1 - t_2}{\frac{x_1}{k_1} + \frac{x_2}{k_2}}$ etc.

### Curved Surfaces

When calculating the heat losses from curved surfaces, the resistance is not based on the actual thickness of the insulation, but on an "equivalent thickness." Even though the thickness of insulation on a flat and a curved surface is the same, the total volume, as well as the external surface area of the insulation on the curved surface is much greater. For this reason, where the heat loss is to be based on the outer surface, the equivalent thickness is equal to $r_2 \log_e \frac{r_2}{r_1}$. *Where heat loss is to be based on the pipe surface, the equivalent thickness is equal to* $r_1 \log_e \frac{r_2}{r_1}$.

In figuring heat losses from curved surfaces, it is necessary to substitute the value for equivalent thickness in the formula for heat flow. Thus, for insulated curved surfaces, when only one material is used:

(4) $$U = \frac{t_1 - t_2}{\frac{r_2 \log_e \frac{r_2}{r_1}}{k}} = \frac{k(t_1 - t_2)}{r_2 \log_e \frac{r_2}{r_1}}$$

(Heat loss based on outer surface)

and,

(5) $$U = \frac{t_1 - t_2}{\frac{r_1 \log_e \frac{r_2}{r_1}}{k}} = \frac{k(t_1 - t_2)}{r_1 \log_e \frac{r_2}{r_1}}$$

(Heat loss based on pipe surface)



and substitution in the formula gives the transmission per square foot of designated surface.

Where more than one material is used in the covering, as is the case where a Hy-Temp inner layer and an 85% Magnesia outer layer is employed, this formula becomes:

(6) $$U = \frac{t_1 - t_2}{\frac{r_3 \log_e \frac{r_2}{r_1}}{k_1} \frac{r_3 \log_e \frac{r_3}{r_2}}{k_2}}$$

(Heat loss based on outer surface)

and,

(7) $$U = \frac{t_1 - t_2}{\frac{r_1 \log_e \frac{r_2}{r_1}}{k_1} \frac{r_1 \log_e \frac{r_3}{r_2}}{k_2}}$$

(Heat loss based on pipe surface)

in which $t_2$ and $t_1$ are temperatures of the outside surface of the outer layer and the inside surface of the inner layer, respectively, and $r_1$, $r_2$ and $r_3$ are radii of the inner layer, outer layer, and outer surface respectively.

### Surface Temperatures

The formulae given enable the calculation of the heat flow through coverings in terms of the thermal conductivity of the materials involved, in terms of the flow per square foot of designated surface of covering, and in terms of the temperature difference between the inner and outer surface of the covering. Generally speaking, the temperature given is that of the surrounding air rather than of the outer surface. Therefore, it is necessary to set the outer surface temperature; to do this, it is necessary to resort to a trial and error method of calculation. The first step is to assume an outer surface temperature, carrying through the heat loss calculation in terms of the assumed outer temperature. Then,

(8) $$t = \frac{272.5\ U}{U \frac{564}{DO.19}}$$

This computed value of $t_2$ should be compared to the value of $t_2$ that was assumed in the heat loss formula. If the error in the first assumption was relatively large, the computed $t_2$ should be used as a guide to correct the assumed $t_2$ and the formula re-solved until accuracy is satisfactory.

On insulated flat surfaces, heat losses per unit area of outer surface are the same as the inner surface unit losses. Consequently, the formula for outer curved surface is simplified to:



This 16" steam line is almost 10,000 ft. long. To minimize drop in pressure and temperature, an insulation combination of 1½" Hy-Temp and 2" 85% Magnesia Pipe Covering was applied by the mechanics of Armstrong's contracting organization. Weatherproof finish is three-ply asbestos roofing felt wired in place.



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(9) $$t_2 = \frac{272.5 \times U}{U+295} t_a$$

The fact that outer-insulation (canvas) temperatures are likely to be but slightly higher than air temperatures can be misleading as to the magnitude of the actual heat losses taking place. The cooling action of even light air currents results in many times the theoretical losses that are based on ideal still air conditions.

### Conductivity Factors (k)

Thermal conductivities of materials, as used in the heat loss formulae should be based on the mean temperature of the layer of insulation considered. Conductivities of nearly all materials vary with the temperature. Since the conductivities must be chosen before the formulae are solved, it is necessary to assume approximate inter-face temperatures in order to arrive at mean temperatures. Where the utmost in accuracy is desired, these assumed interface temperatures and the resulting conductivities should be checked by calculating the inter-face temperature. If the temperatures, as calculated, do not agree with those assumed, then choose a new conductivity value for that originally used and solve the formula again. This process should be continued until the desired degree of accuracy is reached.

In multiple layer insulations, the temperature drops through the various layers can be calculated by dividing the total temperature difference between the inner surface of the inner layer, and the outer surface of the outer layer by the sum of all resistances, and then multiplying the result by the resistance of each layer. If the temperature drop of each layer is subtracted successively from the temperature of the inner surface of each layer, all inter-face temperatures will be found. In other words, multiplying the B.t.u. loss per square foot per hour by the resistance of each layer will give the temperature drop through each layer of insulating material.

### Problem Example 1

Given a superheated steam pipe 16″ in diameter, one mile long, carrying steam at 800° F., calculate the dollar saving per day in steam if the pipe is insulated with Hy-Temp Combination Covering consisting of an inner 1½″ Hy-Temp Covering with an outer layer of 2″ Magnesia Pipe Covering.

**Terms**

$r_1 = 8.00''$
$r_2 = 8.00'' + 1.50'' = 9.50''$
$r_3 = 8.00'' + 3.50'' = 11.50''$
$t_a = 50°$ F. (assumed)
$K = K_1 - .80$ (Assumed mean temperature 650°—extrapolated from curve) Hy-Temp
$K_{mag} = -.45$ (Assumed mean temperature 310°—from curve)
$x_1 = 1.5''$
$x_2 = 2.0''$
$D = 23.0''$
$t_1 = 800°$ F.
$t_a = 50°$ F.
$t_2 = 100°$ F. (assumed)

and, substituting in equation No. 7

$$U = \frac{800 - 100}{\frac{8.00 \log_e \frac{9.50}{8.0}}{.80} + \frac{8.00 \log_e \frac{11.50}{9.50}}{.45}} = \frac{700}{5.0}$$

= 140 BTU per sq. ft. of *16″ pipe surface* per hour.

However, since the surface temperature ($t_2$) was assumed as 100° F., this must be calculated to determine the actual surface temperature, and U again calculated—thus minimizing the limits of error.

Thus, substituting in equation No. 8

$$t_2 = \frac{272.5 \times 140}{140 + \frac{564}{23} 0.19} = \frac{272.5 \times 140}{140 + \frac{564}{3.1}}$$

And, re-calculating equation No. 7

$$U = \frac{800 - 118}{\text{(same denominator)}}$$

= 136 BTU per sq. ft. of 16″ pipe surface per hour.

Again, substituting in equation No. 8

$$t_2 = \frac{272.5 \times 136}{136 + \frac{564}{3.1}} = 116° \text{ F.}$$

Again, re-calculating equation No. 7

$$U = \frac{800 - 116}{\text{(same denominator)}} = 136.5 \text{ BTU per sq. ft. 16″ pipe surface per hour.}$$

And again, substituting in equation No. 8



$$t_2 = \frac{272.5 \times 136.5}{136.5 + \frac{564}{3.1}} = 117°$$

Thus, where assumed and calculated surface temperature, ($t_2$) checks very closely.

U = 136.5 BTU per sq. ft. 16″ pipe surface per hour.

Now, since values for "K" were selected on basis of estimated mean temperatures actual inter-face temperatures between Hy-Temp Covering and Magnesia Covering must be calculated to determine accurately the correct mean temperature—and the value for U re-calculated for a high degree of accuracy.

Total temp drop = $t_1 - t_2$ = 800 — 116 = 684° F.

Total resistance (R) of combined Hy-Temp and Magnesia covering = denominator of equation (7) = 5.0

Temp drop across Hy-Temp Covering

$$= 684° \times \frac{\text{Resistance of Hy-Temp}}{\text{Total resistance}}$$

$$= 684 \times \frac{1.71}{5.0}$$

$$= 234°$$

Thus, temperature at inner-face of Hy-Temp and Magnesia Covering is 800°—234°=566° F.

And, mean temp thru Hy-Temp Covering

$$= \frac{800° + 566°}{2} = 683° \text{ F.}$$

And, mean temp thru Magnesia Covering

$$= \frac{566° + 116°}{2} = 340° \text{ F.}$$

Recapitulating,

| | *Hy-Temp Covering* | *Magnesia Covering* |
|---|---|---|
| 1. Assumed Mean Temp, corresponding K | 650° F. .80 | 310° F. .45 |
| 2. Actual Mean Temp, corresponding K | 683° F. .80 (close) | 340° F. .46 (close) |

Thus, since actual calculated values correspond so closely with assumed values, no further refinements in the calculation are necessary.
Thus: 1 lin. ft. 16″ pipe = 4.188 sq. ft. surface (from Table, Page 210).
Then: U, or 136.5 × 4.188 = 570 BTU per lin. ft. per hour (insulated).
Also from Efficiency Table, Page 119. U or heat loss of bare 16″ pipe = 21,366 BTU per lin. ft. per hour.
Total saving = 21,366 — 570 = 20,796 BTU per lin. ft. per hour.
For one mile = 20,796 × 5280 = 110,000,000 BTU per hour.
Assuming an average cost of producing steam as $.40 per million BTU
Then, savings per hour
= $.40 × 110 = $44.00 per hour
= $1056.00 per day.

### Problem Example 2

### Flat Surface Block Insulation

Given a cylindrical steel tank 6′0″ diameter containing a liquid maintained at 400° F. Calculate heat loss per sq. ft. per hour if insulated with 3″ Magnesia blocks. Tank is located indoors.

**Thus**

Assume flat surface formulae:

$U = \frac{t_1 - t_2}{\frac{x}{k}}$ $\frac{x}{k}$ for tank shell may be eliminated because it is negligible compared to that of insulation

$t_1 = 400°$ F.
$t_a = 75°$ F.
$t_2 = 100°$ F. (assumed)
$K_{mag} = .43$ (mean temperature of 250° F.)
$x = 3''$

Solving:

$$U = \frac{400 - 100}{\frac{3}{.43}} = 43 \text{ BTU per sq. ft. per hour}$$

Checking for assumed value of $t_2$; substitute in equation No. 9

$$t_2 = \frac{272.5 \times 43}{43 + 295} \qquad 75 = 109.6° \text{ F.}$$

Assuming 109° F. as $t_2$, solving for U

$$U = \frac{400 - 109}{\frac{3}{.43}} = 41.6 \text{ BTU per sq. ft. per hour}$$

And again checking for assumed $t_2$

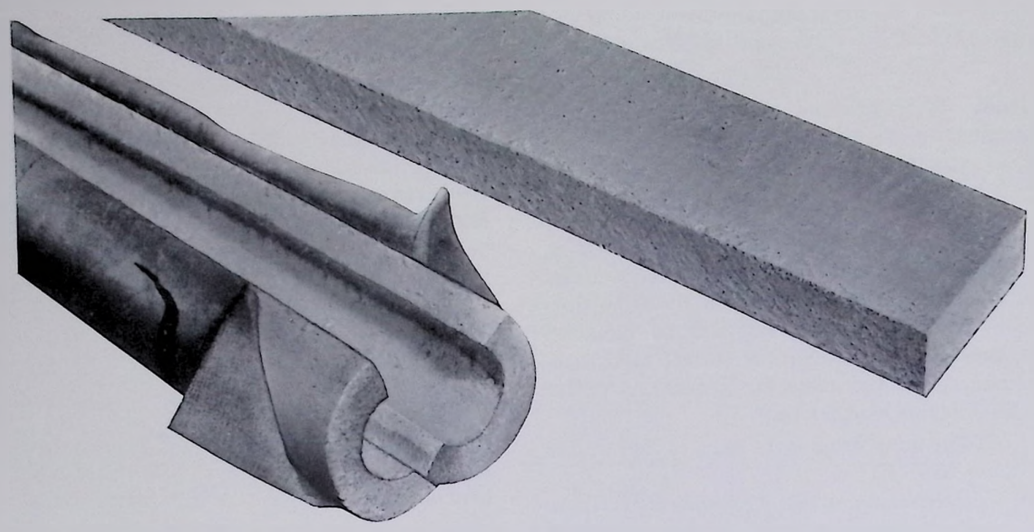
$$t_2 = \frac{272.5 \times 41.6}{41.6 \times 295} \qquad 75 = 108.7° \text{ F.}$$

This checks closely, and hence value for U is approximately correct.

U = 41.6 BTU per sq. ft. per hour.



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# 85% Magnesia Pipe Covering and Block

The Armstrong Cork Company furnishes and installs the 85% Magnesia Pipe Covering and Block and other heat insulation products of the Keasbey and Mattison Company in most of the nation's leading industrial centers.

85% Magnesia insulation is the most widely used material in the heat insulation field for temperatures up to 600° F. This material combines the high insulating properties of basic carbonate of magnesia with the proper amount of clean asbestos fiber as a binding agent, resulting in an insulation that is exceptionally light and highly efficient. It consists of not less than 95% by weight of a mixture of hydrated basic carbonate of magnesia and long fiber asbestos. The magnesia and asbestos mixture is homogeneous and not less than 85% of the total is hydrated basic carbonate of magnesia and not less than 10% is asbestos fiber.

Through many years of dependable service, 85% Magnesia insulation has demonstrated that it is the most efficient and durable molded type heat insulation material manufactured today. In addition to its light weight and high insulating efficiency, it is absolutely fireproof and has the mechanical strength necessary to withstand all ordinary usage to which insulations of this type are subjected. Water has no deteriorating effect on 85% Magnesia. It can become completely water soaked, and when dried out regains its original strength and efficiency characteristics. When properly applied and maintained, it will not crack, crumble, or fail mechanically. 85% Magnesia is manufactured in sectional or segmental forms for application to pipes, and in block form for flat surfaces.

## 85% Magnesia Pipe Insulation

85% Magnesia pipe insulation is manufactured in half sections and in sets of segmental blocks 3 feet long, in the following thicknesses:

Standard, 1½", 2"
Double Standard (supplied in two layers) and
Three Inch Thick (supplied in two layers)

(See table, "85% Magnesia Insulation Thicknesses" on Page 111.)

Half sections of pipe insulation are split horizontally and furnished with factory applied canvas jackets, forming hinge and lap. They are shipped with necessary brass lacquered bands for proper application. Segmental blocks for insulation of piping are supplied without jackets.



### Physical Characteristics of 85% Magnesia Pipe Insulation

(All properties are on the bone dry basis with the exception of Shipping Density)

Shipping Density, lbs./cu. ft., average.....13.3
plus or minus 10%

Thermal Conductivity (k) BTU/hr./sq. ft./(°F./in.), average
Mean Temperature 100° F.....0.36
Mean Temperature 300° F.....0.42

Modulus of Rupture, psi., average.....50.0

Heat Tests (6 hrs. at 500° F.)
% linear shrinkage, average..... 0.2
% loss in weight, average.....14.0

### Minimum Thicknesses for 85% Magnesia Pipe Insulation

| Temperature in degrees F. | Pressure in lbs. per sq. in. | Pipe Sizes | | |
|---|---|---|---|---|
| | | 1½" and smaller | 2" to 4" | 4½" and over |
| Hot Water and Up to 267 | 0–25 | Standard | Standard | Standard |
| 268 to 337 | 26–100 | Standard | Standard | 1½" |
| 338 to 387 | 101–200 | Standard | 1½" | 2" |
| 388 to 499 | Low Superheat | 1½" | 2" | Double Standard |
| 500 to 600 | Superheat | 2" | Double Standard | 3" |

Where the insulation is to be applied on weather-exposed surfaces or extremely long lines, or where it is highly desirable to minimize steam condensation, increase thickness at least ½" greater than those shown in table.

### 85% Magnesia Pipe Insulation Thicknesses

| Nominal Pipe Size Inches | Standard Thickness | 1½" Thick | 2" Thick | Double Standard Thick | | 3" Thick Broken Joint | |
|---|---|---|---|---|---|---|---|
| | Inches | Inches | Inches | 1st Course Inches | 2nd Course Inches | 1st Course Inches | 2nd Course Inches |
| ½ | a 1 | a 1½ | a 2 | a 1 | a 1⅛ | *a 1 | a 2 |
| ¾ | a 1 | a 1½ | a 2 | a 1 | a 1 1/32 | *a 1 | a 2 |
| 1 | a 1 | a 1½ | a 2 | a 1 | a 1 3/16 | a 1½ | a 1½ |
| 1¼ | a 1 | a 1½ | a 2 | a 1 | a 1 1/32 | *a 1 9/16 | a 1½ |
| 1½ | a 1 | a 1½ | a 2 | a 1 | a 1⅛ | a 1½ | a 1½ |
| 2 | a 1 1/32 | a 1½ | a 2 | a 1 1/32 | a 1⅛ | *a 1 9/16 | a 1½ |
| 2½ | a 1 1/32 | a 1½ | a 2 | a 1 1/32 | a 1⅛ | *a 1 5/16 | a 1½ |
| 3 | a 1 1/32 | a 1½ | a 2 | a 1 | a 1⅛ | a 1½ | a 1½ |
| 3½ | a 1 1/32 | a 1½ | a 2 | a 1¼ | a 1⅛ | *a 1 5/16 | a 1½ |
| 4 | a 1⅛ | a 1½ | a 2 | a 1 5/16 | a 1⅛ | a 1½ | a 1½ |
| 4½ | a 1⅛ | a 1½ | a 2 | a 1¼ | a 1¼ | *a 1 5/16 | a 1½ |
| 5 | a 1⅛ | a 1½ | a 2 | a 1 1/32 | a 1¼ | a 1½ | a 1½ |
| 6 | a 1⅛ | a 1½ | a 2 | a 1⅛ | a 1¼ | a 1½ | a 1½ |
| 7 | a 1¼ | a 1½ | a 2 | a 1¼ | a 1¼ | a 1½ | a 1½ |
| 8 | a 1¼ | a 1½ | a 2 | a 1¼ | a 1¼ | a 1½ | b 1½ |
| 9 | a 1¼ | a 1½ | a 2 | a 1¼ | b 1¼ | a 1½ | ab 1½ |
| 10 | a 1¼ | a 1½ | a 2 | a 1¼ | b 1¼ | a 1½ | b 1½ |
| 12 | ab 1½ | ab 1½ | ab 2 | ab 1½ | b 1½ | ab 1½ | b 1½ |
| 14 | b 1½ | b 1½ | b 2 | b 1½ | b 1½ | b 1½ | b 1½ |
| 16 | b 1½ | b 1½ | b 2 | b 1½ | b 1½ | b 1½ | b 1½ |
| 18 | b 1½ | b 1½ | b 2 | b 1½ | b 1½ | b 1½ | b 1½ |
| 20 | b 1½ | b 1½ | b 2 | b 1½ | b 1½ | b 1½ | b 1½ |
| 24 | b 1½ | b 1½ | b 2 | b 1½ | b 1½ | b 1½ | b 1½ |
| 30 | b 1½ | b 1½ | b 2 | | | | |

Sections and Segments (curved block) are thirty-six inches in length.
a—Furnished standard in tubular half sections.
ab—Furnished standard in segments. Can be furnished in tubular half sections when specifically ordered.
b—Furnished standard in segments.
* These Sizes do not run exactly Three Inches of Thickness.



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## Heat Losses from Bare Pipes and Efficiencies of 85% Magnesia Pipe Insulation

| Nominal Pipe Size, inches | Insulation Thickness, inches | | Temperature difference between pipe and surrounding air, °F. 50° | 100° | 150° | 200° | 250° | 300° | 350° | 400° | 450° | 500° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Temperature of pipe, °F. (Temperature of surrounding air, 75° F.) 125° | 175° | 225° | 275° | 325° | 375° | 425° | 475° | 525° | 575° |
| | | | Heat Losses per linear foot of bare pipe per hour and Efficiencies of insulation | | | | | | | | | |
| 1 | 0 | Bare pipe loss, B.t.u.... | 33.6 | 74.0 | 123.8 | 183.4 | 253.7 | 337.4 | 436.5 | 555.2 | 690.6 | 846.2 |
| | Std. | Efficiency %..... | 69.89 | 72.18 | 74.60 | 76.63 | 78.44 | 80.11 | 81.77 | 83.28 | 84.58 | 85.73 |
| | 1½ | " %..... | 75.88 | 77.84 | 79.78 | 81.48 | 82.99 | 84.37 | 85.73 | 86.96 | 88.02 | 88.94 |
| | Dbl. Std. | " %..... | 77.44 | 79.21 | 81.07 | 82.68 | 84.10 | 85.39 | 86.64 | 87.79 | 88.80 | 89.68 |
| | 2 | " %..... | 78.69 | 80.33 | 82.09 | 83.58 | 85.92 | 86.16 | 87.36 | 88.47 | 89.41 | 90.24 |
| | 3 | " %..... | 82.00 | 83.39 | 84.88 | 86.18 | 87.33 | 88.34 | 89.38 | 90.28 | 91.08 | 92.68 |
| 1½ | 0 | Bare pipe loss, B.t.u.... | 48.7 | 107.2 | 179.3 | 265.4 | 367.3 | 487.0 | 631.8 | 803.8 | 999.7 | 1225.1 |
| | Std. | Efficiency %..... | 73.18 | 75.25 | 77.33 | 79.29 | 80.88 | 82.36 | 83.80 | 85.16 | 86.35 | 87.46 |
| | 1½ | " %..... | 79.38 | 81.01 | 82.67 | 84.16 | 85.46 | 86.59 | 87.75 | 88.75 | 89.69 | 90.46 |
| | Dbl. Std. | " %..... | 80.74 | 82.31 | 83.88 | 85.28 | 86.50 | 87.57 | 88.63 | 89.63 | 90.46 | 91.18 |
| | 2 | " %..... | 81.91 | 83.35 | 84.84 | 86.14 | 87.29 | 86.30 | 89.33 | 90.23 | 91.02 | 91.74 |
| | 3 | " %..... | 84.97 | 86.23 | 88.44 | 88.57 | 89.51 | 90.36 | 91.18 | 91.94 | 92.62 | 93.17 |
| 2 | 0 | Bare pipe loss, B.t.u.... | 60.9 | 133.9 | 223.9 | 331.5 | 458.7 | 608.3 | 789.2 | 1003.9 | 1248.6 | 1530.1 |
| | Std. | Efficiency %..... | 77.14 | 79.93 | 80.65 | 82.22 | 83.62 | 84.88 | 86.12 | 87.26 | 88.46 | 89.33 |
| | 1½ | " %..... | 80.92 | 82.45 | 83.98 | 85.34 | 86.53 | 87.58 | 88.66 | 89.63 | 90.44 | 91.18 |
| | 2 | " %..... | 83.62 | 84.88 | 86.24 | 87.40 | 88.44 | 89.38 | 90.28 | 91.09 | 91.83 | 92.46 |
| | Dbl. Std. | " %..... | 83.75 | 85.10 | 86.38 | 87.58 | 88.60 | 89.50 | 90.39 | 91.18 | 91.93 | 92.54 |
| | 3 | " %..... | 86.51 | 87.60 | 88.70 | 89.69 | 90.55 | 91.31 | 92.05 | 92.74 | 93.32 | 93.86 |
| 2½ | 0 | Bare pipe loss, B.t.u.... | 73.4 | 161.6 | 270.4 | 400.3 | 553.9 | 734.5 | 952.8 | 1212.1 | 1511.6 | 1852.4 |
| | Std. | Efficiency %..... | 78.23 | 79.93 | 81.64 | 83.17 | 84.48 | 85.64 | 86.85 | 87.94 | 88.88 | 89.73 |
| | 1½ | " %..... | 82.23 | 83.62 | 85.03 | 86.27 | 88.40 | 88.89 | 89.38 | 90.19 | 91.06 | 91.74 |
| | 2 | " %..... | 84.71 | 85.96 | 87.17 | 88.29 | 89.24 | 90.10 | 90.96 | 91.72 | 92.39 | 92.98 |
| | Dbl. Std. | " %..... | 84.91 | 86.14 | 87.33 | 88.43 | 89.38 | 90.20 | 91.06 | 91.81 | 92.48 | 93.07 |
| | 3 | " %..... | 87.58 | 88.65 | 89.65 | 90.55 | 91.34 | 92.03 | 92.72 | 93.34 | 93.87 | 94.35 |
| 3 | 0 | Bare pipe loss, B.t.u.... | 89.6 | 197.3 | 330.1 | 488.8 | 676.3 | 898.8 | 1163.4 | 1480.0 | 1840.8 | 2255.8 |
| | Std. | Efficiency %..... | 79.27 | 80.92 | 82.48 | 83.90 | 85.19 | 86.32 | 87.46 | 88.48 | 89.38 | 90.19 |
| | 1½ | " %..... | 83.14 | 84.52 | 85.82 | 87.04 | 88.07 | 89.02 | 89.96 | 90.82 | 91.54 | 92.30 |
| | 2 | " %..... | 85.69 | 86.77 | 87.96 | 89.20 | 89.88 | 90.18 | 91.49 | 91.31 | 92.86 | 93.42 |
| | Dbl. Std. | " %..... | 85.96 | 87.08 | 88.22 | 89.23 | 90.00 | 90.88 | 91.66 | 92.35 | 92.96 | 93.52 |
| | 3 | " %..... | 88.59 | 89.51 | 90.43 | 91.27 | 91.94 | 92.62 | 93.22 | 93.79 | 94.27 | 94.52 |
| 3½ | 0 | Bare pipe loss, B.t.u.... | 102.3 | 225.3 | 376.9 | 558.1 | 772.2 | 1024.0 | 1328.4 | 1689.9 | 2101.8 | 2575.6 |
| | Std. | Efficiency %..... | 79.85 | 81.46 | 83.01 | 84.47 | 85.60 | 86.68 | 87.84 | 88.84 | 89.74 | 90.54 |
| | 1½ | " %..... | 83.84 | 85.15 | 86.38 | 87.53 | 88.53 | 89.46 | 90.34 | 91.13 | 91.79 | 92.48 |
| | 2 | " %..... | 86.28 | 87.40 | 88.48 | 89.47 | 90.33 | 91.13 | 91.86 | 92.56 | 93.17 | 93.70 |
| | Dbl. Std. | " %..... | 86.74 | 87.80 | 88.85 | 89.78 | 90.60 | 91.36 | 92.08 | 92.76 | 93.34 | 93.86 |
| | 3 | " %..... | 89.15 | 89.92 | 90.89 | 91.66 | 92.26 | 92.93 | 93.52 | 94.07 | 94.55 | 94.96 |
| 4 | 0 | Bare pipe loss, B.t.u.... | 115.1 | 253.5 | 424.2 | 627.9 | 868.8 | 1152.1 | 1494.6 | 1901.3 | 2364.8 | 2897.9 |
| | Std. | Efficiency %..... | 81.37 | 82.81 | 84.25 | 85.55 | 86.68 | 87.67 | 88.67 | 89.63 | 90.41 | 91.13 |
| | 1½ | " %..... | 84.29 | 85.51 | 86.80 | 87.89 | 88.87 | 89.74 | 90.62 | 91.40 | 92.07 | 92.70 |
| | 2 | " %..... | 86.74 | 87.85 | 88.88 | 89.84 | 90.70 | 91.45 | 92.16 | 92.82 | 93.40 | 93.92 |
| | Dbl. Std. | " %..... | 87.80 | 88.75 | 89.72 | 90.55 | 91.34 | 92.03 | 92.68 | 93.29 | 93.84 | 94.28 |
| | 3 | " %..... | 89.56 | 90.41 | 91.16 | 92.03 | 92.68 | 93.25 | 93.82 | 94.34 | 94.79 | 95.18 |
| 4½ | 0 | Bare pipe loss, B.t.u.... | 127.9 | 281.5 | 470.9 | 697.2 | 964.7 | 1279.2 | 1659.5 | 2111.1 | 2627.8 | 3220.1 |
| | Std. | Efficiency %..... | 81.91 | 83.26 | 84.73 | 85.96 | 87.08 | 88.03 | 89.05 | 89.93 | 90.72 | 91.45 |
| | 1½ | " %..... | 84.68 | 85.87 | 87.08 | 88.20 | 89.11 | 89.96 | 90.82 | 91.59 | 92.27 | 92.86 |
| | 2 | " %..... | 87.12 | 88.16 | 89.20 | 90.14 | 90.94 | 91.67 | 92.38 | 93.02 | 93.59 | 94.10 |
| | Dbl. Std. | " %..... | 87.94 | 88.93 | 89.87 | 90.73 | 91.49 | 92.29 | 92.92 | 93.45 | 93.97 | 94.44 |
| | 3 | " %..... | 89.88 | 90.72 | 91.53 | 92.26 | 92.89 | 93.47 | 94.04 | 94.55 | 94.97 | 95.36 |



| Nominal Pipe Size, inches | Insulation Thickness, inches | | Temperature difference between pipe and surrounding air, °F. 50° | 100° | 150° | 200° | 250° | 300° | 350° | 400° | 450° | 500° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Temperature of pipe, °F. (Temperature of surrounding air, 75° F.) 125° | 175° | 225° | 275° | 325° | 375° | 425° | 475° | 525° | 575° |
| | | | Heat Losses per linear foot of bare pipe per hour and Efficiencies of insulation | | | | | | | | | |
| 5 | 0 | Bare pipe loss, B.t.u.... | 142.2 | 313.1 | 523.8 | 755.5 | 1073.0 | 1423.0 | 1846.0 | 2348.4 | 2922.9 | 3581.8 |
| | Std. | Efficiency %..... | 82.04 | 83.44 | 84.84 | 86.12 | 87.22 | 88.21 | 89.18 | 90.10 | 90.85 | 91.54 |
| | 1½ | " %..... | 85.04 | 86.23 | 87.40 | 88.43 | 89.38 | 90.20 | 91.04 | 91.80 | 92.45 | 93.02 |
| | 2 | " %..... | 87.44 | 88.48 | 89.46 | 90.37 | 91.16 | 91.90 | 92.57 | 93.20 | 93.75 | 94.24 |
| | Dbl. Std. | " %..... | 88.46 | 89.38 | 90.32 | 91.17 | 91.85 | 92.53 | 93.15 | 93.73 | 94.21 | 94.65 |
| | 3 | " %..... | 90.25 | 91.04 | 91.85 | 92.75 | 93.16 | 93.74 | 94.26 | 94.74 | 95.15 | 95.54 |
| 6 | 0 | Bare pipe loss, B.t.u.... | 169.4 | 371.9 | 623.9 | 923.7 | 1278.1 | 1694.9 | 2198.7 | 2797.1 | 3480.9 | 4265.6 |
| | Std. | Efficiency %..... | 82.58 | 83.96 | 85.31 | 86.50 | 87.58 | 88.57 | 89.78 | 90.37 | 91.15 | 91.68 |
| | 1½ | " %..... | 85.46 | 86.59 | 87.76 | 88.84 | 89.73 | 90.50 | 91.64 | 92.03 | 92.60 | 93.24 |
| | 2 | " %..... | 87.98 | 88.96 | 89.94 | 90.82 | 91.54 | 92.23 | 92.07 | 92.99 | 94.00 | 94.48 |
| | Dbl. Std. | " %..... | 88.97 | 89.83 | 90.74 | 91.54 | 92.19 | 92.81 | 93.45 | 93.98 | 94.47 | 94.90 |
| | 3 | " %..... | 90.72 | 91.45 | 92.23 | 92.89 | 93.47 | 94.01 | 94.56 | 95.00 | 95.40 | 95.77 |
| 7 | 0 | Bare pipe loss, B.t.u.... | 195.0 | 430.4 | 720.0 | 1066.0 | 1475.6 | 1956.0 | 2539.0 | 3228.0 | 4006.9 | 4910.2 |
| | Std. | Efficiency %..... | 84.29 | 85.48 | 86.72 | 87.80 | 88.75 | 89.61 | 90.46 | 91.12 | 91.91 | 92.53 |
| | 1½ | " %..... | 85.72 | 86.95 | 88.07 | 89.10 | 89.96 | 90.77 | 91.55 | 92.26 | 92.89 | 93.43 |
| | 2 | " %..... | 88.31 | 89.24 | 90.21 | 91.04 | 91.76 | 92.44 | 93.07 | 93.67 | 94.18 | 94.63 |
| | Dbl. Std. | " %..... | 89.92 | 90.73 | 91.55 | 92.30 | 92.92 | 93.47 | 94.04 | 94.55 | 94.97 | 95.36 |
| | 3 | " %..... | 91.08 | 91.80 | 92.53 | 93.17 | 93.75 | 94.24 | 94.74 | 95.19 | 95.58 | 95.92 |
| 8 | 0 | Bare pipe loss, B.t.u.... | 220.6 | 485.7 | 812.5 | 1203.0 | 1664.5 | 2207.3 | 2863.6 | 3642.8 | 4530.8 | 5552.2 |
| | Std. | Efficiency %..... | 84.38 | 85.60 | 86.83 | 87.94 | 88.89 | 89.74 | 90.59 | 91.36 | 92.05 | 92.65 |
| | 1½ | " %..... | 86.18 | 87.28 | 88.37 | 89.38 | 90.21 | 91.00 | 91.76 | 92.47 | 93.08 | 93.65 |
| | 2 | " %..... | 88.64 | 89.55 | 90.45 | 91.28 | 92.00 | 92.65 | 93.26 | 93.84 | 94.35 | 94.78 |
| | Dbl. Std. | " %..... | 90.20 | 91.00 | 91.78 | 92.49 | 93.10 | 93.67 | 94.21 | 94.70 | 95.12 | 95.50 |
| | 3 | " %..... | 91.36 | 92.04 | 92.75 | 93.38 | 93.93 | 94.42 | 94.91 | 95.35 | 95.72 | 96.07 |
| 9 | 0 | Bare pipe loss, B.t.u.... | 246.0 | 542.0 | 907.0 | 1343.0 | 1860.0 | 2465.0 | 3200.0 | 4070.0 | 5056.8 | 6196.7 |
| | Std. | Efficiency %..... | 84.61 | 85.82 | 87.02 | 88.12 | 89.27 | 89.91 | 90.74 | 91.49 | 92.17 | 92.77 |
| | 1½ | " %..... | 86.33 | 87.40 | 88.52 | 89.47 | 90.33 | 91.13 | 91.86 | 92.53 | 93.12 | 93.65 |
| | 2 | " %..... | 88.73 | 89.65 | 90.58 | 91.43 | 92.13 | 92.84 | 93.37 | 93.93 | 94.43 | 94.87 |
| | Dbl. Std. | " %..... | 91.44 | 91.22 | 92.01 | 92.71 | 93.29 | 93.83 | 94.36 | 94.82 | 95.23 | 95.60 |
| | 3 | " %..... | 91.54 | 92.26 | 92.94 | 93.57 | 94.11 | 94.59 | 95.06 | 95.49 | 95.84 | 96.17 |
| 10 | 0 | Bare pipe loss, B.t.u.... | 275.4 | 606.2 | 1014.1 | 1501.5 | 2077.5 | 2775.0 | 3574.1 | 4546.6 | 5655.0 | 6929.8 |
| | Std. | Efficiency %..... | 84.75 | 85.96 | 87.13 | 88.21 | 89.14 | 90.01 | 90.83 | 91.59 | 92.26 | 92.84 |
| | 1½ | " %..... | 86.60 | 87.67 | 88.75 | 89.69 | 90.51 | 91.27 | 92.00 | 92.70 | 93.28 | 93.79 |
| | 2 | " %..... | 88.97 | 89.87 | 90.77 | 91.58 | 93.29 | 92.89 | 93.52 | 94.07 | 94.55 | 95.00 |
| | Dbl. Std. | " %..... | 90.63 | 91.51 | 92.17 | 92.84 | 93.44 | 93.97 | 94.49 | 94.96 | 95.37 | 95.73 |
| | 3 | " %..... | 91.72 | 92.60 | 93.10 | 93.71 | 94.24 | 94.72 | 95.18 | 95.54 | 95.95 | 96.26 |
| 12 | 0 | Bare pipe loss, B.t.u.... | 326.0 | 719.0 | 1203.0 | 1780.0 | 2465.0 | 3266.0 | 4235.0 | 5390.0 | 6700.9 | 8211.5 |
| | Std. | Efficiency %..... | 86.84 | 87.86 | 88.93 | 89.84 | 90.70 | 91.45 | 92.17 | 92.84 | 93.43 | 93.94 |
| | 2 | " %..... | 89.24 | 90.10 | 91.00 | 91.81 | 92.47 | 93.09 | 93.70 | 94.24 | 94.69 | 95.11 |
| | Dbl. Std. | " %..... | 91.92 | 92.59 | 93.28 | 93.88 | 94.38 | 94.87 | 95.31 | 95.71 | 96.04 | 96.35 |
| 14 | 0 | Bare pipe loss, B.t.u.... | 377.0 | 786.0 | 1318.0 | 1950.0 | 2700.0 | 3580.0 | 4645.0 | 5905.0 | 7353.3 | 9011.1 |
| | Std. | Efficiency %..... | 86.93 | 88.03 | 89.05 | 90.02 | 90.82 | 91.58 | 92.26 | 92.93 | 93.48 | 94.01 |
| | 2 | " %..... | 89.33 | 90.19 | 91.40 | 91.90 | 92.56 | 93.18 | 93.77 | 94.33 | 94.79 | 95.20 |
| | Dbl. Std. | " %..... | 92.06 | 92.71 | 93.40 | 93.99 | 94.48 | 94.96 | 95.38 | 95.80 | 96.14 | 96.47 |
| 16 | 0 | Bare pipe loss, B.t.u.... | 408.0 | 901.0 | 1510.0 | 2237.0 | 3095.0 | 4100.0 | 5320.0 | 6765.0 | 8407.2 | 10302 |
| | Std. | Efficiency %..... | 87.07 | 88.12 | 89.15 | 90.10 | 90.91 | 91.63 | 92.35 | 93.00 | 93.57 | 94.08 |
| | 2 | " %..... | 89.56 | 90.41 | 91.67 | 92.00 | 92.74 | 93.34 | 93.91 | 94.46 | 94.92 | 95.32 |
| | Dbl. Std. | " %..... | 92.24 | 92.89 | 93.55 | 94.13 | 94.63 | 95.09 | 95.50 | 95.90 | 96.25 | 96.54 |



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## Packaging Data–85% Magnesia Pipe Insulation Carton Contents

| Nominal Pipe Size Inches | Nominal Weight Per Section Lbs. | Sections Per Carton | Carton No. | Nominal Net Weight Per Carton Lbs. | Nominal Gross Weight Per Carton Lbs. |
|---|---|---|---|---|---|
| **Table 1.–Standard Thick** | | | | | |
| ½ | 1.39 | 48 | 256 | 67 | 73 |
| ¾ | 1.58 | 45 | 120 | 71 | 77 |
| 1 | 1.78 | 40 | 120 | 71 | 77 |
| 1¼ | 2.07 | 32 | 120 | 66 | 72 |
| 1½ | 2.21 | 28 | 120 | 62 | 68 |
| 2 | 3.20 | 18 | 120 | 58 | 64 |
| 2½ | 3.66 | 15 | 120 | 55 | 61 |
| 3 | 4.23 | 15 | 258 | 63 | 70 |
| 3½ | 4.68 | 9 | 120 | 42 | 48 |
| 4 | 5.69 | 8 | 120 | 46 | 52 |
| 4½ | 6.19 | 8 | 258 | 50 | 57 |
| 5 | 6.75 | 6 | 120 | 41 | 47 |
| 6 | 7.87 | 4 | 202 | 32 | 38 |
| 7 | 10.02 | 4 | 259 | 40 | 47 |
| 8 | 11.08 | 2 | 248 | 22 | 27 |
| 9 | 12.32 | 2 | 256 | 25 | 31 |
| 10 | 13.43 | 2 | 120 | 27 | 33 |
| **Table 2.–1½ Inch Thick** | | | | | |
| ½ | 3.18 | 21 | 256 | 67 | 73 |
| ¾ | 3.50 | 18 | 256 | 63 | 69 |
| 1 | 3.84 | 18 | 120 | 69 | 75 |
| 1¼ | 4.34 | 16 | 120 | 69 | 75 |
| 1½ | 4.58 | 15 | 120 | 69 | 75 |
| 2 | 5.24 | 12 | 120 | 63 | 69 |
| 2½ | 5.91 | 9 | 120 | 53 | 59 |
| 3 | 6.72 | 8 | 120 | 54 | 60 |
| 3½ | 7.38 | 8 | 120 | 59 | 65 |
| 4 | 8.04 | 7 | 258 | 56 | 63 |
| 4½ | 8.70 | 6 | 120 | 52 | 58 |
| 5 | 9.45 | 4 | 202 | 38 | 44 |
| 6 | 10.94 | 4 | 259 | 44 | 51 |
| 7 | 12.26 | 4 | 260 | 49 | 57 |
| 8 | 13.59 | 2 | 248 | 27 | 32 |
| 9 | 15.08 | 2 | 256 | 30 | 36 |
| 10 | 16.39 | 2 | 257 | 33 | 39 |
| **Table 3.–2 Inch Thick** | | | | | |
| ½ | 5.10 | 10 | 248 | 51 | 56 |
| ¾ | 5.54 | 10 | 248 | 55 | 60 |
| 1 | 5.98 | 12 | 120 | 72 | 78 |
| 1¼ | 6.62 | 8 | 248 | 53 | 58 |
| 1½ | 6.97 | 9 | 120 | 63 | 69 |
| 2 | 7.85 | 8 | 120 | 63 | 69 |
| 2½ | 8.71 | 7 | 120 | 61 | 67 |
| 3 | 9.81 | 6 | 257 | 59 | 65 |
| 3½ | 10.69 | 6 | 120 | 64 | 70 |
| 4 | 11.57 | 4 | 202 | 46 | 52 |
| 4½ | 12.43 | 4 | 202 | 50 | 56 |
| 5 | 13.44 | 4 | 259 | 54 | 61 |
| 6 | 15.41 | 4 | 260 | 62 | 70 |
| 7 | 17.17 | 2 | 248 | 34 | 39 |
| 8 | 18.93 | 2 | 256 | 38 | 44 |
| 9 | 20.88 | 2 | 257 | 42 | 48 |
| 10 | 22.63 | 2 | 258 | 45 | 52 |



| Nominal Pipe Size Inches | Nominal Weight Per Section Lbs. | Sections Per Carton | Carton No. | Nominal Net Weight Per Carton Lbs. | Nominal Gross Weight Per Carton Lbs. |
|---|---|---|---|---|---|
| **Table 4.–Double Standard Thick** | | | | | |
| ½ | 5.22 | 12 | 256 | 63 | 69 |
| ¾ | 5.18 | 12 | 256 | 62 | 68 |
| 1 | 6.40 | 9 | 256 | 58 | 64 |
| 1¼ | 6.22 | 9 | 256 | 56 | 62 |
| 1½ | 7.14 | 9 | 120 | 64 | 70 |
| 2 | 8.78 | 8 | 120 | 70 | 76 |
| 2½ | 9.74 | 7 | 120 | 68 | 74 |
| 3 | 10.70 | 6 | 120 | 64 | 70 |
| 3½ | 13.82 | 4 | 258 | 55 | 62 |
| 4 | 13.05 | 4 | 258 | 52 | 59 |
| 4½ | 17.02 | 4 | 202 | 68 | 74 |
| 5 | 15.93 | 4 | 202 | 64 | 70 |
| 6 | 19.19 | 2 | 248 | 38 | 43 |
| 7 | 22.62 | 2 | 256 | 45 | 51 |
| 8 | 24.80 | 2 | 257 | 50 | 56 |

## Key Table to Carton Sizes

| Carton No. | Inside Dimensions Inches | Outside Dimensions Inches | Tare Wt. Lbs. |
|---|---|---|---|
| 248 | 11¾ x 23¾ x 36 | 12¼ x 24¼ x 36½ | 5 |
| 256 | 13 x 26 x 36 | 13½ x 26½ x 36½ | 6 |
| 257 | 14 x 28 x 36 | 14½ x 28½ x 36½ | 6 |
| 120 | 14½ x 27¼ x 36 | 15 x 27¾ x 36½ | 6 |
| 258 | 15 x 30½ x 36 | 15½ x 31 x 36½ | 7 |
| 202 | 18 x 18 x 36 | 18½ x 18½ x 36½ | 6 |
| 259 | 20¾ x 20¾ x 36 | 21¼ x 21¼ x 36½ | 7 |
| 260 | 22 x 22 x 36 | 22½ x 22½ x 36½ | 8 |

## 85% Magnesia Blocks and Lagging

85% Magnesia Blocks and Lagging are light, efficient insulating materials for flat, curved, and irregular surfaces such as boilers, breechings, oil stills, tanks, and other heated equipment, where the temperature does not exceed 600° F. Where temperatures are in excess of 600° F., 85% Magnesia should be used in combination with Hy-Temp Blocks.

85% Magnesia Blocks are furnished in standard 36″ lengths in 3″, 6″, 9″, and 12″ widths. Thicknesses range from 1″ to 4″ inclusive.

### Physical Characteristics of 85% Magnesia Blocks and Lagging

(All properties are on the bone dry basis with exception of shipping density)

Shipping Density, lbs./cu. ft., average.....12.2 plus or minus 10%

Thermal Conductivity (k) BTU/hr./sq. ft. (°F./in.), average
- Mean Temperature 100° F..... 0.36
- Mean Temperature 300° F..... 0.42

Modulus of Rupture, psi., average.....50.0

Heat Tests–6 hrs. at 500° F.
- % linear shrinkage, average..... 0.2
- % loss in weight, average.....14.0

### Recommended Minimum Thicknesses

| Temperature °F. | 85% Magnesia Blocks Thickness—inches |
|---|---|
| Hot Water | 1″ |
| 212° to 266° | 1½″ |
| 267° to 337° | 2″ |
| 338° to 387° | 2½″ |
| 388° to 499° | 3″ |
| 500° to 600° | 3½″ |

NOTE: No thickness recommendation can apply to all conditions. These recommendations have been found to be satisfactory and economical for most cases.



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## Heat Losses and Efficiencies of 85% Magnesia Blocks and Lagging

| Thickness of Insulation, inches | | Temperature* Difference between Hot Surface and Surrounding Air: 50°F | 100°F | 150°F | 200°F | 250°F | 300°F | 350°F | 400°F | 450°F | 500°F |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Temperature of Hot Surface: 125°F | 175°F | 225°F | 275°F | 325°F | 375°F | 425°F | 475°F | 525°F | 575°F |
| 0 | Bare Surface Loss —B.T.U. | Heat losses per Sq. Ft. Bare Surfaces per Hour in B.T.U.: 97.5 | 215.2 | 360.0 | 533.0 | 738.8 | 978.0 | 1269.4 | 1614.0 | 2007.5 | 2460.0 |
| 1 | Efficiency % | 79.2 | 81.0 | 82.8 | 84.4 | 85.8 | 87.0 | 88.2 | 89.3 | 90.2 | 91.0 |
| 1½ | " % | 86.2 | 87.3 | 88.6 | 89.6 | 90.5 | 91.3 | 92.1 | 92.8 | 93.5 | 94.0 |
| 2 | " % | 89.5 | 90.5 | 91.4 | 92.2 | 92.9 | 93.5 | 94.1 | 94.6 | 95.1 | 95.5 |
| 2½ | " % | 91.7 | 92.7 | 93.1 | 93.7 | 94.3 | 94.8 | 95.3 | 95.7 | 96.1 | 96.4 |
| 3 | " % | 93.0 | 93.7 | 94.3 | 94.8 | 95.2 | 95.7 | 96.1 | 96.4 | 96.7 | 97.1 |
| 3½ | " % | 94.1 | 94.6 | 95.1 | 95.5 | 95.9 | 96.3 | 96.6 | 96.9 | 97.2 | 97.5 |
| 4 | " % | 94.8 | 95.3 | 95.7 | 96.1 | 96.4 | 96.7 | 97.0 | 97.3 | 97.5 | 97.7 |

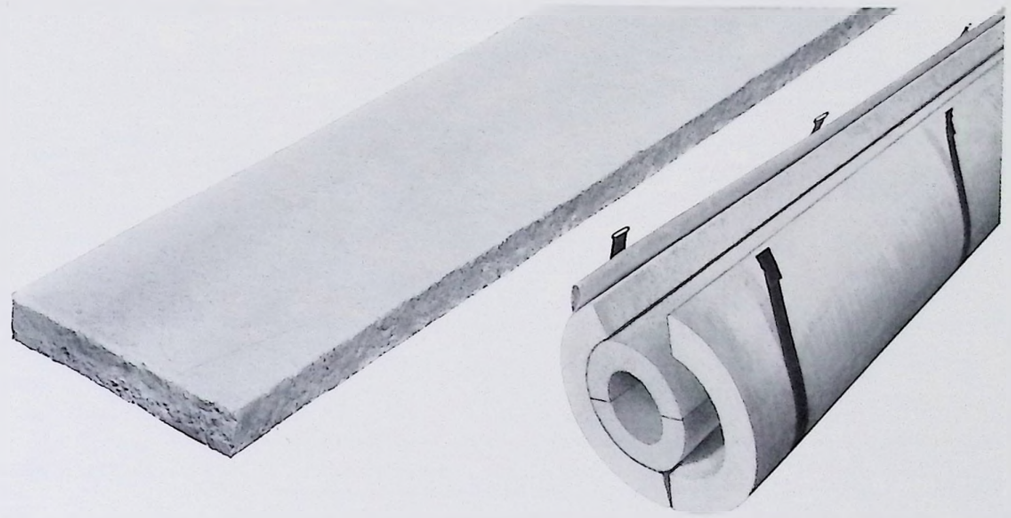
* Temperature of surrounding air taken as 75°F.

## Packaging Information—85% Magnesia Blocks

| Dimensions of Blocks | Weight per Block, lbs. | Carton or Crate No. | Blocks per Carton or Crate | Gross Wt. per Carton or Crate |
|---|---|---|---|---|
| 1" x 3" x 36" | 0.76 | 114 | 72 | 60 |
| 1¼" x 3" x 36" | 0.95 | 114 | 58 | 60 |
| 1½" x 3" x 36" | 1.14 | 114 | 48 | 60 |
| 1¾" x 3" x 36" | 1.33 | 114 | 42 | 61 |
| 2" x 3" 36" | 1.53 | 114 | 36 | 60 |
| 2¼" x 3" x 36" | 1.72 | 114 | 32 | 60 |
| 2½" x 3" x 36" | 1.91 | 114 | 30 | 62 |
| 3" x 3" x 36" | 2.29 | 114 | 24 | 60 |
| 3½" x 3" x 36" | 2.67 | | | |
| 4" x 3" x 36" | 3.05 | 114 | 18 | 60 |
| 1" x 6" x 36" | 1.52 | 114 | 36 | 60 |
| 1¼" x 6" x 36" | 1.90 | 114 | 29 | 60 |
| 1½" x 6" x 36" | 2.29 | 114 | 24 | 60 |
| 1¾" x 6" x 36" | 2.67 | 114 | 21 | 61 |
| 2" x 6" x 36" | 3.05 | 114 | 18 | 60 |
| 2¼" x 6" x 36" | 3.43 | 114 | 16 | 60 |
| 2½" x 6" x 36" | 3.81 | 114 | 15 | 62 |
| 3" x 6" x 36" | 4.57 | 114 | 12 | 60 |
| 3½" x 6" x 36" | 5.33 | crate | 28 | 174 |
| 4" x 6" x 36" | 6.10 | 114 | 9 | 60 |
| 1" x 12" x 36" | 3.05 | 114 | 18 | 60 |
| 1¼" x 12" x 36" | 3.81 | 114 | 14 | 58 |
| 1½" x 12" x 36" | 4.57 | 114 | 12 | 60 |
| 1¾" x 12" x 36" | 5.33 | 114 | 10 | 58 |
| 2" x 12" x 36" | 6.10 | 114 | 9 | 60 |
| 2¼" x 12" x 36" | 6.86 | 114 | 8 | 60 |
| 2½" x 12" x 36" | 7.62 | 114 | 7 | 58 |
| 3" x 12" x 36" | 9.14 | 114 | 6 | 60 |
| 3½" x 12" x 36" | 10.67 | crate | 14 | 174 |
| 4" x 12" x 36" | 12.19 | crate | 12 | 171 |

Crate—I.D. 24" x 24½" x 36½"—Tare Weight 25 lbs.
Carton No. 114—I.D. 12½" x 18⅞" x 36"—O.D. 13" x 19⅜" x 36½"—Tare Weight 5 lbs.





# Hy-Temp Pipe Covering and Block

Hy-temp insulation is recommended for heated lines and surfaces where temperatures range from above 600° F. to 1900° F. This material is made from calcined diatomaceous earth, asbestos fiber, magnesia carbonate, and binders.

Hy-temp insulation is generally used as an inner layer in combination with an outer layer of 85% Magnesia. The inner layer of Hy-Temp is used in a thickness sufficient to reduce the temperature at the 85% Magnesia to within safe limits for that product. Because hy-temp insulation will withstand higher temperatures than 85% Magnesia, but is not so efficient an insulator as 85% Magnesia, a combination of the two materials utilizes the high heat resistance of the high temperature insulation and the greater efficiency of 85% Magnesia to best advantage. Hy-temp insulation possesses sufficient strength so that it can be handled without breakage.

### Physical Characteristics of Hy-Temp Pipe and Block Insulation

(All properties on bone dry basis with exception of shipping density)

Shipping Density, lbs./cu. ft., average.... 23.6
plus or minus 10%

Thermal Conductivity (k),
BTU/hr./sq. ft./(°F./in.) average
Mean Temperature 550° F..... 0.72
Mean Temperature 800° F..... 0.80

Modulus of Rupture, psi, average..... 70

Heat Tests (6 hours at 1500° F.)
% linear shrinkage..... 1.0
% loss in weight..... 9.0

### Hy-Temp Pipe Insulation

Hy-Temp Pipe Insulation is furnished in tubular half sections and sets of curved segmental blocks 3 ft. in length and in thicknesses from 1" to 3". Half sections are furnished for pipe sizes of 10" and smaller. Insulation for pipe sizes larger than 10" in single layer or inner layer only of double standard thick or 3" thick broken joint construction is furnished in segments. The 12" size can be furnished in sectional covering 1 9/16" and 2⅛" thick on specific order.

In most applications Hy-Temp Pipe Insulation is wired on as an inner layer, in combination with an outer layer of 85% Magnesia. It is furnished without canvas jacket and bands.



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## Recommended Minimum Thicknesses of Combination Hy-Temp and 85% Magnesia Pipe Insulation—Indoor Piping

| Temperature | 600°—699° F. | | 700°—799° F. | | 800°—1000° F. | |
|---|---|---|---|---|---|---|
| Nominal Pipe Sizes, inches | Thickness of Insulation—Inches | | | | | |
| | Hy-Temp | 85% Magnesia | Hy-Temp | 85% Magnesia | Hy-Temp | 85% Magnesia |
| *1½ & smaller | Single layer only of Hy-Temp, 2" thick | | | | | |
| 2 | 1¼ | 1½ | 1¼ | 2 | 1 9/16 | 1½ |
| 2½ | 1 5/16 | 1½ | 1 5/16 | 2 | 1 5/16 | 1½ |
| 3 | 1 9/16 | 1½ | 1 9/16 | 2 | 2 1/16 | 1½ |
| 3½ | 1 5/16 | 1½ | 1 5/16 | 2 | 1 5/16 | 1½ |
| 4 | 1 9/16 | 1½ | 1 9/16 | 2 | 2 1/16 | 1½ |
| 4½ | 1 5/16 | 1½ | 1 5/16 | 2 | 1 5/16 | 2 |
| 5 & larger | 1½ | 1½ | 1½ | 2 | 2 | 2 |

*All insulation on pipes 1½" and smaller shall be single layer of Hy-Temp Pipe Insulation.

Where insulation is to be applied on weather-exposed surfaces or extremely long lines, or where it is desirable to minimize loss of superheat, increase thickness at least ½" greater than those shown in table.

## Heat Losses from Bare Pipes and Efficiencies of Hy-Temp Combination Pipe Insulation

(Hy-Temp Insulation with "Featherweight" 85% Magnesia as outer layer)

| Nominal Pipe Size, inches | Thickness Hy-Temp Insulation, inches | Pipe Size of 85% Magnesia, inches | Thickness of 85% Magnesia, inches | Total Thickness of Combination Insulation, inches | | Temperature Difference between pipe and surrounding air, Deg. F. 425° 525° 625° 725° / Temperature of Pipe, Deg. F. 500° 600° 700° 800° (Surrounding air temperature 75° F.) Heat losses per linear foot of bare pipe per hour and Efficiencies of insulation | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1½ | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 395.3 | 593.3 | 837.5 | 1123.8 |
| | 1½ | (no outer layer) | | 1½ | Efficiency % | 81.05 | 84.00 | 86.15 | 87.72 |
| | 2 | (no outer layer) | | 2 | Efficiency % | 82.96 | 85.66 | 87.60 | 89.02 |
| 2 | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 497.3 | 745.5 | 1043.8 | 1406.5 |
| | 1½ | (no outer layer) | | 1½ | Efficiency % | 83.09 | 85.66 | 87.55 | 88.94 |
| | 2 | (no outer layer) | | 2 | Efficiency % | 84.95 | 87.30 | 89.00 | 90.22 |
| 1 | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 620.5 | 929.3 | 1306.3 | 1754.5 |
| | 1½ | (no outer layer) | | 1½ | Efficiency % | 84.75 | 87.09 | 88.80 | 90.06 |
| | 2 | (no outer layer) | | 2 | Efficiency % | 86.55 | 88.68 | 90.20 | 91.34 |
| 1¼ | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 786.3 | 1176.0 | 1656.3 | 2218.5 |
| | 1½ | (no outer layer) | | 1½ | Efficiency % | 86.16 | 88.30 | 89.85 | 90.96 |
| | 2 | (no outer layer) | | 2 | Efficiency % | 87.97 | 89.84 | 91.20 | 92.18 |
| 1½ | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 896.8 | 1346.5 | 1893.8 | 2537.5 |
| | 1½ | (no outer layer) | | 1½ | Efficiency % | 86.85 | 88.90 | 90.36 | 91.44 |
| | 2 | (no outer layer) | | 2 | Efficiency % | 88.60 | 90.38 | 91.68 | 92.60 |
| 2 | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 1122.0 | 1680.0 | 2368.8 | 3175.5 |
| | 1¼ | 4½ | 1½ | 2¾ | Efficiency % | 91.57 | 92.90 | 93.84 | 94.52 |
| | 1¼ | 4½ | 2 | 3¼ | Efficiency % | 92.30 | 93.50 | 94.36 | 95.00 |
| 2½ | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 1360.0 | 2037.0 | 2862.5 | 3842.5 |
| | 1 5/16 | 5 | 1½ | 2 5/16 | Efficiency % | 92.30 | 93.50 | 94.36 | 95.00 |
| | 1 5/16 | 5 | 2 | 3 5/16 | Efficiency % | 93.01 | 94.10 | 94.87 | 95.43 |
| 3 | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 1653.3 | 2478.0 | 3487.5 | 4676.3 |
| | 1 9/16 | 6 | 1½ | 3 1/16 | Efficiency % | 93.20 | 94.26 | 95.01 | 95.58 |
| | 1 9/16 | 6 | 2 | 3 9/16 | Efficiency % | 93.78 | 94.76 | 95.45 | 95.94 |



## Heat Losses from Bare Pipes and Efficiencies of Hy-Temp Combination Pipe Insulation (con't)

(Hy-Temp Insulation with "Featherweight" 85% Magnesia as outer layer)

| Nominal Pipe Size, inches | Thickness Hy-Temp Insulation, inches | Pipe Size of 85% Magnesia, inches | Thickness of 85% Magnesia, inches | Total Thickness of Combination Insulation, inches | | Temperature Difference between pipe and surrounding air, Deg. F. 425° 525° 625° 725° / Temperature of Pipe, Deg. F. 500° 600° 700° 800° (Surrounding air temperature 75° F.) Heat losses per linear foot of bare pipe per hour and Efficiencies of insulation | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3½ | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 1891.3 | 2829.8 | 3981.3 | 5343.3 |
| | 1 5/16 | 6 | 1½ | 2 5/16 | Efficiency % | 93.24 | 94.30 | 95.05 | 95.60 |
| | 1 5/16 | 6 | 2 | 3 5/16 | Efficiency % | 93.90 | 94.86 | 95.53 | 96.02 |
| 4 | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 2125.0 | 3186.8 | 4481.3 | 6010.3 |
| | 1 9/16 | 7 | 1½ | 3 1/16 | Efficiency % | 93.81 | 94.78 | 95.47 | 95.96 |
| | 1 9/16 | 7 | 2 | 3 9/16 | Efficiency % | 94.35 | 95.25 | 95.88 | 96.33 |
| 4½ | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 2363.0 | 3538.5 | 4981.3 | 6677.3 |
| | 1 5/16 | 7 | 2 | 3 5/16 | Efficiency % | 94.38 | 95.25 | 95.86 | 96.31 |
| 5 | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 2626.5 | 3937.5 | 5537.5 | 7431.3 |
| | 1½ | 8 | 2 | 3½ | Efficiency % | 94.74 | 95.56 | 96.14 | 96.57 |
| 6 | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 3128.0 | 4688.3 | 6593.8 | 8845.0 |
| | 1½ | 9 | 2 | 3½ | Efficiency % | 95.03 | 95.79 | 96.34 | 96.73 |
| 7 | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 3604.0 | 5397.0 | 7593.8 | 10186.3 |
| | 1½ | 10 | 2 | 3½ | Efficiency % | 95.22 | 95.96 | 96.50 | 96.89 |
| 8 | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 4071.5 | 6100.5 | 8587.5 | 11513.0 |
| | 1½ | 11 | 2 | 3½ | Efficiency % | 95.39 | 96.10 | 96.62 | 96.99 |
| 9 | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 4547.5 | 6809.3 | 9581.3 | 12854.3 |
| | 1½ | 12 | 2 | 3½ | Efficiency % | 95.52 | 96.22 | 96.72 | 97.07 |
| 10 | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 5083.0 | 7617.8 | 10718.8 | 14369.5 |
| | 1 9/16 | 14 | 2 | 3 9/16 | Efficiency % | 95.72 | 96.37 | 96.84 | 97.19 |
| 12 | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 6022.3 | 9024.8 | 12700.0 | 17030.3 |
| | 1 9/16 | 16 | 2 | 3 9/16 | Efficiency % | 95.85 | 96.49 | 96.95 | 97.28 |
| 14 | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 6608.8 | 9901.5 | 13937.5 | 18690.5 |
| | 1½ | 17 | 2 | 3½ | Efficiency % | 95.85 | 96.51 | 96.97 | 97.30 |
| 16 | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 7556.5 | 11324.3 | 15931.3 | 21365.8 |
| | 1½ | 19 | 2 | 3½ | Efficiency % | 95.95 | 96.59 | 97.02 | 97.36 |
| 18 | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 8504.3 | 12741.8 | 17925.0 | 24041.0 |
| | 1½ | 21 | 2 | 3½ | Efficiency % | 96.04 | 96.66 | 97.10 | 97.42 |
| 20 | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 9447.8 | 14159.3 | 19918.8 | 26716.3 |
| | 1½ | 23 | 2 | 3½ | Efficiency % | 96.09 | 96.70 | 97.12 | 97.45 |
| 24 | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 11339.0 | 16989.0 | 23900.0 | 32052.3 |
| | 1½ | 27 | 2 | 3½ | Efficiency % | 96.18 | 96.78 | 97.22 | 97.53 |
| 30 | 0 | | 0 | 0 | Bare pipe loss, B.t.u. | 14173.8 | 21236.3 | 29881.3 | 40070.8 |
| | 1½ | 33 | 2 | 3½ | Efficiency % | 96.28 | 96.86 | 97.27 | 97.58 |



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## Hy-Temp Combination Pipe Covering

Temperatures to 800° F.
Hy-Temp Approximately 1½" thick

| | INNER LAYER Hy-Temp | OUTER LAYER (85% Magnesia) |
|---|---|---|
| Nominal Pipe Sizes Inches | Approx. Thickness Inches | Nominal Pipe Sizes Inches |
| ½ | 1½ | 3 |
| ¾ | 1½ | 3½ |
| 1 | 1⅜ | 4 |
| 1¼ | 1⅜ | 4 |
| 1½ | 1½ | 4½ |
| 2 | 1⅝ | 4½ |
| 2½ | 1⅝ | 5 |
| 3 | 1½ | 6 |
| 3½ | 1⅝ | 6 |
| 4 | 1½ | 7 |
| 4½ | 1⅝ | 7 |
| 5 | 1½ | 8 |
| 6 | 1½ | 9 |
| 7 | 1½ | 10 |
| 8 | 1½ | *11 |
| 9 | 1½ | *12 |
| 10 | 1⅜ | *14 |
| *11 | 1½ | *15 |
| *12 | 1⅜ | *16 |
| *14 o.d. | 1½ | *17 |
| *16 o.d. | 1½ | *19 |
| *18 o.d. | 1½ | *21 |
| *20 o.d. | 1½ | *23 |
| *24 o.d. | 1½ | *27 |
| *30 o.d. | 1½ | *33 |

## Hy-Temp Combination Pipe Covering

Temperatures 800° to 1000° F.
Hy-Temp Approximately 2" thick

| | INNER LAYER Hy-Temp | OUTER LAYER (85% Magnesia) |
|---|---|---|
| Nominal Pipe Sizes Inches | Approx. Thickness Inches | Nominal Pipe Sizes Inches |
| ½ | 2 | 4½ |
| ¾ | 1⅞ | 4½ |
| 1 | 2 | 5 |
| 1¼ | 1⅞ | 5 |
| 1½ | 2¼ | 6 |
| 2 | 2 | 6 |
| 2½ | 1⅞ | 6 |
| 3 | 2 | 7 |
| 3½ | 1¾ | 7 |
| 4 | 2 | 8 |
| 4½ | 2 | 8 |
| 5 | 2 | 9 |
| 6 | 2⅛ | 10 |
| 7 | 2 | *11 |
| 8 | 2 | *12 |
| 9 | 2⅛ | *14 |
| 10 | 2⅛ | *15 |
| *11 | 2 | *16 |
| *12 | 2⅛ | *17 |
| *14 o.d. | 2 | *18 |
| *16 o.d. | 2 | *20 |
| *18 o.d. | 2 | *22 |

*Hy-Temp and Magnesia for pipe sizes larger than 10" is furnished in Segmental blocks.

## Number and Sizes of Segments of 85% Magnesia and Hy-Temp Segmental Pipe Insulation

| Nominal Pipe Size Inches | 1½" Thick | | | 2" Thick | | Double Std. or 3" Thick B/J Method | | | |
|---|---|---|---|---|---|---|---|---|---|
| | O. D. of Iron Pipe | Segments per Course | Size of Segments Inches | Segments per Course | Size of Segments Inches | Segments per Course | 1st Course Size of Segments | Segments per Course | 2nd Course Size of Segments |
| 12" | 12.75" | 8 | 5.06 x 6.24 | 8 | 5.06 x 6.63 | 8 | 5.06 x 6.24 | 9 | 5.59 x 6.64 |
| 14" | 14" | 8 | 5.55 x 6.73 | 8 | 5.55 x 7.12 | 8 | 5.55 x 6.73 | 10 | 5.42 x 6.37 |
| 15" | 15" | 9 | 5.28 x 6.33 | 9 | 5.28 x 6.68 | 9 | 5.28 x 6.33 | 10 | 5.74 x 6.68 |
| 16" | 16" | 9 | 5.63 x 6.68 | 9 | 5.63 x 7.03 | 9 | 5.63 x 6.68 | 11 | 5.50 x 6.36 |
| 17" | 17" | 10 | 5.39 x 6.33 | 10 | 5.39 x 6.64 | 10 | 5.39 x 6.33 | 11 | 5.79 x 6.65 |
| 18" | 18" | 10 | 5.70 x 6.64 | 10 | 5.70 x 6.96 | 10 | 5.70 x 6.64 | 12 | 5.57 x 6.35 |
| 19" | 19" | 11 | 5.47 x 6.32 | 11 | 5.47 x 6.61 | 11 | 5.47 x 6.32 | 12 | 5.83 x 6.62 |
| 20" | 20" | 11 | 5.75 x 6.61 | 11 | 5.75 x 6.90 | 11 | 5.75 x 6.61 | 13 | 5.58 x 6.31 |
| 21" | 21" | 12 | 5.54 x 6.32 | 12 | 5.54 x 6.58 | 12 | 5.54 x 6.32 | 13 | 5.87 x 6.59 |
| 22" | 22" | 12 | 5.80 x 6.58 | 12 | 5.80 x 6.84 | 12 | 5.80 x 6.58 | 14 | 5.63 x 6.30 |
| 23" | 23" | 13 | 5.58 x 6.31 | 13 | 5.58 x 6.55 | 13 | 5.58 x 6.31 | 14 | 5.92 x 6.55 |
| 24" | 24" | 13 | 5.83 x 6.56 | 13 | 5.83 x 6.80 | 13 | 5.83 x 6.56 | 14 | 6.08 x 6.75 |
| 26" | 26" | 14 | 5.90 x 6.52 | 14 | 5.87 x 6.77 | 14 | 5.90 x 6.52 | 15 | 6.10 x 6.72 |
| 28" | 28" | 15 | 5.90 x 6.52 | 15 | 5.90 x 6.73 | 15 | 5.90 x 6.52 | 16 | 6.11 x 6.70 |
| 30" | 30" | 16 | 5.91 x 6.50 | 16 | 5.91 x 6.70 | 16 | 5.91 x 6.50 | 18 | 5.78 x 6.30 |



## Packaging Data—Hy-Temp and Combination Pipe Insulation

(Crate No. 71 is used unless otherwise noted)

### Sections per crate—Jacketed Hy-Temp Pipe Insulation

| Thickness of Insulation | Nominal Pipe Sizes | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ½ | ¾ | 1 | 1¼ | 1½ | 2 | 2½ | 3 | 3½ | 4 | 4½ | 5 | 6 | 7 | 8 | 9 | 10 |
| 1½" Thick | 58 | 50 | 46 | 38 | 38 | 28 | 24 | 20 | 16 | 14 | 14 | 11 | 9 | 6–#70 | 6–#70 | 6–#72 | 6–#73 |
| 2" Thick | 38 | 32 | 28 | 24 | 24 | 20 | 16 | 14 | 14 | 11 | 11 | 9 | 6–#70 | 6 | 6–#72 | 6–#73 | 5–#201 |

### Sections per crate—Hy-Temp Combination Pipe Insulation

| Thickness of Outer Layer | Nominal Pipe Size of Outer Layer As Shown on Data Page IN-67B | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 3½ | 4 | 4½ | 5 | 6 | 7 | 8 | 9 | 10 |
| Standard | 28 | 24 | 19 | 15 | 14 | 11 | 7 | 6–#70 | 6 | 10–#72 |
| 1½" | 20 | 16 | 14 | 14 | 11 | 9 | 6–#70 | 6–#70 | 6–#72 | 6–#73 |
| 2" | 14 | 14 | 11 | 11 | 9 | 6–#70 | 6 | 6–#72 | 6–#73 | 5–#201 |
| Dbl. Std. | 14 | 11 | 11 | 7 | 7 | 6–#70 | 6–#72 | 6–#73 | x | x |
| Dbl. 1½" | 9 | 6 | 6–#70 | 6–#70 | 6 | 6–#72 | 6–#73 | x | x | x |

### Sections per crate—Hy-Temp Inner Layer of Combination Pipe Insulation (When Outer Layer Is Segmental Block)

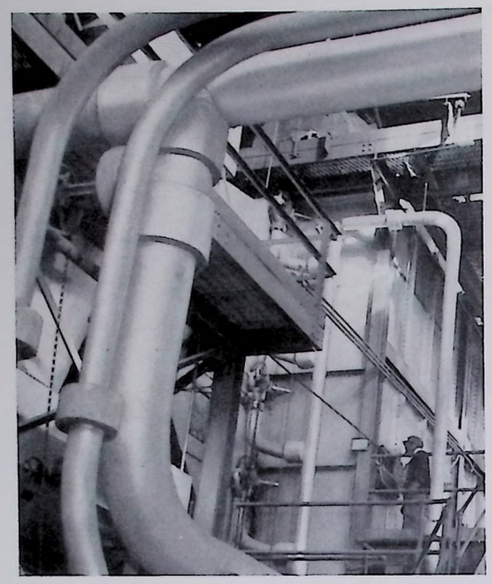
| Thickness of Inner Layer | Nominal Pipe Size of HY-TEMP Inner Layer | | | | |
|---|---|---|---|---|---|
| | 6 | 7 | 8 | 9 | 10 |
| 1½" | 12 | 9 | 8 | 10–#72 | 10–#72 |
| 2" | 9 | 8 | 10–#72 | 10–#72 | 10–#72 |

### Key to Crate Dimensions

| Crate No. | Inside Dimensions (inches) | Outside Dimensions (inches) | Tare Weight (lbs.) |
|---|---|---|---|
| 200 | 34¼ x 34 x 36¼ | 37¼ x 35 x 37¼ | 55 |
| 201 | 37 x 35¾ x 36¼ | 40 x 36¾ x 37¼ | 60 |
| 70 | 34½ x 23 x 36¼ | 37½ x 24 x 37¼ | 40 |
| 71 | 37 x 25 x 36¼ | 40 x 26 x 37¼ | 45 |
| 72 | 41 x 27 x 36¼ | 44 x 28 x 37¼ | 55 |
| 73 | 42 x 28 x 36¼ | 45 x 29 x 37¼ | 60 |



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## Hy-Temp Block Insulation

Hy-Temp Blocks are furnished in standard widths of 3″, 6″, 9″, and 12″ and in 36″ lengths flat. Thicknesses range from 1″ to 4″. Curved blocks are furnished in standard 6″ widths and 36″ lengths. Thicknesses range from 1½″ to 2″.

Hy-Temp Blocks are usually used in combination with an outer layer of 85% Magnesia Blocks. The Hy-Temp Blocks are applied as an inner layer to bring the temperature at the magnesia down to the limits of that product.

This main steam header, carrying superheated steam at 400 pounds pressure from the boiler in the background to the power plant turbine, is insulated with 1½″ thick Hy-Temp Covering and a similar thickness of 85% Magnesia Covering. Hy-Temp Block is used under the steel shell to reduce heat losses through the boiler walls.

**Recommended Minimum Thickness of Combination Hy-Temp and 85% Magnesia Block Insulation**

| Maximum Temperature on Hy-Temp deg. F. | Thickness of Hy-Temp Inches | Thickness of Magnesia Inches | Total Thickness Inches |
|---|---|---|---|
| 750 | 1½ | 2½ | 4 |
| 900 | 2½ | 2 | 4½ |
| 1000 | 3 | 2 | 5 |
| 1200 | 3½ | 1½ | 5 |

Where insulation is to be applied on weather-exposed surfaces, increase thicknesses at least ½″ greater than those shown in table.

**Hy-Temp Carton Contents**

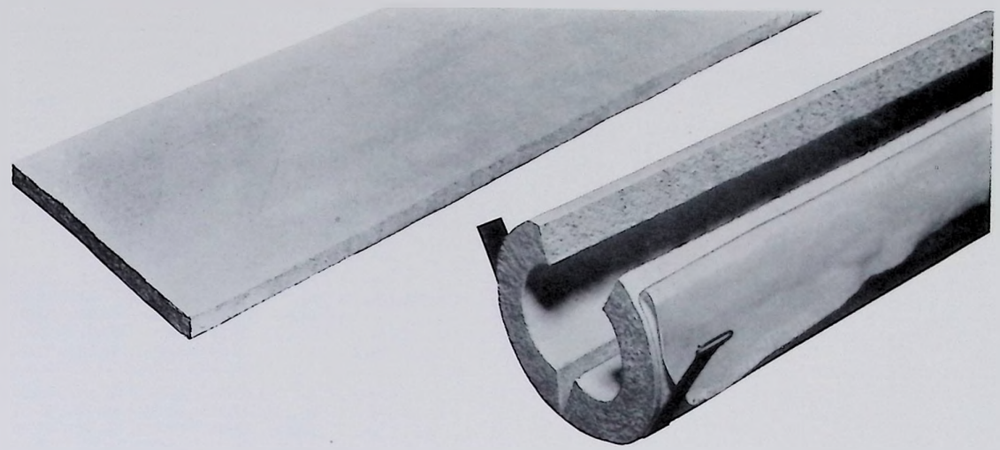
Empty carton weight—4 lbs.

Approximate gross weight—85 lbs. for Hy-Temp Blocks

Outside dimensions of carton—13″ x 12 15/16″ x 37″.

| Size in Inches | Thickness in Inches | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 1¼ | 1½ | 1¾ | 2 | 2¼ | 2½ | 3 | 4 |
| 3 x 36 | | | | | | | | | |
| Blocks per Carton | 48 | 38 | 32 | 28 | 24 | 20 | 20 | 16 | 12 |
| Sq. Ft. per Carton | 36 | 28½ | 24 | 21 | 18 | 15 | 15 | 12 | 9 |
| 6 x 36 | | | | | | | | | |
| Blocks per Carton | 24 | 19 | 16 | 14 | 12 | 10 | 10 | 8 | 6 |
| Sq. Ft. per Carton | 36 | 28½ | 24 | 21 | 18 | 15 | 15 | 12 | 9 |
| 12 x 36 | | | | | | | | | |
| Blocks per Carton | 12 | 9 | 8 | 7 | 6 | 5 | 5 | 4 | 3 |
| Sq. Ft. per Carton | 36 | 27 | 24 | 21 | 18 | 15 | 15 | 12 | 9 |





# Bestfelt Pipe Covering and Block

Bestfelt Insulation is made in pipe covering and block form of built-up layers of crimped asbestos paper. There are approximately 33 layers of paper per inch of insulation thickness. The material is suitable for use on heated pipes and surfaces where temperatures do not exceed 700° F. It is often specified in place of 85% Magnesia for applications where the insulation is subjected to excessive conditions of vibration or where it must be removed and replaced frequently. For example, removable flange covers made of Bestfelt have the high strength necessary to resist damage that occurs to many insulations when the covers are removed and replaced.

For thermal conductivity of Bestfelt Insulation, see curve on Page 126.

## Bestfelt Pipe Insulation

Bestfelt Pipe Covering is supplied in three-foot sections with canvas jackets and brass lacquered bands for application. It is available for pipe sizes from ½″ to 24″.

Standard Thickness approximates 1″. Thicknesses of 1″, 1½″, 2″, and 2½″ are furnished in single layer construction. A 3″ thickness is supplied with broken joint construction in two equal thicknesses.

**Recommended Minimum Thickness of Bestfelt Pipe Insulation—Indoor Conditions**

| Steam Pressure or condition | Temp. Deg. F. | Pipe Sizes | | |
|---|---|---|---|---|
| | | Up to 1½″ | 2″ to 4″ | 4½″ and over |
| Hot Water | — | 1″ | 1″ | 1″ |
| 0– 25 lbs. | 212 to 266 | 1″ | 1″ | 1″ |
| 25–100 lbs. | 267 to 337 | 1″ | 1″ | 1½″ |
| 100–200 lbs. | 338 to 387 | 1″ | 1½″ | 2″ |
| Low Superheat | 388 to 499 | 1½″ | 2″ | 2½″ |
| Superheat | 500 to 599 | 2″ | 2½″ | 3″ |
| High Superheat | 600 to 700 | 2″ | 3″ | 3″ |




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## Heat Losses from Bare Pipes and Efficiencies of Bestfelt Insulation

| Nominal Pipe Size, inches | Insulation thickness, inches | | Temperature of pipe—deg. Fahr. 125 | 175 | 225 | 275 | 325 | 375 | 425 | 475 | 525 | 575 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Temperature difference between pipe and air—deg. Fahr. 50 | 100 | 150 | 200 | 250 | 300 | 350 | 400 | 450 | 500 |
| ¾ | 1 | Efficiency % | 71.46 | 73.21 | 76.11 | 77.31 | 79.00 | 80.27 | 81.90 | 82.98 | 84.87 | 85.76 |
| | 1½ | " " | 73.91 | 75.70 | 77.60 | 79.30 | 80.71 | 82.17 | 83.40 | 84.69 | 85.80 | 86.91 |
| | 2 | " " | 76.80 | 78.43 | 80.10 | 81.60 | 83.00 | 84.10 | 85.40 | 86.41 | 87.50 | 88.60 |
| | 2½ | " " | 78.57 | 80.10 | 81.60 | 83.10 | 84.37* | 85.52 | 86.57 | 87.60 | 88.51 | 89.31 |
| | 3 | " " | 80.33 | 81.67 | 83.10 | 84.41 | 85.50 | 86.60 | 87.52 | 88.51 | 89.47 | 89.99 |
| 1 | 1 | " " | 74.00 | 75.70 | 77.61 | 79.50 | 80.70 | 82.00 | 83.57 | 84.79 | 85.92 | 86.91 |
| | 1½ | " " | 76.70 | 78.13 | 79.82 | 81.33 | 82.72 | 83.97 | 85.10 | 86.20 | 87.21 | 88.11 |
| | 2 | " " | 79.50 | 80.85 | 82.37 | 83.62 | 84.80 | 85.90 | 87.00 | 87.95 | 89.00 | 89.61 |
| | 2½ | " " | 81.12 | 82.40 | 83.80 | 85.07 | 86.13 | 87.12 | 88.15 | 89.12 | 89.91 | 90.63 |
| | 3 | " " | 82.62 | 83.82 | 85.14 | 86.20 | 87.17 | 88.10 | 89.00 | 89.82 | 90.62 | 91.22 |
| 1½ | 1 | " " | 77.25 | 78.82 | 80.50 | 82.00 | 83.09 | 84.30 | 85.51 | 86.67 | 87.50 | 88.39 |
| | 1½ | " " | 80.00 | 81.27 | 82.75 | 83.99 | 85.12 | 86.13 | 87.21 | 88.23 | 88.99 | 89.81 |
| | 2 | " " | 82.57 | 83.90 | 84.99 | 86.17 | 87.12 | 88.02 | 88.96 | 89.82 | 90.52 | 91.22 |
| | 2½ | " " | 84.30 | 85.41 | 86.52 | 87.51 | 88.42 | 89.21 | 90.02 | 90.82 | 91.43 | 92.03 |
| | 3 | " " | 85.70 | 86.72 | 87.69 | 88.62 | 89.43 | 90.12 | 90.90 | 91.61 | 92.25 | 92.67 |
| 2 | 1 | " " | 78.80 | 80.22 | 81.72 | 83.03 | 84.22 | 85.32 | 86.42 | 87.52 | 88.31 | 89.11 |
| | 1½ | " " | 81.51 | 82.81 | 84.03 | 85.23 | 86.29 | 87.19 | 88.13 | 89.05 | 89.79 | 90.51 |
| | 2 | " " | 84.02 | 85.13 | 86.32 | 87.31 | 88.20 | 89.05 | 89.90 | 90.70 | 91.31 | 91.93 |
| | 2½ | " " | 85.73 | 86.71 | 87.80 | 88.70 | 89.50 | 90.22 | 90.97 | 91.66 | 92.25 | 92.78 |
| | 3 | " " | 86.99 | 87.94 | 88.83 | 89.69 | 90.42 | 91.08 | 91.77 | 92.37 | 92.91 | 93.40 |
| 2½ | 1 | " " | 79.98 | 81.33 | 82.71 | 83.97 | 85.08 | 86.10 | 87.13 | 88.11 | 88.96 | 89.71 |
| | 1½ | " " | 82.65 | 83.83 | 85.03 | 86.14 | 87.12 | 88.00 | 88.91 | 89.77 | 90.47 | 91.13 |
| | 2 | " " | 85.10 | 86.16 | 87.20 | 88.17 | 89.01 | 89.78 | 90.55 | 91.30 | 91.88 | 92.50 |
| | 2½ | " " | 86.76 | 87.69 | 88.67 | 89.54 | 90.28 | 90.99 | 91.69 | 92.35 | 96.90 | 93.41 |
| | 3 | " " | 87.94 | 88.80 | 89.70 | 90.48 | 91.17 | 91.77 | 92.40 | 93.00 | 93.50 | 93.95 |
| 3 | 1 | " " | 80.97 | 82.24 | 83.60 | 84.80 | 85.90 | 86.83 | 87.90 | 88.80 | 89.60 | 90.30 |
| | 1½ | " " | 83.57 | 84.65 | 85.85 | 86.87 | 87.80 | 88.68 | 89.50 | 90.31 | 91.00 | 91.61 |
| | 2 | " " | 86.09 | 87.03 | 88.02 | 88.93 | 89.68 | 90.42 | 91.14 | 91.82 | 92.39 | 92.92 |
| | 2½ | " " | 87.79 | 88.59 | 89.50 | 90.27 | 90.95 | 91.59 | 92.22 | 92.84 | 93.35 | 93.80 |
| | 3 | " " | 88.90 | 89.67 | 90.43 | 91.16 | 91.79 | 92.39 | 92.96 | 93.50 | 93.95 | 94.37 |
| 3½ | 1 | " " | 81.55 | 82.29 | 84.16 | 85.24 | 86.28 | 87.20 | 88.13 | 89.05 | 89.80 | 90.50 |
| | 1½ | " " | 84.17 | 85.25 | 86.37 | 87.37 | 88.26 | 89.07 | 89.87 | 90.57 | 91.30 | 91.90 |
| | 2 | " " | 86.55 | 87.53 | 88.47 | 89.38 | 90.13 | 90.82 | 91.52 | 92.15 | 92.72 | 93.22 |
| | 2½ | " " | 88.32 | 89.11 | 89.93 | 90.68 | 91.35 | 91.95 | 92.55 | 93.15 | 93.61 | 94.04 |
| | 3 | " " | 89.56 | 90.25 | 91.02 | 91.69 | 92.26 | 92.82 | 93.35 | 93.86 | 94.26 | 94.66 |
| 4 | 1 | " " | 82.07 | 83.27 | 84.53 | 85.63 | 86.63 | 87.57 | 88.50 | 89.39 | 90.11 | 90.77 |
| | 1½ | " " | 84.63 | 85.67 | 86.73 | 87.73 | 88.57 | 89.39 | 90.19 | 90.93 | 91.57 | 92.16 |
| | 2 | " " | 87.10 | 87.98 | 88.90 | 89.74 | 90.47 | 91.13 | 91.81 | 92.45 | 92.97 | 93.47 |
| | 2½ | " " | 88.73 | 89.52 | 90.32 | 91.07 | 91.69 | 92.27 | 92.86 | 93.41 | 93.87 | 94.30 |
| | 3 | " " | 89.91 | 90.59 | 91.31 | 91.96 | 92.55 | 93.06 | 93.57 | 94.08 | 94.50 | 94.86 |
| 4½ | 1 | " " | 82.31 | 83.50 | 84.70 | 85.83 | 86.85 | 87.77 | 88.67 | 89.52 | 90.27 | 90.93 |
| | 1½ | " " | 85.10 | 86.10 | 87.15 | 88.09 | 88.91 | 89.68 | 90.45 | 91.18 | 91.78 | 92.36 |
| | 2 | " " | 87.47 | 88.32 | 89.19 | 90.00 | 90.72 | 91.38 | 92.02 | 92.67 | 93.20 | 93.67 |
| | 2½ | " " | 89.04 | 89.81 | 90.61 | 91.33 | 91.93 | 92.50 | 93.08 | 93.61 | 94.06 | 94.47 |
| | 3 | " " | 90.22 | 90.95 | 91.61 | 92.26 | 92.81 | 93.31 | 93.79 | 94.30 | 94.67 | 95.02 |
| 5 | 1 | " " | 82.75 | 83.91 | 85.11 | 86.21 | 87.18 | 88.07 | 88.97 | 89.84 | 90.52 | 91.19 |
| | 1½ | " " | 85.37 | 86.32 | 87.37 | 88.27 | 89.11 | 89.88 | 90.65 | 91.37 | 91.97 | 92.52 |
| | 2 | " " | 87.81 | 88.65 | 89.54 | 90.31 | 90.99 | 91.64 | 92.26 | 92.87 | 93.37 | 93.83 |
| | 2½ | " " | 89.41 | 90.13 | 90.90 | 91.59 | 92.18 | 92.76 | 93.27 | 93.81 | 94.25 | 94.65 |
| | 3 | " " | 90.53 | 91.21 | 91.87 | 92.50 | 93.01 | 93.50 | 94.02 | 94.50 | 94.86 | 95.21 |
| 6 | 1 | " " | 83.28 | 84.37 | 85.53 | 86.58 | 87.53 | 88.39 | 89.29 | 90.10 | 90.77 | 91.40 |
| | 1½ | " " | 85.77 | 86.79 | 87.77 | 88.67 | 89.50 | 90.21 | 90.93 | 91.64 | 92.21 | 92.72 |
| | 2 | " " | 88.34 | 89.11 | 89.95 | 90.68 | 91.36 | 91.97 | 92.60 | 93.16 | 93.65 | 94.10 |
| | 2½ | " " | 89.87 | 90.59 | 91.32 | 92.00 | 92.56 | 93.09 | 93.60 | 94.10 | 94.51 | 94.88 |
| | 3 | " " | 91.00 | 91.62 | 92.28 | 92.87 | 93.39 | 93.86 | 94.41 | 94.76 | 95.10 | 95.43 |



| Nominal Pipe Size, inches | Insulation thickness, inches | | Temperature of pipe—deg. Fahr. 125 | 175 | 225 | 275 | 325 | 375 | 425 | 475 | 525 | 575 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Temperature difference between pipe and air—deg. Fahr. 50 | 100 | 150 | 200 | 250 | 300 | 350 | 400 | 450 | 500 |
| 7 | 1 | Efficiency % | 83.50 | 84.63 | 85.78 | 86.85 | 87.73 | 88.60 | 89.72 | 90.24 | 90.92 | 91.53 |
| | 1½ | " " | 86.23 | 87.17 | 88.12 | 88.99 | 89.77 | 90.51 | 91.20 | 91.87 | 92.44 | 92.98 |
| | 2 | " " | 88.63 | 89.43 | 90.25 | 91.00 | 91.63 | 92.23 | 92.83 | 93.38 | 93.86 | 94.27 |
| | 2½ | " " | 90.24 | 90.93 | 91.62 | 92.27 | 92.81 | 93.32 | 93.85 | 94.32 | 94.71 | 95.08 |
| | 3 | " " | 91.37 | 91.96 | 92.58 | 93.15 | 93.63 | 94.09 | 94.53 | 94.95 | 95.31 | 95.62 |
| 8 | 1 | " " | 83.93 | 84.99 | 86.11 | 87.13 | 88.03 | 88.87 | 89.68 | 90.50 | 91.11 | 91.72 |
| | 1½ | " " | 86.47 | 87.40 | 88.37 | 89.23 | 89.97 | 90.67 | 91.37 | 92.03 | 92.57 | 93.10 |
| | 2 | " " | 88.91 | 89.67 | 90.45 | 91.17 | 91.81 | 92.41 | 92.97 | 93.52 | 93.97 | 94.37 |
| | 2½ | " " | 90.50 | 91.18 | 91.82 | 92.48 | 92.99 | 93.51 | 93.99 | 94.47 | 94.83 | 95.21 |
| | 3 | " " | 91.57 | 92.20 | 92.77 | 93.37 | 93.83 | 94.27 | 94.67 | 95.10 | 95.43 | 95.75 |
| 9 | 1 | " " | 84.05 | 85.12 | 86.25 | 87.23 | 88.10 | 88.93 | 89.75 | 90.52 | 91.18 | 91.76 |
| | 1½ | " " | 86.63 | 87.53 | 88.49 | 89.35 | 90.09 | 90.78 | 91.46 | 92.15 | 92.69 | 93.19 |
| | 2 | " " | 89.11 | 89.85 | 90.66 | 91.35 | 91.95 | 92.52 | 93.09 | 93.61 | 94.05 | 94.50 |
| | 2½ | " " | 90.69 | 91.36 | 92.04 | 92.65 | 93.16 | 93.67 | 94.13 | 94.58 | 94.95 | 95.30 |
| | 3 | " " | 91.77 | 92.37 | 92.95 | 93.51 | 93.97 | 94.39 | 94.82 | 95.22 | 95.55 | 95.87 |
| 10 | 1 | " " | 85.03 | 85.99 | 87.05 | 88.12 | 89.02 | 89.57 | 90.35 | 91.07 | 92.03 | 92.71 |
| | 1½ | " " | 86.95 | 87.81 | 88.72 | 89.55 | 90.30 | 90.99 | 91.64 | 92.30 | 92.83 | 93.35 |
| | 2 | " " | 89.31 | 90.05 | 90.82 | 91.51 | 92.11 | 92.69 | 93.21 | 93.77 | 94.20 | 94.61 |
| | 2½ | " " | 90.89 | 91.53 | 92.20 | 92.80 | 93.30 | 93.77 | 94.25 | 94.72 | 95.07 | 95.41 |
| | 3 | " " | 91.98 | 92.55 | 93.17 | 93.70 | 94.15 | 94.57 | 94.99 | 95.37 | 95.68 | 95.99 |
| 12 | 1½ | " " | 87.11 | 87.99 | 88.91 | 89.74 | 90.50 | 91.15 | 91.78 | 92.45 | 92.96 | 93.43 |
| | 2 | " " | 89.53 | 90.27 | 91.04 | 91.70 | 92.31 | 92.86 | 93.39 | 93.91 | 94.33 | 94.72 |
| | 2½ | " " | 91.17 | 91.77 | 92.39 | 92.97 | 93.51 | 93.95 | 94.41 | 94.86 | 95.22 | 95.55 |
| | 3 | " " | 92.23 | 92.79 | 93.37 | 93.87 | 94.31 | 94.72 | 95.11 | 95.52 | 95.85 | 96.13 |
| 14 | 1½ | " " | 87.25 | 88.13 | 89.05 | 89.87 | 90.58 | 91.25 | 91.89 | 92.55 | 93.04 | 93.52 |
| | 2 | " " | 89.67 | 90.41 | 91.16 | 91.85 | 92.46 | 92.99 | 93.53 | 94.03 | 94.46 | 94.85 |
| | 2½ | " " | 91.22 | 91.86 | 92.51 | 93.09 | 93.60 | 94.06 | 94.51 | 94.93 | 95.27 | 95.60 |
| | 3 | " " | 92.35 | 92.88 | 93.46 | 93.95 | 94.41 | 94.81 | 95.21 | 95.60 | 95.91 | 96.19 |
| 16 | 1½ | " " | 87.36 | 88.23 | 89.11 | 89.93 | 90.63 | 91.31 | 91.99 | 92.60 | 93.11 | 93.59 |
| | 2 | " " | 89.71 | 90.47 | 91.19 | 91.90 | 92.49 | 93.03 | 93.58 | 94.09 | 94.50 | 94.89 |
| | 2½ | " " | 91.31 | 91.95 | 92.58 | 93.16 | 93.68 | 94.10 | 94.57 | 94.99 | 95.35 | 95.67 |
| | 3 | " " | 92.39 | 92.97 | 93.54 | 94.06 | 94.52 | 94.90 | 95.30 | 95.67 | 95.97 | 96.25 |
| 18 | 1½ | " " | 87.46 | 88.33 | 89.23 | 90.06 | 90.76 | 91.40 | 92.06 | 92.66 | 93.17 | 93.65 |
| | 2 | " " | 89.76 | 90.52 | 91.30 | 91.98 | 92.56 | 93.09 | 93.64 | 94.13 | 94.55 | 94.93 |
| | 2½ | " " | 91.47 | 92.09 | 92.69 | 93.29 | 93.75 | 94.23 | 94.67 | 95.10 | 95.44 | 95.75 |
| | 3 | " " | 92.48 | 93.08 | 93.61 | 94.15 | 94.57 | 94.97 | 95.37 | 95.73 | 96.03 | 96.33 |

## Packaging Information
## Carton Contents of Bestfelt Pipe Insulation

Standard Thickness

| Nominal Pipe Size | Feet | Sections | Gross Wt. per Carton, Lbs.* |
|---|---|---|---|
| ½" | 81 | 27 | 124 |
| ¾" | 72 | 24 | 124 |
| 1" | 60 | 20 | 116 |
| 1¼" | 51 | 17 | 113 |
| 1½" | 45 | 15 | 108 |
| 2" | 36 | 12 | 101 |
| 2½" | 27 | 9 | 88 |
| 3" | 21 | 7 | 80 |
| 3½" | 18 | 6 | 76 |
| 4" | 18 | 6 | 83 |
| 4½" | 15 | 5 | 75 |
| 5" | 12 | 4 | 67 |
| 6" | 6 | 2 | 41 |

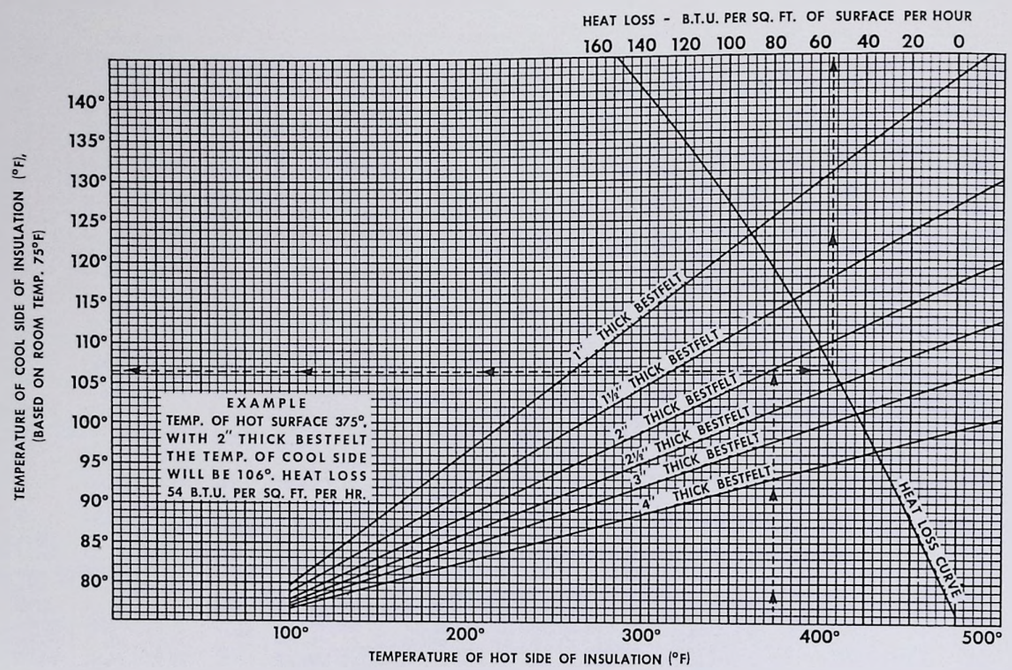
*Empty carton wt. 5 lbs.

Outside dimensions of carton 14" x 20½" x 37".



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## Bestfelt Sheets and Blocks—Heat Losses, Surface Temperature, and Conductivity

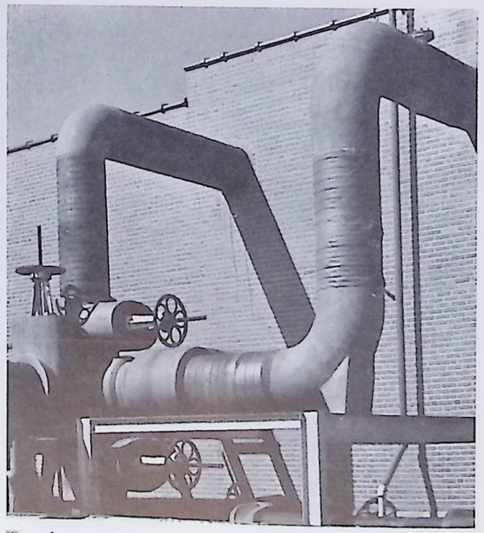



### Bestfelt Sheets and Blocks

Bestfelt sheets and blocks, for the insulation of flat, curved and irregular surfaces, are available in standard widths of 6″, 9″, 12″, 18″, 24″, and 36″. All are 36″ in length and thicknesses are ½″, 1″, 1½″, 2″, 2½″, 3″, 3½″, and 4″. The laminations run the length of the block, allowing for greater flexibility and ease of application to curve surfaces. Weight of Bestfelt Block is approximately 3 lbs. per sq. ft. per inch of thickness.

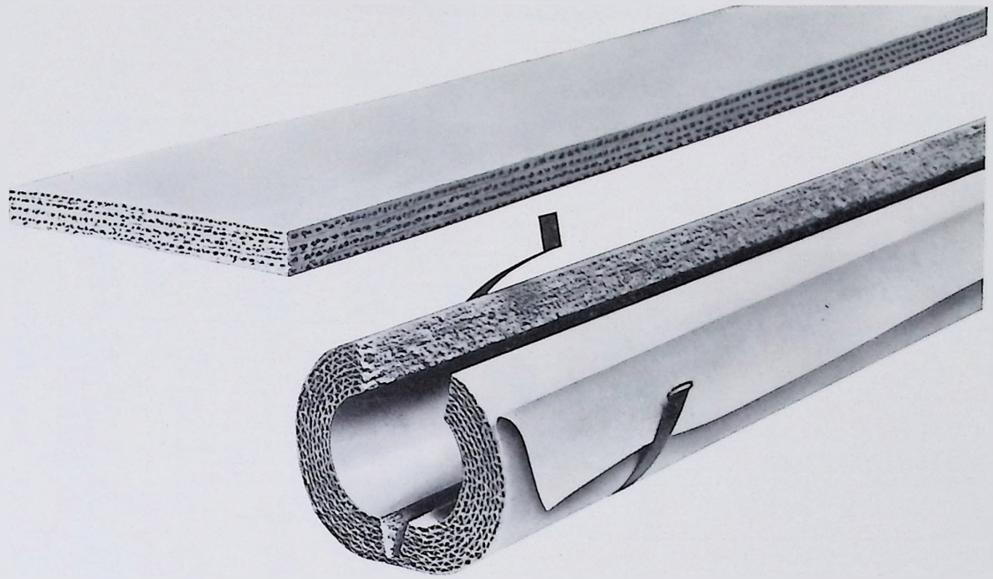
**Recommended Thicknesses—Bestfelt Sheets and Blocks**

| Steam Pressure or Condition | Temp. Degrees F. | Thickness |
|---|---|---|
| Hot Water | | 1″ |
| 0– 25 lbs. | 212 to 266 | 1″ |
| 25–100 lbs. | 267 to 337 | 1½″ |
| 100–200 lbs. | 338 to 387 | 2″ |
| Low Superheat | 388 to 499 | 2½″ |
| Superheat | 500 to 599 | 3″ |
| High Superheat | 600 to 700 | 3″ |



Two layers of 1½″ thick Bestfelt Pipe Covering, applied with joints staggered, were used to insulate these 16″ and 20″ steam lines. All laps in the asbestos roofing jacket were sealed with weatherproof cement.





# Air Cell Insulations

Air cell insulations are recommended for use on steam, hot water lines, and other heated surfaces where temperatures do not exceed 300° F. Pipe covering and blocks are made of alternate layers of corrugated and flat asbestos felt bonded together by a special laminating process. In air cell block insulation, the corrugated layers are crossed at right angles to give the block greater rigidity and durability. Air cell insulation is light in weight, rigid, and sufficiently strong for applications where service conditions are not severe.

Air cell insulation is available in three types: air cell, fine corrugated air cell, and special fine air cell. The difference in the three types lies in the number of layers of corrugated asbestos felt used per inch of thickness. The greater the number of corrugations per inch, the higher is the strength and insulating efficiency of the product.

### Air Cell Pipe Insulation (Four Plies per Inch)

Air cell pipe insulation is furnished in standard thicknesses of 4 plies, each ply being approximately ¼″ thick. Greater thicknesses will be furnished when requested. Pipe covering sections are three feet long and are shipped complete with canvas jacket and lacquered bands for application to all standard sizes of pipes.

**Recommended Thicknesses—Air Cell Pipe Insulation**

| Temperature Range | Description | 1½″ and smaller | 2″ to 4″ | 4½″ and over |
|---|---|---|---|---|
| Up to 170 | Hot water, condensate return lines, etc. | ¾″–3 ply | ¾″–3 ply | ¾″–3 ply |
| Up to 212 | Hot water, boiler feed water supply, etc. | ¾″–3 ply | 1″ –3 ply | ¾″–4 ply |
| 212–300 | Low pressure steam | 1″ –4 ply | 1″ –4 ply | 1″ –4 ply |



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asbestosclaims.law/library/21245/65

## Efficiencies of Air Cell Pipe Insulation

| Nominal Pipe size, inches | Number of plies | | Temperature difference between pipe and surrounding air, °F. 50° | 100° | 150° | 200° | 250° | 300° |
|---|---|---|---|---|---|---|---|---|
| | | | Temperature of Pipe, °F. (Temperature of surrounding air, 75°) 125° | 175° | 225° | 275° | 325° | 375° |
| ½ | 2 | Efficiencies % | 49.5 | 51.1 | 53.3 | 55.2 | 56.9 | 58.2 |
| | 3 | " % | 54.3 | 56.0 | 58.3 | 60.3 | 62.1 | 63.4 |
| | 4 | " % | 58.0 | 59.6 | 61.7 | 63.6 | 65.4 | 66.3 |
| ¾ | 2 | " % | 53.6 | 54.9 | 57.1 | 58.5 | 60.1 | 61.9 |
| | 3 | " % | 58.2 | 59.6 | 61.9 | 63.7 | 65.0 | 67.0 |
| | 4 | " % | 62.0 | 63.4 | 65.1 | 66.9 | 68.4 | 69.8 |
| 1 | 2 | " % | 57.3 | 58.3 | 60.2 | 61.7 | 62.9 | 64.5 |
| | 3 | " % | 62.2 | 63.5 | 63.6 | 66.8 | 68.3 | 69.7 |
| | 4 | " % | 65.7 | 67.0 | 68.7 | 70.2 | 71.7 | 72.6 |
| 1¼ | 2 | " % | 59.9 | 61.1 | 62.9 | 64.0 | 64.2 | 66.0 |
| | 3 | " % | 64.0 | 66.2 | 67.9 | 69.5 | 70.8 | 72.2 |
| | 4 | " % | 68.6 | 69.9 | 71.4 | 72.8 | 73.9 | 75.1 |
| 1½ | 2 | " % | 61.4 | 62.9 | 64.2 | 65.3 | 66.2 | 67.9 |
| | 3 | " % | 66.3 | 67.2 | 69.2 | 70.8 | 71.9 | 73.2 |
| | 4 | " % | 70.1 | 71.2 | 72.9 | 74.1 | 75.3 | 76.2 |
| 2 | 2 | " % | 63.4 | 64.4 | 65.9 | 67.0 | 67.9 | 69.8 |
| | 3 | " % | 68.6 | 69.6 | 71.1 | 72.4 | 73.6 | 75.1 |
| | 4 | " % | 72.1 | 73.2 | 74.5 | 75.7 | 76.9 | 78.2 |
| 2½ | 2 | " % | 64.3 | 65.7 | 67.2 | 68.2 | 69.2 | 71.1 |
| | 3 | " % | 70.0 | 71.0 | 72.4 | 73.6 | 74.8 | 76.1 |
| | 4 | " % | 73.6 | 74.6 | 75.9 | 77.0 | 78.0 | 79.0 |
| 3 | 2 | " % | 66.0 | 66.8 | 68.1 | 69.3 | 70.3 | 72.1 |
| | 3 | " % | 71.3 | 72.3 | 73.6 | 74.8 | 75.7 | 77.1 |
| | 4 | " % | 74.9 | 75.9 | 77.0 | 78.2 | 79.1 | 80.2 |
| 3½ | 2 | " % | 66.6 | 67.4 | 68.7 | 69.9 | 70.8 | 72.7 |
| | 3 | " % | 72.0 | 73.0 | 74.2 | 75.4 | 76.3 | 78.0 |
| | 4 | " % | 75.6 | 76.5 | 77.7 | 78.8 | 79.8 | 80.8 |
| 4 | 2 | " % | 67.1 | 67.9 | 69.2 | 70.3 | 71.3 | 73.2 |
| | 3 | " % | 72.7 | 73.5 | 74.8 | 75.9 | 76.8 | 78.4 |
| | 4 | " % | 76.2 | 77.1 | 78.2 | 79.3 | 80.2 | 81.3 |
| 4½ | 2 | " % | 67.7 | 68.3 | 69.6 | 70.6 | 71.6 | 73.8 |
| | 3 | " % | 73.1 | 74.0 | 75.2 | 76.3 | 77.2 | 78.9 |
| | 4 | " % | 76.7 | 77.6 | 78.7 | 79.7 | 80.6 | 81.7 |
| 5 | 2 | " % | 68.0 | 68.7 | 70.0 | 71.0 | 72.0 | 74.2 |
| | 3 | " % | 73.5 | 74.4 | 75.6 | 76.7 | 77.6 | 79.2 |
| | 4 | " % | 77.2 | 78.0 | 79.1 | 80.1 | 81.1 | 82.1 |
| 6 | 2 | " % | 68.6 | 69.4 | 70.5 | 71.5 | 72.4 | 74.6 |
| | 3 | " % | 74.3 | 74.9 | 76.2 | 77.0 | 78.0 | 79.8 |
| | 4 | " % | 77.8 | 78.6 | 79.7 | 80.6 | 81.5 | 82.5 |
| 7 | 2 | " % | 69.1 | 69.7 | 70.9 | 71.8 | 72.7 | 74.9 |
| | 3 | " % | 74.6 | 75.4 | 76.6 | 77.5 | 78.4 | 80.3 |
| | 4 | " % | 78.3 | 79.0 | 80.1 | 81.0 | 81.9 | 83.0 |
| 8 | 2 | " % | 69.4 | 70.0 | 71.2 | 72.1 | 73.2 | 75.3 |
| | 3 | " % | 75.0 | 75.8 | 76.9 | 77.9 | 78.7 | 80.5 |
| | 4 | " % | 78.6 | 79.4 | 80.5 | 81.3 | 82.1 | 83.4 |
| 9 | 2 | " % | 69.7 | 70.2 | 71.3 | 72.3 | 73.6 | 75.6 |
| | 3 | " % | 75.2 | 75.9 | 77.0 | 78.0 | 79.0 | 80.9 |
| | 4 | " % | 78.9 | 79.7 | 80.7 | 81.6 | 82.3 | 83.7 |
| 10 | 2 | " % | 69.9 | 70.4 | 71.5 | 72.5 | 73.8 | 75.8 |
| | 3 | " % | 75.5 | 76.1 | 77.3 | 78.2 | 79.1 | 81.1 |
| | 4 | " % | 79.2 | 79.9 | 81.0 | 81.8 | 82.5 | 83.9 |



## Packaging Information—Air Cell Pipe Insulation Carton Contents

| Nominal Pipe Size | Three Ply (Per Carton) Ft. | Sec. | Gross Wt. lbs. | Four Ply (Per Carton) Ft. | Sec. | Gross Wt. lbs. |
|---|---|---|---|---|---|---|
| ½" | 180 | 60 | 61 | 132 | 44 | 66 |
| ¾" | 165 | 55 | 64 | 120 | 40 | 65 |
| 1" | 138 | 46 | 64 | 96 | 32 | 60 |
| 1¼" | 108 | 36 | 59 | 81 | 27 | 57 |
| 1½" | 96 | 32 | 57 | 72 | 24 | 56 |
| 2" | 72 | 24 | 50 | 54 | 18 | 50 |
| 2½" | 54 | 18 | 43 | 45 | 15 | 47 |
| 3" | 45 | 15 | 43 | 36 | 12 | 44 |
| ** 3½" | 51 | 17 | 52 | 42 | 14 | 56 |
| ** 4" | 45 | 15 | 52 | 33 | 11 | 49 |
| ** 5" | 33 | 11 | 46 | 21 | 7 | 38 |
| ** 6" | 21 | 7 | 36 | 18 | 6 | 39 |
| ** 8" | 15 | 5 | 33 | 12 | 4 | 33 |
| **10" | 12 | 4 | 33 | 9 | 3 | 31 |

**Shipped knocked down.
Empty carton weight—6 lbs.

Outside dimensions of carton 15" x 27¾" x 36¾".

## Simplex "Super Shrunk" Pipe Insulation

This pipe insulation is identical to four-ply air cell, except that instead of a pasted canvas outer jacket it is supplied with an outer casing of white asbestos felt. This outer felt is specially processed to produce a water repellent surface. It can be readily painted and easily cleaned with a damp cloth. Super shrunk pipe insulation is furnished in three-ply and four-ply only and is shipped complete with bands and fasteners.

Efficiencies for Simplex Pipe Insulation are the same as those given for Air Cell Pipe Insulation on Page 128.

## Packaging Information—Simplex Pipe Insulation Carton Contents

| Nominal Pipe Sizes | Three Ply (Per Carton) Ft. | Sec. | Gross Wt. lbs. | Four Ply (Per Carton) Ft. | Sec. | Gross Wt. lbs. |
|---|---|---|---|---|---|---|
| ½" | 180 | 60 | 61 | 132 | 44 | 66 |
| ¾" | 165 | 55 | 64 | 120 | 40 | 65 |
| 1" | 138 | 46 | 64 | 96 | 32 | 60 |
| 1¼" | 108 | 36 | 59 | 81 | 27 | 57 |
| 1½" | 96 | 32 | 57 | 72 | 24 | 56 |
| 2" | 72 | 24 | 49 | 54 | 18 | 50 |
| 2½" | 54 | 18 | 44 | 45 | 15 | 47 |
| 3" | 45 | 15 | 44 | 36 | 12 | 44 |
| 3½" | 36 | 12 | 39 | 27 | 9 | 38 |
| 4" | 27 | 9 | 33 | 24 | 8 | 37 |
| 5" | 21 | 7 | 32 | 15 | 5 | 29 |
| 6" | 18 | 6 | 32 | 15 | 5 | 33 |
| 8" | 12 | 4 | 28 | — | — | — |

Empty carton weight—6 lbs.

Outside dimensions of carton 15" x 27¾" x 36¾".

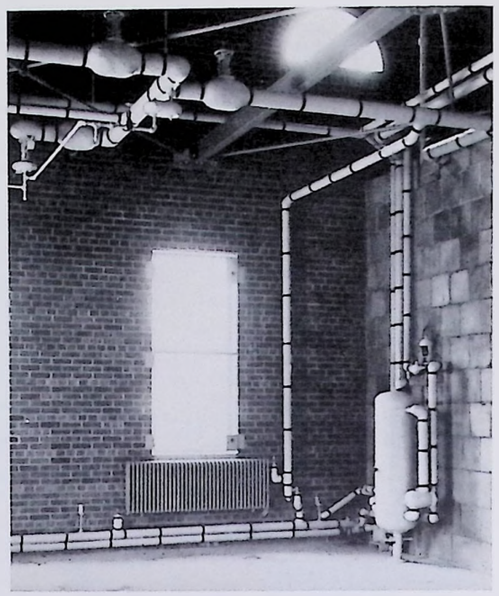


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## Fine Corrugated Air Cell Pipe Insulation

The greater strength of fine corrugated air cell pipe covering makes it specially suited for insulating medium and low pressure steam and hot water lines subject to excessive vibration. This sturdy material is unaffected by rough usage and can be removed and replaced many times without damage or loss of insulating properties.

Fine corrugated air cell is furnished in standard thickness of 4 and 6 plies, and each ply is approximately 1/16" thick. Greater thicknesses will be furnished when requested. Pipe covering sections are 3 feet long complete with canvas jacket and brass lacquered bands for application on all standard sizes of pipe.



Photograph shows part of the steam heating system at the U. S. Veterans' Hospital at Ft. Custer, Michigan. Fine corrugated Air Cell Covering was applied, then finished with a 4-oz. rewrapped canvas jacket sized and painted with lead and oil paint. Metal bands were then applied.

**Approx. Net Weights in Pounds per Standard 3 Foot Section**

| Thickness | Nominal Pipe Sizes, Inches | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ½ | ¾ | 1 | 1¼ | 1½ | 2 | 2½ | 3 | 3½ | 4 | 5 | 6 |
| 4 Ply | 0.92 | 1.07 | 1.22 | 1.44 | 1.55 | 1.86 | 2.16 | 2.53 | 2.81 | 3.12 | 3.75 | 4.43 |
| 6 Ply | 1.61 | 1.81 | 2.04 | 2.35 | 2.52 | 2.94 | 3.39 | 3.92 | 4.35 | 4.78 | 5.69 | 6.65 |

## Special Fine Corrugated Air Cell Pipe Insulation

Special fine corrugated air cell insulation, constructed with 8 plies per inch, provides high mechanical strength, greater efficiency with minimum heat loss for temperatures up to 300° F. Because it will withstand rougher handling and more severe service conditions, this covering is widely used in place of regular air cell in industrial applications for insulation of medium and low pressure steam and hot water lines.

Special fine corrugated air cell is furnished in thicknesses of 4, 6, and 8 plies. Each ply is approximately 1/8" thick. Greater thicknesses can be supplied on special order. Individual pipe covering sections are 3' long and are shipped complete with canvas jackets and brass lacquered bands, for application.

## Air Cell Sheets and Blocks

Air cell sheets and blocks are used for the insulation of low pressure boilers, feed water heaters, dry kilns, warm air ducts, boiler room ceilings, partitions, ovens, and stoves operating at medium and low temperatures.

Sheets and blocks are furnished in standard 6", 9", 12", 18", 36", and 72" lengths. They are 36" wide and thicknesses range from ½" to 4". Other sizes and thicknesses can be specially ordered. Each corrugated ply of the material is a full 1/16" thick. Air cell sheets and blocks weigh approximately 1 lb. per sq. ft. per 1" thickness.



**Heat Losses and Efficiencies of Air Cell Sheets and Blocks**

| Thickness of insulation, inches | Temperature difference between hot surface and surrounding air, Deg. F. / Temperature of hot surface (Temperature of surrounding air, 75° F.) / Heat losses per square foot of bare surface per hour; and Efficiencies of insulation | | | | | |
|---|---|---|---|---|---|---|
| | | 50° / 125° | 100° / 175° | 150° / 225° | 200° / 275° | 250° / 325° |
| 0 | Bare surface loss, B.t.u. | 97.5 | 215.2 | 360.0 | 533.0 | 737.8 |
| 1 | Efficiency % | 79.95 | 80.89 | 81.13 | 81.37 | 81.80 |
| 1½ | " % | 85.62 | 86.21 | 86.40 | 86.55 | 86.80 |
| 2 | " % | 88.74 | 89.23 | 89.29 | 89.47 | 89.68 |
| 2½ | " % | 90.74 | 91.09 | 91.14 | 91.33 | 91.52 |
| 3 | " % | 92.17 | 92.41 | 92.50 | 92.66 | 92.74 |
| 3½ | " % | 93.19 | 93.40 | 93.49 | 93.62 | 93.71 |
| 4 | " % | 94.05 | 94.20 | 94.25 | 94.34 | 94.43 |

## Fine Corrugated Air Cell Sheets and Blocks

These sheets and blocks are mechanically stronger and possess higher insulating efficiency than the ordinary four-ply air cell material.

They are furnished in standard 6", 9", 12", 18", 36", and 72" lengths and in 36" widths, in thicknesses of ½", 1", 1½", 2", 2½", 3", 3½", and 4". Other sizes and thicknesses can be furnished on request. Each ply is a full 1/16" thick. Fine corrugated air cell sheets and blocks weigh approximately 1.3 lbs. per sq. ft. per 1" thickness.

**Heat Losses and Efficiencies of Fine Corrugated Air Cell Sheets and Blocks**

| Thickness of insulation, inches | Temperature difference between hot surface and surrounding air, Deg. F. / Temperature of hot surface (Temperature of surrounding air, 75° F.) / Heat losses per square foot of bare surface per hour; and Efficiencies of insulation | | | | | |
|---|---|---|---|---|---|---|
| | | 50° / 125° | 100° / 175° | 150° / 225° | 200° / 275° | 250° / 325° |
| 0 | Bare surface loss, B.t.u. | 97.5 | 215.2 | 360.0 | 533.0 | 737.8 |
| 1 | Efficiency % | 80.87 | 81.96 | 82.59 | 83.10 | 83.81 |
| 1½ | " % | 86.28 | 87.00 | 87.50 | 87.88 | 88.32 |
| 2 | " % | 89.29 | 89.84 | 90.19 | 90.54 | 90.88 |
| 2½ | " % | 91.19 | 91.63 | 91.94 | 92.21 | 92.51 |
| 3 | " % | 92.44 | 92.88 | 93.15 | 93.43 | 93.60 |
| 3½ | " % | 93.53 | 93.82 | 94.05 | 94.27 | 94.45 |
| 4 | " % | 94.44 | 94.56 | 94.75 | 94.93 | 95.08 |



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### Packaging Information—Carton Contents
### Air Cell and Fine Corrugated Air Cell Sheets and Blocks

| Size of Sheets and Blocks | Thickness inches—Ply | | | | | | |
|---|---|---|---|---|---|---|---|
| | *½"–2<br>**½"–3 | *¾"–3 | *1"–4<br>**1"–6 | *1¼"–5 | *1½"–6<br>**1½"–9 | *1¾"–7 | *2"–8<br>**2"–12 |
| | Number of Sheets or Blocks per Carton | | | | | | |
| 36" x 36" | 23 | 15 | 12 | 9 | 8 | 7 | 6 |
| 12" x 36" | 69 | 45 | 36 | 27 | 24 | 21 | 18 |
| 6" x 36" | 138 | 90 | 72 | 54 | 48 | 42 | 36 |
| Sq. Feet per Carton | 207 | 135 | 108 | 81 | 72 | 63 | 54 |

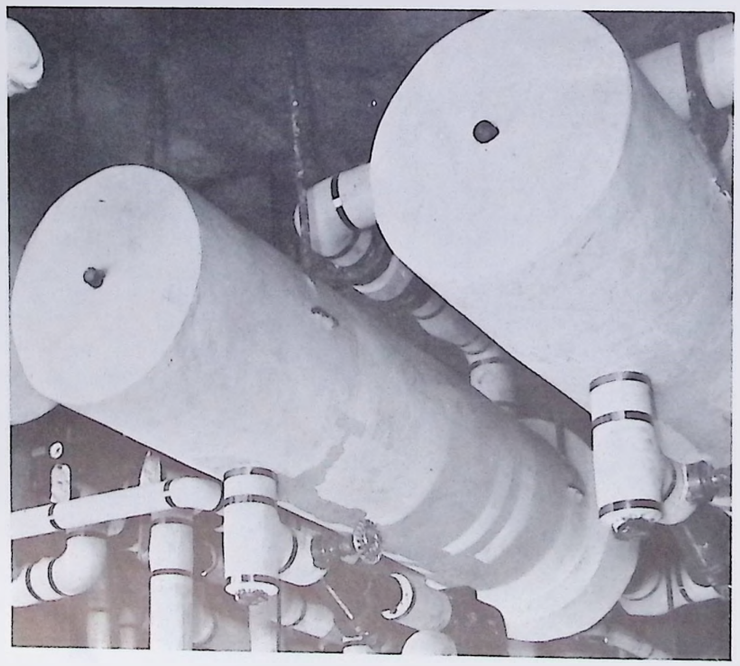
*Air Cell Sheets and Blocks.
**Fine Corrugated Air Cell Sheets and Blocks.

Gross Weight approx.—80 lbs. per carton for Air Cell Sheets and Blocks.
Gross Weight approx.—110 lbs. per carton for Fine Corrugated Air Cell Sheets and Blocks.

Empty Carton weight—5 lbs.
Outside Dimensions of Carton—36¾" x 36¾" x 13".

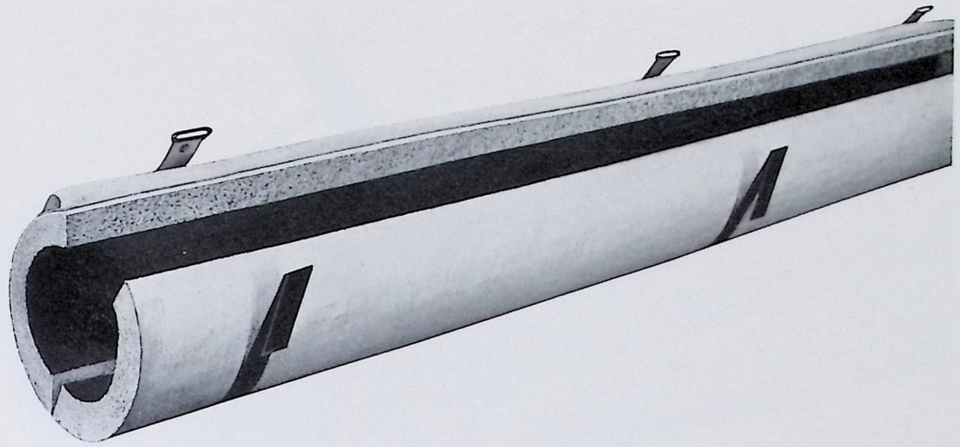
## Special Fine Corrugated Air Cell Sheets and Blocks

Special fine corrugated air cell sheets and blocks possess high mechanical strength and insulating efficiency. They are furnished in standard thicknesses of 9, 12, 18, 36, and 72" lengths and in 36" widths. Thicknesses are 4-ply, 6-ply, and 8-ply. Each ply is approximately ⅛" thick. Other sizes and thicknesses of Air Cell Sheets and Blocks can be supplied on special order.



Two layers of Air Cell Board, each 1" thick were used to insulate these hot water converters. Finishing cement then was trowelled on over hexagonal wire mesh.





# Duplex Pipe Insulation

Duplex Pipe Insulation is adaptable for the insulation of either hot or cold water service lines. Its top temperature limit is 212° F. This material is composed of a special interliner of saturated felt impregnated with waterproofing compound, followed by a continuous wrapping of specially creped felt. An outer wrapping of asbestos paper is then applied over the felt and the covering is finished with a canvas jacket. When applied to the line, it has a white appearance similar to magnesia and air cell pipe covering. Single layer Duplex Pipe Insulation is manufactured in 3 feet long sections in thicknesses of ½", ¾", and 1". It is supplied complete with canvas jacket and the necessary lacquered bands for application.

Double layer Duplex Pipe Insulation is manufactured in two layers of equal thickness to a total thickness of 1", 1½", and 2".

Duplex Pipe Insulation is furnished with a canvas jacket and necessary bands for application.

### Heat Transmission Through Duplex

BTU's per sq. ft. of pipe surface/hr./degree F. temperature difference between pipe and surrounding air

| Pipe Size Inches | Thickness of Covering Inches | | | |
|---|---|---|---|---|
| | ½ | ¾ | 1 | 1½ |
| ½" | .776 | .658 | .585 | .495 |
| ¾" | .719 | .605 | .530 | .444 |
| 1" | .670 | .556 | .483 | .398 |
| 1¼" | .633 | .516 | .446 | .362 |
| 1½" | .610 | .495 | .424 | .343 |
| 2" | .581 | .469 | .398 | .316 |
| 2½" | .561 | .448 | .378 | .298 |
| 3" | .545 | .430 | .361 | .281 |
| 3½" | .535 | .420 | .350 | .271 |
| 4" | .527 | .412 | .343 | .264 |
| 4½" | .520 | .405 | .336 | .257 |
| 5" | .514 | .399 | .331 | .251 |
| 6" | .505 | .389 | .321 | .243 |

### Packaging Information—Carton Contents Duplex Pipe Insulation

| Nominal Pipe Size | ½" Thick | | | ¾" Thick* | | | 1" & Double ½" Thick | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ft. | Sec. | Gross Wt. lbs. | Ft. | Sec. | Gross Wt. lbs. | Ft. | Sec. | Gross Wt. lbs. |
| ½" | 180 | 60 | 68 | 114 | 38 | 74 | 81 | 27 | 81 |
| ¾" | 150 | 50 | 63 | 96 | 32 | 72 | 72 | 24 | 81 |
| 1" | 123 | 41 | 63 | 84 | 28 | 73 | 60 | 20 | 76 |
| 1¼" | 96 | 32 | 59 | 69 | 23 | 70 | 51 | 17 | 75 |
| 1½" | 84 | 28 | 56 | 60 | 20 | 66 | 45 | 15 | 71 |
| 2" | 60 | 20 | 49 | 45 | 15 | 59 | 36 | 12 | 67 |
| 2½" | 45 | 15 | 44 | 36 | 12 | 55 | 27 | 9 | 59 |
| 3" | 36 | 12 | 42 | 27 | 9 | 49 | 21 | 7 | 53 |
| 3½" | 27 | 9 | 36 | 21 | 7 | 43 | 18 | 6 | 51 |

*Note—Double ¾" thickness not stocked. Shipped in crates.
Empty carton weight—5 lbs.

Outside dimensions of carton 14" x 20½" x 36¾".



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# Non-Frost Pipe Insulation

Non-Frost Pipe Insulation is applied to retard freezing in cold water and drain pipes in unheated rooms or where they are exposed to outside temperatures under normal conditions.

This insulation is constructed of layers of hair felt covered with several layers of paper felt and lined with a layer of specially treated paper felt to prevent the hair felt from coming in direct contact with the pipe surface. The hair felt because of its excellent insulating properties, is used to retard the escape of heat from the water in the pipes to the colder surrounding air. The paper felt jacket and the inner layer of treated paper felt protects the hair felt from infiltration of moisture that would impair its insulating efficiency.

Non-Frost Pipe Insulation should be used only on cold water pipes that are exposed to moderate rather than extremely low temperatures, or where the time that the surrounding air would be below the freezing point is of short duration. When Non-Frost Pipe Insulation is applied to outdoor piping, special provisions must be made for weatherproofing and protecting it.

Pipe covering is furnished in 3′ sections, with canvas jacket and brass lacquered bands for application. It is manufactured in one thickness, 1¼″, for all pipe sizes from ½″ up.

### Heat Transmission of Non-Frost Pipe Insulation

Heat Transmission of Non-Frost Pipe Covering (1¼″ thick) in B. T. U. per hour, per deg. F. temperature difference between pipe and air. (Based on 50° temperature difference—between pipe and surrounding air.)

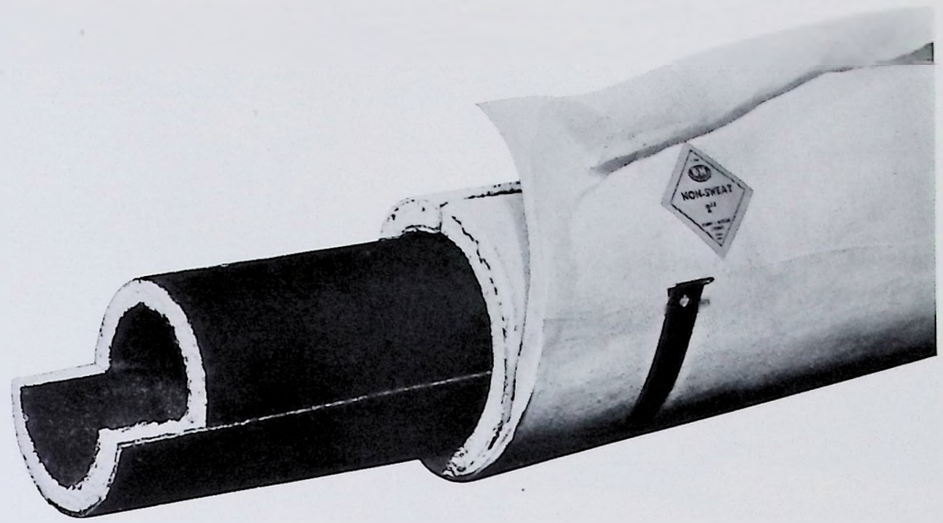
| Pipe Size | Per lin. ft. |
|---|---|
| ½″ | .133 |
| ¾″ | .151 |
| 1″ | .170 |
| 1¼″ | .196 |
| 1½″ | .211 |
| 2″ | .249 |
| 2½″ | .284 |
| 3″ | .330 |
| 3½″ | .366 |
| 4″ | .400 |
| 4½″ | .435 |
| 5″ | .472 |
| 6″ | .550 |

### Packaging Information—Carton Contents

| Nominal Pipe Size | Ft. | Sec. | Gross Wt. lbs. |
|---|---|---|---|
| ½″ | 63 | 21 | 89 |
| ¾″ | 54 | 18 | 85 |
| 1″ | 45 | 15 | 79 |
| 1¼″ | 42 | 14 | 84 |
| 1½″ | 36 | 12 | 77 |
| 2″ | 33 | 11 | 82 |
| 2½″ | 24 | 8 | 69 |
| 3″ | 18 | 6 | 59 |
| 3½″ | 18 | 6 | 65 |
| 4″ | 12 | 4 | 49 |

Empty carton weight—5 lbs.
Outside dimensions of carton 14″ x 20½″ x 36½″.






# Non-Sweat Pipe Insulation

Non-Sweat Pipe Insulation is a combination of insulating and waterproofing felts used to prevent condensation on cold water lines. The insulating felts protect the flow of heat to the pipe. The waterproofing felt protects the insulation from the moisture in the air.

Non-Sweat Pipe Insulation is furnished in single and double layer construction. Single layer Non-Sweat is made in thicknesses of ½″ and ¾″. Double layer is made in thicknesses of 1″, 1½″, 2″. The illustration on this page shows double layer or broken joint construction used in thicknesses of 1″ and over. This construction eliminates the longitudinal and abutting joints that in ordinary pipe covering extend from the outside of the covering to the pipe.

### Recommended Thicknesses—Non-Sweat Pipe Insulation

| Air Temperature under 100 deg. F. | | | |
|---|---|---|---|
| Pipe Temp. Deg. F. | Humidity Range, % | Thickness of Non-Sweat on Pipes | Thickness of Hair Felt on Fitting |
| Over 50 | Under 75 | ½″–1″ | ½″–1″ |
| Over 50 | 75 to 80 | 1″–1½″ | 1″–1½″ |
| 32 to 50 | Under 75 | 1½″–2″ | 1½″–2″ |

### Heat Transmission Through Non-Sweat Pipe Insulation

Rates of heat transmission are given in B.t.u. per hour, per deg. F. temperature difference, per linear foot and per square foot of pipe surface.

| Insulation | ½″ thick | | ¾″ thick | | 1″ thick | | 1½″ thick | | 2″ thick | |
|---|---|---|---|---|---|---|---|---|---|---|
| Pipe size, inches | B.t.u. per lin. ft. | B.t.u. per sq. ft. | B.t.u. per lin. ft. | B.t.u. per sq. ft. | B.t.u. per lin. ft. | B.t.u. per sq. ft. | B.t.u. per lin. ft. | B.t.u. per sq. ft. | B.t.u. per lin. ft. | B.t.u. per sq. ft. |
| ½ | .212 | .963 | .185 | .841 | .167 | .758 | .143 | .649 | .128 | .581 |
| ¾ | .245 | .891 | .212 | .770 | .189 | .687 | .160 | .581 | .142 | .515 |
| 1 | .286 | .830 | .243 | .706 | .215 | .625 | .180 | .523 | .158 | .460 |
| 1¼ | .338 | .777 | .284 | .653 | .249 | .572 | .206 | .473 | .180 | .413 |
| 1½ | .374 | .751 | .312 | .627 | .272 | .546 | .223 | .448 | .194 | .389 |
| 2 | .443 | .713 | .367 | .591 | .318 | .512 | .257 | .413 | .221 | .356 |
| 2½ | .518 | .688 | .425 | .564 | .364 | .484 | .292 | .388 | .249 | .331 |
| 3 | .611 | .666 | .497 | .542 | .423 | .462 | .337 | .367 | .284 | .310 |
| 3½ | .685 | .655 | .553 | .528 | .468 | .447 | .369 | .353 | .311 | .297 |
| 4 | .757 | .643 | .611 | .518 | .515 | .437 | .404 | .343 | .338 | .287 |



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## Packaging Information—Non-Sweat Pipe Insulation
### Carton Contents

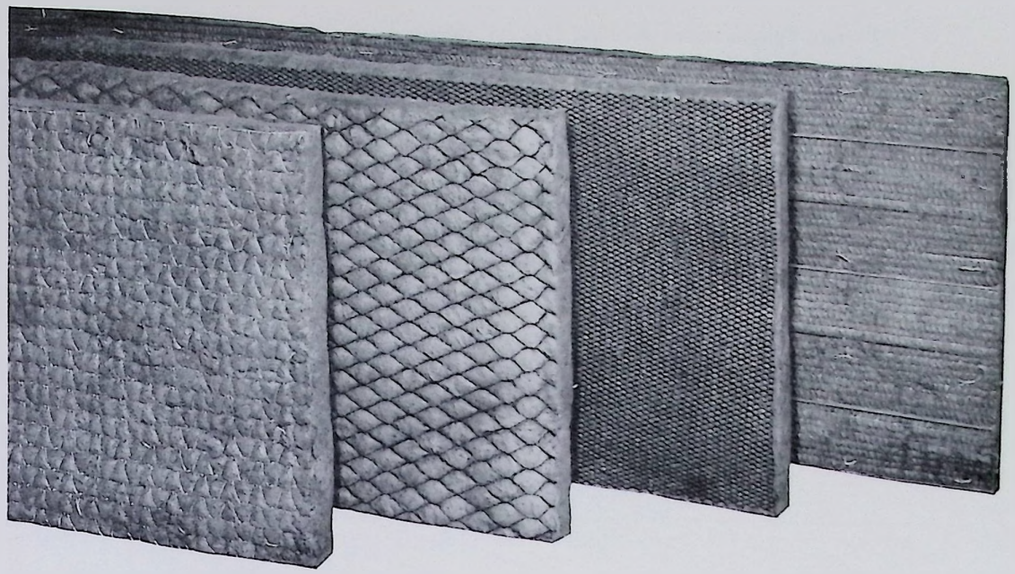
| Nominal Pipe Size | ½" Thick | | | ¾" Thick* | | | 1" & Double ½" Thick | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ft. | Sec. | Gross Wt. lbs. | Ft. | Sec. | Gross Wt. lbs. | Ft. | Sec. | Gross Wt. lbs. |
| ½" | 180 | 60 | 68 | 114 | 38 | 74 | 81 | 27 | 81 |
| ¾" | 150 | 50 | 63 | 96 | 32 | 72 | 72 | 24 | 81 |
| 1" | 123 | 41 | 63 | 84 | 28 | 73 | 60 | 20 | 76 |
| 1¼" | 96 | 32 | 59 | 69 | 23 | 70 | 51 | 17 | 75 |
| 1½" | 84 | 28 | 56 | 60 | 20 | 66 | 45 | 15 | 71 |
| 2" | 60 | 20 | 49 | 45 | 15 | 59 | 36 | 12 | 67 |
| 2½" | 45 | 15 | 44 | 36 | 12 | 55 | 27 | 9 | 59 |
| 3" | 36 | 12 | 42 | 27 | 9 | 49 | 21 | 7 | 53 |
| 3½" | 27 | 9 | 36 | 21 | 7 | 43 | 18 | 6 | 51 |

*Note—Double ¾" thickness not stocked. Shipped in crates.

## Approximate Net Weights of Pipe Insulations
(Pounds Per Three Foot Section)

| Type of Insulation | Thickness Inches | Nominal Pipe Sizes, Inches | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ½" | ¾" | 1" | 1¼" | 1½" | 2" | 2½" | 3" | 3½" | 4" | 4½" | 5" | 6" | 7" | 8" | 9" | 10" | 12" |
| 85% Magnesia | Std. | 1.39 | 1.58 | 1.78 | 2.07 | 2.21 | 3.20 | 3.66 | 4.23 | 4.68 | 5.69 | 6.19 | 6.75 | 7.87 | 10.02 | 11.08 | 12.32 | 13.43 | 18.70 |
| 85% Magnesia | 1½ | 3.18 | 3.50 | 3.84 | 4.34 | 4.58 | 5.24 | 5.91 | 6.72 | 7.38 | 8.04 | 8.70 | 9.45 | 10.94 | 12.26 | 13.59 | 15.08 | 16.39 | 18.70 |
| 85% Magnesia | 2 | 5.10 | 5.54 | 5.98 | 6.62 | 6.97 | 7.85 | 8.71 | 9.81 | 10.69 | 11.57 | 12.43 | 13.44 | 15.41 | 17.17 | 18.93 | 20.88 | 22.63 | 25.80 |
| 85% Magnesia | Dbl. Std. | 5.22 | 5.18 | 6.40 | 6.22 | 7.14 | 8.78 | 9.74 | 10.70 | 13.83 | 13.05 | 17.02 | 15.93 | 19.19 | 22.62 | 24.80 | | | |
| 85% Magnesia | 3 | 10.34 | 10.04 | 12.02 | 13.43 | 13.30 | 14.86 | 14.28 | 17.69 | 16.88 | 20.34 | 19.31 | 22.85 | 25.81 | 28.92 | | | | |
| Hy-Temp | 1½ | 5.61 | 6.17 | 6.78 | 7.65 | 8.09 | 9.65 | 8.61 | 12.04 | 10.57 | 14.40 | 12.54 | 16.51 | 19.13 | 21.45 | 23.77 | 25.20 | 30.00 | |
| Hy-Temp | 2 | 9.01 | 9.76 | 10.57 | 11.71 | 12.31 | 14.64 | 13.60 | 17.54 | 16.07 | 20.68 | 18.82 | 24.46 | 27.05 | 30.14 | 33.24 | 38.02 | 41.21 | |
| Air Cell | 3 Ply | .92 | 1.05 | 1.26 | 1.47 | 1.58 | 1.79 | 2.10 | 2.52 | 2.73 | 3.05 | 3.36 | 3.68 | 4.31 | 4.83 | 5.46 | 6.09 | 6.72 | 7.88 |
| Air Cell | 4 Ply | 1.37 | 1.47 | 1.68 | 1.89 | 2.10 | 2.42 | 2.73 | 3.15 | 3.57 | 3.89 | 4.20 | 4.62 | 5.46 | 6.09 | 6.83 | 7.67 | 8.30 | 9.77 |
| Fine Corrugated | 4 Ply | .92 | 1.07 | 1.22 | 1.44 | 1.55 | 1.86 | 2.16 | 2.53 | 2.81 | 3.12 | 3.41 | 3.75 | 4.43 | | | | | |
| Fine Corrugated | 6 Ply | 1.61 | 1.81 | 2.04 | 2.35 | 2.52 | 2.94 | 3.39 | 3.92 | 4.35 | 4.78 | 5.20 | 5.69 | 6.65 | | | | | |
| Special Fine Corrugated | 6 Ply | 1.33 | 1.54 | 1.75 | 2.06 | 2.23 | 2.63 | 3.06 | 3.55 | 3.98 | 4.37 | 4.78 | 5.25 | 6.14 | 6.97 | 7.79 | 8.77 | 9.59 | 11.24 |
| Special Fine Corrugated | 8 Ply | 1.97 | 2.31 | 2.60 | 3.02 | 3.21 | 3.76 | 4.34 | 5.00 | 5.54 | 6.12 | | 7.25 | 8.53 | | 10.71 | | 13.07 | |
| Bestfelt | 1 | 4.39 | 4.94 | 5.54 | 6.38 | 6.85 | 8.04 | 9.22 | 10.67 | 11.80 | 12.98 | 14.07 | 15.44 | 18.14 | 20.43 | 22.74 | 25.49 | 28.60 | 32.55 |
| Non-Sweat | ½ | 1.55 | 1.84 | 2.11 | 2.56 | 2.77 | 3.32 | 3.93 | 4.60 | 5.19 | 5.73 | | | | | | | | |
| Non-Sweat | ¾ | 2.73 | 3.17 | 3.61 | 4.24 | 4.60 | 5.44 | 6.30 | 7.31 | 8.19 | 9.07 | | 10.83 | 12.75 | 14.39 | 16.17 | 18.10 | 19.80 | |
| Non-Sweat | 1 | 4.26 | 4.79 | 5.40 | 6.20 | 6.64 | 7.77 | 8.95 | 10.29 | 11.45 | 11.87 | | 14.97 | 17.60 | 19.87 | 22.05 | 24.74 | 27.03 | |
| Non-Sweat | 1½ | 8.09 | 8.88 | 9.77 | 11.03 | 11.70 | 13.44 | 15.12 | 17.22 | 18.90 | 20.58 | | 24.19 | 27.97 | 31.50 | 34.86 | 38.64 | 42.00 | |
| Duplex | ½ | 1.05 | 1.16 | 1.41 | 1.70 | 1.83 | 2.21 | 2.60 | 3.05 | 3.43 | 3.80 | 4.18 | 4.61 | 5.46 | | 6.41 | | | |
| Duplex | ¾ | 1.81 | 2.10 | 2.42 | 2.81 | 3.05 | 3.59 | 4.17 | 4.86 | 5.43 | 6.01 | 6.56 | 7.25 | 8.48 | | 10.72 | | | |
| Duplex | 1 | 2.81 | 3.17 | 3.57 | 4.13 | 4.43 | 5.17 | 5.95 | 6.86 | 7.62 | 8.37 | 9.07 | 10.02 | 11.72 | | 14.73 | | | |
| Duplex | 1½ | 5.38 | 5.88 | 6.49 | 7.35 | 7.79 | 8.95 | 10.08 | 11.59 | 12.60 | 13.71 | | 16.21 | 18.69 | | | | | |
| Non-Frost | Std. (1¼) | 4.01 | 4.46 | 4.94 | 5.67 | 6.03 | 6.98 | 7.94 | 9.03 | 9.98 | 10.92 | | | | | | | | |





# Mineral Wool Blankets

Mineral Wool Blankets are suitable for insulation of hot surfaces up to 1200° F. These blankets are made by felting high temperature and moisture resistant insulating wool in large flat sheets between various styles of metal fabrics.

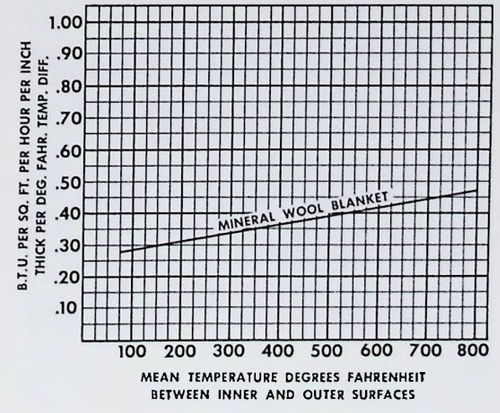
These blankets are flexible, and can be applied to equipment having curved or irregular surfaces at minimum cost.

Mineral Wool Blankets are manufactured in standard sizes of 2 x 4 feet and 2 x 8 feet and in thicknesses of 1" to 8". Special sizes can be made upon request.

Standard styles of Mineral Wool Blankets are:

| Style | Description |
|---|---|
| 1 | 1" wire mesh both sides |
| 2 | 1" wire mesh and stucco lath |
| 2-A | 1" wire mesh and expanded metal lath |
| 3 | Stucco lath both sides |
| 3-A | Expanded metal lath both sides |
| 3-B | Stucco lath one side—expanded metal lath other side |
| 4 | Stucco lath and ⅜" ribbed lath (rib turned in) |
| 4-A | Stucco lath and ⅜" ribbed lath (rib turned out) |
| 5 | Stucco lath and ¾" ribbed lath (rib turned in) |
| 5-A | Stucco lath and ¾" ribbed lath (rib turned out) |
| 6 | ⅜" ribbed lath both sides (rib turned in) |

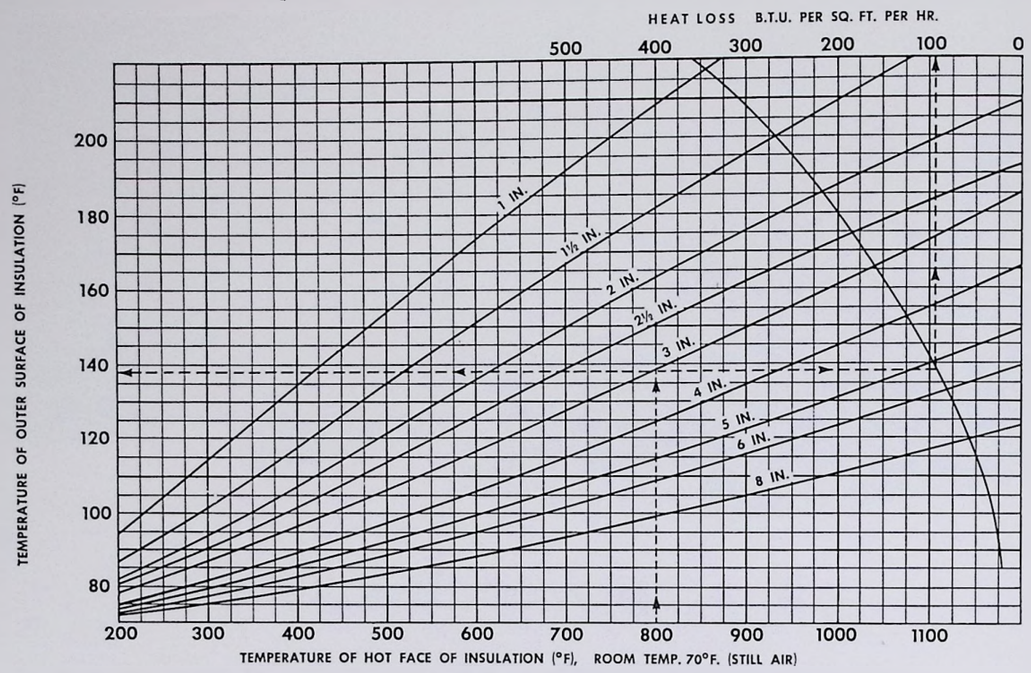
**Conductivity vs Mean Temperature**
**Mineral Wool Blanket**






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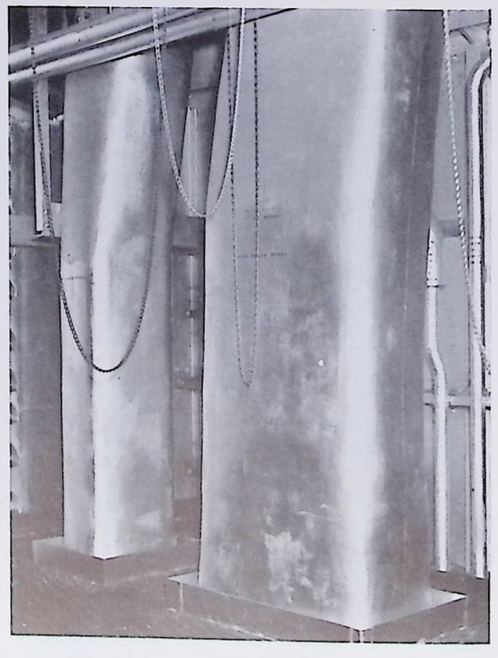
**Surface Temperatures and Heat Loss for Mineral Wool Blanket Insulation**



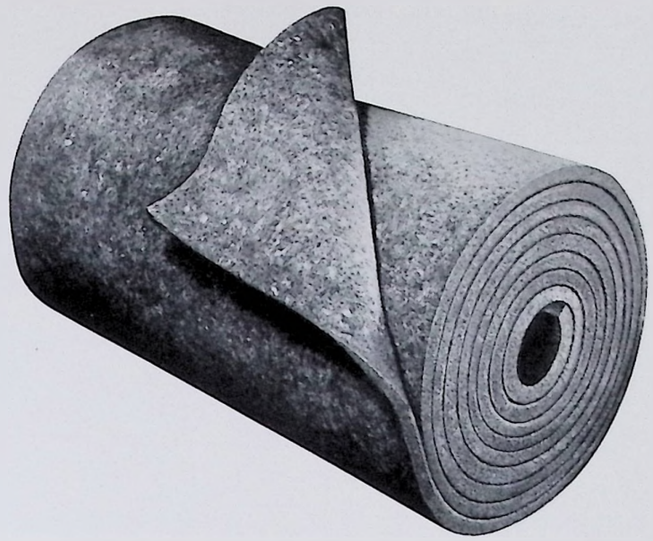

Heat Loss Chart—To determine the surface temperature of a given thickness of Blanket, read the chart as follows: Under table of recommended thicknesses, a 3-in. Blanket is suggested for equipment having a hot surface temperature of 800° F. Therefore follow vertically from the 800° F. point until that line intercepts the 3-in. curve. At that point, follow in a horizontal line to the left until it intercepts the margin, and it will be seen that at that point the figure is 138, which is the temperature in degrees Fahrenheit of the cold surface on the outside of the mineral wool blanket.

Similarly, to determine the heat loss for a given condition, refer again to the example on the chart:

Follow vertically from the 800° F. mark, to an intersection with the 3-in. curve. From that point, follow horizontally to the right until intercepting the heat loss curve. At this point, go vertically to the upper margin which is calibrated in terms of b.t.u. heat loss, and it will be seen that the heat loss for this particular condition is 95 b.t.u. per sq. ft. per hour.







# Hair Felt Insulation (Navy Standard)

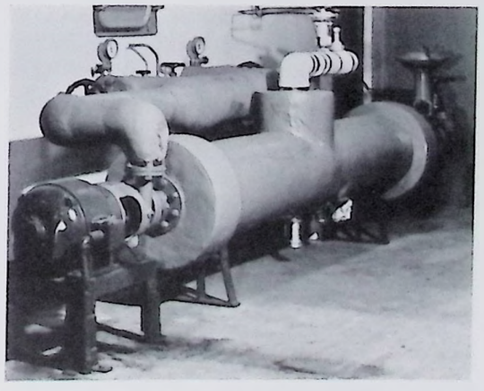
Hair Felt is composed of 100% selected cattle hair processed into roll blankets. The primary use of hair felt insulation is to prevent water pipes from freezing. This material is used in a specified number of built-up layers of 1″ thicknesses, bound in place on the pipe with heavy jute twine and protected on the outer surface with a weatherproof jacket.

Hair Felt is furnished in standard rolls of 3′ x 100′, 3′ x 50′, 6′ x 50′, and 9′ x 50′ in the thicknesses and weights shown in the table below:

| Thicknesses | Approx. weight per sq. ft. | Approx. weight per 300 sq. ft. roll |
|---|---|---|
| ¼″ | 4 oz. | 75 lbs. |
| ½″ | 6¼ oz. | 120 lbs. |
| ¾″ | 8½ oz. | 160 lbs. |
| 1″ | 11 oz. | 210 lbs. |
| 1¼″ | 13½ oz. | 255 lbs. |
| 1½″ | 16 oz. | 300 lbs. |
| 2″ | 21 oz. | 395 lbs. |

It must be remembered that no insulation, regardless of thickness or effectiveness, will prevent water in pipes from freezing where insufficient circulation of water exists, or where the outside temperature remains sufficiently low for any appreciable length of time. Insulation will retard freezing of water in pipes if there is a certain amount of circulation. With no circulation, if the air remains at low temperature for only a short period of time freezing can be prevented by the insulation.

The table on Page 140 gives rates of heat transmission through 2 layer, 3 layer, and 4 layer built-up hair felt insulation on pipes from ½″ to 12″ in diameter.



Fittings on the line supplying cold water to this hot water generator are insulated with built-up hair felt. Non-Sweat Pipe Covering was used on straight pipe run.



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## Data on Freezing of Water in Pipes

| Nominal pipe size inches | Insulation, No. of layers each 1 in. thick | B.T.U. per deg. F. temp. diff. per hour per lin. ft. | Hours to cool to freezing point | Lb. water flow per hr. per lin. ft. to prevent freezing |
|---|---|---|---|---|
| ½ | 2 | .0895 | .417 | .537 |
| | 3 | .0747 | .500 | .448 |
| | 4 | .0660 | .565 | .396 |
| 1 | 2 | .1125 | .825 | .675 |
| | 3 | .0911 | 1.02 | .548 |
| | 4 | .0798 | 1.16 | .480 |
| 1½ | 2 | .1400 | 1.40 | .840 |
| | 3 | .1126 | 1.74 | .676 |
| | 4 | .0972 | 2.02 | .583 |
| 2 | 2 | .1586 | 1.94 | .952 |
| | 3 | .1244 | 2.48 | .747 |
| | 4 | .1063 | 2.90 | .638 |
| 3 | 2 | .2062 | 3.25 | 1.237 |
| | 3 | .1572 | 4.27 | .943 |
| | 4 | .1322 | 5.08 | .793 |
| 4 | 2 | .2450 | 4.55 | 1.470 |
| | 3 | .1850 | 6.02 | 1.110 |
| | 4 | .1548 | 7.20 | .929 |
| 5 | 2 | .2887 | 5.92 | 1.733 |
| | 3 | .2146 | 7.96 | 1.289 |
| | 4 | .1764 | 9.69 | 1.059 |
| 6 | 2 | .3302 | 7.35 | 1.981 |
| | 3 | .2434 | 9.88 | 1.460 |
| | 4 | .1984 | 12.20 | 1.191 |
| 8 | 2 | .4100 | 10.05 | 2.460 |
| | 3 | .2960 | 13.90 | 1.776 |
| | 4 | .2390 | 17.25 | 1.434 |
| 10 | 2 | .4930 | 13.00 | 2.960 |
| | 3 | .3536 | 18.10 | 2.122 |
| | 4 | .2830 | 22.70 | 1.698 |
| 12 | 2 | .5720 | 15.80 | 3.432 |
| | 3 | .4090 | 22.20 | 2.454 |
| | 4 | .3222 | 28.10 | 1.933 |

Figures are given to show the time required for the water in a pipe to cool 10° F. from 42° to 32° F., but a difference in temperature between water and air at 60° F., which would correspond to an air temperature of 18° below zero. Water should not be allowed to remain in the pipes without circulation for longer than ½ the time mentioned.

The last column of figures in the table indicates the minimum amount of water that should be supplied per hour at 42° F., per each lineal foot of pipe in order to prevent the temperature of the water from dropping to the freezing point. As a safety factor to provide against temporary reduction of flow due to lower pressure or other causes, the rate of flow should be at least double that given in the table. Figures on time and flow apply only to the given conditions.

For example, if water enters the pipes at 52° F., instead of 42° F. it will take double the given time to cool the water to the freezing point and only half the amount of water will be required to circulate to prevent freezing.

On the other hand, if water enters at 33° F. it will be cooled to 32° F. in $\frac{1}{10}$ the time given in the table and 10 times as much water will have to be circulated to prevent freezing.

The times shown in the table are those required to lower the water to the freezing point. Actually, longer times would be required to freeze all the water in the pipes, but once the water starts to freeze the danger point has been reached. If frozen at only one point, flow will be stopped and the entire line endangered.

If the water remains without circulation longer than the safe time indicated, the only positive way to protect the line is to provide a small steam or hot water line along side the cold water line and then apply insulation so that it entirely surrounds both lines.





# Insulating Cements and Finishes

Insulating cements are used as insulation and as finishes. They are applied as insulation to fittings too small to be insulated with blocks, and on irregular surfaces or inaccessible surfaces that cannot be practically covered with pipe insulation or blocks. Insulating cements, like other heat insulating materials, have top temperature limits at which they may be expected to perform efficiently. Other important physical characteristics that must be considered in the choice of a cement are outlined under the descriptive material on each cement.

### No. 152 Asbestos Cement

This is an inexpensive, high-grade insulating cement made of asbestos fibers and binding materials. It may be applied to hot surfaces up to 600° F. As a finishing cement, it produces a hard, durable and smooth finish. This is a natural colored cement which dries to a very light gray shade. Where extra hard finish is required, Portland Cement may be added to No. 152 Asbestos Cement, mixing three parts asbestos cement and one part Portland Cement by weight. No. 152 Asbestos Cement is also used for roughing in.

### Hy-Temp Cement

This cement is similar in composition to Hy-temp insulation in powder form and can be used on surfaces up to temperatures of 1900° F. It is recommended for use on irregular or small surfaces where the application of Hy-temp blocks or pipe insulation is impractical, and for pointing up of Hy-temp block and pipe insulation applications. Because of its relatively porous nature, Hy-temp cement is not recommended as a finishing cement.

### 85% Magnesia Cement

This cement is similar in composition to 85% Magnesia Pipe Covering and Block Insulation but it is made in powder form. Efficiency of 85% Magnesia Cement is higher than that of any other plastic insulation. It is also extremely light in weight. The cement may be used on heated surfaces up to 600° F.

This cement is not ordinarily used as a finishing cement. Usually a layer of asbestos cement is used over 85% Magnesia Cement as a finish. When an extra hard finish is required, Portland



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Cement is added to the asbestos cement. (See "No. 152 Asbestos Cement.")

### Amblerex No. 2 Cement

This insulating cement is particularly recommended for roughing in. It is composed of asbestos fibers, 85% Magnesia, and binders. It is ideal for use on fittings, irregular surfaces, and other places where highly efficient insulation is desired at a cost that is considerably below that of 85% Magnesia Cement. It may be used for temperatures up to 1000° F.

### Mineral Wool Cement

Mineral Wool Cement is a plastic insulation made of heat resisting mineral wool combined with asbestos fiber and special clays. It will withstand temperatures up to 1800° F. It can be reclaimed if the temperatures have not exceeded 1200° F. It is an ideal plastic insulation for insulating surfaces not suited to preformed types of insulation.

### Power House Cement

Power House Cement is manufactured by the Baldwin Hill Company and is a hydraulic setting mineral wool cement. It is both a finishing and an insulating cement. It has exceptionally low shrinkage and can be applied in one coat without cracking. Due to its high adhesive strength it can be installed without wire reinforcement.

### Fibrous Adhesive

Fibrous Adhesive is a plastic material for use as an adhesive to temporarily hold in place insulation sheets, blocks, and segmental covering until permanent outer binding support is completed. This material is of thin trowelling consistency and is recommended for use where insulation is applied to brick, concrete, metal, or other surfaces. It is also used for binding insulating blocks together in multiple layer construction. Fibrous Adhesive is applied to the surface of the insulation and then pressed in place against the surface to be insulated. A spotting of the adhesive on the material is generally sufficient for this purpose.

It is necessary to remove all paint on surfaces to be insulated before applying insulation and fibrous adhesive. Otherwise the insulation will loosen after the adhesive dries out. The surface also must be clean, dry, and free of grease.

Fibrous Adhesive is furnished ready for use in 75 lb., 175 lb., 350 lb., and 600 lb. metal drums. Covering capacity is as follows:

1. Insulation against metal surfaces—50 lbs. per 100 sq. ft. of surface.
2. Insulation against masonry surfaces—75 lbs. per 100 sq. ft. of surface.

## Insulating Cement Data

| Product | Use | Type | Temperature Limit | Average Covering Capacity Sq. ft./100 lbs. One In. Thick | Mixing Proportions Gallons water per 100 lbs. | Lbs. per bag |
|---|---|---|---|---|---|---|
| 152 Asbestos | Finishing | Asbestos | 1000° | 20 | 15½ gals. | 100 |
| Hy-Temp | Insulating | Diatomaceous Earth | 1900° | 45 | 28 gals. | 75 |
| 85% Magnesia | Insulating | 85% Magnesia | 600° | 67 | 42 gals. | 50 |
| Amblerex No. 2 | Insulating | Asbestos-Magnesia | 600° | 20 | 14¼ gals. | 50 |
| Mineral Wool | Insulating | Mineral Wool Hydraulic Setting | 1800° | 50 | 24 gals. | 50 |
| Power House | Insulating and Finishing | Mineral Wool | 1700° | 25 | 16 gals. | 50 |



# Outdoor Finishes

### Factory Applied Weatherproof Jackets For Pipe Insulations

Three types of weatherproof jackets applied at the factory on special order are available. They include Standard Weatherproof Jackets, Heavy Weight Weatherproof Jackets, and 50 lb. Asbestos Jackets. All three types include 6" wide strips or collars for covering the circumferential joints at the ends of the sectional covering. The weatherproof jackets are lapped along the longitudinal joints, but the lap is loose so that the insulation can be applied over the pipe in the usual manner.

Standard Weatherproof Jackets are made from a rag felt saturated and coated with asphalt. They weigh 35 lbs. per 108 sq. ft.

Heavy Weight Weatherproof Jackets are made from a rag felt saturated and coated with asphalt. They are almost twice as heavy as the Standard Weatherproof Jackets, weighing approximately 60 lbs. per 108 sq. ft.

50 lb. Asbestos Jackets are made from asbestos felt, saturated and coated on both sides with asphalt, and given a final coat of talc and mica on both sides. These jackets weigh approximately 58 lbs. per 108 sq. ft.

When specifying weatherproof jackets for pipe insulation, the exact type required should be mentioned. Unless this is done, all orders for pipe insulation calling for "roofing jackets" or "weatherproof jackets" without detailed specifications as to weight and quality will be made up with Standard Weatherproof Jackets.

Where the specifications call for "roofing jackets" or "weatherproof jackets" weighing in excess of 35 lbs. per 108 sq. ft., orders will be made up with Heavy Weight Weatherproof Jackets.

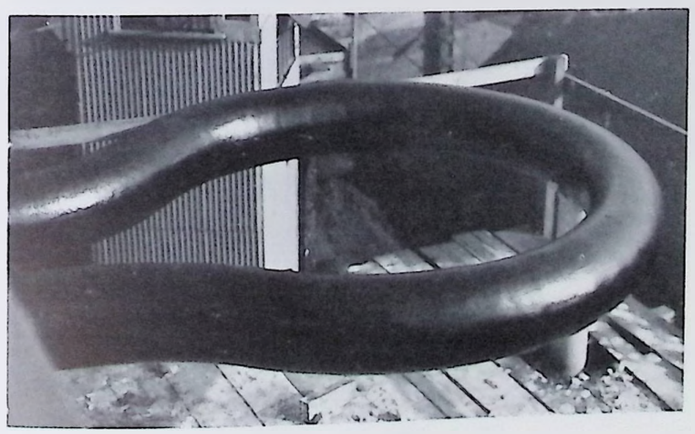
When factory applied weatherproof jackets are ordered, the necessary lap cement for sealing joints, and wire or bands, are furnished.

### Armstrong's Insulmastic

Insulmastic is a factory-mixed combination of Armstrong's Asphalt Emulsion with special fibers and fillers. It is recommended for use where a fire-resistant finish is required. Applied in two coats, each approximately ⅛" thick, Insulmastic is an excellent finishing material for low-temperature insulation exposed to the weather. On high towers, vessels, elevated lines, large ducts, breechings, etc., galvanized wire mesh should be applied directly to the insulation before Armstrong's Insulmastic is troweled on.

Armstrong's Insulmastic possesses the tensile strength necessary to withstand normal movement without cracking or rupturing, is not affected by temperature changes, does not slip or sag at high temperatures, and bonds well with the corkboard insulation surface.

When Insulmastic is applied in two coats, each about ⅛" thick, the two coats will dry to a final thickness of 3/16".



Armstrong's Insulmastic is an excellent finish for expansion loops and fittings on outdoor steam lines. It will withstand movement without rupturing or cracking and does not slip or sag.



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# Specifications for the Application Of High Pressure Insulation

These specifications are included for the convenience of architects, engineers, and owners who wish to specify high pressure insulations.

### 1. Scope of Work

The insulation contractor shall furnish, deliver, and apply all materials and labor necessary for the complete insulation of the (*specify whether piping, equipment, ducts, boilers, etc.*) in accordance with the drawings listed below and the following specifications, all of which form a part of this contract.

### 2. Material Specifications

**2a. 85% Magnesia**

Magnesia insulation shall consist of not less than 85% hydrated basic carbonate of magnesia ($4\ MgCO_3,\ MgO_2H_2\ 5\ H_2O$) with a minimum of 10% long fibre asbestos as the binding element, thoroughly mixed and uniformly distributed throughout the covering. It shall be capable of withstanding a maximum temperature of 600° F. without disintegration.

Thermal conductivity shall not exceed 0.40 Btu/Sq.Ft./Hr./In./°F. at 100° F. (mean) or 0.46 Btu/Sq.Ft./Hr./In./°F. at 300° F. (mean).

**2b. High Temperature**

High temperature insulations shall be composed of calcined diatomaceous earth, magnesium carbonate and asbestos fibre binders, and shall be recommended for temperatures to 1900° F.

Thermal conductivity shall not exceed 0.70 Btu/Sq.Ft./Hr./In./°F. at 400° F. (mean); 0.78 Btu / Sq. Ft. / Hr. / In. / °F. at 600° F. (mean); 0.85 Btu/Sq.Ft./Hr./In./°F. at 800° F. (mean).

**2c. Combination Insulation**

All flat surfaces as well as piping 2″ and larger and at temperatures of 600° F. or higher shall be insulated with combination insulation. The inner high temperature covering shall be suitable to resist temperatures up to 1900° F. and shall lower the temperature on the outer layer of insulation to a point below its temperature limit. The outer layer shall be 85% magnesia insulation suitable for temperatures to 600° F.

**2d. Bestfelt**

Bestfelt insulation shall be constructed of built-up layers of crimped asbestos paper having approximately 33 layers of laminations per inch of thickness and shall not disintegrate when used at temperatures of up to 700° F.

Thermal conductivity shall not exceed 0.51 Btu/Sq.Ft./Hr./In./°F. at 200° F. (mean); 0.61 Btu / Sq. Ft. / Hr. / In. / °F. at 400° F. (mean); 0.70 Btu/Sq.Ft./Hr./In./°F. at 600° F. (mean).

**2e. Mineral Wool Blanket**

Mineral wool blanket insulation shall be of felted high temperature and moisture-resistant insulating wool having a density of not less than 12 pounds per cubic foot. The blankets shall be reinforced with (specify from table below). Material shall be recommended for temperatures to 1200° F.

1. 1 in. Wire Mesh both sides
2. 1 in. Wire Mesh one side, Stucco Lath other side
3. 1 in. Wire Mesh one side, Expanded Metal Lath other side
4. Stucco Lath both sides
5. Expanded Metal Lath both sides
6. Stucco Lath one side, Expanded Metal Lath other side
7. Stucco Lath one side, 3/8 in. Rib Lath (rib turned in) other side
8. Stucco Lath one side, 3/8 in. Rib Lath (rib turned out) other side
9. Stucco Lath one side, 3/4 in. Rib Lath (rib turned in) other side
10. Stucco Lath one side, 3/4 in. Rib Lath (rib turned out) other side
11. 3/8 in. Rib Lath both sides (rib turned in)

Thermal conductivity shall not exceed 0.37 Btu/Sq.Ft./Hr./In./°F. at 300° F. (mean); 0.45 Btu / Sq. Ft. / Hr. / In. / °F. at 600° F. (mean); 0.50 Btu/Sq.Ft./Hr./In./°F. at 800° F. (mean).

### 3. Insulation Thickness

Thicknesses of insulation as given below are for piping, equipment, etc., located indoors. Where 85% Magnesia, High Temperature Combination, Bestfelt, and Mineral Wool Blanket insulations are to be applied on weather exposed surfaces, thickness should be increased by 1/2″.

**3a. 85% Magnesia Pipe Covering and Block**

| Temperature Degrees F. | Thickness of Insulation | | | | |
|---|---|---|---|---|---|
| | Pipe Smaller than 2″ | Pipes 2″ to 4″ | Pipes 5″ to 10″ | Pipes 12″ to 30″ | Blocks |
| Hot Water | Std. | Std. | Std. | 1½″ or Std. | 1″ |
| 212° to 266° | Std. | Std. | Std. | 1½″ or Std. | 1½″ |
| 267° to 337° | Std. | Std. | 1½″ | 2″ | 2″ |
| 338° to 387° | Std. | 1½″ | 2″ | 2½″ | 2½″ |
| 388° to 499° | 1½″ | Dbl. Std. or 2″ | Dbl. Std. or 2½″ | Dbl. Std. or 3″ | 3″ |
| 500° to 600° | Dbl. Std. or 2″ | 2½″ | 3″ | Dbl. Std. or 3″ | 3½″ |

**3b. High Temperature-Combination Pipe Covering**

| Temperature | 600°–699° F. | | 700°–799° F. | | 800°–1000° F. | |
|---|---|---|---|---|---|---|
| Nominal Pipe Sizes, Inches | Hy-Temp | 85% Magnesia | Hy-Temp | 85% Magnesia | Hy-Temp | 85% Magnesia |
| 1½ and smaller | 2″ | | 2″ | | 2″ | |
| 2 | 1¼ | 1½ | 1¼ | 2 | 1 15/16 | 1½ |
| 2½ | 1 5/16 | 1½ | 1 5/16 | 2 | 1 15/16 | 1½ |
| 3 | 1 9/16 | 1½ | 1 9/16 | 2 | 2 1/16 | 1½ |
| 3½ | 1 5/16 | 1½ | 1 5/16 | 2 | 1 15/16 | 1½ |
| 4 | 1 9/16 | 1½ | 1 9/16 | 2 | 2 1/16 | 1½ |
| 4½ | 1 5/16 | 1½ | 1 5/16 | 2 | 1 15/16 | 2 |
| 5 and larger | 1½ | 1½ | 1½ | 2 | 2 | 2 |

**3c. Combination High Temperature and 85% Magnesia Block**

| Max. Temp. on Hy-Temp. Deg. F. | Thickness of Hy-Temp. Inches | Thickness of 85% Magnesia Inches | Total Thickness Inches |
|---|---|---|---|
| 300 | ... | 2 | 2 |
| 400 | ... | 2½ | 2½ |
| 500 | ... | 3 | 3 |
| 600 | ... | 3½ | 3½ |
| 750 | 1½ | 2½ | 4 |
| 900 | 2½ | 2 | 4½ |
| 1000 | 3 | 2 | 5 |
| 1200 | 3½ | 1½ | 5 |





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### 3d. Bestfelt Pipe Covering and Block

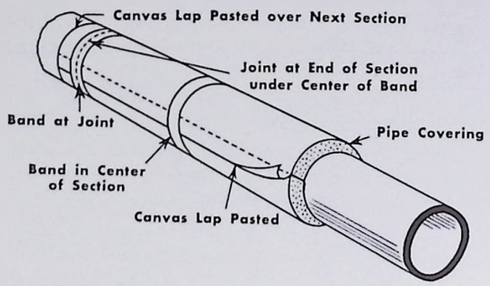
| Steam Pressure or condition | Temp. Deg. F. | Pipe Sizes | | | Sheets and Blocks |
|---|---|---|---|---|---|
| | | up to 1½" | 2" to 4" | 4½" and over | |
| Hot Water | — | 1" | 1" | 1" | 1" |
| 0– 25 lbs. | 212 to 266 | 1" | 1" | 1" | 1" |
| 25–100 lbs. | 267 to 337 | 1" | 1" | 1½" | 1½" |
| 100–200 lbs. | 338 to 387 | 1" | 1½" | 2" | 2" |
| Low Superheat | 388 to 499 | 1½" | 2" | 2½" | 2½" |
| Superheat | 500 to 599 | 2" | 2½" | 3" | 3" |
| High Superheat | 600 to 700 | 2" | 3" | 3" | 3" |

### 3e. Mineral Wool Blanket

| Flat Surface Temperature | Thickness |
|---|---|
| 100° F.– 200° F. | 1" |
| 200° F.– 300° F. | 1½" |
| 300° F.– 500° F. | 2" |
| 500° F.– 700° F. | 2½" |
| 700° F.– 900° F. | 3" |
| 900° F.–1100° F. | 3½" |
| 1100° F.–1200° F. | 4" |

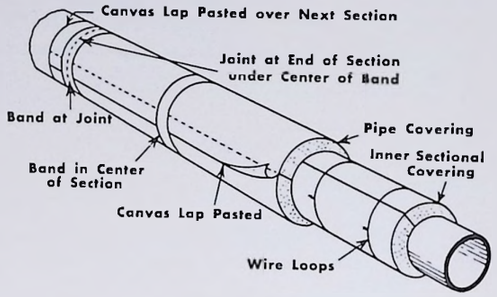
## 4. Application Specifications–Indoor Piping

### 4a. Single Layer Pipe Covering–Pasted and Banded




All sectional covering shall be carefully fitted to the pipe with side and end joints tightly butted and the laps of the factory applied canvas jackets neatly pasted in place. Covering shall be additionally secured with two standard metal bands per section. One band shall be placed at the mid-point of the covering and one centered over the joint between sections.

### 4b. Double Layer Pipe Covering–Pasted and Banded




Double layer pipe covering shall be applied in two layers with the first layer securely wired in place with three loops per section on pipe sizes up to 6" and four loops per section on larger sizes. The second layer shall be applied over the first layer with both side and end joints broken. The factory applied canvas jacket on the outer layer shall be pasted smoothly in place and the covering shall be additionally secured with two

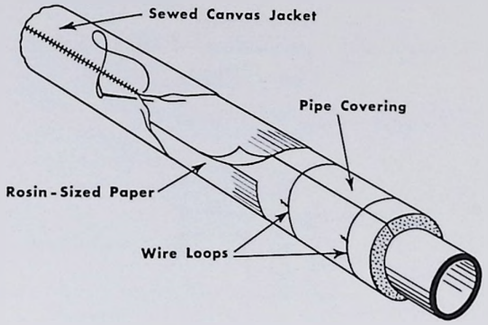


standard bands per section, one to be placed at the mid-point and one to be centered over the end joint.

In all cases, canvas jackets shall be omitted from the inner layer of insulation.

For a combination of high temperature and 85% Magnesia insulation, the thicknesses of each layer shall be as specified. All joints in the inner layer shall be pointed up with high temperature cement where necessary.

### 4c. Single Layer Covering–Sewed Canvas Finish




All sectional covering shall be carefully fitted to the pipes with side and end joints butted tightly together and held firmly in place with suitable wire, not less than three loops per section on pipe sizes up to 6" and not less than four loops per section on larger sizes. A layer of 40 lb. rosin sized paper shall then be wrapped around the insulation before applying the 6- or 8-oz. canvas jacket, as specified. The canvas shall be stretched smoothly over the covering and sewed in place with not less than 3 stitches per inch, with seams located where least visible.

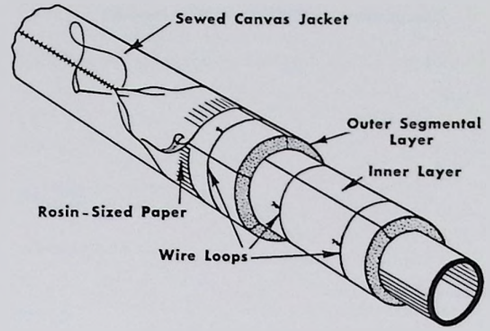
On all segmental covering, the joints shall be pointed up with asbestos cement where necessary to present a smooth even surface.

### 4d. Double Layer Covering–Sewed Canvas Finish

Double layer covering shall be applied in two layers with the first layer securely wired in place with suitable wire, using not less than 3 loops per section on pipe sizes up to 6" and 4 loops per section on larger sizes.

In all cases, the canvas shall be omitted from the first layer of insulation.

The second layer shall be applied over the first layer with both side and end joints broken

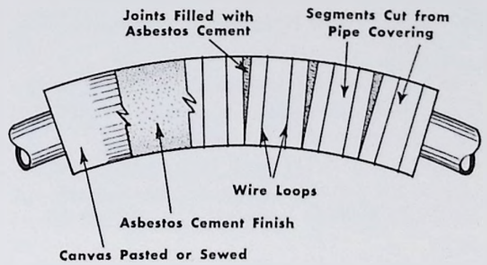



and held in place with suitable wire. All joints shall be pointed with asbestos cement where necessary.

A layer of 40 lb. rosin sized paper shall then be wrapped around the outer layer of insulation and over this an 8- or 6-oz. canvas jacket, as specified, shall be stretched smoothly and sewed in place with no less than three stitches per inch. All seams shall be located where least visible.

On high temperature combination covering, the thickness of each layer shall be as specified, and the joints in the inner layer shall be pointed with high temperature cement. On all outer layer segmental covering, the joints shall be pointed with asbestos cement where necessary to present a smooth, even surface.

### 4e. Insulation of Pipe Bends



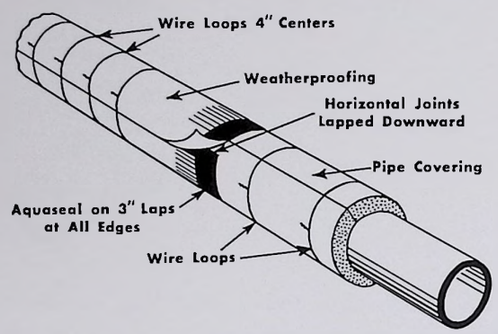

All pipe covering on bends shall be applied in mitered segments to conform to the contour of the bend. Each segment shall be wired securely in place with wire and all joints pointed with asbestos cement. A finishing coat of asbestos cement shall be applied over the mitered sections to present a smooth, even surface.



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## 5. Application Specifications—Outdoor Piping

### 5a. Single Layer Covering—Weatherproof Finish




The insulation shall be carefully fitted to the pipe with side and end joints butted tightly together and firmly held in place with suitable wire, no less than 3 loops per section on pipe sizes up to 6" and no less than 4 loops per section on larger sizes.

Over the covering apply asphalt saturated and coated weatherproofing jackets weighing not less than 45 lbs. per 100 sq. ft. The jacket shall be tightly wrapped over the insulation with 3" laps at longitudinal and end joints, the laps sealed with asphalt emulsion when specified. The horizontal laps shall be placed at the side of the pipe and shall be made downward to shed water. The weatherproof jacket shall be held securely in place with separate loops of copper clad wire spaced on 4" centers.

### 5b. Double Layer Covering—Weatherproof Finish

Double layer covering shall be applied in two layers. First layer shall be applied as specified for single layer covering in paragraph 5a.

The second layer shall be applied over the first with both side and end joints broken and the joints pointed with asbestos cement where necessary.

A weatherproofing finish shall then be applied as described in paragraph 5a.

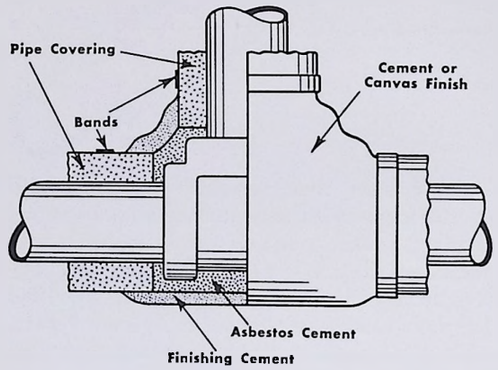
### 5c. Pipe Bends—Weatherproofing Finish

All insulation on pipe bends shall be applied in mitered segments to conform to the contour of the bend. Each segment shall be securely wired in place and all joints shall be pointed with asbestos cement. A single coat of asbestos cement shall then be trowelled on, scratched, and allowed to dry.

The insulation shall then be given a weatherproof finish of Armstrong's Insulmastic applied in two coats, which dry to final thickness of approximately ⅛". The Insulmastic shall be trowelled to a smooth, even finish, and shall overlap the weatherproof jacket on the adjacent piping by at least 3" to provide a tight seal. Over the insulation on bends for 12" pipe size and over, a 1" wire mesh shall be applied prior to the installation of the plastic weatherproof finish.

## 6. Application Specifications—Fittings, Valves, and Flanges

### 6a. Fittings on Pipe Sizes Under 4"




Fittings on pipe sizes under 4" shall be insulated with asbestos cement for service up to 600° F. in the same total thickness as the covering on the adjacent piping.

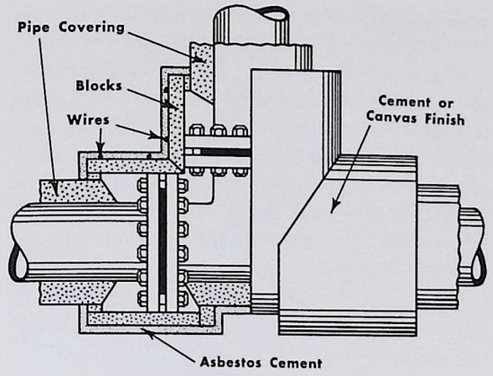
For temperatures higher than 600° F. two types of insulating cement shall be used. The inner layer shall be of high temperature cement, and the outer layer of asbestos cement.

In all cases, the cement shall be applied in two layers, and each layer shall be allowed to dry before the succeeding layer is applied. The final coat of cement shall be trowelled to a smooth, even surface.

### 6b. Fittings for Pipe Sizes 4" and Larger

The fittings on pipe sizes four inches and larger shall be covered with block insulation of the same type used on adjacent piping. Thickness shall be ½" less than on adjacent piping to allow

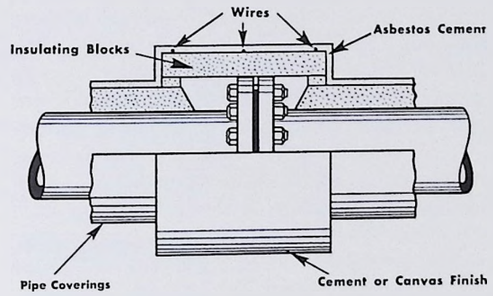





for a ½" coating of finish cement.

Blocks shall be carefully fitted and securely wired in place. Over the surface of the block, asbestos cement shall then be applied in two layers to a total thickness of approximately one-half inch with the final surface trowelled to a smooth, even finish.

### 6c. Insulation of Flanges




Flanges shall be insulated with narrow block, or where the diameter is large enough, with pieces of sectional or segmental covering of the same material as used on the adjacent piping. Thickness shall be approximately ½" less than on adjacent piping to allow for the cement finish. The insulation shall extend at least 2" over the adjacent pipe covering on either side of the flange and the joints shall be filled with insulation and sealed with asbestos cement.

The insulation shall be securely wired in place, and given a coating of asbestos cement approximately ½" thick, applied in two layers, the final surface to be trowelled to a smooth, hard finish.

The pipe covering at the flanges shall be stopped short and bevelled off to permit removal of the flange bolts. Factory applied canvas jackets on the covering shall be cut off a distance back from the flange to eliminate any possibility of burning of the canvas.

### 6d. Finishes for Indoor Flanges, Fittings, and Valves

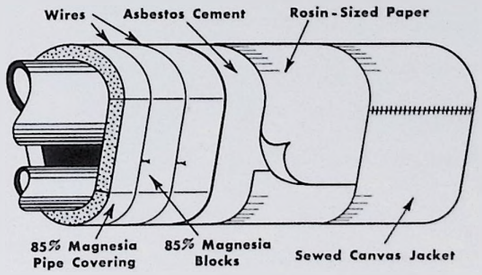
The insulation on flanges, fittings, and valves located indoors shall be finished with canvas to conform to the finish on the adjacent pipe covering. The canvas shall be stretched tightly over the surface of the insulation and pasted in place so as to present a smooth, even surface.

### 6e. Outdoor Finish for Fittings, Valves, and Flanges

All insulation on fittings, valves, and flanges located out of doors shall be finished with Armstrong's Insulmastic applied over a coat of cement in two coats and trowelled to a smooth, even finish. It shall overlap the weatherproof jackets on the adjacent pipe covering by at least 3" to provide a tight seal.

## 7. Application Specifications—Parallel or Nested Piping

### 7a. Application of Insulation




Half sections of pipe covering shall be fitted to the upper half of the large pipe and the lower half of the small pipe. Lower half sections of covering shall be held in place with temporary wire supports or with fibrous adhesive. Block insulation shall then be applied between the edges of upper and lower pipe covering and both the covering and the block securely fastened in place with separate loops of wire on 4" centers.



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Where pipes are of the same size and are spaced closely together, insulation shall be applied in the same manner as stated above.

All joints shall be thoroughly pointed with asbestos cement and a thin finishing coat of asbestos cement shall be applied where necessary, to present a smooth, even surface. Where pipe spacing requires additional support for the blocks, wire mesh shall be wrapped around the pipes before the insulation is applied.

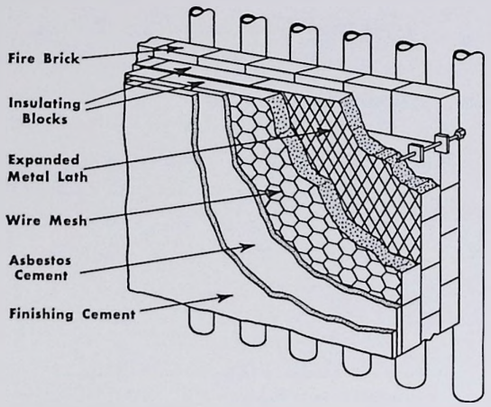
### 7b. Finishes for Parallel or Nested Piping

Pasted canvas finish as described in specification 6d, sewn canvas finish as described in specification 4c or weatherproof finish as described in specification 5a shall be applied.

## 8. Application Specifications—Block Insulation

The application of block insulation to boiler walls must be considered in detail for each particular design. In general, the following specifications will apply.

### 8a. Water Cooled Boiler Walls




Where tubes, clamps, nuts, bolts, or metal projections are exposed on the outside of the water tube wall, a filler coat of high temperature cement shall be applied thick enough to cover the high points. This shall be trowelled to a smooth, level surface.

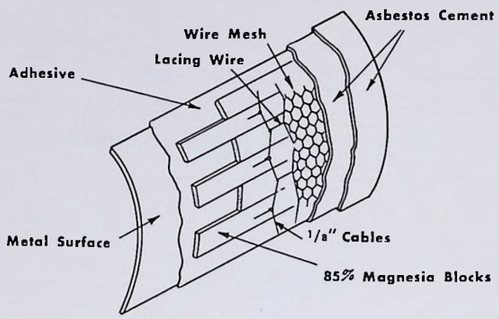
The block shall be temporarily held in place with fibrous adhesive and permanently fastened with annealed iron wire lacings. Where access to water tubes with minimum disturbance to the insulation is specified, the insulating block shall be placed with their longest dimension vertical.

Where two layers of insulating block are used, all joints shall be staggered and pointed up with cement. Where a combination insulation of high temperature block and 85% Magnesia block is specified, the high temperature block shall be applied as the inner layer and the joints shall be pointed up with high temperature cement where necessary.

For a cement finish, a layer of hexagonal wire mesh shall be secured in place over the insulating block. The cement finish shall then be applied in 2 layers to a total thickness of ½", and trowelled to a smooth finish.

Where a panel finish is to be applied, the hexagonal wire mesh shall be omitted, and panels of asbestos board or sheet steel shall be applied over the blocks and held in place by vertical and horizontal steel strip battens.

### 8b. Boiler Drums



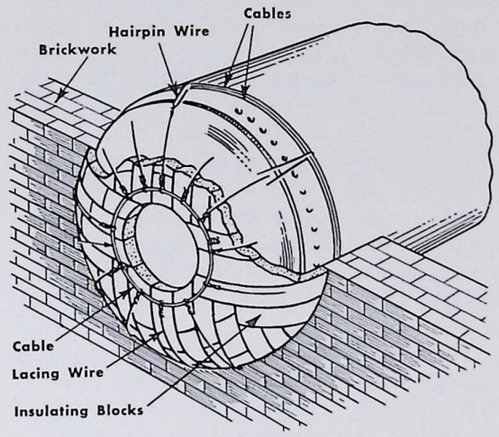

Blocks of insulation shall be carefully fitted and placed against the steel surface and held securely in place with cables or steel bands and additionally fastened with suitable wire where necessary. Wire may replace cables and bands on smaller diameters. To facilitate application, fibrous adhesive shall be used to hold the blocks in place until the wires or bands are applied.

Double layer and combination block shall be applied as specified in 8a.

After the blocks have been wired in place, hexagonal mesh netting shall be stretched tightly and fastened securely over the block with suitable wire. Over the netting, asbestos cement shall be applied in two coats to an approximate thickness of ½" and the surface of the second coat trowelled to a smooth, even finish.



### 8c. Boiler Drum Heads



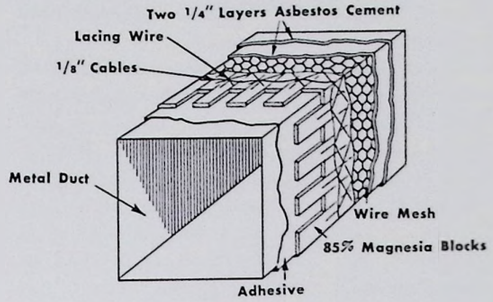

Provision for securing the insulating blocks to drum heads shall be made before the equipment is installed. On riveted drum heads, two heavy wires or wire cables should be tightly wrapped around the surface of the shell behind the rivets, and hairpin wires shall be looped around these cables at frequent intervals and drawn outward to clear the brickwork.

The insulating block shall be applied with fibrous adhesive to hold it in place until annealed iron lacing wires are attached to the hairpin wires. The iron lacing wires shall then be drawn tightly to a floating ring or cable looped around the manhole opening.

After the blocks have been secured in place, hexagonal mesh netting shall be stretched tightly and fastened securely over the blocks with suitable wire. Over the netting, asbestos cement shall be applied in two layers to an approximate thickness of ½" with the surface trowelled to a smooth finish.

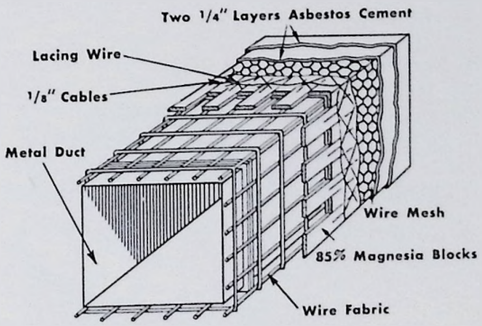
In the case of welded drum heads, suitable welded anchoring devices such as ⅜" standard nuts, or ⅜" standard washers are required on the surface of the shell. The two heavy wires or wire cable can then be threaded through these anchorages and held securely in place. Application of block insulation shall be the same as described above.

### 8d. Ducts, Breechings, and Flues




When the surface of the duct, breeching, or flue has no stiffeners or other projections, and if no provision for expansion and contraction is required, insulation shall be applied directly to the surface. On large size ducts, breechings, and flues, suitable anchoring devices shall be welded to the surface to be insulated. The insulation shall be applied and held in place with cables or steel bands and additionally fastened with suitable lacing wire where necessary.

Metal corner guards or beading shall be used on the corners to prevent the straps or wires from cutting into the insulation.




Where metal stiffeners occur on the outer surfaces of ducts, breechings, and flues, and where expansion is not a problem, the insulating block shall be carefully cut to fit tightly between the stiffeners. If the stiffeners protrude beyond the insulation, pipe or block insulation shall be built up around the projections and wired in place. Stiffeners equal to or less than the block insulation thickness shall be covered with a minimum of 1" thick block insulation.

Where stiffeners or other projections are



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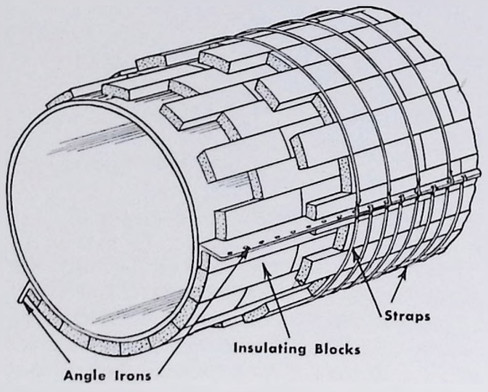
closely spaced, or where provision for expansion and contraction is desired, wire fabric 4″ x 4″ or 6″ x 6″, or a 1″ V-ribbed metal lath shall be welded over the stiffeners.

Blocks of insulation shall be carefully fitted, and held securely in place with suitable wire laced through the wire fabric or metal lath. Where there are two layers of block, all joints shall be staggered and pointed with asbestos cement. When a combination insulation is used, the high temperature block shall be applied as the inner layer and the inner layer shall be pointed up with high temperature cement. After the blocks have been completely wired in place, hexagonal mesh netting shall be stretched tightly and fastened securely with suitable wire. Over the netting, asbestos cement shall be applied in two layers to an approximate thickness of ½″ with the surface trowelled to a smooth finish.

### 8e. Heaters and Exchangers

When block insulation is to cover plate or heads of heaters or exchangers, the insulation shall be cut back so that the bolts can be removed without disturbing the insulation. The heads of shell and tube bundles which must be opened frequently for cleaning shall be provided with removable insulation lined sheet metal covers, when specified.

### 8f. Horizontal Tanks and Vessels



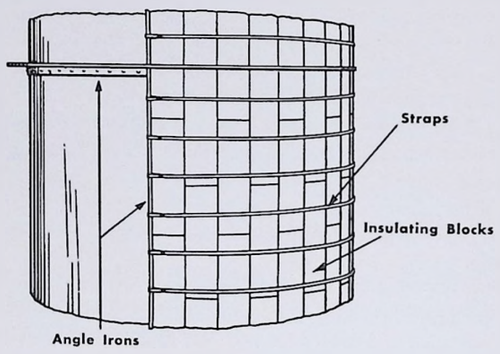

On the cylindrical body of tanks or vessels, the insulation blocks in each layer, if more than one layer is used, shall be held in place with metal bands or straps, three per 3′ section of block.

On large tanks and vessels, where additional support is required for insulation on the underside, two angle irons of the same length as the tank shall be welded longitudinal to the underside and spaced 120° apart, equally distant from the bottom center. Insulating block shall then be applied and held in place by metal bands or straps anchored to the angle iron. Six bands to the block shall be used on the bottom third of the tank or vessel, three bands for the upper two-thirds of the circumference.

On tank ends, insulation block shall be applied with fibrous adhesive to hold them in place until they can be firmly anchored with wire laced over the blocks and fastened to a wire cable looped around the circumference of the tank behind rivet heads, piping, or other projections, or behind or through angle iron clips welded to the circumference of the tank.

After the blocks have been attached, hexagonal mesh netting shall be stretched tightly and fastened securely with suitable wire. Over the netting, asbestos cement shall be applied in two layers to an approximate thickness of ½″ with the surface trowelled to a smooth finish.

### 8g. Vertical Tanks, Towers, etc.




The sides of the vertical tanks, towers, and vessels, shall be insulated with one or more layers of insulating block secured in place with metal bands or strapping, three per 3′ section of block. On large vertical tanks, to provide anchorage for the metal bands or strappings, vertical angle irons welded to the tank are required at intervals of approximately 20′.

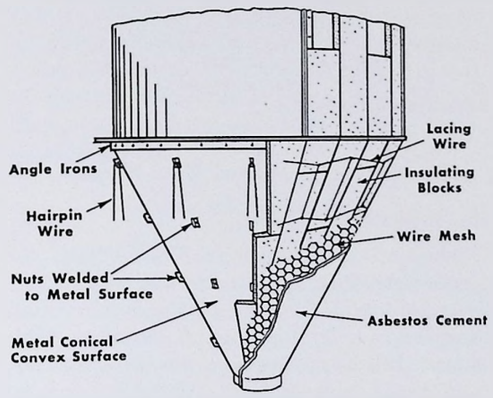
The insulation should be supported on circumferential angle irons welded to the tank at regular intervals of approximately 12′.



The tops of vertical tank and towers shall be insulated with blocks set in a layer of fibrous adhesive, further secured in place with metal bands.

After the blocks have been attached, hexagonal mesh netting shall be stretched tightly and fastened securely with suitable wire. Over the netting, asbestos cement shall be applied in two layers to a total thickness of ½″ with the surface trowelled to a smooth finish.

### 8h. Conical Convex Bottom Tanks and Vessels




The cylindrical portions of such tanks and vessels shall be insulated in the same manner as the cylindrical portions of any other tank.

To hold the insulation to the conical convex section, metal anchors such as punched angle clips, nuts, etc., welded to the surface are required and should be spaced on a pattern of conical rings, with equal spacing between the anchors in each ring and between the rings. The rings shall start a few inches below the juncture of the cylindrical and convex or conical sections and extend to the tip of the cone or the end of the convex section. Hairpin wires shall be attached to each anchor with the wires projecting outward. The insulation blocks shall then be applied and held in place with wires drawn through the holes in the anchors. The projecting metal ends of the hairpin wires shall be used for anchoring the cross lacing wire and the hexagonal mesh wire.

After the blocks have been completely wired in place, hexagonal mesh netting shall be stretched tightly and securely wired in place. Over the netting, asbestos cement shall be applied in two layers with the surface trowelled to a smooth finish.

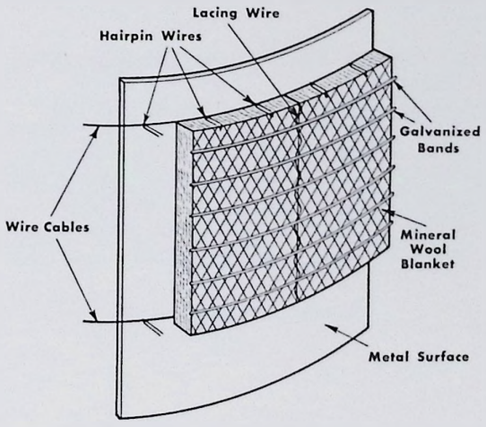
### 8i. Weatherproofing Block Insulation

After the blocks have been wired in place, approximately ½″ thick coat of asbestos cement shall be applied and the surface left with a rough trowelled finish. Hexagonal wire netting shall be applied over the cement and securely wired in place. A weatherproof finish of Armstrong's Insulmastic shall be applied over the netting in two coats to a finished thickness of approximately ⅛″ when dry, trowelled to a smooth, even surface.

**Note:** Wherever possible all welding of anchoring devices and reinforcing steel used in the application of insulation shall be done by the equipment manufacturer or the contractor installing the equipment to insure proper treatment of the metal parts involved.

## 9. Application Specifications Mineral Wool Blankets

### 9a. Curved Surfaces—Wire Cable Method



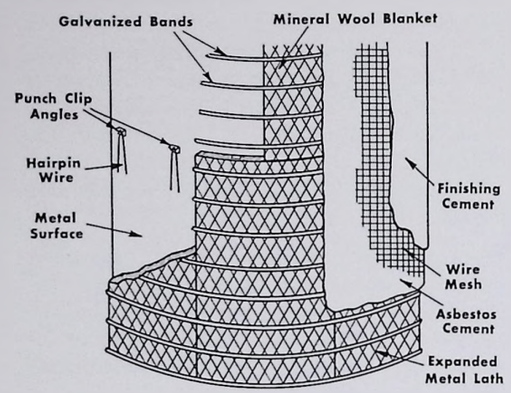

Before applying mineral wool blankets to curved surfaces, ⅛ inch wire cable shall be tightly pulled around the surface of the vessel on approximately 4 foot centers. Mineral wool blankets shall then be secured in place with hairpin wires attached to the cables. The expanded metal lath side of the blanket shall be



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on the exposed surface. The edges of the blanket shall be laced tightly together with suitable wire and the blankets shall be additionally secured with galvanized bands.

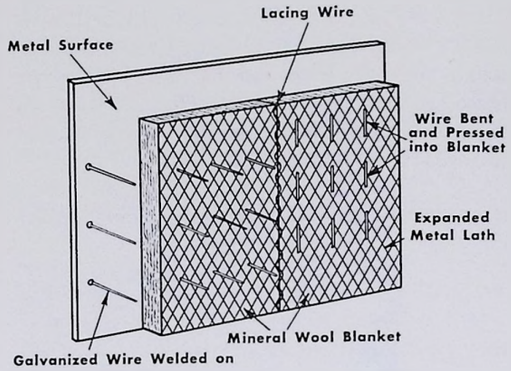
### 9b. Curved Surfaces—Clip Angle Method




Punched clip angles shall be welded on 1 foot centers around the vessel at 8 foot intervals, starting 8 feet from the bottom. Mineral wool blankets shall be hung from the angles with suitable wire and additionally secured with galvanized bands on approximately 8-inch centers.

### 9c. Curved or Flat Surfaces—Galvanized Wire Method

No. 9 gauge galvanized wire, 3 inches longer than the blanket thickness shall be welded perpendicular to the surface of the equipment, and spaced on 8-inch centers. Blankets shall be impaled on the galvanized wire with the expanded metal lath side exposed and the wires shall then be bent upward and pressed firmly into the blankets. Blanket edges shall be laced together with suitable wire.




### 10. Finishes for Mineral Wool Blankets

#### 10a. Indoor Finish

Asbestos Cement or Mineral Wool Cement, as specified, shall be applied and forced into the expanded metal lath side of the blanket and trowelled to a level surface. A second coat of cement shall be applied to a smooth, even surface. Where a canvas finish is desired, a canvas jacket shall be sewed or pasted firmly in place.

#### 10b. Outdoor Finish—Armstrong's Insulmastic

A cement finish shall be applied as specified in 10a. After the cement is thoroughly dry, galvanized wire netting shall be stretched tightly over the surface and wired in place. Armstrong's Insulmastic shall be applied over the wire netting in two coats and trowelled to a smooth, even surface.



# Specifications for the Application Of Low Pressure Insulation

These specifications are included for the convenience of architects, engineers, and owners who wish to specify low pressure insulations.

### 1. Scope of Work

The insulation contractor shall furnish, deliver and apply all materials and labor necessary for the complete insulation of the (*specify whether piping, equipment, ducts, boilers, etc.*) in accordance with the drawings listed below and the following specifications, all of which form a part of this contract.

### 2. Material Specifications

#### 2a. Air Cell Insulation

Air Cell covering and block shall consist of alternate layers of corrugated and flat asbestos felts bonded together with a suitable inorganic binder and shall be (*specify whether 4, 6, or 8*) plies per inch thickness. This material shall be suitable for temperatures up to 300° F.

Thermal conductivity shall not exceed the values given below.

| Mean Temp. | 4 Ply | 6 Ply | 8 Ply |
|---|---|---|---|
| 100° F. | 0.54 | 0.49 | 0.46 |
| 200° F. | 0.64 | 0.56 | 0.53 |
| 300° F. | 0.74 | 0.63 | 0.60 |

#### 2b. Duplex

Duplex pipe covering shall be composed of a continuous wrapping of specially creped felt having an inner saturated felt lining impregnated with a water proofing compound. The outer wrapping of asbestos paper over the felt and beneath the canvas jacket shall be factory applied. Recommended for top temperature limit of 212° F.

Thermal conductivity shall not exceed 0.33 Btu/Sq. Ft./Hr./In./°F. at 100° F. (mean); 0.38 Btu/Sq. Ft./Hr./In./°F. at 200° F. (mean).

#### 2c. Non-Sweat

Non-Sweat pipe covering shall be a combination of flat non-creped insulating and water proofing felts specifically designed to prevent condensation on cold water piping.

Thermal conductivity shall not exceed 0.52 Btu/Sq. Ft./Hr./In./°F. at 100° F. (mean).

#### 2d. Non-Frost

Non-Frost pipe insulation shall be constructed of layers of hair felt separated by paper felt with a treated paper felt inner lining to prevent the hair coming in direct contact with the pipe surface. Thermal conductivity shall not exceed 0.28 Btu/Sq. Ft./Hr./In./°F. at 50° F. (mean).

### 3. Insulation Thickness

#### 3a. Air Cell

| Temperature Range | Description | 1½" and smaller | 2" to 4" | 4½" and over | Sheets and Blocks |
|---|---|---|---|---|---|
| Up to 170 | Hot water, condensate return lines, warm air ducts, (block) etc. | ¾"–3 ply | ¾"–3 ply | ¾"–3 ply | ¾"–3 ply |
| Up to 212 | Hot water, boiler feed water supply, etc. | ¾"–3 ply | 1"–3 ply | ¾"–4 ply | 1"–4 ply |
| 212–300 | Low pressure steam Low pressure boilers | 1"–4 ply | 1"–4 ply | 1"–4 ply | 1"–4 ply |



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### 3b. Duplex

| Temp. of Pipe Surface | Application | Single Layer Pipe Size: up to 1½" | Single Layer Pipe Size: 2"–4" | Single Layer Pipe Size: 4½" and over | Double Layer Pipe Size: up to 1½" | Double Layer Pipe Size: 2"–4" | Double Layer Pipe Size: 4½" and over |
|---|---|---|---|---|---|---|---|
| 32– 50 | Cold Water Service | ¾" | ¾" | ¾" | 1" | 1" | 1" |
| 170 | Hot Water Service | ¾" | ¾" | ¾" | 1" | 1" | 1" |
| 32–212 | Dual Purpose; Hot Water—Cold Water | ¾" | 1" | 1" | 1" | 1½" | 1½" |

### 3c. Non-Sweat

| Humidity | Temperature difference Deg. F., Water to Air: 50° Maximum | 60° Maximum | 70° Maximum |
|---|---|---|---|
| Up to 60% | ½" | ¾" | 1" |
| 60%–70% | 1" | 1" | 1½" |
| 70%–80% | 1½" | 2" | 2" |

### 3d. Non-Frost

1¼" thickness only

### 3e. Hair Felt

| | | |
|---|---|---|
| Plus | 15° F. to plus 40° F. | .....2" insulation |
| Minus | 5° F. to plus 15° F. | .....3" insulation |
| Minus | 20° F. to minus 5° F. | .....4" insulation |
| Minus | 40° F. to minus 20° F. | .....5" insulation* |
| Minus | 60° F. to minus 40° F. | .....6" insulation* |

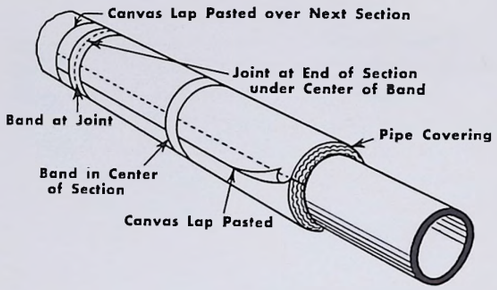
* Pipes smaller than 3½" at temperature from minus 20 to minus 60° F., deduct 1" insulation.

Where other than average service conditions prevail, the most economical thickness of insulation shall be calculated, and the insulation applied in the thicknesses specified.

### 4. Application Specifications—Indoor Piping

#### 4a. Single Layer Covering—Pasted and Banded

All sectional covering shall be carefully fitted to the pipe with side and end joints tightly butted together. Side and end laps of factory applied canvas jackets shall be pasted down smoothly




and the covering additionally secured with two standard metal bands per section. One band shall be placed at the mid-point of the covering and one centered over the end joint.

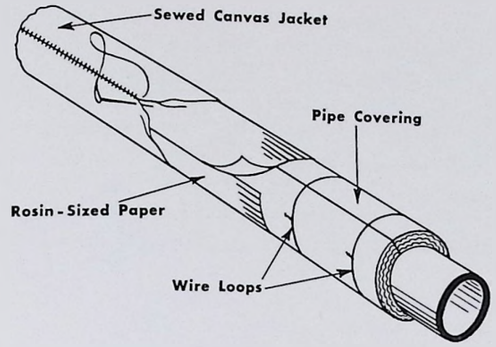
#### 4b. Double Layer Covering (Pasted and Banded)

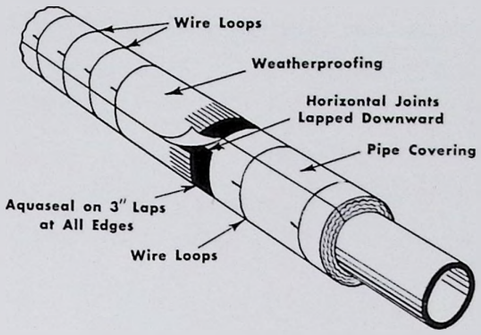
Double Layer Pipe Covering shall be applied in the same manner as single layer covering. All vertical and longitudinal joints in the second layer shall be staggered in relation to those in the first layer.

#### 4c. Single Layer Covering (Sewed Canvas Finish)

The pipe covering shall be carefully fitted to the pipe with side and end joints butted together. The insulation shall be secured in place with suitable wire using not less than 3 loops per section on pipe sizes up to 6" and not less than 4 loops per section on the larger sizes.






40-lb. rosin sized paper shall be wrapped around the insulation and a jacket of 8-oz., 6-oz., 4-oz. canvas, as specified, shall then be stretched smoothly over the covering and sewed in place with no less than 3 stitches per inch. All seams shall be located where least visible.

#### 4d. Double Layer Covering (Sewed Canvas Finish)

Double Layer Covering shall be applied in the same manner as single layer covering as outlined in specification 4c. All vertical and longitudinal joints in the second layer shall be overlapped in relation to the joints in the first layer.

#### 4e. Insulation of Fittings

Fittings on pipe sizes under 4" shall be insulated with asbestos cement. The cement shall be applied in two layers, each layer being allowed to dry before the succeeding layer is applied. Canvas or muslin shall then be stretched tightly over the entire cemented surface and pasted securely in place. For pipe sizes 4" and larger, fittings shall be insulated as described under specification 6b, High Pressure Insulation, Page 148.

**Note:** When insulation is specified for flanges, they shall be insulated with 85% Magnesia Block as described under Specification 6c For the Application of High Pressure Insulation, on Page 149 of this section.

### 5. Insulation Specifications—Outdoor Piping

#### 5a. Single Layer Covering

Single Layer Covering shall be applied as outlined in specification 5a, High Pressure Covering, on Page 148.

Over the covering asphalt saturated and coated weatherproofing jacket shall be applied, weighing not less than 45 lbs. per 100 sq. ft., the jackets being tightly wrapped over the insulation with 3" laps at longitudinal and end joints and sealed with Asphalt Emulsion when specified. The horizontal laps shall be placed at the side of the pipe and all laps shall be made downward to shed water. The weatherproof jacket shall be held securely in place with separate loops of copper clad wire spaced on 4" centers.

#### 5b. Double Layer Covering

Double layer covering shall be applied as described in specification 5b, High Pressure Insulation, on Page 148.

Weatherproofing shall be applied as described for single layer covering in specification 5a.

#### 5c. Fittings

Fittings shall be insulated as described in specification 4e and shall be finished with Armstrong's Insulmastic. The Insulmastic shall be applied over a coat of cement which shall be scored and allowed to dry. Insulmastic shall be applied in two coats and trowelled to a smooth, even finish. It shall overlap the weatherproof jackets on the adjacent pipe covering by at least 3" to provide a tight seal.

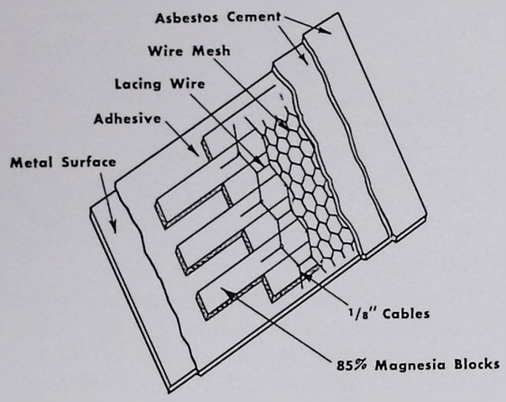
**Note:** Fittings on lines insulated with Non-Sweat and Non-Frost pipe insulations shall be insulated with Hair Felt and weatherproofed in the same manner as described in "Specifications for the Application of Hair Felt," on Page 159 (Specification 7e).



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## 6. Application Specifications—Sheets and Blocks

### 6a. Flat Surfaces




Sheets or blocks shall be carefully fitted and held temporarily in place against the surface with fibrous adhesive. Metal bands or wire shall then be applied, attached to or laced through suitable anchoring devices.

For large vertical and underside surfaces, suitable anchoring devices as ⅜″ standard nuts, ⅜″ standard washers, ⅛″ hairpin wires welded to the metal surface to be insulated where required. Where welding is not possible, as in the case of thin gauge ducts, mechanical hangers shall be erected in a suitable adhesive as additional support for the insulation.

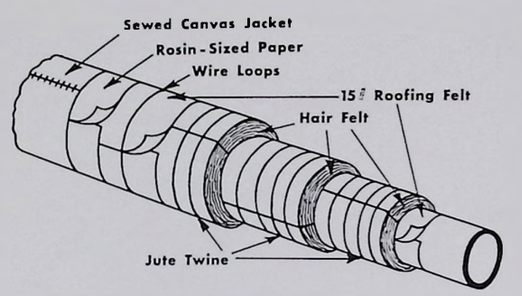
After the sheets or blocks have been secured in place, hexagonal mesh wire shall be stretched tightly and fastened securely over the sheets or blocks. Asbestos cement shall then be applied in two coats to an approximate thickness of ½″ and the surface trowelled to a smooth finish.

Where a canvas finish is desired, 8-, 6-, 4-oz. canvas, as specified, shall be sewed or pasted smoothly in place.

## 7. Application Specification—Hair Felt

### 7a. Built-up Method (Light Duty Service)

A layer of waterproof paper (15-lb. roofing felt) shall first be applied to the pipe and secured by wrappings of jute twine. Consecutive layers of hair felt shall be applied with all joints snug and tight and with no overlapping or buckling, and shall be held securely in place with jute



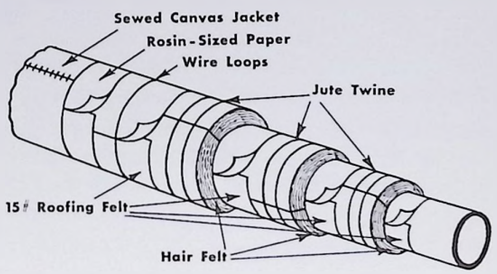

twine wrapped at 1″ spacings. In multiple layer construction, both end and side seams in the hair felt shall be staggered.

A layer of waterproof paper shall be wrapped over the outer surface of each layer of hair felt as it is applied, and secured by a wrapping of heavy jute twine at 1″ spacings.

The final layer of waterproof paper shall be secured with separate loops of copper clad steel wire on 4″ spacings, with loops firmly twisted and neatly bent over to avoid projections. All layers of waterproof paper shall have a 3″ lap at all edges.

When a sewed or pasted canvas finish is desired, a layer of rosin sized paper shall be wrapped over the waterproof paper. A jacket of 8- or 6-oz. canvas shall then be stretched smoothly over the paper and neatly pasted or sewed in place with not less than 3 stitches per inch. All seams shall be located where they are least visible.

### 7b. Non-Sectionalized (Heavy Duty Service)




A layer of 15-lb. roofing felt shall first be applied to the pipe and secured by wrappings of jute twine. Each layer of hair felt shall then be applied and securely held in place by wrappings of heavy jute twine on 1″ spacings. The surface



of each layer of hair felt shall be heavily coated with hot asphalt, or wrapped with asphalt coated canvas, or with membrane sealing tape wound on spirally so that at no point are there less than two plies of tape. When tape is specified, each course shall be given a coat of Asphaltic Paint.

The outer layer of hair felt shall be covered with waterproof paper secured with separate loops of copper clad steel wire firmly twisted and neatly bent over to avoid projections.

When a sewed or pasted canvas finish is desired, it shall be applied as specified in paragraph 7a.

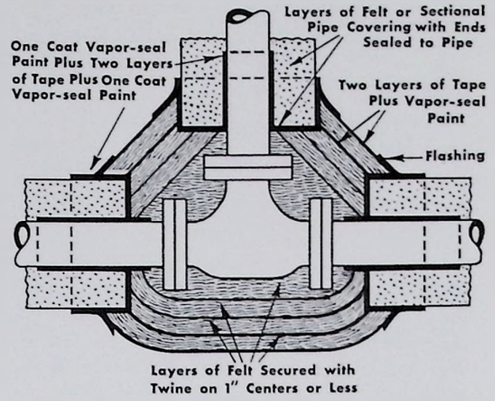
### 7c. Air Seal Method—Sectionalized—Super Heavy Duty Service

Hair felt insulation shall be applied in the same manner as described in specification 7b, except that each course of insulation shall be sealed off in sections by the application of membrane tape sealed to the roofing felt on the pipe. Succeeding layers of felt shall also be sectionalized by membrane tape sealed to the heavy asphaltic coated canvas, membrane sealing tape, or asphalt coating between each layer of hair felt.

### 7d. Insulation of Fittings

Flanges, valves, and fittings shall be insulated separately from the adjacent pipe insulation. The fitting shall be first wrapped with membrane sealing tape. Then the hair felt shall be carefully cut and fit and built up around the fitting.

In addition, the sealing tape on the fitting shall extend over the adjacent hair felt pipe covering and shall be painted with asphaltic paint and firmly sealed to the covering.




A single coat of plaster of paris or asbestos cement shall then be applied to the body of the insulated fitting. Two coats of Armstrong's Insulmastic shall be applied to a final thickness of approximately ⅛″. This finish shall extend over the edge of the fitting so as to seal the joints between covering and fitting.

On indoor applications, sewed or pasted canvas finish may be applied to match the adjacent pipe covering.

### 7e. Weatherproof Finish

The Weatherproof Finish on hair felt insulated lines shall be an asphalt saturated and coated jacket. This shall be tightly wrapped around the insulation with 3″ laps at all edges sealed with Asphalt Emulsion. Jackets shall be held securely in place with copper clad wires on 4″ centers. All laps shall be placed at the side and shall be made downward to shed water.



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# Maintenance of Heat Insulation

Industrial heat insulation is an investment in fuel savings, and like any investment, some means of protection must be exercised if the full measure of the original cost is to be realized.

The most economical protection of the original investment comes in the form of frequent and periodic inspection, maintenance, and repair. Proper care and maintenance will insure better performance and longer life for heat insulation. Neglect pushes up operating expenses and cancels out savings expected in original insulation specifications. Continued neglect will eventually cause serious failures, destroying insulation to the point where simple repairs aren't possible and major replacements are necessary.

Maintenance of heat insulation is not complicated. In the case of wired or banded on insulation located indoors, nothing more than an annual inspection is required, at which time loose or broken wires or bands should be tightened or replaced.

Lines finished with paint over sewed canvas jackets should be repainted occasionally to keep the old paint from cracking and peeling.

Damage caused by accidental bumping and abrasion should be repaired immediately. Minor breaks can be patched with asbestos cement. If the damage has caused a complete break in the insulation, it should be replaced with the same materials and in the same thickness as originally applied. If it is noted that such damage occurs frequently, the insulation should be permanently protected with sheet metal guards or some form of bump railing.

Outdoor lines, tanks, and towers, require more frequent maintenance than those located indoors. Equipment and lines protected with roofing felt should be inspected annually for broken and loose wires or bands. Felt which has been torn or damaged by wind or hail should be replaced at once.

Roofing felt on outdoor lines should be given a good coat of asphaltic paint at least every two years. This prevents cracking of the felt caused by oxidation of the asphalt.

Particular care should be taken to maintain a weather-tight seal on outdoor lines insulated with asbestos paper covering. Vapor infiltration will rapidly deteriorate asbestos paper and a high loss of insulating value will result.

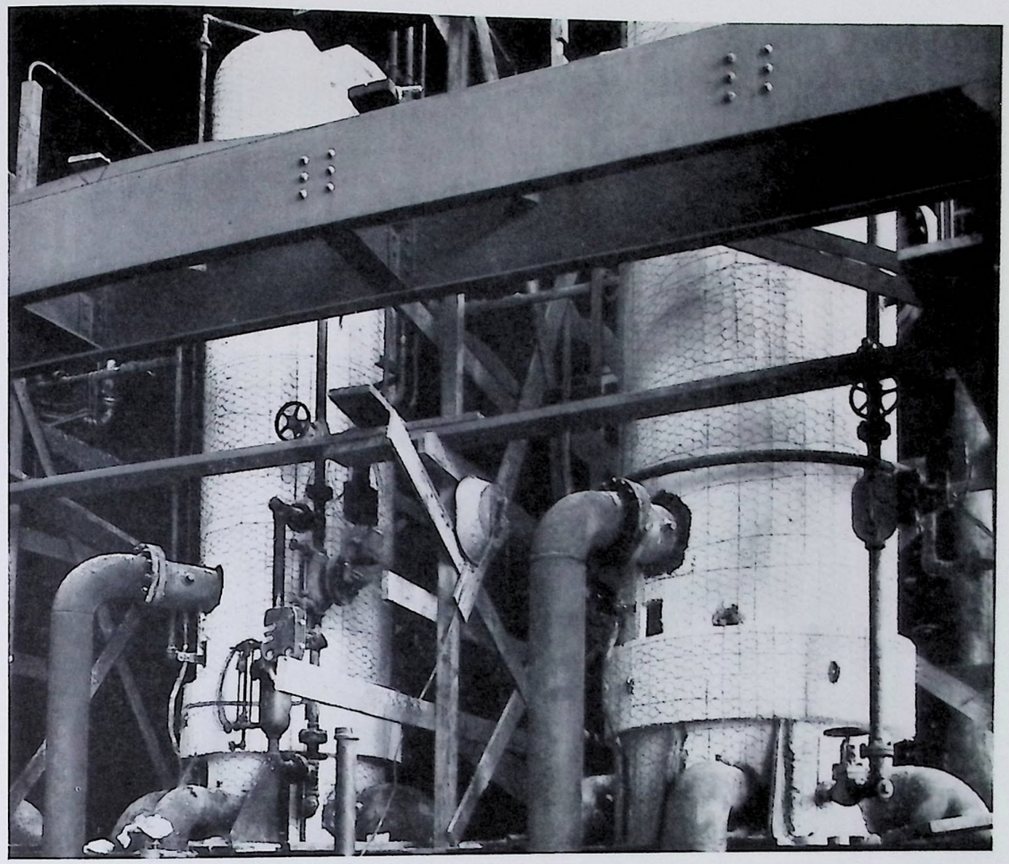
Plastic type weatherproofing, such as used on expansion loops and outdoor equipment, should be watched for cracks or breaks due to bumping. The damaged finish can be quickly repaired with a trowelled on coat of the same material. If the insulation underneath has been damaged, it can be patched with asbestos cement, or replaced, if the area where damage has occurred is large.

Quite frequently, steam pressures in lines are increased without providing any additional thickness of insulation on the lines and equipment. In these cases, the insulation on these lines frequently appears to be in an excellent condition, but on close inspection it will be seen that underneath the finish, the insulation has shrunk, deteriorated, charred, or otherwise failed. Even though the insulation has not failed, where steam pressures have been increased heat losses become uneconomically high. In either case, a complete replacement job or additional insulation applied over the old covering, if it is in sound condition, will pay for itself in a relatively short time.

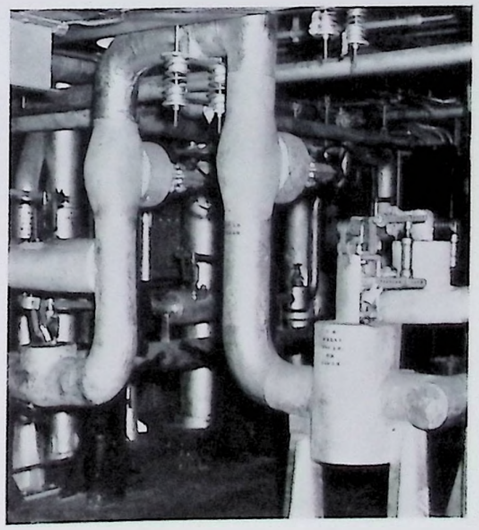


Replacement of damaged insulation pays off in fuel savings, and by preventing progressive deterioration of the covering.





Above: Here are two of the twenty feedwater heaters in the heater bay of the Philadelphia Electric Company's Southwark Station. They are insulated with 85% Magnesia Block, wired in place, over which 2"-mesh netting was applied. The final finish was 8-oz. canvas over a ½" coat of asbestos cement. Insulation work was done by Armstrong's Contracting Organization.



Right: This is a pressure reducing station at a large Eastern power plant. Lines and fittings were insulated by Armstrong mechanics, with Hy-Temp and 85% Magnesia Pipe Covering.



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Section VII

# INSULATING REFRACTORIES

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# The Advantages of Insulating Fire Brick

Insulating fire brick are lightweight, porous refractory materials which have considerable structural strength and high insulating efficiency. They will resist heat effectively at the temperatures for which they are designed.

Conventional fire brick are dense, heavy products made of refractory clays. They have great structural strength and resistance to heat but little practical insulating value.

Furnaces built entirely of heavy fire brick waste heat in two ways. First, much of the heat required to bring the furnace up to operating temperature is lost through storage in the furnace structure. Second, a major portion of the total heat input required to maintain operating temperatures is lost by transmission through walls.

Storage losses are high because the heat capacity of a material is directly related to its weight. These losses are even more costly in furnaces which are intermittently fired because heavy fire brick increase the time required to bring the furnace up to operating temperature and to cool it when the firing cycle is completed. Transmission losses are high because fire brick have a low resistance to the passage of heat.

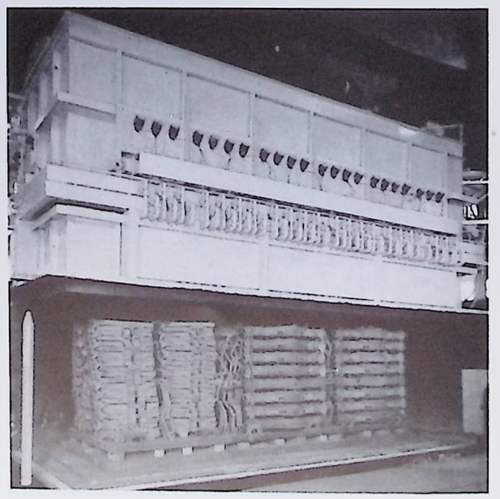
### Losses Reduced by Insulating Fire Brick

These losses are substantially reduced by the use of insulating fire brick. The light weight of insulating fire brick gives this material a very low heat storage capacity. Its porous structure, consisting of tiny dead air spaces, makes insulating fire brick highly resistant to heat flow.

Tests made by Armstrong's Research Laboratories illustrate the savings in both fuel and production time made possible by Armstrong's Insulating Fire Brick. The results of these tests are shown in the illustration and chart at the bottom of the opposite page.



Each insulating fire brick in this 21 foot wide arch is tapered for exact fit. The high strength and light weight of Armstrong's brick permit great freedom of design.



The high strength of Armstrong's Insulating Fire Brick enables them to withstand the severe service to which they are subjected when used to line cover type furnaces.



In practice, the use of Armstrong's Insulating Fire Brick can reduce heat loss as much as 80% and shorten the time required to bring furnaces up to operating temperature by 80% to 90%.

In addition to the operating economies made possible by reduced fuel costs and more efficient firing cycles, insulating fire brick offers the following important practical advantages:

### More Accurate Temperature Control

By reducing heat loss, insulating fire brick help maintain even temperatures in all parts of the furnace. This minimizes temperature fluctuations during processing and results in a more uniform heat treatment, less scrap, and increased quality of the finished product.

### Simplified Furnace Design

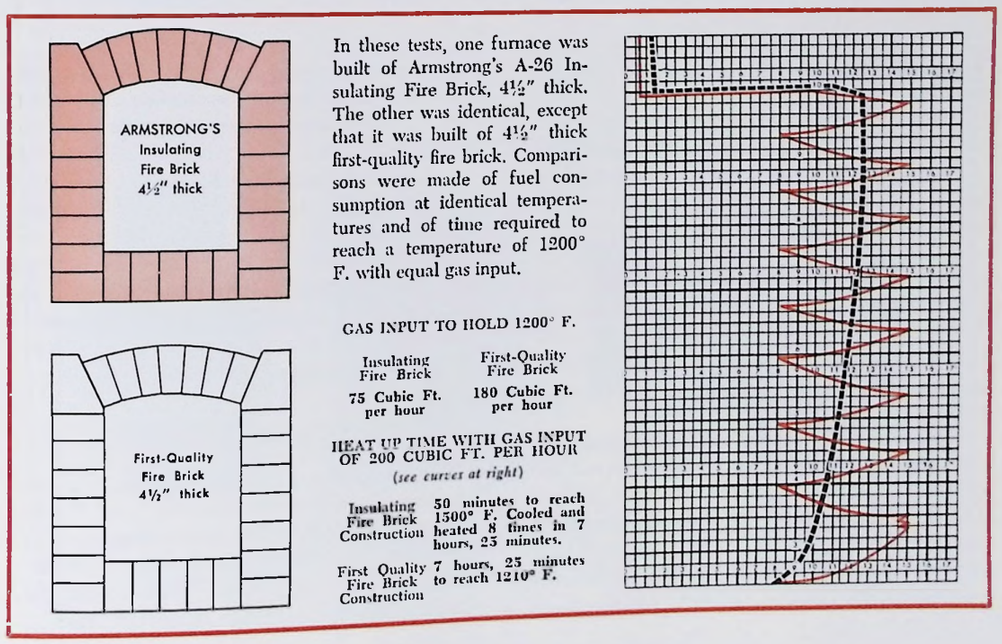
By permitting thinner walls and reduced construction weight, insulating fire brick simplify furnace design. A 4½" wall of insulating fire brick has the same thermal efficiency as a wall 13½" to 18" thick constructed of fire brick. Thinner walls mean substantial savings in space, or permit larger hearths for the same outside dimensions. By reducing the over-all weight of furnace construction, they also cut the amount of structural steel needed and lower the cost of foundations and footings.

### Reduced Construction Costs

Insulating fire brick are considerably easier to handle on the job than regular fire brick. They weigh from about 1.80 pounds to 2.75 pounds per 9" x 4½" x 2½" brick as compared with about 7.5 lbs. per standard fire brick. Insulating fire brick are easily cut and shaped on the job with a saw or rasp. Because they are strong, accurately sized, and made in a number of standard and special shapes, insulating fire brick lay up with a minimum of effort.

### Quieter Furnace Operation

Due to their porous structure, insulating fire brick have a noise reduction coefficient comparable to most acoustical materials, and as a result their use in furnace construction reduces furnace roar and burner noises substantially.






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# Armstrong's Insulating Fire Brick

Armstrong manufactures a complete line of insulating fire brick for temperatures from 1600° to 2800° F. These brick are used directly exposed as furnace linings or as back-up insulation behind heavy refractory brick. In the manufacture of Armstrong's Insulating Fire Brick, selected refractory clays and carefully sized particles of finely ground cork are combined in a wet mix and molded. The brick are then fired in tunnel kilns and the cork particles burn out, leaving a lightweight, porous structure containing thousands of small air spaces. These air spaces give these insulating fire brick their high resistance to heat flow.

The use of cork results in more than just high insulating efficiency. Because cork does not absorb water, clays that produce a stronger finished product can be used in brick formulation without reducing the plasticity of the wet mix. Also, the combustion rate of cork can be controlled in the firing kilns. By burning out the cork slowly, a brick can be produced that is free from laminations and internal strains that weaken its strength.

In its temperature range, each type of Armstrong's Insulating Fire Brick is manufactured to possess high insulating efficiency. At the same time each brick must have the high strength necessary to resist spalling and shrinkage, yet be light in weight. Armstrong's Insulating Fire Brick are manufactured with the following essential physical properties in careful balance to provide high thermal efficiency, longer furnace life, and lower installation costs.

### Low Thermal Conductivity

The fundamental purpose of an insulating refractory is to prevent heat loss. Low thermal conductivity, therefore, is a most important requirement. The brick manufactured by Armstrong all have the lowest conductivities that can be attained without sacrificing strength.



### High Strength

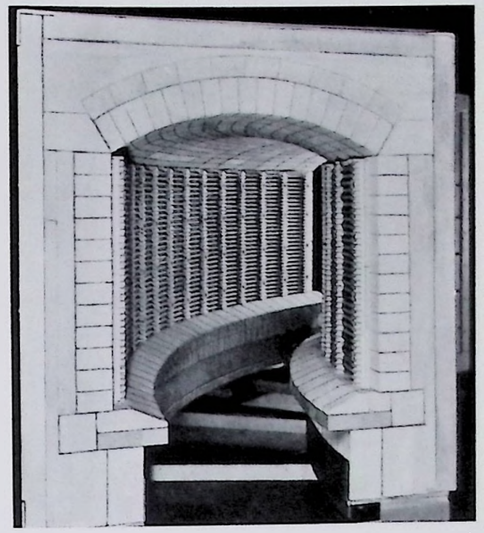
High strength contributes greatly to the life of an insulating refractory in service. It provides for more dependable furnace operation and low maintenance costs. The high strength and exceptional ruggedness of Armstrong's Insulating Fire Brick result from the cork burn-out which allows the use of stronger refractory clays and close control in firing the brick.

Because of the high strength of these brick, they offer great resistance to wear and to erosion by high velocity gases and flame impingement. High strength also eliminates dusting and flaking on ware in the furnace and permits stable suspended arch and wall construction.

### Resistance to Spalling and Shrinkage

The ability of an insulating fire brick to stand up in direct exposure depends largely on its resistance to spalling and shrinkage.

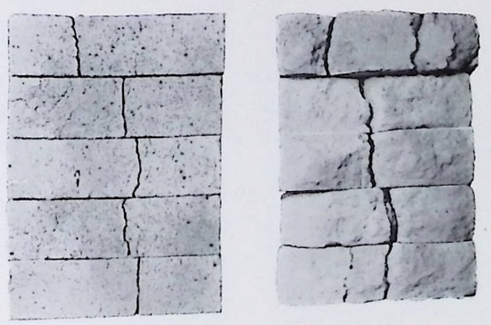
The uniform, porous structure, absence of laminations, and elimination of internal strains due to controlled combustion of cork during manufacture produce brick with exceptionally high resistance to spalling. Armstrong's Insulating Fire Brick are fired in modern tunnel kilns at or above the temperatures for which they are recommended. This carefully controlled firing process assures that all six types will have uniformly low shrinkage under operating conditions.



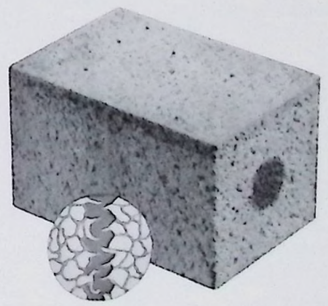
The great strength of Armstrong's Insulating Fire Brick permits shipment of factory built units without damage.

### Light Weight

Armstrong's Insulating Fire Brick are formulated and manufactured to offer the lightest possible weight without undue sacrifice in strength. They are light enough to absorb little heat, yet strong enough to resist mechanical abrasion and accidental bumping. They have good load-bearing characteristics and resist breaking and cracking from furnace stresses.



High resistance to spalling of Armstrong's Brick, left, is compared to other insulating brick, right. Both brick were subjected to identical testing.



The irregular pore structure and fine grained composition of Armstrong's Insulating Fire Brick provide for an extra tight, strong mortar bond.



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### Uniformity and Texture

The uniform texture of Armstrong's Insulating Fire Brick makes possible easy machining and fabrication at the factory or on the job. Their porous structure and fine-grained composition provide for an excellent mortar bond and take dense refractory wash coats well. All brick are made slightly oversize and then accurately machined to specified dimensions with a maximum allowable tolerance of .035". This accurate sizing permits an extremely thin cemented joint and assures tight joints if the insulation is laid up dry.

### Pyrochemical Stability

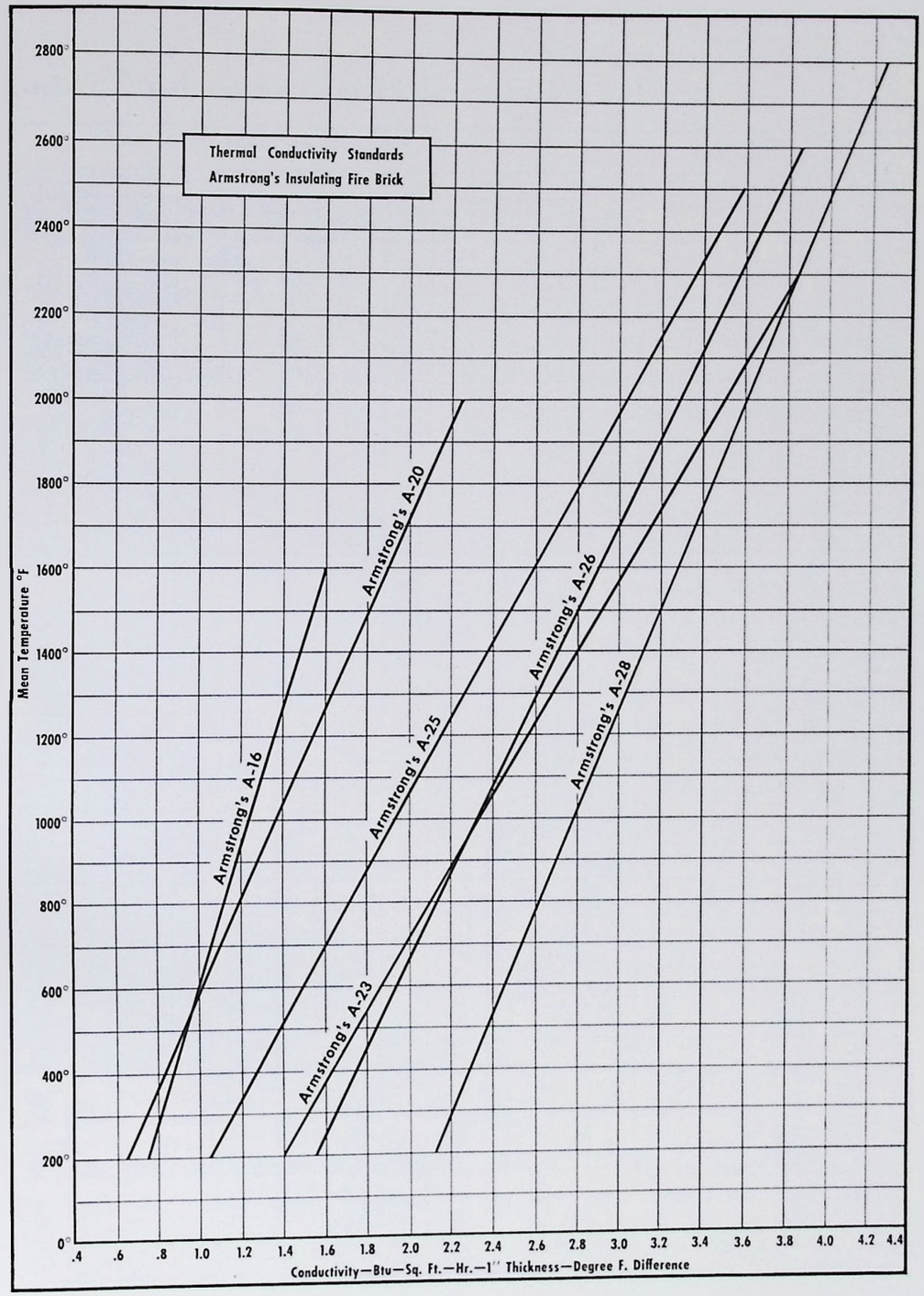
Armstrong's Insulating Fire Brick offer resistance to chemical attack or chemical reaction at high temperatures. When brick are properly selected, normal furnace atmospheres and controlled special atmospheres do not cause them to deteriorate. In the case of controlled atmospheres, the pyrochemical stability of the brick types will vary with the atmospheres to which they are subjected. Armstrong's Insulating Fire Brick have been used successfully in sulphur burning furnaces, phosphate furnaces, magnesium furnaces, and electrolytic cells and reactor chamber linings in the petroleum and chemical industries. However, not every brick type is recommended for all service conditions. An Armstrong engineer should be consulted to determine the brick best suited to each special atmosphere application.

Each of the six types of Armstrong's Insulating Fire Brick offers dependable service within the temperature range and other general conditions for which it is designed. Two or more types are often used in combination to achieve furnace economy which would not be possible with one type of brick. The physical properties of all six types of Armstrong's Insulating Fire Brick are given in the table below. Conductivity curves for all brick types are on page 169.

## Physical Properties of Armstrong's Insulating Fire Brick

| Type | A-16 | A-20 | A-23 | A-25 | A-26 | A-28 |
|---|---|---|---|---|---|---|
| Maximum hot face temperature | 1600° F. | 2000° F. | 2300° F. | 2500° F. | 2600° F. | 2800° F. |
| Flexural Strength (Lbs./sq. in.) Test Method: A.S.T.M. C93-46. | 120 | 70 | 210 | 105 | 225 | |
| Compressive Strength, minimum (Lbs./sq. in.) Test Method: A.S.T.M. C93-46. | 175 | 175 | 430 | 250 | 325 | 234 |
| P. C. E. No., minimum Test Method: A.S.T.M. C24-46. | 29 | 29 | 31 | 29 | 33 | 36 |
| Corresponding Softening Point | 2984° F. | 2939° F. | 3056° F. | 2984° F. | 3173° F. | 3290° F. |
| Weight per 9-inch straight. Lbs. maximum | 1.85 | 1.90 | 2.75 | 2.35 | 2.80 | 3.25 |
| Weight, lbs. per cu. ft. maximum | 31.6 | 32.4 | 47.0 | 40.2 | 47.8 | 55.15 |
| Spalling Loss—Average per cent See page 167. | 0.25 | 3.0 | 5.0 | 9.0 | 5.0 | 15.0 |
| Shrinkage, Linear change per cent at maximum hot face temperatures (maximum) Test Method: A.S.T.M. C210-46, for 24-hour period. | 0.5 | 1.10 | 1.75 | 2.00 | 2.00 | 2.00 |
| Conductivity, Btu. per sq. ft. per hr. per in. thickness at max. mean temperature | | | | | | |
| 400° F. | .890 | .846 | 1.620 | 1.253 | 1.753 | 2.292 |
| 1200° F. | 1.362 | 1.532 | 2.543 | 2.140 | 2.532 | 2.945 |
| Test Method: Guarded Hot Plate Method. | | | | | | |








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# Btu Heat Loss and Heat Storage for Various

HOT FACE OF WALL

| WALL STRUCTURE (INCHES OF THICKNESS) ARMSTRONG'S INSULATING FIRE BRICK, FIRE CLAY BRICK, AND COMBINATIONS | | | 1000° F. | | 1200° F. | | 1400° F. | | 1600° F. | | 1800° F. | | 2000° F. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Heat Loss | Heat Storage | Heat Loss | Heat Storage | Heat Loss | Heat Storage | Heat Loss | Heat Storage | Heat Loss | Heat Storage | Heat Loss | Heat Storage |
| ←4½"→ | | | | | | | | | | | | | | |
| A-16 | | | 186 | 1363 | 240 | 1693 | 300 | 2027 | 364 | 2375 | | | | |
| A-20 | | | 186 | 1409 | 248 | 1753 | 316 | 2104 | 392 | 2467 | 474 | 2840 | 566 | 3211 |
| A-23 | | | 326 | 2147 | 424 | 2658 | 533 | 3182 | 651 | 3721 | 776 | 4273 | 918 | 4830 |
| A-25 | | | 265 | 1788 | 348 | 2186 | 441 | 2666 | 545 | 3125 | 655 | 3576 | 779 | 4061 |
| A-26 | | | 341 | 2196 | 438 | 2712 | 545 | 3244 | 660 | 3789 | 783 | 4350 | 915 | 4908 |
| A-28 | | | 418 | 2608 | 528 | 3223 | 649 | 3850 | 776 | 4491 | 912 | 5126 | 1053 | 5798 |
| FB | | | 971 | 6830 | 1260 | 8370 | 1577 | 9999 | 1917 | 11607 | 2290 | 13273 | 2687 | 14903 |
| ←4½"→ | 2½" | ← "A-16; A-20, etc. | | | | | | | | | | | | |
| FB | 16 | " | 254 | 10471 | 328 | 13039 | 410 | 15730 | 496 | 18462 | 589 | 21213 | | |
| FB | 20 | " | 253 | 10504 | 330 | 13064 | 418 | 15734 | 516 | 18430 | 621 | 21147 | 736 | 23920 |
| FB | 25 | " | 327 | 10382 | 426 | 12855 | 535 | 15495 | 655 | 18157 | 785 | 20843 | 926 | 23596 |
| A-20 | 16 | " | 126 | 2303 | 166 | 2904 | 209 | 3530 | 257 | 4186 | 309 | 4853 | 367 | 5557 |
| A-23 | 16 | " | 170 | 3577 | 221 | 4459 | 276 | 5403 | 336 | 6348 | 401 | 7345 | 471 | 8354 |
| A-26 | 20 | " | 168 | 3683 | 219 | 4571 | 275 | 5505 | 336 | 6443 | 403 | 7423 | 475 | 8411 |
| A-28 | 20 | " | 184 | 4329 | 237 | 5378 | 295 | 6440 | 360 | 7535 | 427 | 8634 | 500 | 9759 |
| A-28 | 25 | " | 222 | 4219 | 285 | 5233 | 353 | 6277 | 426 | 7311 | 504 | 8422 | 589 | 9522 |
| FB | FB | " | 678 | 9990 | 873 | 12341 | 1085 | 14703 | 1314 | 17119 | 1560 | 19589 | 1823 | 22130 |
| ← 9" → | | | | | | | | | | | | | | |
| A-16 | | | 96 | 2635 | 124 | 3260 | 154 | 3904 | 187 | 4575 | | | | |
| A-20 | | | 96 | 2702 | 127 | 3348 | 162 | 4014 | 201 | 4708 | 243 | 5394 | 289 | 6126 |
| A-23 | | | 171 | 4041 | 222 | 5025 | 278 | 6014 | 339 | 7050 | 406 | 8075 | 477 | 9161 |
| A-25 | | | 138 | 3408 | 180 | 4216 | 228 | 5086 | 281 | 5932 | 339 | 6833 | 401 | 7753 |
| A-26 | | | 180 | 4118 | 231 | 5119 | 286 | 6133 | 345 | 7179 | 409 | 8213 | 477 | 9318 |
| A-28 | | | 224 | 4892 | 283 | 6044 | 344 | 7224 | 410 | 8441 | 480 | 9694 | 553 | 10940 |
| FB | | | 549 | 12487 | 704 | 15367 | 873 | 18415 | 1054 | 21466 | 1248 | 24508 | 1456 | 27681 |
| ←4½"→ | ←4½"→ | | | | | | | | | | | | | |
| FB | A-16 | | 162 | 11393 | 209 | 14184 | 260 | 17106 | 315 | 20066 | | | | |
| FB | A-20 | | 161 | 11426 | 211 | 14210 | 268 | 17113 | 330 | 20064 | 399 | 23029 | 475 | 26083 |
| FB | A-25 | | 216 | 11510 | 282 | 14318 | 355 | 17170 | 435 | 20128 | 522 | 23196 | 616 | 26251 |
| A-20 | A-16 | | 99 | 2935 | 129 | 3694 | 163 | 4494 | 199 | 5323 | 239 | 6165 | 283 | 7031 |
| A-23 | A-16 | | 123 | 4318 | 159 | 5391 | 200 | 6522 | 242 | 7682 | 289 | 8846 | 339 | 10080 |
| A-23 | A-20 | | 121 | 4175 | 158 | 5434 | 201 | 6554 | 247 | 7699 | 298 | 8849 | 353 | 10031 |
| A-26 | A-16 | | 124 | 4389 | 160 | 5476 | 199 | 6608 | 241 | 7769 | 286 | 8933 | 334 | 10136 |
| A-26 | A-20 | | 122 | 4440 | 159 | 5506 | 200 | 6637 | 245 | 7777 | 295 | 8933 | 348 | 10115 |
| A-28 | A-20 | | 129 | 5128 | 168 | 6361 | 211 | 7614 | 257 | 8907 | 307 | 10245 | 361 | 11534 |
| A-28 | A-25 | | 164 | 5124 | 211 | 6356 | 263 | 7605 | 319 | 8902 | 380 | 10196 | 443 | 11540 |
| ← 9" → | ←4½"→ | | | | | | | | | | | | | |
| FB | A-16 | | 143 | 20495 | 185 | 25545 | 230 | 30706 | 278 | 36041 | 329 | 41570 | | |
| FB | A-20 | | 141 | 20572 | 185 | 25556 | 234 | 30670 | 287 | 35959 | 345 | 41439 | 408 | 46894 |
| FB | A-25 | | 183 | 20067 | 238 | 24981 | 298 | 30007 | 364 | 35037 | 436 | 40537 | 512 | 45908 |
| A-23 | A-16 | | 92 | 6790 | 120 | 8517 | 149 | 10294 | 182 | 12144 | 216 | 14014 | 254 | 15941 |
| A-25 | A-16 | | 83 | 5664 | 108 | 7126 | 136 | 8635 | 166 | 10223 | 199 | 11820 | 234 | 13520 |
| A-26 | A-16 | | 94 | 6926 | 120 | 8670 | 149 | 10450 | 181 | 12305 | 214 | 14176 | 250 | 16111 |
| A-26 | A-20 | | 91 | 7024 | 118 | 8743 | 148 | 10513 | 181 | 12339 | 216 | 14179 | 254 | 16066 |
| A-28 | A-16 | | 103 | 8237 | 131 | 10222 | 161 | 12265 | 193 | 14410 | 227 | 16626 | 264 | 18839 |
| A-28 | A-20 | | 100 | 8334 | 129 | 10286 | 160 | 12370 | 194 | 14433 | 230 | 16616 | 269 | 18770 |
| FB | | | 385 | 17893 | 492 | 22049 | 608 | 26483 | 732 | 30921 | 865 | 35312 | 1006 | 39962 |
| ← 9" → | ← 9" → | | | | | | | | | | | | | |
| FB | A-25 | | 112 | 22787 | 146 | 28364 | 183 | 34035 | 224 | 39916 | 268 | 45971 | 317 | 51614 |
| FB | A-20 | | 82 | 22716 | 108 | 28256 | 137 | 34018 | 169 | 39896 | 203 | 45775 | 241 | 51334 |
| FB | A-16 | | 83 | 22634 | 107 | 28212 | 133 | 33985 | 162 | 39879 | | | | |
| FB | A-25 | A-16 | 97 | 23288 | 125 | 29068 | 157 | 35032 | 191 | 41169 | 227 | 47315 | 266 | 53630 |
| FB | | | 298 | 13143 | 380 | 28686 | 468 | 34301 | 563 | 40090 | 664 | 46052 | 772 | 51929 |
| ← 18" → | | ←4½"→ | | | | | | | | | | | | |
| FB | | A-25 | 142 | 35378 | 183 | 43853 | 228 | 52903 | 273 | 61853 | 329 | 71334 | 385 | 80822 |
| FB | | A-20 | 114 | 36997 | 149 | 46017 | 187 | 55215 | 228 | 64750 | 273 | 74327 | 321 | 84160 |
| FB | | A-16 | 117 | 36786 | 150 | 45889 | 186 | 55228 | 225 | 64913 | 266 | 74640 | 311 | 84957 |
| FB | A-25 | A-16 | 90 | 32266 | 116 | 40204 | 145 | 48496 | 176 | 56970 | 210 | 65451 | 246 | 74211 |
| FB | | | 243 | 28384 | 309 | 35094 | 381 | 41962 | 457 | 49100 | 539 | 56395 | 626 | 63645 |



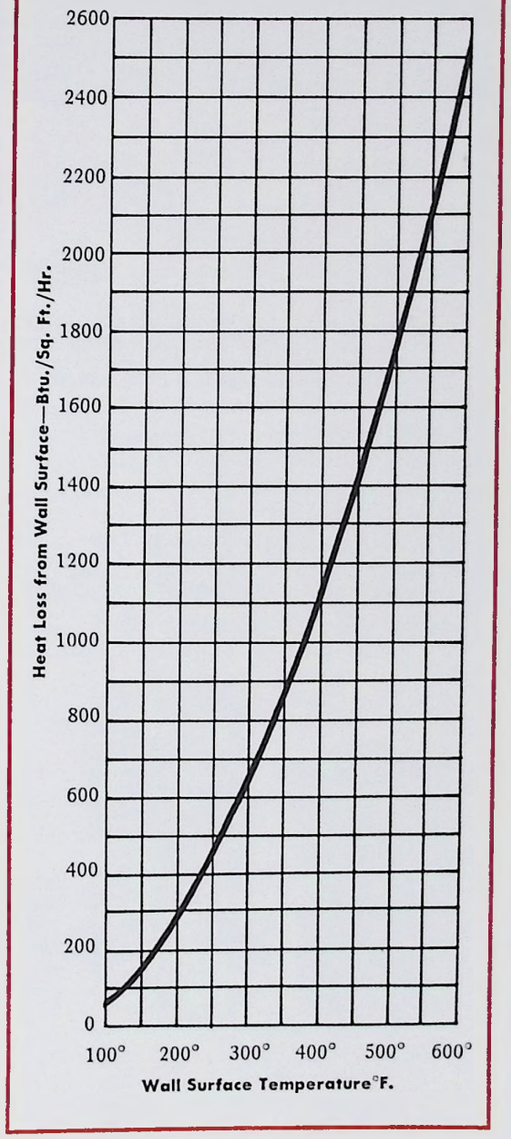
# Furnace Temperatures

HOT FACE TEMPERATURES

| 2200° F. | | 2400° F. | | 2600° F. | | 2800° F. | |
|---|---|---|---|---|---|---|---|
| Heat Loss | Heat Storage | Heat Loss | Heat Storage | Heat Loss | Heat Storage | Heat Loss | Heat Storage |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| 1065 | 5416 | | | | | | |
| 912 | 4538 | 1051 | 5044 | | | | |
| 1056 | 5499 | 1206 | 6083 | 1364 | 6675 | | |
| 1202 | 6463 | 1358 | 7138 | 1526 | 7826 | 1697 | 8528 |
| 3109 | 16622 | 3559 | 18304 | 4038 | 19943 | 4539 | 21675 |
| | | | | | | | |
| | | | | | | | |
| 859 | 26793 | | | | | | |
| 1078 | 26409 | 1239 | 29206 | 1410 | 32058 | 1591 | 34956 |
| | | | | | | | |
| 545 | 9389 | | | | | | |
| 551 | 9395 | 634 | 10429 | 722 | 11449 | | |
| 577 | 10913 | 663 | 12050 | 750 | 13209 | 842 | 14393 |
| 677 | 10619 | 773 | 11768 | 871 | 12876 | 976 | 14070 |
| 2104 | 24626 | 2400 | 27174 | 2715 | 29756 | 3044 | 32391 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| 553 | 10237 | | | | | | |
| 469 | 8672 | 541 | 9610 | | | | |
| 549 | 10412 | 626 | 11530 | 706 | 12662 | | |
| 630 | 12262 | 711 | 13556 | 795 | 14830 | 883 | 16174 |
| 1678 | 30845 | 1911 | 34052 | 2156 | 37325 | 2416 | 40641 |
| | | | | | | | |
| | | | | | | | |
| 553 | 29197 | | | | | | |
| 718 | 29306 | 826 | 32405 | 941 | 35696 | 1063 | 38807 |
| | | | | | | | |
| | | | | | | | |
| 412 | 11251 | | | | | | |
| | | | | | | | |
| 405 | 11335 | 467 | 12530 | 532 | 13761 | | |
| 419 | 12910 | 481 | 14261 | 546 | 15645 | | |
| 512 | 12906 | 585 | 14260 | 663 | 15614 | 744 | 17046 |
| | | | | | | | |
| | | | | | | | |
| 476 | 52281 | 547 | 58039 | | | | |
| 595 | 51232 | 682 | 56870 | 776 | 62415 | 874 | 68205 |
| 294 | 17936 | | | | | | |
| 272 | 15168 | 313 | 16938 | | | | |
| 288 | 18087 | 329 | 20070 | 372 | 22072 | | |
| 294 | 18017 | 338 | 19933 | 385 | 21901 | | |
| 303 | 21029 | 343 | 23379 | | | | |
| 310 | 20932 | 354 | 23130 | 401 | 25380 | 450 | 27639 |
| 1157 | 44566 | 1315 | 49268 | 1481 | 54032 | 1657 | 58931 |
| | | | | | | | |
| 368 | 58128 | 423 | 64299 | 481 | 70844 | 543 | 76991 |
| 282 | 58010 | | | | | | |
| | | | | | | | |
| 308 | 60138 | 353 | 66564 | | | | |
| 885 | 57936 | 1005 | 64325 | 1132 | 70337 | 1265 | 76730 |
| | | | | | | | |
| 445 | 90243 | 509 | 100211 | 577 | 110051 | 649 | 119641 |
| 372 | 94267 | 427 | 104205 | 486 | 114387 | 548 | 124725 |
| 357 | 94956 | | | | | | |
| 284 | 83212 | 324 | 92124 | | | | |
| 718 | 71340 | 815 | 78936 | 917 | 86692 | 1024 | 94545 |

### Outside Wall Surface Temperatures

Outside wall surface temperatures may be estimated from this curve, using the heat loss figures shown in chart at left. For example: 4½" A-16 wall at 1400° F. shows a heat loss of 300 Btu. per sq. ft. per hr. The curve below indicates that the outside surface temperature of the furnace wall is 200° F.



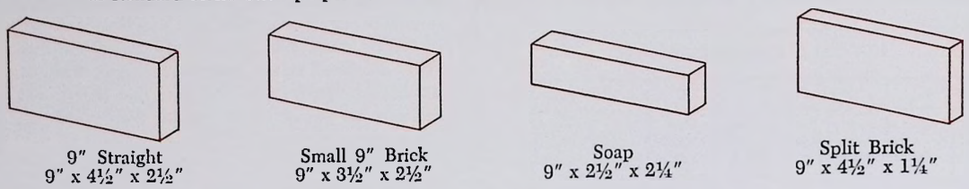




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## Standard Brick

Square edged rectangular sizes that can be cut from 9" x 4½" x 2½" straight brick are classified as standard brick. Their proper nomenclature and dimensions are diagrammed in the first group.



9" Straight
9" x 4½" x 2½"

Small 9" Brick
9" x 3½" x 2½"

Soap
9" x 2½" x 2¼"

Split Brick
9" x 4½" x 1¼"

3" Split Brick
9" x 4½" x 1½"

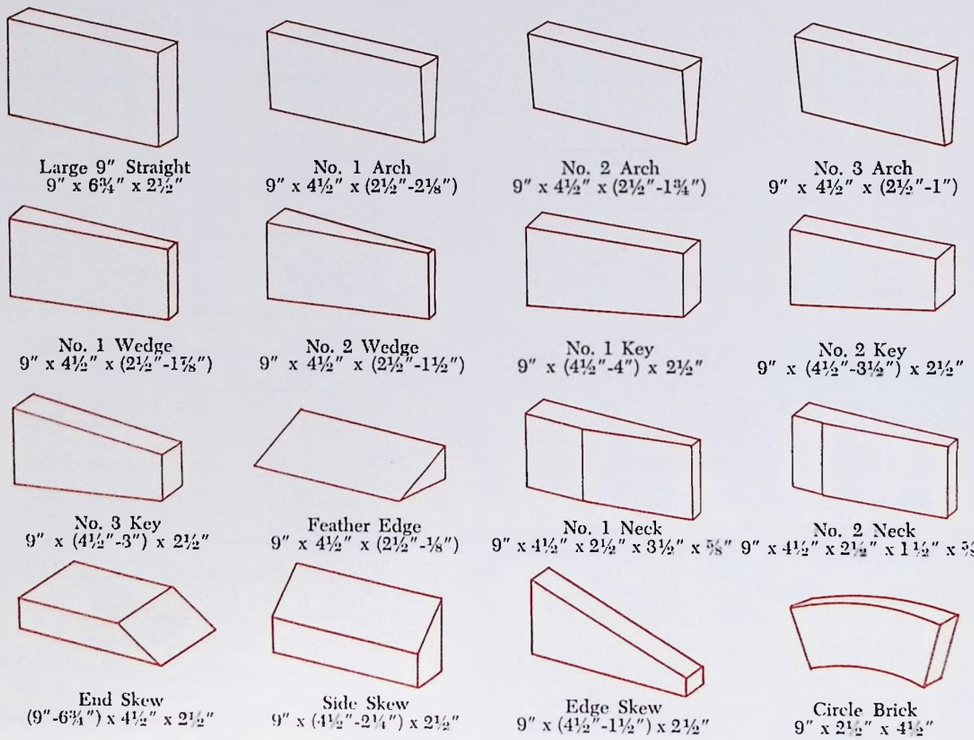
2" Brick
9" x 4½" x 2"

Square Edged
Sizes from 9" Straight

NOTE: In addition to these standard brick, which are classified as the 2½" series, standard brick are also available in the 3" series, cut from 9" x 4½" x 3" straights.

## Standard Shapes

All types of brick diagrammed below are classified as standard shapes and are cut from 9" straights. This classification includes brick and standard shapes in the 9" x 6¾" x 2½" series. Standard shapes can also be furnished with dimensions "tailor made" to exact specifications or radius and taper. See Pages 176 and 177 for details.



Large 9" Straight
9" x 6¾" x 2½"

No. 1 Arch
9" x 4½" x (2½"-2⅛")

No. 2 Arch
9" x 4½" x (2½"-1¾")

No. 3 Arch
9" x 4½" x (2½"-1")

No. 1 Wedge
9" x 4½" x (2½"-1⅞")

No. 2 Wedge
9" x 4½" x (2½"-1½")

No. 1 Key
9" x (4½"-4") x 2½"

No. 2 Key
9" x (4½"-3½") x 2½"

No. 3 Key
9" x (4½"-3") x 2½"

Feather Edge
9" x 4½" x (2½"-⅛")

No. 1 Neck
9" x 4½" x 2½" x 3½" x ⅝"

No. 2 Neck
9" x 4½" x 2½" x 1½" x ⅝"

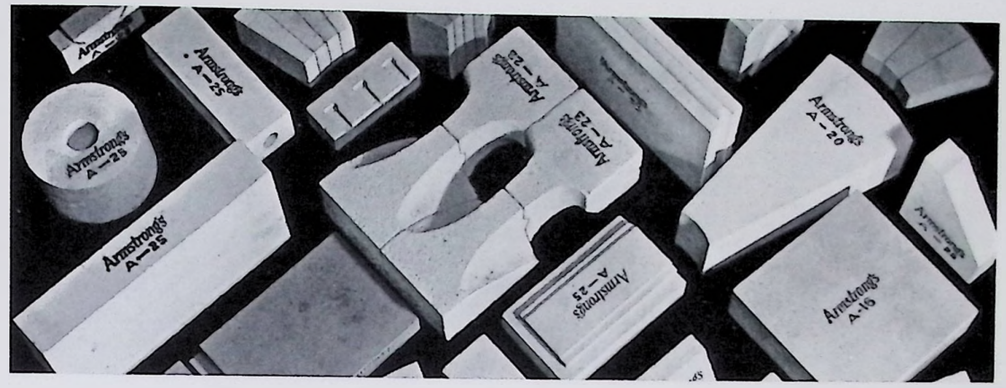
End Skew
(9"-6¾") x 4½" x 2½"

Side Skew
9" x (4½"-2¼") x 2½"

Edge Skew
9" x (4½"-1½") x 2½"

Circle Brick
9" x 2½" x 4½"






# Special Shapes

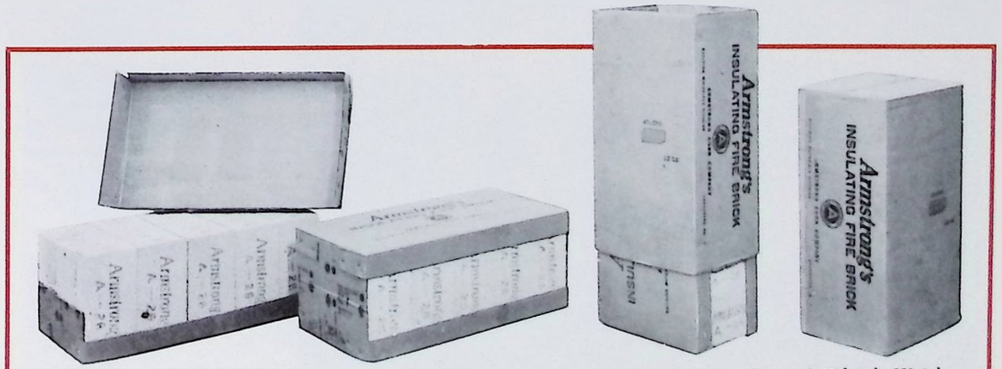
Special shapes are made up in any of the six types of brick in the Armstrong Line from rectangular pieces having the three greatest dimensions of the finished piece. An assortment of rough stock is maintained at the factory so that quick service can be provided on shapes and sizes most commonly called for. On orders for unusual sizes, the tile from which the shapes are cut must be made up, so extra time must be allowed for molding, drying, and firing.

The high strength and fine-grained structure of Armstrong's Insulating Fire Brick, combined with careful machining, result in finished shapes having clean sharp edges, square corners, and extremely accurate dimensions throughout.

### Packaging Data on Insulating Fire Brick

For carload shipments directly to the job, Standard Insulating Fire Brick are packaged in the patented tray-type carton shown below. This carton provides full protection for carload shipment and also makes the brick easier to handle on the job. By slitting the paper tape with a trowel and lifting off the top tray, 25 brick are exposed, conveniently arranged for fast handling.

LCL shipments are made in tray-type cartons enclosed with a sleeve or in enclosed cartons.




Carton for carload shipment of 25 brick. Shipping weights: A-16, 47.5 lbs.; A-20, 49.75 lbs.; A-23, 70 lbs.; A-25, 59.5 lbs.; A-26, 70.5 lbs.; A-28, 88.5 lbs.

Sleeve or enclosed LCL package of 25 brick. Weights: A-16, 48.75 lbs.; A-20, 51 lbs.; A-23, 71.25 lbs.; A-25, 60.75 lbs.; A-26, 71.75 lbs.; A-28, 89.75 lbs.



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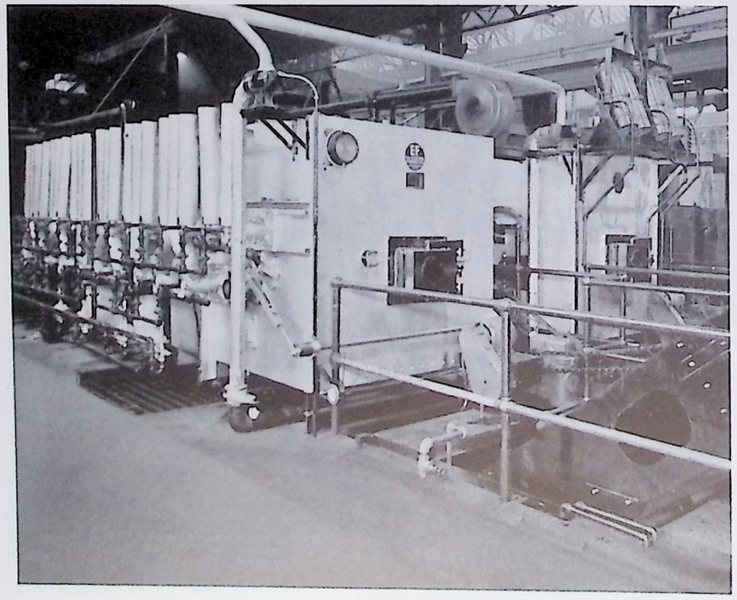
# General Recommendations for Use of Insulating Fire Brick

All six types of Armstrong's Insulating Fire Brick can be used directly exposed up to the temperatures for which they are recommended in equipment fired with gas, oil, electricity, or powdered coal. They should not be exposed to molten metal, slags, or severe mechanical abrasion. When those conditions prevail, insulating fire brick should be used as back-up insulation behind a heavy refractory lining.

In the selection of an insulating refractory, the top temperature limit of the brick must be considered, but it is not always the final determining factor in brick choice. Strength under hot load, resistance to various types of furnace atmospheres, and many factors that vary from one type of furnace to another all have a bearing on brick selection. For example, a furnace operating at 1750° F. would take an A-20 insulating fire brick lining if temperature alone were taken into account. But that furnace may operate under an atmosphere that would deteriorate the A-20, but would have no adverse effects upon Armstrong's A-23 Brick. In this case, the A-23 would then be the logical choice.

Because the conditions that determine brick selection vary widely from furnace to furnace and because brick properties also vary from type to type, it is recommended that an Armstrong engineer be consulted for recommendations when any unusual condition that might affect brick performance is encountered.

The table at right is a guide to the use of Armstrong's Insulating Fire Brick under normal conditions in the applications listed.



Exceptional resistance to the deteriorating effects of controlled atmosphere gases is offered by Armstrong's Insulating Fire Brick. The special atmosphere furnace shown at the left has been in operation since 1938.



## Guide for Application of Armstrong's Insulating Fire Brick

| Type of Brick | A-16 1600° F. | A-20 2000° F. | A-25 2500° F. | A-23 2300° F. | A-26 2600° F. | A-28 2800° F. |
|---|---|---|---|---|---|---|
| **METAL WORKING INDUSTRIES** | | | | | | |
| Blast Furnace Mains | B | B | B | | | |
| Blast Furnace Stoves | B | B | B | | | |
| Coke Ovens | | B | B | | | |
| Core Drying Ovens | E | | | | | |
| Ducts, Flues, Mains | B | B & E | B | E | E | E |
| Forge Furnaces | B | B | B | | E | E |
| Galvanizing Tanks | B | B | | E | | |
| Heating Furnaces | | | | | | |
| Billet and Slab | B | B | B | | | |
| Plate | B | B | B | | E | E |
| Rod | B | | | E | E | |
| Soaking Pit | B | B | B | | | |
| Soaking Pit Covers | | | | | | E |
| Soaking Pit Dampers | | | | | E | |
| Heat Treating Furnaces | | | | | | |
| Annealing | B & E | B & E | E | E | | |
| Carburizing | B | E | E | E | E | |
| Drawing | B | E | E | E | | |
| Hardening | B | E | E | E | E | |
| Malleablizing | B | | E | E | E | |
| Normalizing | B | E | E | E | | |
| Salt Bath | B | B | B | | | |
| Spherodizing | B | E | | | | |
| Stress Relieving | E | E | | | | |
| Melting Furnaces | | | | | | |
| Crucible Type | | | B | | | E |
| Electric | | | B | | | |
| Open Hearth | B | B | B | | | |
| Regenerators | B | B | B | | | |
| Recouperators | B | B | B | | | |
| Waste Heat Boilers | B | B | | | E | |
| **CERAMICS AND GLASS** | | | | | | |
| Ceramic Kilns | | | | | | |
| Periodic Kilns | B | B | B & E | E | E | E |
| Tunnel Kilns | B | B | B & E | E | E | E |
| Pottery Kilns | B | B | B & E | E | E | E |
| Experimental Furnaces | B & E | B & E | B & E | E | E | E |
| Enameling Furnaces | B | E | E | E | E | |
| Gas Producers | B | B | B | | | |
| Glass Annealing Lehrs | B & E | E | | | | |
| Glass Bending Furnaces | B & E | E | | E | | |
| Glass Melting Tanks | | | | | | |
| Crown | | | B | | | |
| Regenerators | B | B | | | | |
| Uptakes | | B | B | | | |
| Port Arch | | | B | | | |
| Forehearths | | B | | | | |
| Forehearths (above metal line) | | | | | E | |
| **PETROLEUM INDUSTRY** | | | | | | |
| Air and Gas Heaters | B | B | E | E | E | |
| Oil Heaters and Stills | B | B | E | E | E | |
| Reactor Chambers | B | B | E | E | E | |
| **CHEMICAL INDUSTRY** | | | | | | |
| Calcining Furnaces | B | B | | B | | |
| Sulfur Furnaces | B | | B | E | E | |
| High-Temp. Pressure Vessels | B | B & E | B & E | E | E | |
| **POWER PLANTS** | | | | | | |
| Boilers | | | | | | |
| Oil and Gas Fired | B | B & E | B | E | E | E |
| Coal Fired | B | B | | E | E | |
| Waste Heat | B | B | | E | E | E |
| Breaching and Ducts | B | B & E | | E | E | |
| **GENERAL** | | | | | | |
| Domestic Oil Burners | | E | E | E | E | |
| Incinerators | B | B | B | E | E | |
| Stacks | B | B & E | | | | |

B—Used as Back-Up Insulation. E—Used directly exposed as furnace lining where temperature on brick does not exceed limits shown.

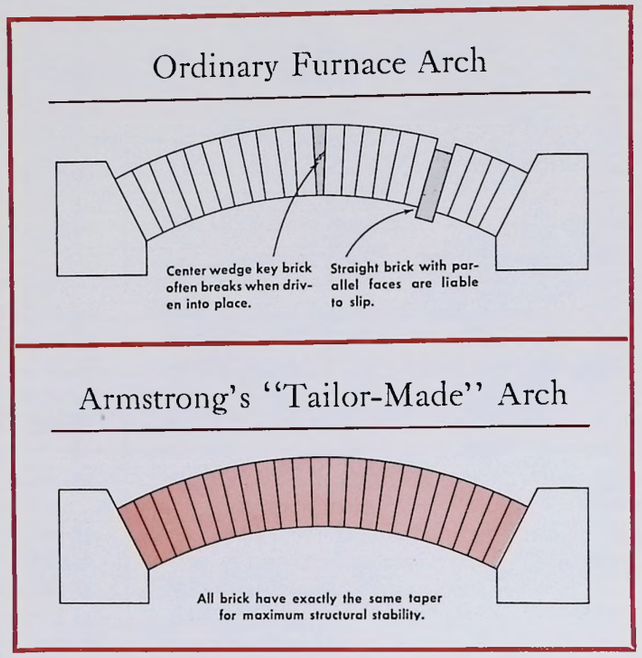


*Armstrong's Industrial Insulations (1951)*
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# Armstrong's "Tailor-Made" Arches

Armstrong's "Tailor-made" arches lay up faster and are stronger because each insulating fire brick is cut to the same size and taper. This feature provides a more positive keying action with a maximum of structural stability that cannot be obtained when straight and standard arch or wedge brick are combined to form the arch.

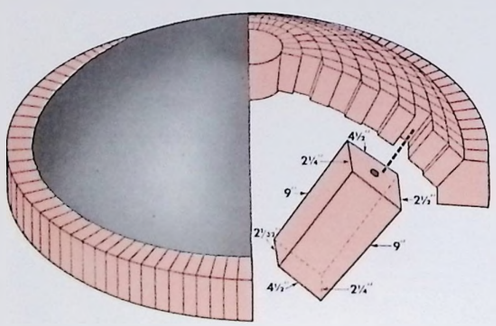
When ordering Armstrong's "Tailor-made" arches, simply state the span, rise, thickness, and length of the arch. The brick are precision machined at the factory for perfect fit. In addition, the large ends of tapered brick are marked with a colored dot to save bricklaying time and to avoid errors. "Tailor-made" arches are available in all six types of Armstrong's Brick at standard arch or wedge brick prices.




# Armstrong's "Tailor-Made" Domes

"Tailor-made" domes simplify furnace design and provide for maximum strength and structural stability. In addition, installation costs can be reduced as much as 25% because these domes are pre-assembled at the factory before shipment, and each course is carefully marked for quick identification on the job. Cartons in which the brick are shipped are also marked so that bricklaying can be done rapidly and economically. Because the brick are cut from standard stock sizes, this custom work can be done promptly and the brick, if damaged, can be replaced at relatively small cost. Armstrong engineers will design the entire dome for you without extra charge.

"Tailor-made" domes are available in all six types of Armstrong's Insulating Fire Brick. Each brick is precision tapered on all sides to fit perfectly into the dome construction without any gaps or open spaces. These domes are so perfectly fitted that they will lay up dry with no slippage of any brick.



Precision-cut insulating brick in Armstrong's "Tailor-Made" Domes have exact taper required for perfect fit.

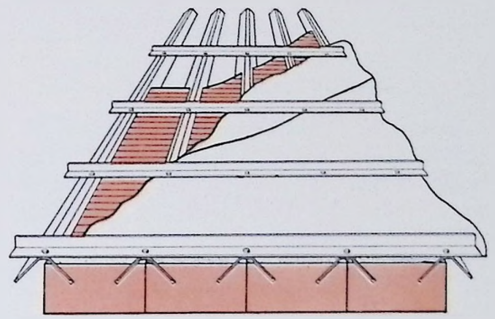


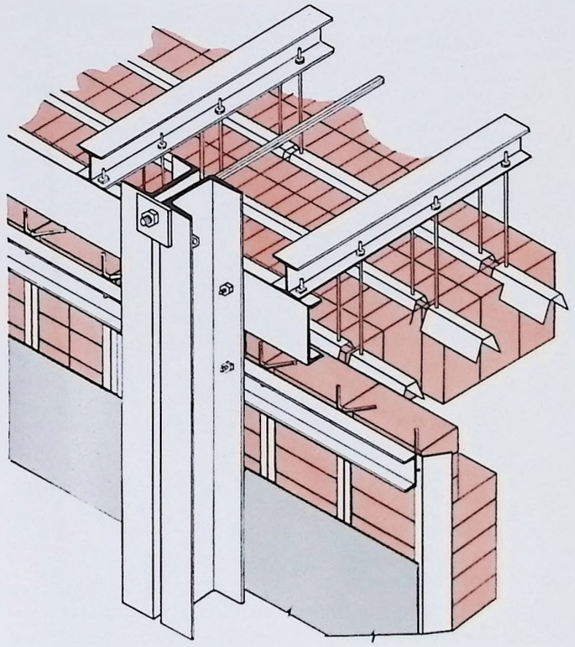
# Suspended Arch and Wall Construction

Suspended arches and walls offer distinct advantages to furnace builders and designers. They make possible the practical construction of wide span flat arches and permit erection of thin, lightweight walls of high thermal efficiency and structural stability. The use of insulating fire brick in suspended construction reduces over-all weight by eliminating the need for heavy steel members, thus reducing foundation costs. It also provides positive means for supporting brickwork in applications where equipment design demands thin walls of high efficiency.

Armstrong offers insulating fire brick shapes for flat arches and suspended walls of many types in addition to the typical ones illustrated on this page. All are extremely simple in design and are planned for fast, low-cost erection. A minimum of shapes is employed, and all shapes are factory cut from standard Armstrong's Insulating Fire Brick, making it unnecessary for the average user to stock special shapes for repair and maintenance work.

Armstrong's Insulating Fire Brick are accurately machined with square edges and corners that assure heat-tight joints. Brick fabricated for suspended construction are available in all six types of Armstrong's Insulating Fire Brick. Their high strength, hot or cold, their accurate sizing, and their exceptional resistance to spalling make them ideally suited for this type of construction.





**Typical Suspended Construction Details**

Detail above shows typical method of applying Armstrong's Insulating Fire Brick on the inside of a metal casing such as a duct, breeching, or furnace shell. Brick are accurately cut at the factory to fit the butterfly angles. Brick can be turned 9" way when greater thicknesses are required.

Detail at left illustrates suspended arch and wall application to furnace construction. Ease of fabrication at the factory or on the job permits use of standard shapes that are convenient to stock. Costly special shapes are unnecessary.

If you have a problem involving the use of suspended arch or wall construction, there is a trained sales engineer in a near-by Armstrong office who will be glad to help you solve it. Feel free to call on these men for assistance at any time. There's no obligation.




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# Armstrong's Refractory Cements

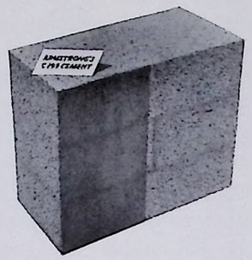
In addition to a complete line of insulating fire brick, Armstrong makes three highly dependable refractory cements. These products have been developed through a careful program of laboratory and on-the-job research. They are designed to provide efficient, long-lasting service with maximum ease and speed of application.

### Armstrong's C 199 Cement

Armstrong's C 199 Cement is a newly-developed air setting refractory mortar for laying and facing all types of insulating fire brick and all types of fire clay brick, including super-duty brick used up to 2900° F.

C 199 Cement is stronger than the average fire brick it bonds. This Armstrong cement takes a strong set at room temperatures and maintains its strength throughout its entire working range. It bonds the cooler portions of the wall as well as the exposed brickwork, assuring a uniformly strong bond through the entire structure.





The unusually low shrinkage of C 199 Cement prevents tearing of the insulating fire brick face. Also note the thin, tight joints possible with this cement.

Exacting specifications for air setting cements call for a cold bonding strength of 200 pounds per square inch. The strength of C 199 Cement is over three times this value.

In the formulation of Armstrong's C 199 Cement, selected refractory clays are combined with special bonding agents to assure sufficient refractoriness to more than meet A.S.T.M., American Refractories Institute, Federal Government, and U. S. Navy Specifications for super-duty mortar at 2910° F.

C 199 Cement will not soften or run out of joints. It provides a tight, dense joint that will withstand abrasion, slagging, and spalling as effectively as the brick itself.

Precision blending of the raw material particle size, plus a new Armstrong development that eliminates the usual bonding and plasticizing agents that cause shrinkage, result in a cement that will not shrink, crack, or crumble.

Armstrong's C 199 Cement is easy to handle on the job. It saves time and money because it is thoroughly mixed and is ready to use as needed. This cement has high plasticity and can be trowelled directly from the container even after many months of storage. It also pours readily and is easily thinned with water to dip joint or facing consistency. In the mortar box, it remains in suspension even when thinned, and one mixing provides a uniform consistency of mortar.

The water retention test outlined in Technical Bulletin No. 60 of the American Refractories Institute specifies a water retention period of



two minutes. The water retention period of Armstrong's C 199 Cement far exceeds this specification. Thus good workability and strong, thin joints are assured, even with the most porous brick. Joints may be spread well ahead of the mason, making brick laying easier and faster.

Armstrong's C 199 Cement is ideally suited to laying insulating fire brick as well as fire clay brick. Many cements have shrinkage characteristics that cause them to tear the surface of insulating fire brick and disrupt the furnace lining. The low shrinkage of Armstrong's C 199 Cement assures high bonding strength without tearing the surface of insulating fire brick.

In addition to its use as a bonding agent, Armstrong's C 199 Cement may be applied by brush or spray gun as a protective facing on fire brick or insulating fire brick furnace linings. This coating will bond tightly to the brick surface, and because of its low shrinkage and compatible expansion characteristics, it will not crack or peel away from the face of the brick.

### Armstrong's No. 26 Cement

Armstrong's No. 26 Cement is a dry cement composed of high-grade refractory materials. They are chemically and physically similar to Armstrong's Insulating Fire Brick.

No. 26 Cement provides an excellent bond of moderate strength. It does not possess strong bonding qualities at lower temperatures, but when exposed to furnace temperatures over 1800° F., a comparatively strong bond is developed. Because this cement does not develop a ceramic bond below 1800° F., it is well suited for laying up insulating fire brick as back-up insulation, allowing the brick to be salvaged for reuse with little or no loss.

Armstrong's No. 26 Cement is used as a mortar for laying all types of insulating fire brick for temperatures up to 2600° F. It is not recommended for use as a brush coat for facing insulating fire brick. This cement is shipped dry, and is mixed with water on the job.

## Characteristics of Armstrong's Refractory Cements

| | ARMSTRONG'S C 199 CEMENT | ARMSTRONG'S No. 26 CEMENT |
|---|---|---|
| | Wet, factory mixed, air setting cement | Dry, mixed on job, heat setting cement |
| Cement used for | Laying and facing all types of insulating fire brick and all types of clay fire brick including super-duty brick. | Laying all types of insulating fire brick and fire brick for service up to 2600° F. |
| Packed in | Steel drums of 16, 50, 100, 200 lbs. net | Bags of 80 lbs. net |
| Weight per cu. ft. as shipped—lbs. | 110 lbs. | 68 lbs. |
| Amount of water needed for dip joint consistency—gals. per 100 lbs. cement | 1 gal. | 9 gals. |
| Amount of water needed for brushing consistency—gals. per 100 lbs. cement | 2 gals. | |
| Lbs. cement needed for dip joint construction per 1000 insulating fire brick | | |
| A-16, A-20, A-25, A-23 | 250 to 300 lbs. | 200 lbs. |
| A-26, A-28 | 250 to 300 lbs. | |
| Lbs. cement needed per 1000 clay fire brick | | |
| Thick trowelled joints | 350 to 400 lbs. | |
| Thin trowelled joints | 300 to 350 lbs. | |
| Dipped joints | 250 to 300 lbs. | |
| Lbs. cement needed for double brush coating one sq. ft. Armstrong's Insulating Fire Brick | | |
| A-16 | 0.5 lb. | 0.35 lb. |
| A-20, A-25, A-23, A-26 | 0.5 lb. | |
| A-28 | 0.5 lb. | |



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# Armstrong's Ingot Insulation

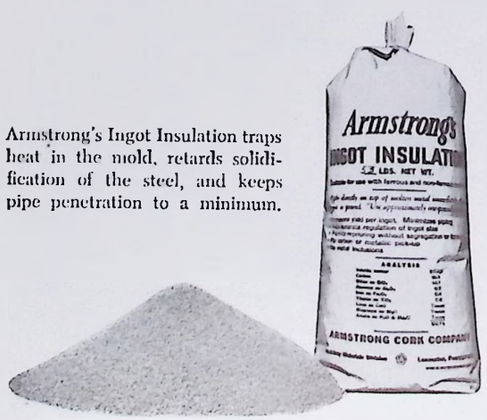
Armstrong's Ingot Insulation is used in steel mills to increase the yield of steel from the ingot by reducing piping. It is a highly efficient insulating material composed of carefully graded particles of cork coated with a film of special clay.

Armstrong's Ingot Insulation is applied to the top of the molten ingot after pouring. There the clay coating protects the cork from the terrific heat and permits the insulating properties of the cork particles to remain effective. The ingot insulation, by preventing rapid cooling, keeps the steel molten longer, allowing it to "feed" properly and fill the pipe as it forms. The use of Armstrong's Ingot Insulation reduces depth of pipe by 20% to 30%, thus reducing proportionally the amount of the ingot that must be cropped and scrapped.

Armstrong's Ingot Insulation lasts until the ingot has solidified. It is still intact and will float to the surface if the ingot is repoured, avoiding entrapment of non-metallic inclusions. The chemical composition of the ingot is not affected and there is no carbon pickup.

Ingot insulation is packed in 50-lb. bags for ease in shipping and handling.

Armstrong engineers will be glad to cooperate with you in conducting tests at your plant to demonstrate how substantial savings may be effected with Armstrong's Ingot Insulation.




Armstrong's Ingot Insulation traps heat in the mold, retards solidification of the steel, and keeps pipe penetration to a minimum.



Cross section of top of steel ingot insulated with sawdust.



No insulation used here. Photo of section shows deep pipe.



Cross section of steel ingot. Insulation used was not specified.



Armstrong's Ingot Insulation produces more useable steel.



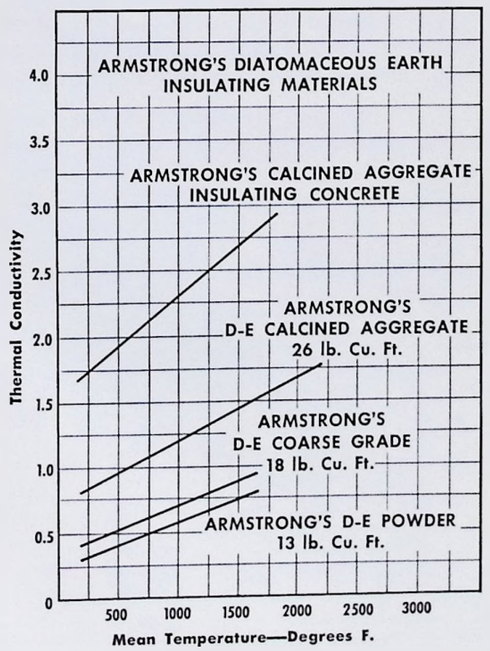
# Diatomaceous Earth (D-E) Insulating Materials

Armstrong's Diatomaceous Earth Insulating Materials include D-E Powder, D-E Coarse Grade, and D-E Calcined Insulating Aggregate. All are highly efficient when used in conjunction with insulating fire brick. D-E Powders are used as fill-type insulation, and D-E Calcined Aggregate is used in mixing insulating refractory concrete. (See data on Page 182.)

Armstrong's D-E Materials are produced from a deposit yielding a very pure grade of diatomaceous silica composed largely of spicular and elongated diatoms. Carefully controlled processing retains the original diatom structure. The high insulating efficiency and light weight of diatomaceous earth are both due to the exceptionally high percentage of minute air cells or voids. Seen under the microscope, Armstrong's D-E Insulating Materials resemble a jackstraw arrangement of diatoms. Between and around these particles are microscopic air cells—several million to the cubic inch—so minute that they efficiently retard the flow of heat.

The high insulating efficiency of Armstrong's D-E Insulating Materials is illustrated by the conductivity curves shown below.

In considering the quality and value of diatomaceous earth, the weight per cubic foot is a deciding factor. The lighter the earth, the greater the insulating value per ton. Armstrong's D-E Insulating Materials are free from impurities and average 10% lighter in weight than earth from other deposits now available. In addition to their low conductivity and light weight, Armstrong's D-E Insulating Materials will not deteriorate or shrink under direct heat at the temperatures to which they will be exposed in service. These materials have a fusion point of approximately 2900° F. D-E powder and D-E coarse materials will withstand temperatures up to 1600° F. without shrinkage. Armstrong's D-E Calcined Insulating Aggregate is processed to withstand direct exposure to temperatures as high as 2100°.



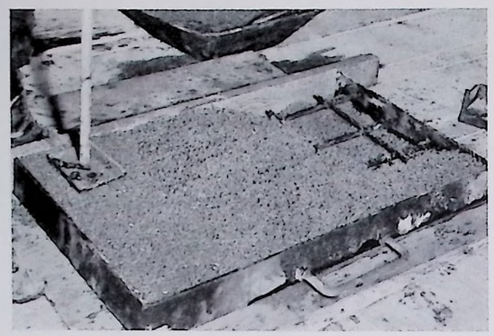

### Application of Armstrong's Fill-Type D-E Insulating Materials

D-E powder insulation and D-E coarse grade insulation find their principal application as fill-type materials. D-E powder insulation is used where it can be tamped into place to the proper density. D-E coarse grade insulation is used where tamping is impractical and where it is necessary to pour the material into place. Both serve very effectively between a refractory lining and the steel shell of metal jacketed equipment. They are especially valuable in applications where insulating fire brick cannot be installed conveniently. Fill-type insulations find wide usage in boilers, hot blast stoves, vertical shaft lime kilns, bakers' ovens, and other furnace applications. D-E powder insulation is especially suited for use over the arches of tunnel kilns, round periodic kilns, and in heated equipment with similar irregular surfaces.




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# Insulating Refractory Concrete Made with Armstrong's D-E Calcined Aggregate





Insulating refractory concrete is a lightweight monolithic insulation highly effective for service at temperatures up to 1800° F. It is convenient to use in a wide variety of applications. Since refractory concrete may be cast in place using simple forms in much the same manner as ordinary structural concrete, it offers great flexibility in design and low installation cost.

Typical applications for insulating refractory concrete are:

Furnace doors
Furnace bases
Furnace car tops
Stack linings
Protective slabs over concrete foundation
Dampers and baffles
Duct linings

**Estimating Data:** To provide for 1 cubic foot of insulating refractory concrete in place (based on a 4 to 1 mix by volume) estimate:

29 lbs. of D-E Calcined Aggregate
20 lbs. of Portland or Lumnite Cement

After drying, properly mixed Armstrong's D-E Insulating Refractory Concrete weighs approximately 49 lbs. per cubic foot. It has a cold crushing strength of approximately 1500 lbs. per sq. in.

## Specifications for Armstrong's D-E Insulating Materials

| | D-E Powder Insulation | D-E Coarse Grade Insulation | D-E Calcined Insulating Aggregate (Meets Federal and Navy Specifications) |
|---|---|---|---|
| Maximum temp. without shrinkage | 1600° F. | 1600° F. | 2200° F. |
| Loose weight per cu. ft. | 9-11 lbs. | 16-18 lbs. | 20-22 lbs. |
| Dry packed weight per cu. ft. | 12-14 lbs. | 18-21 lbs. | 26-28 lbs. |
| Silica content | 80-94% | 80-94% | 80-94% |
| Loss on ignition | 6% | 6% | 0% |
| Moisture | 4% | 8% | 0% |
| Screen analysis | | | |
| % Retained on 3 Mesh | | 0% | 0% |
| 6 Mesh | | 5-15% | 30-53% |
| 10 Mesh | | 18-40% | 50-69% |
| 20 Mesh | | 40-60% | 66-82% |
| 150 Mesh | No more than 6% | | |
| Packaging: Multi-wall paper bags | | | |
| Approx. weight per bag | 50 lbs. | 50 lbs. | 100 lbs. |



# Armstrong's Combustion Chambers

Armstrong's Combustion Chambers are designed for use in oil-burning residential heating plants. They will save up to 15% of the fuel required with heavy fire brick chambers.

Oil burner efficiency depends, to a large extent, on the design of the combustion chamber and the type of material used in it. All heat for the oil-fired furnace is generated within the chamber, located inside the base of the furnace. If complete combustion does not take place, as is the case in a poorly designed chamber, much of the fuel passes right through the combustion chamber and out the flue.

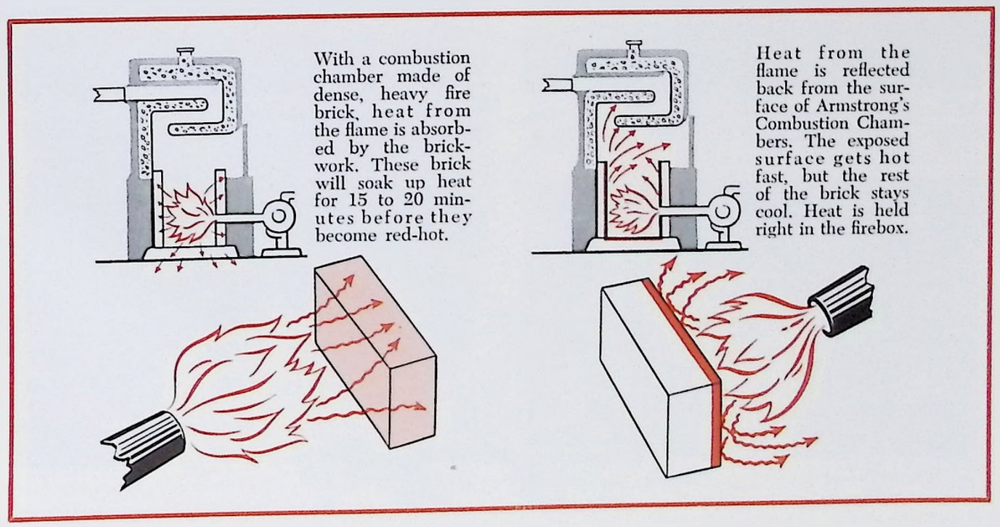
Chambers constructed of heavy fire brick also waste large amounts of fuel because of the heat-up time required. Temperatures ranging from 1800° to 2000° F. are produced in most residential chambers. It takes a considerable amount of time to bring standard fire brick materials up to this temperature range.

The light weight and porous composition of Armstrong's Insulating Fire Brick permit the inner face of combustion chambers built with them to heat up to operating temperatures almost instantaneously. This results in more efficient combustion of fuel oil over a longer period of the heating cycle. Quick heating is particularly important in residential units because of the thermostatically controlled, intermittent cycling of the furnace while in operation.

The length of time it takes to bring the combustion chamber up to efficient firing heat also has a direct effect on the mixture of oil and air which can be sprayed from the nozzle of the oil burner gun. This air-oil ratio can be adjusted to peak firing efficiency on burners with chambers made of insulating fire brick. With the use of denser refractory materials, on the other hand, the efficiency of the air-oil ratio must be reduced to compensate for the period of inefficient combustion while the brick are absorbing heat.

Another important operating advantage of chambers made of insulating fire brick is reduction in furnace roar. This noise is substantially reduced by insulating fire brick because the porous structure has a noise-absorption quality comparable to that of acoustical materials.

Armstrong's Combustion Chambers are supplied as complete packages, containing the insulating fire brick, metal bands, and mortar necessary for correct erection. No special knowledge, tools, or brick laying skills are required to install them. Brick are carefully pre-cut to proper dimensions at the factory.






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Piled before the shipping carton are the factory-cut brick and the wire used to assemble the chamber.

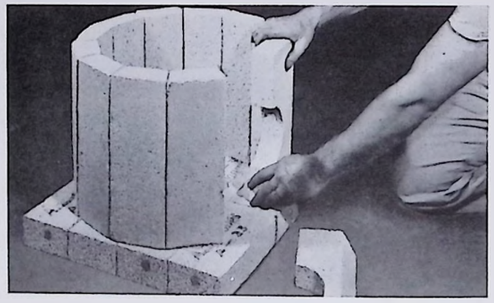
Although the unit can be laid up dry, a can of mortar is furnished for pointing up joints and patching, where desired. If any special fitting is necessary, the brick can be cut or shaped on the job with an old saw blade or rasp.

The space between the outside of the combustion chamber and the interior of the furnace wall should be filled with a loose form of insulation. This fill material is finished off along the top edge with about one inch of mineral wool cement, which is also used to cement the oil gun into position in the burner port.

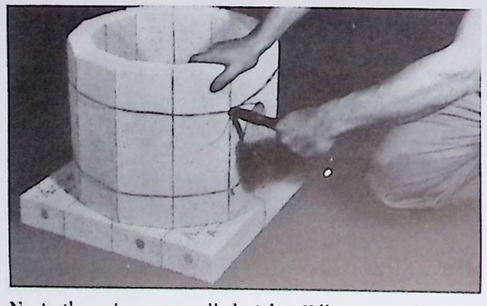
Armstrong's Combustion Chambers are made in three sizes to correspond with the oil burner units most commonly used in homes today. The smallest chamber is designed for burners with a 1 to 1.35 gallons per hour oil rating. The next size is made for burners with a capacity of from 1.35 to 1.65 gallons per hour, and the largest chamber is designed for units using from 1.65 to 2 gallons per hour. All three sizes are available in Armstrong's A-20, A-23, and A-26.



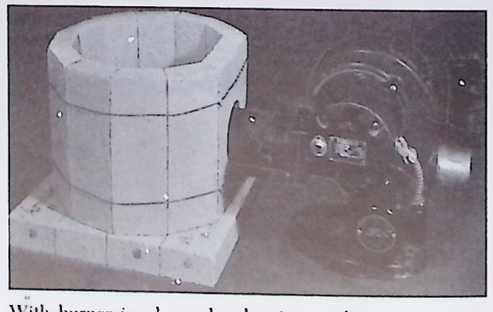
The first step is to lay the square brick to form a base. Wedge-cut sidewall brick are then erected in a circle.



The bricks forming the burner port are the last ones in place. All joints between the bricks should be staggered.

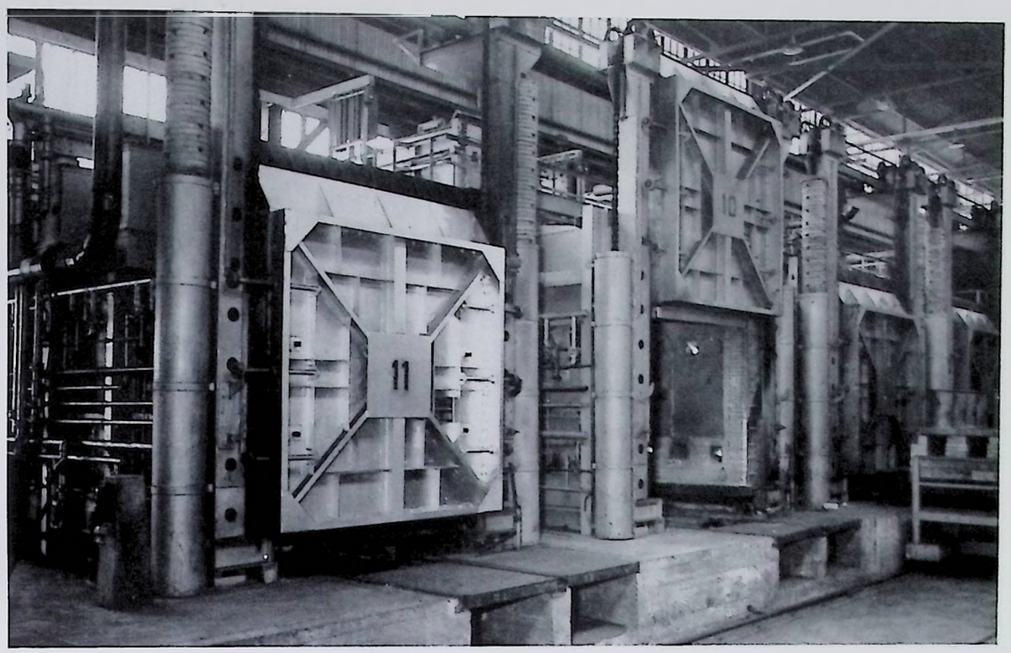


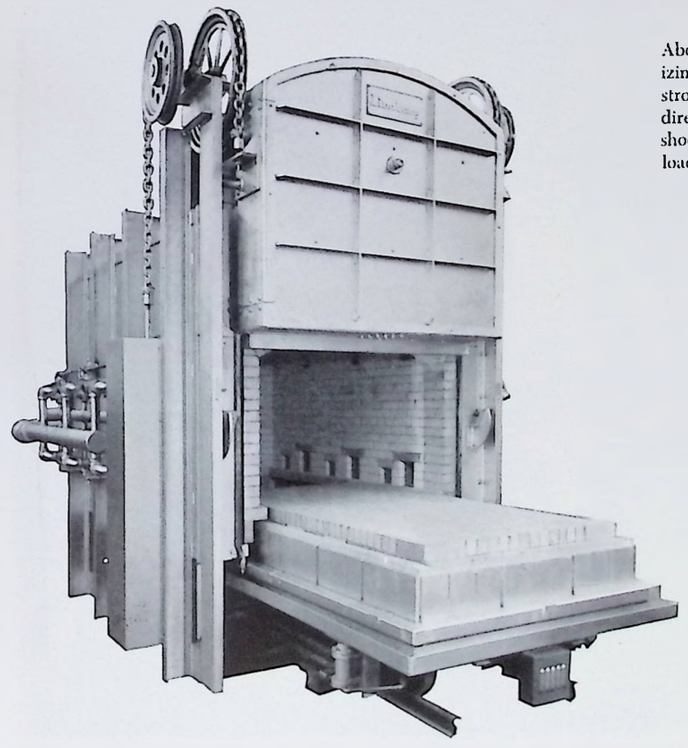
Next, the wires are pulled tight. Fill-type insulation is then placed between the chamber wall and furnace shell.



With burner in place, chamber is complete. Burner port can be shaped with a rasp to fit any firing tube diameter.







Above: This battery of direct-fired normalizing furnaces is built completely of Armstrong's Insulating Fire Brick. A-26's, used directly exposed, withstand the thermal shock of frequent door opening and cold loads. Built by Surface Combustion Corp.

Left: This factory-built car-bottom furnace is lined with strong, lightweight Armstrong's Insulating Fire Brick. One of the reasons these brick were chosen is because their extra ruggedness allows shipment without damage to the finished furnace. Built by Lindberg Engineering Company.



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Section VIII

# EQUIPMENT INSULATIONS

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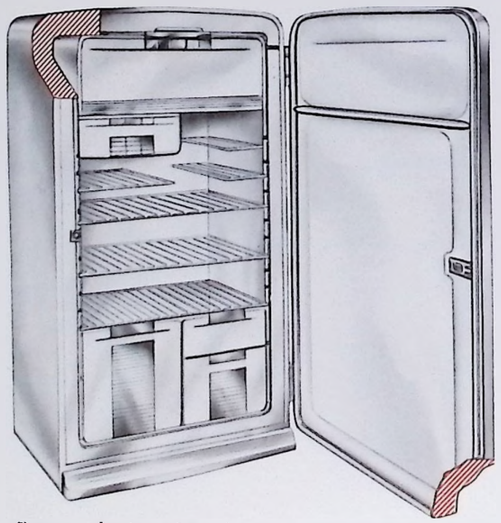
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# Classification of Low-Temperature Equipment

The differences in temperature and vapor pressures between the interior and exterior of refrigerated equipment cause warm, moisture laden air to move through the walls in the same manner as it works its way into a low-temperature room. (See "The Moisture Problem in Low-Temperature Insulation," Page 14.)

The movement of air into the insulation is such an important consideration in design that low-temperature equipment is generally classified by the measures taken to seal the moisture out. The three classifications are as follows:

**Hermetically Sealed Equipment**—Here both inner and outer shells are positively sealed against moisture infiltration. Two types of construction are generally used for building hermetically sealed equipment. One is the all metal cabinet with welded joints sealed with an asphaltic type sealer. The other is the wood frame cabinet with metal inner and outer shells and soldered joints throughout.



Proper selection of insulation can improve refrigerator design. It may increase efficiencies without changing wall thickness, or allow for increased interior cubic footage without change in exterior cabinet dimensions.

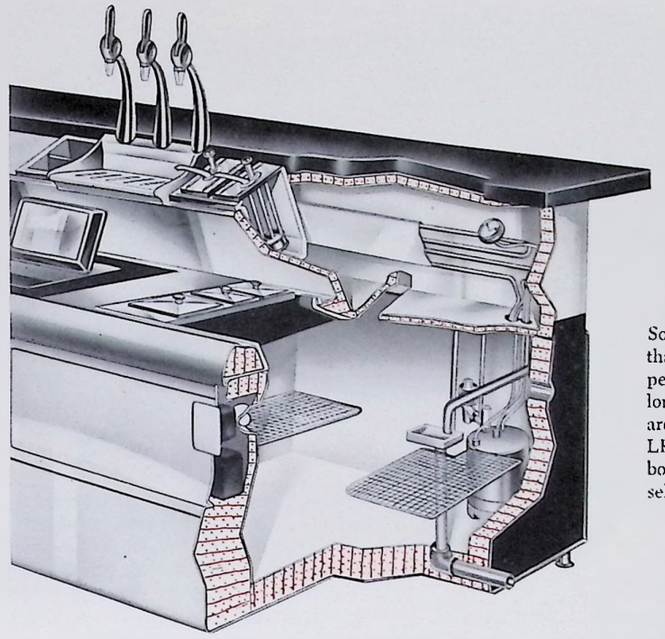
**Partially Sealed Equipment**—This type of construction is used when a positive vapor seal is impossible or impractical to obtain. Partially sealed construction is made as impervious as possible to vapor infiltration by the use of sealing compounds and membranes, pressure fitting of the insulation in assembly, and coating the insulation with a vaporproof sealer. The generally used methods of building equipment in this category are: Wood frame with inner and outer metal shells not soldered, wood or angle iron frame with outer metal porcelain finished sheets, and portable, knock-down equipment such as meat coolers, with metal panels over a wood frame, or of all wooden construction.

**Unsealed Equipment**—This method of construction is used when the size and type of the equipment is such that the cost of obtaining a perfect, or even a good partial seal is prohibitive. Equipment in this category is usually built with plywood, wood, or metal outer and inner shells nailed or screwed to stakes or frames.

### Selecting the Right Insulation

Selection of the right kind of insulation for various types of refrigerated equipment should be determined by the method of sealing used and the final usage to which the equipment will be put. The desirable qualities of any insulating material will vary in importance with the design of the cabinet. In sealed equipment, for example, resistance to moisture is not so important as it is in partially sealed or unsealed equipment.





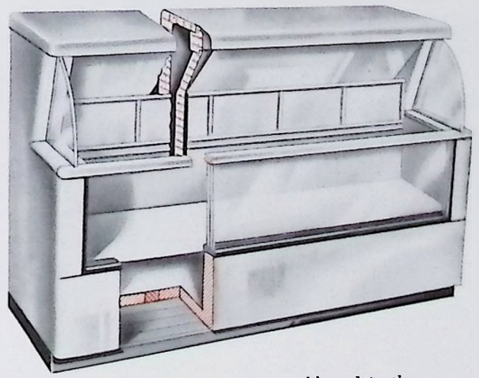
Soda fountains are so intricately constructed that it is impractical to seal the insulation perfectly against moisture penetration. For long service life, these pieces of equipment are usually insulated with moisture-resistant LK Corkboard. Here the extra cost of corkboard is relatively small compared with the selling price of the completed fountain.

The principal points that should be considered when choosing an insulating material are as follows:

- Low thermal conductivity
- Inherent resistance to moisture
- Light weight
- Sterility
- Freedom from odor
- Ease of fabrication
- Fit of joint, insulation to insulation, and insulation to framing
- Load-bearing characteristics, including resilience and resistance to compression, even when the material becomes wet
- Sizes and forms available
- Permanence of form
- Final cost installed in the equipment, as measured by the life of the equipment, and taking all other important factors into careful consideration

While all of these factors are important, the one that receives the most attention is the matter of cost. The cost of an insulation cannot be measured accurately by its price per board foot. True cost also includes cost of installation and cost of shipping the finished piece of equipment. It must also include cutting costs, sealing costs, storage costs, freight costs to the plant, and many other items.

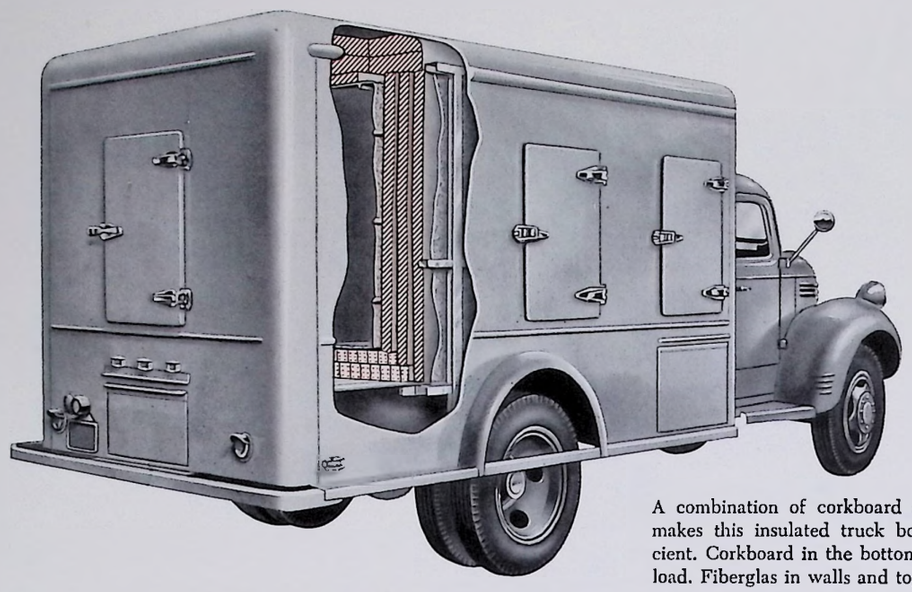
For example, the effect of insulation on cabinet design is really part of the cost of installation. If a relatively expensive insulation, because of its greater efficiency, will allow reduced wall thicknesses, the increased storage capacity and higher selling price of the equipment may make



In this frozen food display case, corkboard in the superstructure resists moisture driven in by circulating air. Temlok strips in the bottom help carry the load. The balance is insulated with efficient, low-cost Fiberglas.



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A combination of corkboard and Fiberglas makes this insulated truck body more efficient. Corkboard in the bottom supports the load. Fiberglas in walls and top cuts weight.

this the less expensive material in the long run. Also, if a more efficient insulation can permit use of a compressor of lower capacity, the savings may well offset the higher installation cost.

Service life of the insulation must also be considered. An insulation that will give long and efficient service and help build a manufacturer's reputation for quality is certainly less expensive than a low-cost insulation that fails.

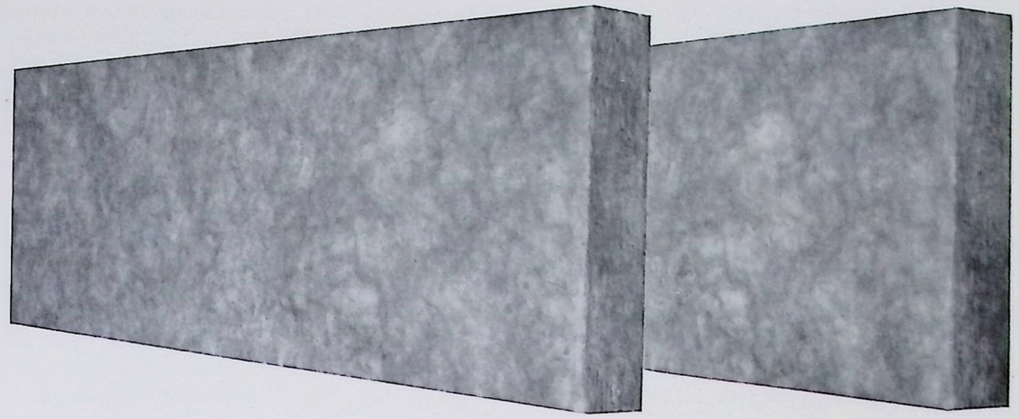
To meet the widely varying requirements of manufacturers of all types of insulated equipment, Armstrong offers three distinct types of insulating materials. They are Armstrong's LK® Corkboard, Temlok®, and Fiberglas*. These materials can be used individually, or in combination one with the other, depending on the design of the refrigerated equipment and the insulating problems that are involved.

*® OCFCorp.

## Physical Data on Armstrong's Equipment Insulations

| MATERIAL | AVERAGE CONDUCTIVITY (At 70° F. Mean) | AVERAGE WEIGHT (per bd. ft.) | SIZES | | FORM | CUT WITH | PACKAGE UNIT |
|---|---|---|---|---|---|---|---|
| | | | LENGTH AND WIDTH | THICKNESSES | | | |
| LK Corkboard | .269 | .57 lb. | 12″ x 36″<br>18″ x 36″<br>24″ x 36″<br>36″ x 36″ | 1″, 1½″, 2″, 2½″, 3″, 3½″, 4″, 5″, 6″ | Rigid Board | Saw (wide set) | Corrugated Cartons |
| Temlok | .31 | 1.35 lbs. | 4′ wide x 4′, 6′, 7′, 8′, 9′, 10′, 11′, and 12′ long | ½″ and 1″ in single ply. Greater thicknesses laminated. | Rigid Fiberboard | Saw (wide set) | Kraft Paper Bundles |
| Fiberglas | | | | | | | |
| PF-611 | .255 | .167 lb. | 24″ x 96″ | 1½″ to 5¾″ | | | |
| PF-612 | .245 | .208 lb. | 24″ x 48″ | 1″ to 5¾″ | | | |
| PF-613 | .235 | .27 lb. | 24″ x 48″ | 1″ to 5¾″ | | | |
| PF-614 | .225 | .354 lb. | 24″ x 48″ | ¾″ to 4¾″ | | | |
| PF-615 | Sound deadening | .5 lb. | 24″ x 48″ | ½″ to 3¼″ | Semi-rigid batts | Knife or Saw having No set | Cartons or Kraft Paper Bundles |
| PF-511 | .25 | .167 lb. | 24″ x 48″ | 1½″ to 5½″ | | | |
| PF-512 | .24 | .188 to .208 lb. | 24″ x 48″ | 1″ to 5½″ | | | |
| PF-513 | .225 | .29 to .313 lb. | 24″ x 48″ | ¾″ to 3¾″ | | | |
| PF-314 | .257 | .042 lb. | 200′x18″, 24″, 54″, 72″ | 1″, 1½″, 2″ | Standard Rolls | Knife or Saw having No set | Kraft Paper Rolls |
| PF-316 | .224 | .083 lb. | 100′x18″, 24″, 54″, 72″<br>200′x18″, 24″, 54″, 72″<br>100′x18″, 24″, 54″, 72″<br>80′x18″, 24″, 54″, 72″ | 1″<br>1¼″ | | | |





# Fiberglas Insulation

Fiberglas is made from strong, pliable threads of glass. These glass fibers are coated with a special binder and then felted and compressed into semi-rigid batts and rolls.

Although Fiberglas is made in three different fiber diameters, and in a wide range of thermal conductivities and densities, the various types all have the following physical characteristics in common:

**Low Thermal Conductivity**—Due to its light weight and the tremendous amount of entrapped air among the interlaced glass fibers, Fiberglas retards the flow of heat. Also, the contact points where the fine, cylindrical fibers touch each other are exceedingly small, so heat cannot pass readily from fiber to fiber.

**High Moisture Resistance**—The high insulating efficiency of Fiberglas is retained in service because the inorganic glass fibers will not absorb moisture. Should they become wet, these solid glass rods won't rot or mat down, and they dry out to their original efficiency. The low capillary attraction of glass helps to keep this insulation dry if it comes in contact with moisture.

**Fire, Verminproof, and Rotproof**—This material possesses the chemical properties of the glass from which it is manufactured. Because it is glass, it will not burn, harbor vermin, rot, or deteriorate in any manner.

**Non-Corrosive and Odorless**—Fiberglas is noncorrosive in contact with steel or aluminum, even when subjected to alternate wetting and drying. Both the glass fibers and the binder that holds them together are entirely odorless.

**Light Weight and Easy to Handle**—Fiberglas is exceptionally light in weight, yet it is not fragile or easily damaged. It can be precut or cut on the job quickly and accurately to any needed shape. It can be compressed for installation in tight places. Because of its springy, resilient nature, Fiberglas completely fills irregularly shaped spaces, and fits tightly against all surfaces.

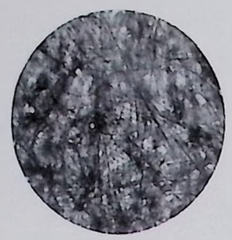
Glass insulation has one important advantage over other types of insulation. Its raw material —glass—can be carefully controlled to produce different kinds of products, all the way from inexpensive containers to the finest optical lenses. The fact that glass can be "worked with" to such a fine degree means that Fiberglas can be made into a whole range of insulations to meet specific insulating problems.

For example, by varying the diameter of the glass fibers, Fiberglas insulation is produced in three classifications—the 600 Series, the 500 Series, and the 300 Series.

Largest fiber diameters are found in the 600 Series. This is the least expensive of the three, because production costs go up as fiber diameter goes down. Because of its low cost, high effi-



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Photomicrograph of Fiberglas, magnified 20 times, shows how the fine glass threads crisscross each other to form air pockets all through the material. These air pockets smother heat as it attempts to work its way through this insulation.

ciency, and ease of handling on the production line, the Fiberglas 600 Series is the most widely used insulation sold today in the low-temperature equipment field. It has proved its dependability in long years of service on all types of refrigerated equipment. Recent improvements in manufacturing techniques have lowered conductivities and improved handleability.

The 300 Series, known as "Aerocor," is made from extremely fine fibers having diameters of only .00017 to .00019 inch. The fine fibers give Aerocor an extremely high insulating efficiency, very light weight, and such great resilience that the material can be compressed to one-fifth its original thickness and will spring back to full thickness when compression is released.

Refrigerated equipment manufacturers use Aerocor in numerous ways. Where light weight and high insulating efficiency are determining factors, Aerocor can be used throughout the model. It is also being specified for places where insulation must be highly efficient, yet very thin —where there isn't room for full thicknesses. Typical examples are in evaporator doors of domestic refrigerators, behind breaker strips and door mullions, and in baffles between freezer and storage compartments. Lightweight Aerocor is also being used in truck and trailer bodies to reduce dead weight and increase payload capacity. Because of its high resilience, Aerocor is also an excellent material for removable plugs for control boxes or fillers for door latches.

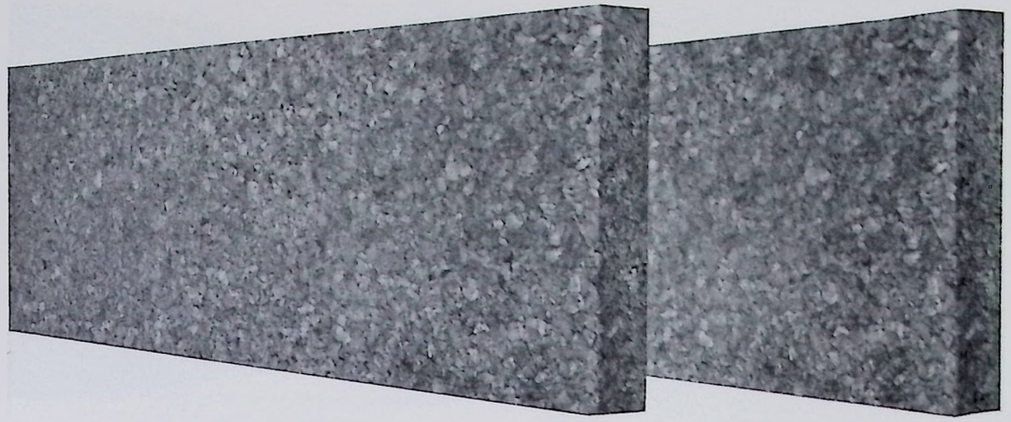
The fiber diameter of the Fiberglas 500 Series falls between that of Aerocor and the 600 Series. In this material, thermal conductivities are so closely controlled that they can be counted upon as being exact. This feature of the 500 Series is of definite advantage to manufacturers of equipment where design constants must be controlled to exceptionally close limits. This insulation also has great resilience and is easy to handle.

Within each Fiberglas Series there is a choice of several thermal conductivities and densities. (See chart below.) Density is controlled in the manufacturing process by varying the amount of glass fibers felted into any given thickness. Thermal conductivity varies with the density.

Regardless of the type of equipment being made or the market to be reached, there is a Fiberglas insulation that will best adapt itself from both a price and design standpoint to each manufacturer's requirements. The Armstrong sales engineer in the office nearest you will be glad to help you in selecting the Fiberglas insulation best suited to your models.

| | Nominal Density Lbs. per Cu. Ft. | Thermal Conductivity at 70° F. Mean Temp. |
|---|---|---|
| "600 Series" | | |
| PF-611 (formerly PFB) | 2.0 | .255 |
| PF-612 (formerly PFD) | 2.5 | .245 |
| PF-613 (formerly PFG) | 3.25 | .235 |
| PF-614 (formerly PFL) | 4.25 | .225 |
| PF-615 (formerly PFT) | 6.0 | |
| "Aerocor" (300 Series) | | |
| PF-314 | .5 | .257 |
| PF-316 | 1.0 | .224 |
| "500 Series" | | |
| PF-511 | 2.0 | .25 guaranteed |
| PF-512 | 2.25–2.5 | .24 guaranteed |
| PF-513 | 3.5 –3.75 | .225 guaranteed |





# Armstrong's LK Corkboard

Armstrong's LK Corkboard is a lightweight material manufactured specially for low-temperature equipment. It is made from carefully sized granules of pure cork, compressed and baked in board form. In the baking process, the natural resins in the cork cement the granules together, and no artificial binder is required.

**Low Thermal Conductivity**—The quantities of still air trapped in the tiny cork cells effectively retard the flow of heat through equipment insulated with Armstrong's LK Corkboard. (See "Properties of Corkboard" on Page 17.) The thermal coefficient of this material is .269 Btu per square foot, per inch thickness, per hour, per degree F., at 70° mean temperature.

**High Moisture Resistance**—The tough, resinous walls of each cork cell effectively seal moisture out, and the cork cells fit so perfectly together that there is no space between them where moisture can collect. This high natural moisture resistance guards against the progressive deterioration and loss of insulating efficiency that accompanies moisture accumulation and frost formation. (See "The Moisture Problem In Low-Temperature Insulation," Page 14.)

**High Resilience**—Because of the high natural resilience of cork, this insulating material will support extremely heavy loads without indentation, crushing, or breaking. A 2" thickness of Armstrong's Corkboard, for example, will compress only .052" under a load of 1100 lbs. per square foot. This characteristic makes corkboard insulation unexcelled for use under truck body floors, in ice cream cabinet bottoms, and wherever equipment design calls for insulation that will carry heavy loads. Also, this resilient insulation stays firmly in place, will not settle and pack down under vibration.

**Light Weight and Easy to Handle**—Armstrong's LK Corkboard weighs only 0.57 lb. per board foot. It is easily handled on the production line and can be accurately cut to desired thicknesses and sizes. Use of larger pieces lowers handling costs and permits fewer joints.

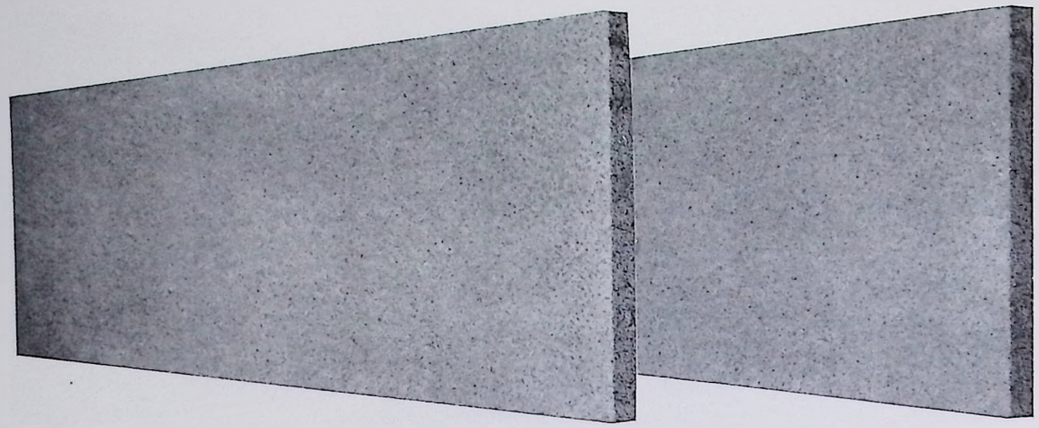
**Other Properties**—LK Corkboard is free from objectionable and contaminating odor. It is classified as a fire-resistant material.

**Sizes**—LK Corkboard is manufactured in 12", 18", 24", and 36" x 36" sizes. Thicknesses range from 1" to 6" in multiples of ½". Special thicknesses from 1" to 6" in multiples of 1/16" are also available to equipment manufacturers.

**Fabrication**—For users of LK Corkboard equipment insulation who require factory fabricated material, Armstrong maintains a special plant cutting section where any special shape or fabrication can be made to order.




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# Armstrong's Temlok

Armstrong's Temlok is a strong, light, board-form insulation made from fibers of southern pine. It can be readily fabricated with wood-working machinery. Temlok, because of its strength and rigidity, is widely used in cabinet bottoms, for mounting boards under mechanical units, and as structural insulation to reduce the weight of framing members. For use in conjunction with non-load bearing types of insulation where construction requires a fabricated material, Temlok is an excellent choice.

The physical properties of this insulating material make it highly satisfactory for use in recommended applications.

**Low Thermal Conductivity**—The thermal conductivity of Temlok Equipment Insulation is 0.31 Btu per square foot, per inch thickness, per degree Fahrenheit temperature difference at a mean temperature of 70° F.

**High Moisture Resistance**—The natural resins in the wood fibers from which Temlok is made give the material a high degree of moisture resistance. The water absorption test for insulating fiberboard outlined in Federal Specification LLL-F-32lb requires that the material shall not pick up more than 7% of water by volume. Tests show Temlok absorbs only 2.2% of water by volume.

**Structurally Strong and Rigid**—Temlok has high load-bearing strength. Two lbs. per square inch is the maximum load that an insulation is called upon to carry in refrigerated equipment. Temlok's deflection under that load, when dry, is only ½ of 1%. When submerged in water for 72 hours, Temlok will deflect only 1½% under the same load. So, even in unsealed equipment, where the insulation invariably becomes wet, Temlok provides strong support.

Also, Temlok will not settle under vibration. It exceeds Federal Specification LLL-F-321b for transverse strength (7 lbs. breaking load for standard specimen) and for Tensile Strength (100 lbs. per sq. in.) and is well within these specifications for deflection (0.25 in. min., 0.85 in. max.).

**Light Weight**—Temlok weighs an average of 1.35 lbs. per board foot.

**Accurate Dimensions**—Temlok can be cut to extremely accurate dimensions with wood-working machinery, thus assuring a tight fit in equipment construction.

**Other Properties**—Temlok is free from objectionable and contaminating odor.

**Sizes**—Temlok is available in 4′, 6′, 7′, 8′, 9′, 10′, 11′, and 12′ lengths, 4′ widths. Thicknesses are ½″, ¾″, and 1″ to 5″ in multiples of ¼″.

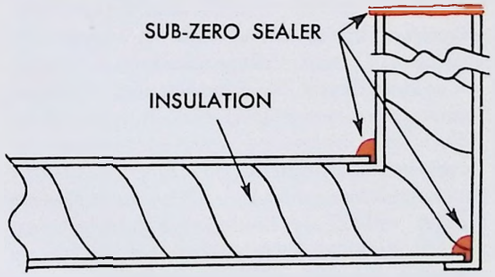
**Fabrication**—A completely equipped factory department will make up specially fabricated pieces to customers' specifications.

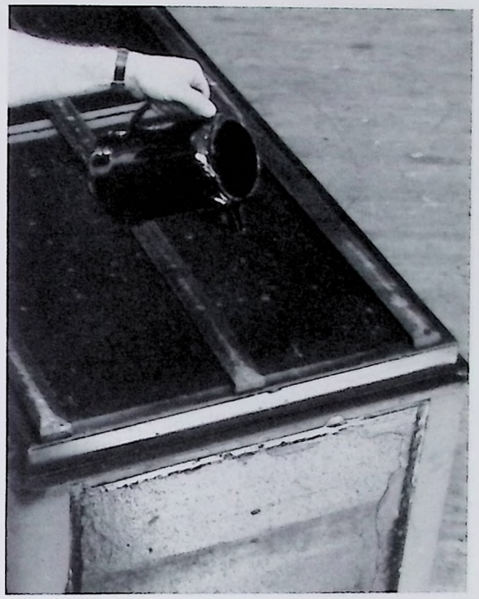


# Sundry Materials for Sealing Equipment Insulation

There are two kinds of sealers generally used in guarding the insulation in low-temperature equipment against vapor infiltration. One is the asphalt emulsion type, which can be applied cold; the other is the hot asphaltic type sealer. Armstrong manufactures both types.

**Armstrong's Sub-Zero Sealer**—This tough, rubber-like resin is applied hot and will not crack in service at temperatures down to 25° F., below zero. Its melting point is approximately 250° F. and its penetration at 77° F. is from 65 to 75 which means the material will not flow at 160° F. This sealer is so flexible when set that at 10° F. below zero a 1/16″ film on 30-lb. kraft paper can be bent slowly around a 1″ mandrel without cracking. Bonding tightly to metal, wood, Temlok, corkboard, glass, and other materials, Sub-Zero Sealer tightly seals the insulated space against vapor and moisture laden air. Sub-Zero Sealer is shipped in 100-lb. fiber containers.



A hot asphaltic type sealer is being used here to halt the infiltration of air and vapor through the construction of the cabinet bottom. Sides have already been sealed.

**Armstrong's Asphalt Emulsion (Aquaseal)**—This product is a clay emulsion of finely dispersed, high-grade asphalt. It can be applied without heating and forms an airtight and moistureproof seal. Armstrong's Asphalt Emulsion is packaged in 55-gallon metal drums.

It is recommended that in all equipment operating at 0° F. and below, Erection Asphalt or Sub-Zero Sealer, rather than a cold asphalt emulsion type sealer, be used.

**Armstrong's Erection Asphalt**—This odorless asphalt, with a melting point between 180° and 200° F., is used hot in sealing refrigerated equipment. It furnishes a tight, lasting bond and a tight seal against air and moisture infiltration. Erection Asphalt is not subject to chemical change, is odorless, and will not crack at temperatures as low as 25° F. below zero.

In all steel construction, both Sub-Zero Sealer and Erection Asphalt are poured along welded seams and under breaker strips. In combination wood and steel construction, they are poured along joints where wood and steel meet. They also are used to seal the top of the insulation in the side walls before the top is put in place.

Armstrong's Erection Asphalt is furnished in 100-lb. paper wrapped rolls, and in 450-lb. drums.



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# General Recommendations For Use of Equipment Insulation

The design of a piece of refrigerated equipment should largely determine the kind of insulating material used. By fully utilizing the various physical properties of the insulating materials offered by Armstrong, equipment manufacturers can often effect worth-while savings, and at the same time improve over-all cabinet performance.

### Sealed Construction

In equipment of sealed construction, in which both inner and outer shells are completely impervious to air and moisture penetration, the most widely used insulation is Fiberglas. This low-cost material offers the manufacturers of domestic refrigerators, meat and dairy display cases, home freezers and other sealed cabinets important advantages.

Fiberglas is resilient. It will not settle and pack down under vibration. Corners fit tightly together, leaving no pockets for heat to pour through. The material is easily and rapidly handled in large production operations.



In this sealed home freezer, Fiberglas insulation is highly efficient and is easy to handle on the production line.

Most important of all, however, from a design standpoint, is the fact that Fiberglas is made in a selection of densities and thermal conductivities. By fully utilizing these unique properties, it is often possible to vary design temperatures within one type of case with no change in insulation thickness specifications.

For example, suppose a dairy case insulated with 3″ thick, 2-lb. density Fiberglas with a K factor of .25 is designed to operate at 38° F. By using 4½-lb. density Fiberglas, with a K factor of .22, the same 3″ thickness may make it possible to lower the temperature to 28° F. for meat display. Thus the same fundamental cabinet design can be used for two types of refrigerated display cases, with no changes in structural or mechanical specifications.

The flexibility of the Fiberglas line also gives equipment manufacturers the opportunity to reduce wall thickness and increase interior capacities without changing the dimensions of the outer shell. For example, a 7.6 cubic foot home freezer with 5″ of insulation has been transformed to a 9 cubic foot cabinet by merely changing to a Fiberglas with a lower conductivity and reducing the insulation thickness to 4″. Although the more efficient insulation was more expensive, its cost was more than made up by the higher price obtained for the model with larger food storage capacity.

Armstrong's Corkboard and Temlok Insulation also are often used in sealed equipment when their strength and load-bearing characteristics improve design. By using these materials to carry the weight under load-bearing bottoms, the use of heavy structural members



can often be avoided and insulating efficiencies increased. Some manufacturers insulate bottoms entirely with Corkboard or Temlok, while others use them in strips, with Fiberglas between. Over an 8′ span, for example, four strips of corkboard or Temlok 3″ wide, anchored in place with asphalt or an asphaltic type sealer, will provide adequate support for any normal load.

Sometimes Temlok sheets are used behind the outer shell in sealed equipment. Here they add strength and rigidity to the design and guard against indentation and buckling. Fiberglas batts are then placed between the sheets of Temlok insulation and the inner lining.

### Partially Sealed Construction

Where equipment can be only partially sealed an insulation should be used that can withstand the effects of moisture. A good example of partially sealed construction is equipment like soda fountains which are often so large and complex that a good seal is impractical to obtain. Another example is equipment, where frequent handling breaks the seal applied at the factory. Also, manufacturers who build display cases, reach-in boxes, and other equipment for a lower priced market, frequently cannot justify the expense of perfectly sealed construction.

Some of the newer type display cases, where the amount of air travel is great, can also be classed as partially sealed. A good example is a frozen food display case where proper temperatures within the case are maintained by use of a curtain of cold air moving around baffles. The pressure of this moving air will force moisture into the smallest openings in the construction, making the use of a moisture resistant insulation necessary. A similar example can be found in equipment that is designed with two widely different temperature zones, such as the new type domestic refrigerators that have large frozen food compartments cooled independently of the normal storage space. Here the temperature differentials are sufficiently great to set up pressures within the equipment that will force air and moisture into the insulated space.

For all of these partially sealed types of equipment Armstrong's LK Corkboard is the most satisfactory insulation to install because of its extremely high natural resistance to moisture.




A solid piece of Temlok in the bottom of this beverage cooler will adequately support the heaviest load. Temlok retains its strength, even when wet, making this an excellent insulation for use in unsealed equipment.

With less expensive Fiberglas insulation, plugs of corkboard or Temlok should be used at places where infiltration is most likely to occur. These materials can be sealed by dipping them in hot asphalt, or they can be applied with a layer of asphaltic sealing compound used between the frame and the rigid insulation.

In all types of partially sealed equipment, the load-bearing properties of corkboard or Temlok recommend these materials for cabinet bottoms. When wood frame construction is used, rigid Temlok, nailed over the frame, gives the construction additional structural strength.

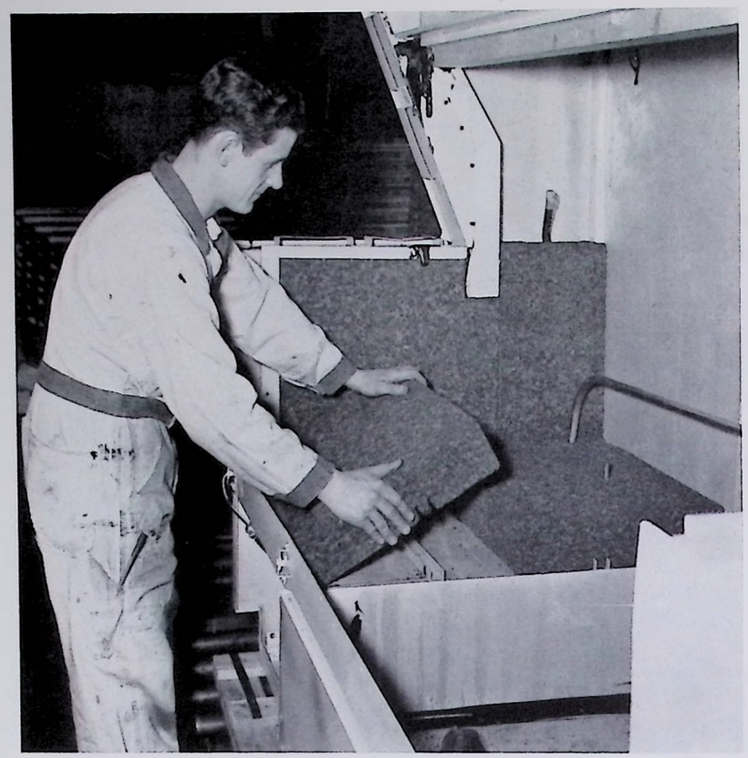
### Unsealed Construction

Two types of refrigerated equipment generally thought of as being totally unsealed are refrigerated truck bodies and walk-in coolers. Because of their size, it is impractical to attempt to seal equipment of this type.

In walk-in coolers, Fiberglas is the insulation most generally used. To guard against moisture, many manufacturers wrap the insulation in moistureproof paper, or use asphalt impregnated paper or asphaltic type sealers between the insulation and the outer shell.



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Where a positive seal against moisture is impractical to attain, Armstrong's LK Corkboard withstands deterioration by water, thus greatly prolonging the life of the equipment. This material can be fabricated to fit any type of construction accurately.

Truck bodies are generally divided into three groups according to the service for which they are designed. In the heavy-duty classification are bodies operating at 0° and lower. Ice cream and frozen food trucks are typical examples. Medium-duty truck bodies are those held at temperatures from 0° to 40° F., and include ice cream and meat trucks. General-duty truck bodies are those that require insulation during extremely hot or cold weather. Milk delivery and bakery trucks fall into this group. Because of their size, and the stresses and strains encountered in over-the-road service, no attempt is made to vapor seal the insulation in truck bodies.

For insulation of heavy-duty trucks where weight is not the governing factor, Armstrong's LK Corkboard is recommended throughout the body. If weight must be held to a minimum, semi-rigid batts of Fiberglas can be used for roof and sidewall insulation. In all cases, corkboard should be used for floor insulation. It has the strength and resilience necessary to support the load without being reinforced by heavy framing members that add dead weight.

Floors of medium-duty trucks should be insulated with corkboard, with Fiberglas in tops and sidewalls. Where extra rigidity of the body is important, Armstrong's Corkboard Insulation should be used throughout. Corkboard is also recommended for trucks that are used generally for medium-duty service, but make heavy-duty trips once or twice a week.

In the general-duty classification, trucks are often unrefrigerated, but insulation is needed to guard perishables from extremes of summer heat or winter cold. In this group, an often neglected factor is floor insulation. The great amount of heat reflected from the road in hot weather can cause spoilage unless floors are properly insulated. Because of its resilience and strength, corkboard is recommended for these floors.

Walls and roofs may be insulated either with Fiberglas or corkboard, depending on the weight factor and general service conditions.

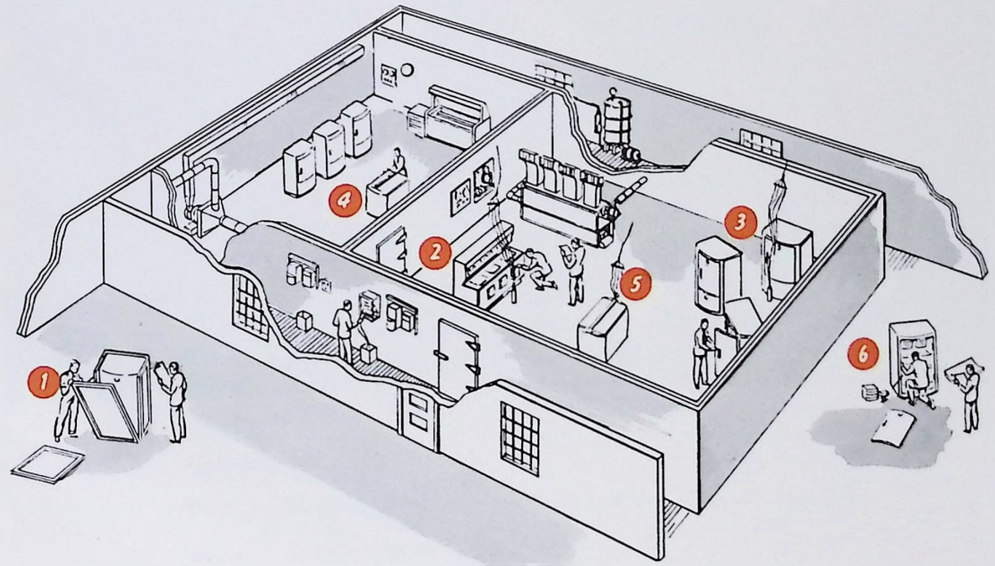


# Armstrong's Life Test Room

Since 1924, many manufacturers of refrigerated equipment have taken advantage of the unusual opportunities offered by Armstrong's Life Test Room. This is one of the first laboratories ever established in which the insulation in refrigerated equipment can be put through severe, scientifically controlled tests that, within a few weeks, simulate years of service. These tests give manufacturers of mechanical refrigerators, ice refrigerators, ice cream cabinets, and other insulated low-temperature equipment a preview of their new models as they will perform after years of operation.

Armstrong offers the use of its Life Test Room to all manufacturers of refrigerated equipment without obligation. Tests are conducted free on experimental or production models of which one in any group must be insulated with one of Armstrong's equipment insulations: LK Corkboard, Fiberglas, or Temlok. Detailed confidential reports outlining all weaknesses in design and construction are sent to the manufacturer as soon as the tests are completed.

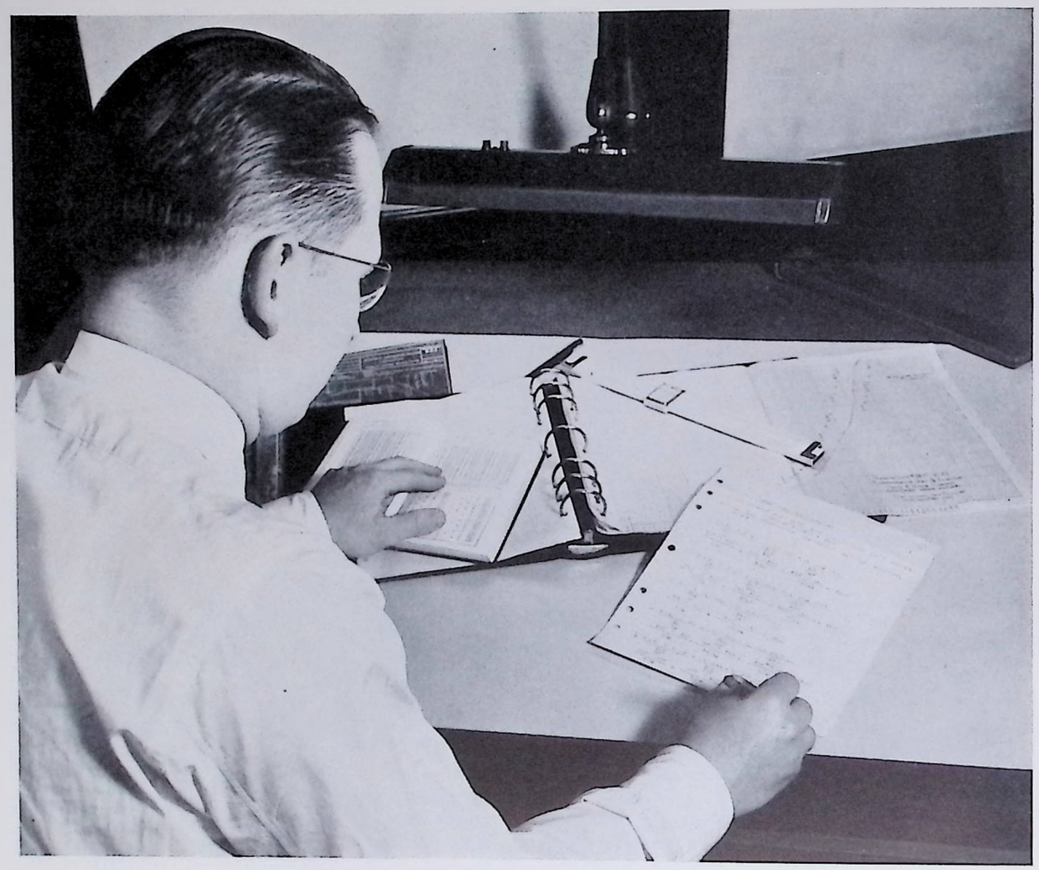
These tests call for accurate control of temperature and humidity, precise recording, and a staff of experienced engineers and technicians. Armstrong has developed these research facilities to a high degree in its Research Laboratories in Lancaster. All the manufacturer of insulated equipment needs to do to receive the benefits of these years of experience is supply one or more experimental or production cabinets to be tested.




1. Crating method is checked when equipment arrives from maker. 2. Cabinet is "conditioned" in 85° F., 50% r.h. room for 3 days before test starts. 3. Meltage of ice placed in cabinet is measured to determine efficiency of design. 4. Operation with cold controls set at maximum for 10 to 14 weeks in 100° F., 80% r.h. room gives equipment "torture test." 5. Ice meltage tests run after torture test determines loss of efficiency. 6. Finally, cabinets are torn down to search for all weaknesses in design and construction and a comprehensive report is then sent to the manufacturer.



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# Temperature Conversion Tables

| −459.4 TO 0 | | | 0 TO 100 | | | 100 TO 1000 | | | 1000 TO 2000 | | | 2000 TO 3000 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C | F | | C | F | | C | F | | C | F | | C | F | |
| −273 | −459.4 | | −17.7 | 0 | 32 | 9.9 | 50 | 122.0 | 538 | 1000 | 1832 | 815 | 1500 | 2732 | 1093 | 2000 | 3632 | 1371 | 2500 | 4532 |
| −268 | −450 | | −17.2 | 1 | 33.8 | 10.4 | 51 | 123.8 | 543 | 1010 | 1850 | 820 | 1510 | 2750 | 1098 | 2010 | 3650 | 1376 | 2510 | 4550 |
| −262 | −440 | | −16.6 | 2 | 35.6 | 11.1 | 52 | 125.6 | 549 | 1020 | 1868 | 827 | 1520 | 2768 | 1104 | 2020 | 3668 | 1382 | 2520 | 4568 |
| −257 | −430 | | −16.1 | 3 | 37.4 | 11.5 | 53 | 127.4 | 554 | 1030 | 1886 | 831 | 1530 | 2786 | 1109 | 2030 | 3686 | 1387 | 2530 | 4586 |
| −251 | −420 | | −15.5 | 4 | 39.2 | 12.1 | 54 | 129.2 | 560 | 1040 | 1904 | 838 | 1540 | 2804 | 1115 | 2040 | 3704 | 1393 | 2540 | 4604 |
| −246 | −410 | | −15.0 | 5 | 41.0 | 12.6 | 55 | 131.0 | 565 | 1050 | 1922 | 842 | 1550 | 2822 | 1120 | 2050 | 3722 | 1398 | 2550 | 4622 |
| −240 | −400 | | −14.4 | 6 | 42.8 | 13.2 | 56 | 132.8 | 571 | 1060 | 1940 | 849 | 1560 | 2840 | 1131 | 2060 | 3740 | 1404 | 2560 | 4640 |
| −234 | −390 | | −13.9 | 7 | 44.6 | 13.7 | 57 | 134.6 | 576 | 1070 | 1958 | 853 | 1570 | 2858 | 1137 | 2070 | 3758 | 1409 | 2570 | 4658 |
| −229 | −380 | | −13.3 | 8 | 46.4 | 14.3 | 58 | 136.4 | 582 | 1080 | 1976 | 860 | 1580 | 2876 | 1142 | 2080 | 3776 | 1415 | 2580 | 4676 |
| −223 | −370 | | −12.7 | 9 | 48.2 | 14.8 | 59 | 138.2 | 587 | 1090 | 1994 | 871 | 1590 | 2894 | 1149 | 2090 | 3794 | 1420 | 2590 | 4694 |
| −218 | −360 | | −12.2 | 10 | 50.0 | 15.6 | 60 | 140.0 | 593 | 1100 | 2012 | 876 | 1610 | 2930 | 1154 | 2100 | 3812 | 1427 | 2600 | 4712 |
| −212 | −350 | | −11.6 | 11 | 51.8 | 16.1 | 61 | 141.8 | 598 | 1110 | 2030 | 882 | 1620 | 2948 | 1160 | 2110 | 3830 | 1432 | 2610 | 4730 |
| −207 | −340 | | −11.1 | 12 | 53.6 | 16.6 | 62 | 143.6 | 604 | 1120 | 2048 | 887 | 1630 | 2966 | 1165 | 2120 | 3848 | 1438 | 2620 | 4748 |
| −201 | −330 | | −10.5 | 13 | 55.4 | 17.1 | 63 | 145.4 | 609 | 1130 | 2066 | 893 | 1640 | 2984 | 1171 | 2130 | 3866 | 1443 | 2630 | 4766 |
| −196 | −320 | | −10.0 | 14 | 57.2 | 17.7 | 64 | 147.2 | 615 | 1140 | 2084 | 898 | 1650 | 3002 | 1176 | 2140 | 3884 | 1449 | 2640 | 4784 |
| −190 | −310 | | −9.4 | 15 | 59.0 | 18.2 | 65 | 149.0 | 620 | 1150 | 2102 | 904 | 1660 | 3020 | 1182 | 2150 | 3902 | 1454 | 2650 | 4802 |
| −184 | −300 | | −8.8 | 16 | 60.8 | 18.8 | 66 | 150.8 | 626 | 1160 | 2120 | 909 | 1670 | 3038 | 1187 | 2160 | 3920 | 1460 | 2660 | 4820 |
| −179 | −290 | | −8.3 | 17 | 62.6 | 19.3 | 67 | 152.6 | 631 | 1170 | 2138 | 915 | 1680 | 3056 | 1193 | 2170 | 3938 | 1465 | 2670 | 4838 |
| −173 | −280 | | −7.7 | 18 | 64.4 | 19.9 | 68 | 154.4 | 637 | 1180 | 2156 | 920 | 1690 | 3074 | 1198 | 2180 | 3956 | 1471 | 2680 | 4856 |
| −169 | −273 | −459.4 | −7.2 | 19 | 66.2 | 20.4 | 69 | 156.2 | 642 | 1190 | 2174 | 926 | 1700 | 3092 | 1204 | 2190 | 3974 | 1476 | 2690 | 4874 |
| −168 | −270 | −454 | −7.2 | 20 | 68.0 | 21.0 | 70 | 158.0 | 648 | 1200 | 2192 | 931 | 1710 | 3110 | 1209 | 2200 | 3992 | 1483 | 2700 | 4892 |
| −162 | −260 | −436 | −6.1 | 21 | 69.8 | 21.5 | 71 | 159.8 | 653 | 1210 | 2210 | 937 | 1720 | 3128 | 1215 | 2210 | 4010 | 1488 | 2710 | 4910 |
| −157 | −250 | −418 | −5.5 | 22 | 71.6 | 22.2 | 72 | 161.6 | 659 | 1220 | 2228 | 942 | 1730 | 3146 | 1220 | 2220 | 4028 | 1494 | 2720 | 4928 |
| −151 | −240 | −400 | −5.0 | 23 | 73.4 | 22.7 | 73 | 163.4 | 664 | 1230 | 2246 | 948 | 1740 | 3164 | 1226 | 2230 | 4046 | 1499 | 2730 | 4946 |
| −146 | −230 | −382 | −4.4 | 24 | 75.2 | 23.3 | 74 | 165.2 | 670 | 1240 | 2264 | 953 | 1750 | 3182 | 1231 | 2240 | 4064 | 1505 | 2740 | 4964 |
| −140 | −220 | −364 | −3.9 | 25 | 77.0 | 23.8 | 75 | 167.0 | 675 | 1250 | 2282 | 959 | 1760 | 3200 | 1237 | 2250 | 4082 | 1510 | 2750 | 4982 |
| −134 | −210 | −346 | −3.3 | 26 | 78.8 | 24.4 | 76 | 168.8 | 681 | 1260 | 2300 | 964 | 1770 | 3218 | 1242 | 2260 | 4100 | 1516 | 2760 | 5000 |
| −129 | −200 | −328 | −2.8 | 27 | 80.6 | 25.0 | 77 | 170.6 | 686 | 1270 | 2318 | 970 | 1780 | 3236 | 1248 | 2270 | 4118 | 1521 | 2770 | 5018 |
| −123 | −190 | −310 | −2.2 | 28 | 82.4 | 25.5 | 78 | 172.4 | 692 | 1280 | 2336 | 975 | 1790 | 3254 | 1253 | 2280 | 4136 | 1527 | 2780 | 5036 |
| −118 | −180 | −292 | −1.6 | 29 | 84.2 | 26.2 | 79 | 174.2 | 697 | 1290 | 2354 | 981 | 1800 | 3272 | 1259 | 2290 | 4154 | 1532 | 2790 | 5054 |
| −112 | −170 | −274 | −1.1 | 30 | 86.0 | 26.8 | 80 | 176.0 | 704 | 1300 | 2372 | 986 | 1810 | 3290 | 1264 | 2300 | 4172 | 1538 | 2800 | 5072 |
| −107 | −160 | −256 | −.6 | 31 | 87.8 | 27.3 | 81 | 177.8 | 708 | 1310 | 2390 | 992 | 1820 | 3308 | 1270 | 2310 | 4190 | 1543 | 2810 | 5090 |
| −101 | −150 | −238 | 0 | 32 | 89.6 | 27.7 | 82 | 179.6 | 715 | 1320 | 2408 | 997 | 1830 | 3326 | 1275 | 2320 | 4208 | 1549 | 2820 | 5108 |
| −96 | −140 | −220 | .5 | 33 | 91.4 | 28.2 | 83 | 181.4 | 719 | 1330 | 2426 | 1003 | 1840 | 3344 | 1281 | 2330 | 4226 | 1554 | 2830 | 5126 |
| −90 | −130 | −202 | 1.1 | 34 | 93.2 | 28.8 | 84 | 183.2 | 726 | 1340 | 2444 | 1008 | 1850 | 3362 | 1286 | 2340 | 4244 | 1560 | 2840 | 5144 |
| −84 | −120 | −184 | 1.6 | 35 | 95.0 | 29.3 | 85 | 185.0 | 734 | 1350 | 2462 | 1014 | 1860 | 3380 | 1292 | 2350 | 4262 | 1565 | 2850 | 5162 |
| −79 | −110 | −166 | 2.2 | 36 | 96.8 | 29.9 | 86 | 186.8 | 737 | 1360 | 2480 | 1019 | 1870 | 3398 | 1297 | 2360 | 4280 | 1571 | 2860 | 5180 |
| −73 | −100 | −148 | 2.7 | 37 | 98.6 | 30.4 | 87 | 188.6 | 741 | 1370 | 2498 | 1025 | 1880 | 3416 | 1303 | 2370 | 4298 | 1576 | 2870 | 5198 |
| −68 | −90 | −130 | 3.3 | 38 | 100.4 | 31.0 | 88 | 190.4 | 748 | 1380 | 2516 | 1030 | 1890 | 3434 | 1308 | 2380 | 4316 | 1582 | 2880 | 5216 |
| −62 | −80 | −112 | 3.8 | 39 | 102.2 | 31.5 | 89 | 192.2 | 752 | 1390 | 2534 | 1036 | 1900 | 3452 | 1315 | 2390 | 4334 | 1587 | 2890 | 5234 |
| −57 | −70 | −94 | 4.4 | 40 | 104.0 | 32.1 | 90 | 194.0 | 760 | 1400 | 2552 | 1041 | 1910 | 3470 | 1320 | 2400 | 4352 | 1593 | 2900 | 5252 |
| −51 | −60 | −76 | 4.9 | 41 | 105.8 | 33.3 | 91 | 195.8 | 765 | 1410 | 2570 | 1047 | 1920 | 3488 | 1326 | 2410 | 4370 | 1598 | 2910 | 5270 |
| −46 | −50 | −58 | 5.5 | 42 | 107.6 | 33.8 | 92 | 197.6 | 771 | 1420 | 2588 | 1052 | 1930 | 3506 | 1331 | 2420 | 4388 | 1604 | 2920 | 5288 |
| −40 | −40 | −40 | 6.6 | 44 | 111.2 | 34.4 | 94 | 201.2 | 776 | 1430 | 2606 | 1058 | 1940 | 3524 | 1337 | 2430 | 4406 | 1609 | 2930 | 5306 |
| −34 | −30 | −22 | 7.1 | 45 | 113.0 | 34.9 | 95 | 203.0 | 782 | 1440 | 2624 | 1063 | 1950 | 3542 | 1342 | 2440 | 4424 | 1615 | 2940 | 5324 |
| −29 | −20 | −4 | 7.7 | 46 | 114.8 | 35.5 | 96 | 204.8 | 787 | 1450 | 2642 | 1069 | 1960 | 3560 | 1348 | 2450 | 4442 | 1620 | 2950 | 5342 |
| −23 | −10 | 14 | 8.2 | 47 | 116.6 | 36.1 | 97 | 206.6 | 793 | 1460 | 2660 | 1074 | 1970 | 3578 | 1353 | 2460 | 4460 | 1626 | 2960 | 5360 |
| −17.7 | 0 | 32 | 8.8 | 48 | 118.4 | 36.6 | 98 | 208.4 | 798 | 1470 | 2678 | 1080 | 1980 | 3596 | 1359 | 2470 | 4478 | 1631 | 2970 | 5378 |
| | | | 9.3 | 49 | 120.2 | 37.1 | 99 | 210.2 | 804 | 1480 | 2696 | 1085 | 1990 | 3614 | 1364 | 2480 | 4496 | 1637 | 2980 | 5396 |
| | | | | | | 37.7 | 100 | 212.0 | 809 | 1490 | 2714 | 1093 | 2000 | 3632 | | 2490 | 4514 | 1642 | 2990 | 5414 |
| | | | | | | | | | | | | | | | | | | 1649 | 3000 | 5432 |

NOTE:—The numbers in BOLD FACE TYPE refer to the temperature either in degrees Centigrade or Fahrenheit which it is desired to convert into the other scale. If converting from Fahrenheit degrees to Centigrade degrees the equivalent temperature will be found in the left column, while if converting from degrees Centigrade to degrees Fahrenheit, the answer will be found in the column on the right.



# Conductivities ($k$) and Conductances ($C$) of Building and Insulating Materials

These constants are expressed in Btu per (hour) (square foot) (Fahrenheit degree temperature difference). Conductivities ($k$) are per inch thickness and conductances ($C$) are for thickness or construction stated, not per inch thickness.

| Material | Description | Density (Lb. per Cu. Ft.) | Mean Temp. (Fahr. Deg.) | Conductivity or Conductance | | Resistance | |
|---|---|---|---|---|---|---|---|
| | | | | ($k$) | (C) | Per Inch Thickness $\left(\frac{1}{k}\right)$ | For Thickness Listed $\left(\frac{1}{C}\right)$ |
| **BUILDING BOARDS (Non-Insulating)** | Compressed cement and asbestos sheets | 123 | 86 | 2.70 | .... | 0.37 | .... |
| | Corrugated asbestos board | 20.4 | 110 | 0.48 | .... | 2.08 | .... |
| | Pressed asbestos mill board | 60.5 | 86 | 0.84 | .... | 1.19 | .... |
| | Gypsum board—gypsum between layers of heavy paper | 62.8 | 70 | 1.41 | .... | 0.71 | .... |
| | ⅜ in. gypsum board | .... | .... | .... | 3.73 | .... | 0.27 |
| | ½ in. gypsum board | .... | .... | .... | 2.82 | .... | 0.35 |
| | ½ in. gypsum board | 53.5 | 90 | .... | 2.60 | .... | 0.38 |
| **FRAME CONSTRUCTION COMBINATIONS** | 1 in. fir sheathing and building paper | .... | 30 | .... | 0.86 | .... | 1.16 |
| | 1 in. fir sheathing, building paper and yellow pine lap siding | .... | 20 | .... | 0.50 | .... | 2.00 |
| | 1 in. fir sheathing, building paper and stucco | .... | 20 | .... | 0.82 | .... | 1.22 |
| | Pine lap siding and building paper, siding 4 in. wide | .... | 16 | .... | 0.85 | .... | 1.18 |
| | Yellow pine lap siding | .... | .... | .... | 1.28 | .... | 0.78 |
| **MASONRY MATERIALS** | | | | | | | |
| Brick | Damp or wet | .... | .... | 5.0 | .... | 0.20 | .... |
| | Common yellow clay brick | .... | .... | 4.8 | .... | 0.21 | .... |
| | One tier yellow common clay brick, one tier face brick, approx. 8 in. thick | .... | .... | .... | 0.77 | .... | 1.30 |
| Clay Tile, Hollow | 2 in. Tile, ½ in. plaster both sides | 120.0 | 110 | .... | 1.00 | .... | 1.00 |
| | 4 in. Tile, ½ in. plaster both sides | 127.0 | 100 | .... | 0.60 | .... | 1.67 |
| | 6 in. Tile, ½ in. plaster both sides | 124.3 | 105 | .... | 0.47 | .... | 2.13 |
| | 8 in. Tile, average of 8 types (Walls No. 59, 63, 64, 66, 67, 90, 91, 92) | .... | .... | .... | 0.52 | .... | 1.92 |
| | 12 in. Clay tile wall: 8 in. x 5 in. x 12 in. and 4 in. x 5 in. x 12 in. | .... | .... | .... | 0.26 | .... | 3.84 |
| Concrete | Sand and gravel aggregate, various ages and mixes | .... | .... | 11.35 to 16.36 | .... | 0.09 to 0.06 | .... |
| | Sand and gravel aggregate | 142 | 75 | 12.6 | .... | 0.08 | .... |
| | Limestone aggregate | 132 | 75 | 10.8 | .... | 0.09 | .... |
| | Cinder aggregate | 97 | 75 | 4.9 | .... | 0.22 | .... |
| | Steam treated limestone slag aggregate | 74.6 | 75 | 2.27 | .... | 0.44 | .... |
| | Pumice (Mined in California) aggregate | 65.0 | 75 | 2.42 | .... | 0.41 | .... |
| | Expanded burned clay aggregate | 59.9 | 75 | 2.28 | .... | 0.44 | .... |
| | Burned clay aggregate | 67.1 | 75 | 2.86 | .... | 0.35 | .... |
| | Blast furnace slag aggregate | 76.0 | 70 | 1.6 | .... | 0.63 | .... |
| | Expanded vermiculite aggregate | 20 | 90 | 0.68 | .... | 1.47 | .... |
| | Expanded vermiculite aggregate | 26.7 | 90 | 0.76 | .... | 1.32 | .... |
| | Expanded vermiculite aggregate | 35 | 90 | 0.86 | .... | 1.16 | .... |
| | Expanded vermiculite aggregate | 50 | 90 | 1.10 | .... | 0.91 | .... |
| | Concrete plank | 76 | 75 | 2.5 | .... | 0.40 | .... |
| | Cellular concrete | 40.0 | 75 | 1.06 | .... | 0.94 | .... |
| | Cellular concrete | 50.0 | 75 | 1.44 | .... | 0.69 | .... |
| | Cellular concrete | 60.0 | 75 | 1.80 | .... | 0.56 | .... |
| | Cellular concrete | 70.0 | 75 | 2.18 | .... | 0.46 | .... |
| 8 Inch Concrete Blocks | 8 in. three oval core, sand and gravel aggregate | 126.4 | 40 | .... | 0.90 | .... | 1.11 |
| | 8 in. three oval core, crushed limestone aggregate | 134.3 | 40 | .... | 0.86 | .... | 1.16 |
| | 8 in. three oval core, cinder aggregate | 86.2 | 40 | .... | 0.58 | .... | 1.73 |
| | 8 in. three oval core, burned clay aggregate | 67.7 | 40 | .... | 0.50 | .... | 2.00 |
| | 8 in. three oval core, expanded blast furnace slag aggregate | .... | 40 | .... | 0.49 | .... | 2.04 |



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# Conductivities ($k$) and Conductances ($C$) of Building and Insulating Materials (Continued)

These constants are expressed in Btu per (hour) (square foot) (Fahrenheit degree temperature difference). Conductivities ($k$) are per inch thickness and conductances ($C$) are for thickness or construction stated, not per inch thickness.

| Material | Description | Density (Lb. per Cu. Ft.) | Mean Temp. (Fahr. Deg.) | Conductivity or Conductance ($k$) | Conductivity or Conductance ($C$) | Resistance: Per Inch Thickness $\left(\frac{1}{k}\right)$ | Resistance: For Thickness Listed $\left(\frac{1}{C}\right)$ |
|---|---|---|---|---|---|---|---|
| MASONRY MATERIALS —(Continued) | | | | | | | |
| 12 Inch Concrete Blocks | 12 in. three oval core, sand and gravel aggregate | 124.9 | 40 | .... | 0.78 | .... | 1.28 |
| | 12 in. three oval core, cinder aggregate | 86.2 | 40 | .... | 0.53 | .... | 1.88 |
| | 12 in. three oval core, burned clay aggregate | 76.7 | 40 | .... | 0.47 | .... | 2.13 |
| Gypsum | 3 in. solid gypsum partition tile | .... | .... | 2.41 | .... | 0.42 | .... |
| | 3 in. three cell gypsum partition tile | .... | .... | .... | 0.74 | .... | 1.35 |
| | 4 in. three cell gypsum partition tile | .... | .... | .... | 0.60 | .... | 1.67 |
| | 87½ per cent gypsum, 12½ per cent wood chips | 51.2 | 74 | 1.66 | .... | 0.60 | .... |
| | Gypsum plaster | .... | .... | 3.30 | .... | 0.30 | .... |
| PLASTERING MATERIALS | Gypsum plaster, ⅝ in. thick | .... | 73 | .... | 8.80 | .... | 0.11 |
| | Cement plaster | .... | .... | 8.00 | .... | 0.13 | .... |
| | Wood, lath and plaster, total thickness ¾ in. | .... | 70 | .... | 2.50 | .... | 0.40 |
| | Gypsum plaster and expanded vermiculite, 4 to 1 mix | 39.9 | 75 | 0.85 | .... | 1.18 | .... |
| | Insulating plaster 0.9 in. thick applied to ⅜-in. gypsum board | 54.0 | 75 | .... | 1.07 | .... | 0.93 |
| ROOFING | Asbestos shingles | 65.0 | 75 | .... | 6.0 | .... | 0.17 |
| | Asphalt, composition or prepared | 70.0 | 75 | .... | 6.5 | .... | 0.15 |
| | Asphalt shingles | 70.0 | 75 | .... | 6.5 | .... | 0.15 |
| | Built-up roofing, bitumen or felt, gravel or slag surfaced | .... | .... | 1.33 | .... | 0.75 | .... |
| | Slate | .... | .... | 10.00 | .... | 0.10 | .... |
| | Wood shingles | .... | .... | .... | 1.28 | .... | 0.78 |
| WOODS | Balsa | 20.0 | 90 | 0.58 | .... | 1.72 | .... |
| | Balsa | 8.8 | 90 | 0.38 | .... | 2.63 | .... |
| | Balsa | 7.3 | 90 | 0.33 | .... | 3.03 | .... |
| | California redwood, 0 per cent moisture | 28.0 | 75 | 0.70 | .... | 1.43 | .... |
| | Cypress | 28.7 | 86 | 0.67 | .... | 1.49 | .... |
| | Douglas fir, 0 per cent moisture | 34.0 | 75 | 0.67 | .... | 1.49 | .... |
| | Eastern hemlock, 0 per cent moisture | 30.0 | 75 | 0.76 | .... | 1.32 | .... |
| | Longleaf yellow pine, 0 per cent moisture | 40.0 | 75 | 0.86 | .... | 1.16 | .... |
| | Mahogany | 34.3 | 86 | 0.90 | .... | 1.11 | .... |
| | Hard maple, 0 per cent moisture | 46.0 | 75 | 1.05 | .... | 0.95 | .... |
| | Maple | 44.3 | 86 | 1.10 | .... | 0.91 | .... |
| | Maple, across grain | 40.0 | 75 | 1.20 | .... | 0.83 | .... |
| | Norway pine, 0 per cent moisture | 32.0 | 75 | 0.74 | .... | 1.35 | .... |
| | Red cypress, 0 per cent moisture | 32.0 | 75 | 0.79 | .... | 1.27 | .... |
| | Red oak, 0 per cent moisture | 48.0 | 75 | 1.18 | .... | 0.85 | .... |
| | Shortleaf yellow pine, 0 per cent moisture | 36.0 | 75 | 0.91 | .... | 1.10 | .... |
| | Soft elm, 0 per cent moisture | 34.0 | 75 | 0.88 | .... | 1.14 | .... |
| | Soft maple, 0 per cent moisture | 42.0 | 75 | 0.95 | .... | 1.05 | .... |
| | Sugar pine, 0 per cent moisture | 28.0 | 75 | 0.64 | .... | 1.56 | .... |
| | Virginia pine | 34.3 | 86 | 0.96 | .... | 1.04 | .... |
| | West coast hemlock, 0 per cent moisture | 30.0 | 75 | 0.79 | .... | 1.27 | .... |
| | White pine | 31.2 | 86 | 0.78 | .... | 1.28 | .... |
| | Yellow pine | .... | .... | 1.00 | .... | 1.00 | .... |
| | Sawdust, various | 12.0 | 90 | 0.41 | .... | 2.44 | .... |
| | Shavings, various from planer | 8.8 | 90 | 0.41 | .... | 2.44 | .... |
| | Shavings, from maple beech and birch (course) | 13.2 | 90 | 0.36 | .... | 2.78 | .... |

Courtesy American Society of Heating and Ventilating Engineers



# Saturated Steam Table

| Gauge Pressure in Lbs./ Sq. In. | Absolute Pressure in Lbs./ Sq. In. | Temp. in Degrees Fahr. | Spec. Vol. of Sat. Vap. in Cu. Ft./Lb. | Latent Heat of Evap. in Btu's/Lb. | Total Heat of Steam in Btu's/Lb. | Gauge Pressure in Lbs./ Sq. In. | Absolute Pressure in Lbs./ Sq. In. | Temp. in Degrees Fahr. | Spec. Vol. of Sat. Vap. in Cu. Ft./Lb. | Latent Heat of Evap. in Btu's/Lb. | Total Heat of Steam in Btu's/Lb. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (These pressures indicated to nearest tenth of a pound. Author's tables do not include gauge pressures.) | 1 | 101.74 | 333.6 | 1036.3 | 1106.0 | 175.3 | 190 | 377.51 | 2.404 | 846.8 | 1197.6 |
| | 2 | 126.08 | 173.73 | 1022.2 | 1116.2 | 185.3 | 200 | 381.79 | 2.288 | 843.0 | 1198.4 |
| | 3 | 141.48 | 118.71 | 1013.2 | 1122.6 | 195.3 | 210 | 385.90 | 2.183 | 839.2 | 1199.0 |
| | 4 | 152.97 | 90.63 | 1006.4 | 1127.3 | 205.3 | 220 | 389.86 | 2.087 | 835.6 | 1199.6 |
| | 5 | 162.24 | 73.52 | 1001.0 | 1131.1 | 215.3 | 230 | 393.68 | 1.9992 | 832.0 | 1200.1 |
| | 6 | 170.06 | 61.98 | 996.2 | 1134.2 | 225.3 | 240 | 397.37 | 1.9183 | 828.5 | 1200.6 |
| | 7 | 176.85 | 53.64 | 992.1 | 1136.9 | 235.3 | 250 | 400.95 | 1.8438 | 825.1 | 1201.1 |
| | 8 | 182.86 | 47.34 | 988.5 | 1139.3 | 245.3 | 260 | 404.42 | 1.7748 | 821.8 | 1201.5 |
| | 9 | 188.28 | 42.40 | 985.2 | 1141.4 | 255.3 | 270 | 407.78 | 1.7107 | 818.5 | 1201.9 |
| | 10 | 193.21 | 38.42 | 982.1 | 1143.3 | 265.3 | 280 | 411.05 | 1.6511 | 815.3 | 1202.3 |
| | 12 | 201.96 | 32.40 | 976.6 | 1146.6 | 275.3 | 290 | 414.23 | 1.5954 | 812.1 | 1202.6 |
| | 14 | 209.56 | 28.04 | 971.9 | 1149.5 | 285.3 | 300 | 417.33 | 1.5433 | 809.0 | 1202.8 |
| .0 | 14.696 | 212.00 | 26.80 | 970.3 | 1150.4 | 305.3 | 320 | 423.29 | 1.4485 | 803.0 | 1203.4 |
| .3 | 15 | 213.03 | 26.29 | 969.7 | 1150.8 | 325.3 | 340 | 428.97 | 1.3645 | 797.1 | 1203.7 |
| 5.3 | 20 | 227.96 | 20.089 | 960.1 | 1156.3 | 345.3 | 360 | 434.40 | 1.2895 | 791.4 | 1204.1 |
| 10.3 | 25 | 240.07 | 16.303 | 952.1 | 1160.6 | 365.3 | 380 | 439.60 | 1.2222 | 785.8 | 1204.3 |
| 15.3 | 30 | 250.33 | 13.746 | 945.3 | 1164.1 | 385.3 | 400 | 444.59 | 1.1613 | 780.5 | 1204.5 |
| 20.3 | 35 | 259.28 | 11.898 | 939.2 | 1167.1 | 405.3 | 420 | 449.39 | 1.1061 | 775.2 | 1204.6 |
| 25.3 | 40 | 267.25 | 10.498 | 933.7 | 1169.7 | 425.3 | 440 | 454.02 | 1.0556 | 770.0 | 1204.6 |
| 30.3 | 45 | 274.44 | 9.401 | 928.6 | 1172.0 | 445.3 | 460 | 458.50 | 1.0094 | 764.9 | 1204.6 |
| 35.3 | 50 | 281.01 | 8.515 | 924.0 | 1174.1 | 465.3 | 480 | 462.82 | 0.9670 | 759.9 | 1204.5 |
| 40.3 | 55 | 287.07 | 7.787 | 919.6 | 1175.9 | 485.3 | 500 | 467.01 | 0.9278 | 755.0 | 1204.4 |
| 45.3 | 60 | 292.71 | 7.175 | 915.5 | 1177.6 | 585.3 | 600 | 486.21 | 0.7698 | 731.6 | 1203.2 |
| 50.3 | 65 | 297.97 | 6.655 | 911.6 | 1179.1 | 685.3 | 700 | 503.10 | 0.6554 | 709.7 | 1201.2 |
| 55.3 | 70 | 302.92 | 6.206 | 907.9 | 1180.6 | 785.3 | 800 | 518.23 | 0.5687 | 688.9 | 1198.6 |
| 60.3 | 75 | 307.60 | 5.816 | 904.5 | 1181.9 | 885.3 | 900 | 531.98 | 0.5006 | 668.8 | 1195.4 |
| 65.3 | 80 | 312.03 | 5.472 | 901.1 | 1183.1 | 985.3 | 1000 | 544.61 | 0.4456 | 649.4 | 1191.8 |
| 70.3 | 85 | 316.25 | 5.168 | 897.8 | 1184.2 | 1085.3 | 1100 | 556.31 | 0.4001 | 630.4 | 1187.8 |
| 75.3 | 90 | 320.27 | 4.896 | 894.7 | 1185.3 | 1185.3 | 1200 | 567.22 | 0.3619 | 611.7 | 1183.4 |
| 80.3 | 95 | 324.12 | 4.652 | 891.7 | 1186.2 | 1285.3 | 1300 | 577.46 | 0.3293 | 593.2 | 1178.6 |
| 85.3 | 100 | 327.81 | 4.432 | 888.8 | 1187.2 | 1385.3 | 1400 | 587.10 | 0.3012 | 574.7 | 1173.4 |
| 90.3 | 105 | 331.36 | 4.232 | 886.0 | 1188.1 | 1485.3 | 1500 | 596.23 | 0.2765 | 556.3 | 1167.9 |
| 95.3 | 110 | 334.77 | 4.049 | 883.2 | 1188.9 | 1585.3 | 1600 | 604.90 | 0.2548 | 538.0 | 1162.1 |
| 100.3 | 115 | 338.07 | 3.882 | 880.6 | 1189.7 | 1685.3 | 1700 | 613.15 | 0.2354 | 519.6 | 1155.9 |
| 105.3 | 120 | 341.25 | 3.728 | 877.9 | 1190.4 | 1785.3 | 1800 | 621.03 | 0.2179 | 501.1 | 1149.4 |
| 110.3 | 125 | 344.33 | 3.587 | 875.4 | 1191.1 | 1885.3 | 1900 | 628.58 | 0.2021 | 482.4 | 1142.4 |
| 115.3 | 130 | 347.32 | 3.455 | 872.9 | 1191.7 | 1985.3 | 2000 | 635.82 | 0.1878 | 463.4 | 1135.1 |
| 120.3 | 135 | 350.21 | 3.333 | 870.6 | 1192.4 | 2185.3 | 2200 | 649.46 | 0.1625 | 424.4 | 1119.2 |
| 125.3 | 140 | 353.02 | 3.220 | 868.2 | 1193.0 | 2385.3 | 2400 | 662.12 | 0.1407 | 382.7 | 1101.1 |
| 130.3 | 145 | 355.76 | 3.114 | 865.8 | 1193.5 | 2585.3 | 2600 | 673.94 | 0.1213 | 337.2 | 1080.2 |
| 135.3 | 150 | 358.42 | 3.015 | 863.6 | 1194.1 | 2785.3 | 2800 | 684.99 | 0.1035 | 284.7 | 1054.8 |
| 145.3 | 160 | 363.53 | 2.834 | 859.2 | 1195.1 | 2985.3 | 3000 | 695.36 | 0.0858 | 217.8 | 1020.3 |
| 155.3 | 170 | 368.41 | 2.675 | 854.9 | 1196.0 | 3185.3 | 3200 | 705.11 | 0.0580 | 62.0 | 934.4 |
| 165.3 | 180 | 373.06 | 2.532 | 850.8 | 1196.9 | 3191.5 | 3206.2 | 705.40 | 0.0503 | 0 | 902.7 |



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# Superheated Steam Table

| Abs. Press. lbs./sq. in. (Sat. Temp.) | | Sat. Vapor | TEMPERATURE in Degrees F. 500° | 600° | 700° | 800° | 900° | 1000° |
|---|---|---|---|---|---|---|---|---|
| 80 (312.03) | v | 5.472 | 7.020 | 7.797 | 8.562 | 9.322 | 10.077 | 10.830 |
| | h | 1183.1 | 1281.1 | 1330.5 | 1379.9 | 1429.7 | 1480.1 | 1531.3 |
| | s | 1.6207 | 1.7346 | 1.7836 | 1.8281 | 1.8694 | 1.9079 | 1.9442 |
| 100 (327.81) | v | 4.432 | 5.589 | 6.218 | 6.835 | 7.446 | 8.052 | 8.656 |
| | h | 1187.2 | 1279.1 | 1329.1 | 1378.9 | 1428.9 | 1479.5 | 1530.8 |
| | s | 1.6026 | 1.7085 | 1.7581 | 1.8029 | 1.8443 | 1.8829 | 1.9193 |
| 120 (341.25) | v | 3.728 | 4.636 | 5.165 | 5.683 | 6.195 | 6.702 | 7.207 |
| | h | 1190.4 | 1277.2 | 1327.7 | 1377.8 | 1428.1 | 1478.8 | 1530.2 |
| | s | 1.5878 | 1.6869 | 1.7370 | 1.7822 | 1.8237 | 1.8625 | 1.8990 |
| 140 (353.02) | v | 3.220 | 3.954 | 4.413 | 4.861 | 5.301 | 5.738 | 6.172 |
| | h | 1193.0 | 1275.2 | 1326.4 | 1376.8 | 1427.3 | 1478.2 | 1529.7 |
| | s | 1.5751 | 1.6683 | 1.7190 | 1.7645 | 1.8063 | 1.8451 | 1.8817 |
| 160 (363.53) | v | 2.834 | 3.443 | 3.849 | 4.244 | 4.631 | 5.015 | 5.396 |
| | h | 1195.1 | 1273.1 | 1325.0 | 1375.7 | 1426.4 | 1477.5 | 1529.1 |
| | s | 1.5640 | 1.6519 | 1.7033 | 1.7491 | 1.7911 | 1.8301 | 1.8667 |
| 180 (373.06) | v | 2.532 | 3.044 | 3.411 | 3.764 | 4.110 | 4.452 | 4.792 |
| | h | 1196.9 | 1271.9 | 1323.5 | 1374.7 | 1425.6 | 1476.8 | 1528.6 |
| | s | 1.5542 | 1.6373 | 1.6894 | 1.7355 | 1.7776 | 1.8167 | 1.8534 |
| 200 (381.79) | v | 2.288 | 2.726 | 3.060 | 3.380 | 3.693 | 4.002 | 4.309 |
| | h | 1198.4 | 1268.9 | 1322.1 | 1373.6 | 1424.8 | 1476.2 | 1528.0 |
| | s | 1.5453 | 1.6240 | 1.6767 | 1.7232 | 1.7655 | 1.8048 | 1.8415 |
| 220 (389.86) | v | 2.087 | 2.465 | 2.772 | 3.066 | 3.352 | 3.634 | 3.913 |
| | h | 1199.6 | 1266.7 | 1320.7 | 1372.6 | 1424.0 | 1475.5 | 1527.5 |
| | s | 1.5372 | 1.6117 | 1.6652 | 1.7120 | 1.7545 | 1.7939 | 1.8308 |
| 240 (397.37) | v | 1.9183 | 2.247 | 2.533 | 2.804 | 3.068 | 3.327 | 3.584 |
| | h | 1200.6 | 1264.5 | 1319.2 | 1371.5 | 1423.2 | 1474.8 | 1526.9 |
| | s | 1.5298 | 1.6003 | 1.6546 | 1.7017 | 1.7444 | 1.7839 | 1.8209 |
| 260 (404.42) | v | 1.7748 | 2.063 | 2.330 | 2.582 | 2.827 | 3.067 | 3.305 |
| | h | 1201.5 | 1262.3 | 1317.7 | 1370.4 | 1422.3 | 1474.2 | 1526.3 |
| | s | 1.5229 | 1.5897 | 1.6447 | 1.6922 | 1.7352 | 1.7748 | 1.8118 |
| 280 (411.05) | v | 1.6511 | 1.9047 | 2.156 | 2.392 | 2.621 | 2.845 | 3.066 |
| | h | 1202.3 | 1260.0 | 1316.2 | 1369.4 | 1421.5 | 1473.5 | 1525.8 |
| | s | 1.5164 | 1.5796 | 1.6354 | 1.6834 | 1.7265 | 1.7662 | 1.8033 |
| 300 (417.33) | v | 1.5433 | 1.7675 | 2.005 | 2.227 | 2.442 | 2.652 | 2.859 |
| | h | 1202.8 | 1257.6 | 1314.7 | 1368.3 | 1420.6 | 1472.8 | 1525.2 |
| | s | 1.5104 | 1.5701 | 1.6268 | 1.6751 | 1.7184 | 1.7582 | 1.7954 |
| 320 (423.29) | v | 1.4485 | 1.6472 | 1.8734 | 2.083 | 2.285 | 2.483 | 2.678 |
| | h | 1203.4 | 1255.2 | 1313.2 | 1367.2 | 1419.8 | 1472.1 | 1524.7 |
| | s | 1.5046 | 1.5611 | 1.6186 | 1.6673 | 1.7108 | 1.7508 | 1.7880 |
| 340 (428.97) | v | 1.3645 | 1.5410 | 1.7569 | 1.9562 | 2.147 | 2.334 | 2.518 |
| | h | 1203.7 | 1252.8 | 1311.6 | 1366.1 | 1419.0 | 1471.5 | 1524.1 |
| | s | 1.4992 | 1.5524 | 1.6108 | 1.6599 | 1.7036 | 1.7437 | 1.7811 |
| 360 (434.40) | v | 1.2895 | 1.4464 | 1.6533 | 1.8431 | 2.025 | 2.202 | 2.376 |
| | h | 1204.1 | 1250.3 | 1310.1 | 1365.0 | 1418.1 | 1470.8 | 1523.5 |
| | s | 1.4941 | 1.5440 | 1.6033 | 1.6529 | 1.6968 | 1.7371 | 1.7745 |
| 380 (439.60) | v | 1.2222 | 1.3616 | 1.5605 | 1.7419 | 1.9149 | 2.083 | 2.249 |
| | h | 1204.3 | 1247.7 | 1308.5 | 1363.8 | 1417.3 | 1470.1 | 1523.0 |
| | s | 1.4891 | 1.5359 | 1.5962 | 1.6462 | 1.6904 | 1.7307 | 1.7683 |
| 400 (444.59) | v | 1.1613 | 1.2851 | 1.4770 | 1.6508 | 1.8161 | 1.9767 | 2.134 |
| | h | 1204.5 | 1245.1 | 1306.9 | 1362.7 | 1416.4 | 1469.4 | 1522.4 |
| | s | 1.4844 | 1.5281 | 1.5894 | 1.6396 | 1.6842 | 1.7247 | 1.7623 |
| 420 (449.39) | v | 1.1061 | 1.2158 | 1.4014 | 1.5684 | 1.7267 | 1.8802 | 2.031 |
| | h | 1204.6 | 1242.5 | 1305.3 | 1361.6 | 1415.5 | 1468.7 | 1521.9 |
| | s | 1.4799 | 1.5205 | 1.5829 | 1.6337 | 1.6783 | 1.7189 | 1.7566 |



# Standard Pipe Data

All dimensions and weights are nominal

| Size Ins. | Diameters: External Inches | Diameters: Internal Inches | Thickness Ins. | Circumference: External Inches | Circumference: Internal Inches | Transverse Areas: External Sq. Ins. | Transverse Areas: Internal Sq. Ins. | Transverse Areas: Metal Square Inches | External Surface Area in Sq. Ft. Per Lineal Ft. of Pipe | Length of Pipe Containing One Cubic Foot Feet | Weight per Foot: Plain Ends Pounds | Weight per Foot: Threaded and Coupled Pounds | Wt. of Water Per Foot Pounds |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ⅛ | .405 | .269 | .068 | 1.272 | .845 | .129 | .057 | .072 | .1060 | 2533.775 | .244 | .245 | .025 |
| ¼ | .540 | .364 | .088 | 1.696 | 1.144 | .229 | .104 | .125 | .1414 | 1383.789 | .424 | .425 | .045 |
| ⅜ | .675 | .493 | .091 | 2.121 | 1.549 | .358 | .191 | .167 | .1767 | 754.360 | .567 | .568 | .083 |
| ½ | .840 | .622 | .109 | 2.639 | 1.954 | .554 | .304 | .250 | .220 | 473.906 | .850 | .852 | .132 |
| ¾ | 1.050 | .824 | .113 | 3.299 | 2.589 | .866 | .533 | .333 | .275 | 270.034 | 1.130 | 1.134 | .231 |
| 1 | 1.315 | 1.049 | .133 | 4.131 | 3.296 | 1.358 | .864 | .494 | .344 | 166.618 | 1.678 | 1.684 | .375 |
| 1¼ | 1.660 | 1.380 | .140 | 5.215 | 4.335 | 2.164 | 1.495 | .669 | .435 | 96.275 | 2.272 | 2.281 | .65 |
| 1½ | 1.900 | 1.610 | .145 | 5.969 | 5.058 | 2.835 | 2.036 | .799 | .498 | 70.733 | 2.717 | 2.731 | .88 |
| 2 | 2.375 | 2.067 | .154 | 7.461 | 6.494 | 4.430 | 3.355 | 1.075 | .622 | 42.913 | 3.652 | 3.678 | 1.45 |
| 2½ | 2.875 | 2.469 | .203 | 9.032 | 7.757 | 6.492 | 4.788 | 1.704 | .753 | 30.077 | 5.793 | 5.819 | 2.07 |
| 3 | 3.500 | 3.068 | .216 | 10.996 | 9.638 | 9.621 | 7.393 | 2.228 | .917 | 19.479 | 7.575 | 7.616 | 3.20 |
| 3½ | 4.000 | 3.548 | .226 | 12.566 | 11.146 | 12.566 | 9.886 | 2.680 | 1.047 | 14.565 | 9.109 | 9.202 | 4.29 |
| 4 | 4.500 | 4.026 | .237 | 14.137 | 12.648 | 15.904 | 12.730 | 3.174 | 1.179 | 11.312 | 10.790 | 10.889 | 5.50 |
| 4½ | 5.000 | 4.506 | .247 | 15.708 | 14.156 | 19.635 | 15.947 | 3.688 | 1.310 | 9.030 | 12.538 | 12.642 | 6.91 |
| 5 | 5.563 | 5.047 | .258 | 17.477 | 15.856 | 24.306 | 20.006 | 4.300 | 1.458 | 7.198 | 14.617 | 14.810 | 8.67 |
| 6 | 6.625 | 6.065 | .280 | 20.813 | 19.054 | 34.472 | 28.891 | 5.581 | 1.736 | 4.984 | 18.974 | 19.185 | 12.51 |
| 7 | 7.625 | 7.023 | .301 | 23.955 | 22.063 | 45.664 | 38.738 | 6.926 | 2.000 | 3.717 | 23.544 | 23.769 | 16.80 |
| 8 | 8.625 | 8.071 | .277 | 27.096 | 25.356 | 58.426 | 51.161 | 7.265 | 2.262 | 2.815 | 24.696 | 25.000 | 22.18 |
| 8 | 8.625 | 7.981 | .322 | 27.096 | 25.073 | 58.426 | 50.027 | 8.399 | 2.262 | 2.878 | 28.554 | 28.809 | 21.70 |
| 9 | 9.625 | 8.941 | .342 | 30.238 | 28.089 | 72.760 | 62.786 | 9.974 | 2.525 | 2.294 | 33.907 | 34.188 | 27.20 |
| 10 | 10.750 | 10.192 | .279 | 33.772 | 32.019 | 90.763 | 81.585 | 9.178 | 2.817 | 1.765 | 31.201 | 32.000 | 35.37 |
| 10 | 10.750 | 10.136 | .307 | 33.772 | 31.843 | 90.763 | 80.691 | 10.072 | 2.817 | 1.785 | 34.240 | 35.000 | 34.95 |
| 10 | 10.750 | 10.020 | .365 | 33.772 | 31.479 | 90.763 | 78.855 | 11.908 | 2.817 | 1.826 | 40.483 | 41.132 | 34.20 |
| 11 | 11.750 | 11.000 | .375 | 36.914 | 34.558 | 108.434 | 95.033 | 13.401 | 3.075 | 1.515 | 45.557 | 46.247 | 41.20 |
| 12 | 12.750 | 12.090 | .330 | 40.055 | 37.982 | 127.676 | 114.800 | 12.876 | 3.344 | 1.254 | 43.773 | 45.000 | 49.70 |
| 12 | 12.750 | 12.000 | .375 | 40.055 | 37.699 | 127.676 | 113.097 | 14.579 | 3.344 | 1.273 | 49.562 | 50.706 | 49.00 |

# Extra Strong Pipe Data

All dimensions and weights are nominal

| Size Inches | Diameters: External Inches | Diameters: Internal Inches | Thickness Inches | Circumference: External Inches | Circumference: Internal Inches | Transverse Areas: External Sq. Ins. | Transverse Areas: Internal Sq. Ins. | Transverse Areas: Metal Sq. Ins. | External Surface Area in Sq. Ft. Per Lineal Ft. of Pipe | Length of Pipe Containing One Cubic Foot Feet | Weight Per Foot Plain Ends Pounds | Weight of Water Per Foot Pounds |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ⅛ | .405 | .215 | .095 | 1.272 | .675 | .129 | .036 | .093 | .1060 | 3966.392 | .314 | .016 |
| ¼ | .540 | .302 | .119 | 1.696 | .949 | .229 | .072 | .157 | .1414 | 2010.290 | .535 | .031 |
| ⅜ | .675 | .423 | .126 | 2.121 | 1.329 | .358 | .141 | .217 | .1767 | 1024.689 | .738 | .061 |
| ½ | .840 | .546 | .147 | 2.639 | 1.715 | .554 | .234 | .320 | .220 | 615.017 | 1.087 | .102 |
| ¾ | 1.050 | .742 | .154 | 3.299 | 2.331 | .866 | .433 | .433 | .275 | 333.016 | 1.473 | .188 |
| 1 | 1.315 | .957 | .179 | 4.131 | 3.007 | 1.358 | .719 | .639 | .344 | 200.193 | 2.171 | .312 |
| 1¼ | 1.660 | 1.278 | .191 | 5.215 | 4.015 | 2.164 | 1.283 | .881 | .435 | 112.256 | 2.996 | .56 |
| 1½ | 1.900 | 1.500 | .200 | 5.969 | 4.712 | 2.835 | 1.767 | 1.068 | .498 | 81.487 | 3.631 | .77 |
| 2 | 2.375 | 1.939 | .218 | 7.461 | 6.092 | 4.430 | 2.953 | 1.477 | .622 | 48.766 | 5.022 | 1.28 |
| 2½ | 2.875 | 2.323 | .276 | 9.032 | 7.298 | 6.492 | 4.238 | 2.254 | .753 | 33.976 | 7.661 | 1.87 |
| 3 | 3.500 | 2.900 | .300 | 10.996 | 9.111 | 9.621 | 6.605 | 3.016 | .917 | 21.801 | 10.252 | 2.86 |
| 3½ | 4.000 | 3.364 | .318 | 12.566 | 10.568 | 12.566 | 8.888 | 3.678 | 1.047 | 16.202 | 12.505 | 3.84 |
| 4 | 4.500 | 3.826 | .337 | 14.137 | 12.020 | 15.904 | 11.497 | 4.407 | 1.179 | 12.525 | 14.983 | 4.98 |
| 4½ | 5.000 | 4.290 | .355 | 15.708 | 13.477 | 19.635 | 14.455 | 5.180 | 1.310 | 9.962 | 17.611 | 6.27 |
| 5 | 5.563 | 4.813 | .375 | 17.477 | 15.120 | 24.306 | 18.194 | 6.112 | 1.458 | 7.915 | 20.778 | 7.88 |
| 6 | 6.625 | 5.761 | .432 | 20.813 | 18.099 | 34.472 | 26.067 | 8.405 | 1.736 | 5.524 | 28.573 | 11.29 |
| 7 | 7.625 | 6.625 | .500 | 23.955 | 20.813 | 45.664 | 34.472 | 11.192 | 2.000 | 4.177 | 38.048 | 14.95 |
| 8 | 8.625 | 7.625 | .500 | 27.096 | 23.955 | 58.426 | 45.663 | 12.763 | 2.262 | 3.154 | 43.388 | 19.78 |
| 9 | 9.625 | 8.625 | .500 | 30.238 | 27.096 | 72.760 | 58.426 | 14.334 | 2.525 | 2.464 | 48.728 | 25.30 |
| 10 | 10.750 | 9.750 | .500 | 33.772 | 30.631 | 90.763 | 74.662 | 16.101 | 2.817 | 1.929 | 54.735 | 32.35 |
| 11 | 11.750 | 10.750 | .500 | 36.914 | 33.772 | 108.434 | 90.763 | 17.671 | 3.075 | 1.587 | 60.075 | 39.40 |
| 12 | 12.750 | 11.750 | .500 | 40.055 | 36.914 | 127.676 | 108.434 | 19.242 | 3.344 | 1.328 | 65.415 | 46.92 |



*Armstrong's Industrial Insulations (1951)*
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# Double Extra Strong Pipe Data

All dimensions and weights are nominal

| Size Inches | Diameters | | Thick-ness Inches | Circumference | | Transverse Areas | | | External Surface Area in Sq. Ft. Per Lineal Ft. of Pipe | Length of Pipe Containing One Cubic Foot Feet | Weight Per Foot Plain Ends Pounds | Weight of Water Per Foot Pounds |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | External Inches | Internal Inches | | External Inches | Internal Inches | External Sq. Ins. | Internal Sq. Ins. | Metal Sq. Ins. | | | | |
| ¼ | .840 | .252 | .294 | 2.639 | .792 | .554 | .050 | .504 | .220 | 2887.164 | 1.714 | .022 |
| ¾ | 1.050 | .434 | .308 | 3.299 | 1.363 | .866 | .148 | .718 | .275 | 973.404 | 2.440 | .064 |
| 1 | 1.315 | .599 | .358 | 4.131 | 1.882 | 1.358 | .282 | 1.076 | .344 | 510.998 | 3.659 | .122 |
| 1¼ | 1.660 | .896 | .382 | 5.215 | 2.815 | 2.164 | .630 | 1.534 | .435 | 228.379 | 5.214 | .273 |
| 1½ | 1.900 | 1.100 | .400 | 5.969 | 3.456 | 2.835 | .950 | 1.885 | .498 | 151.526 | 6.408 | .42 |
| 2 | 2.375 | 1.503 | .436 | 7.461 | 4.722 | 4.430 | 1.774 | 2.656 | .622 | 81.162 | 9.029 | .77 |
| 2½ | 2.875 | 1.771 | .552 | 9.032 | 5.564 | 6.492 | 2.464 | 4.028 | .753 | 58.457 | 13.695 | 1.07 |
| 3 | 3.500 | 2.300 | .600 | 10.996 | 7.226 | 9.621 | 4.155 | 5.466 | .917 | 34.659 | 18.583 | 1.80 |
| 3½ | 4.000 | 2.728 | .636 | 12.566 | 8.570 | 12.566 | 5.845 | 6.721 | 1.047 | 24.637 | 22.850 | 2.53 |
| 4 | 4.500 | 3.152 | .674 | 14.137 | 9.902 | 15.904 | 7.803 | 8.101 | 1.179 | 18.454 | 27.541 | 3.38 |
| 4½ | 5.000 | 3.580 | .710 | 15.708 | 11.247 | 19.635 | 10.066 | 9.569 | 1.310 | 14.306 | 32.530 | 4.36 |
| 5 | 5.563 | 4.063 | .750 | 17.477 | 12.764 | 24.306 | 12.966 | 11.340 | 1.458 | 11.107 | 38.552 | 5.61 |
| 6 | 6.625 | 4.897 | .864 | 20.813 | 15.384 | 34.472 | 18.835 | 15.637 | 1.736 | 7.646 | 53.160 | 8.16 |
| 7 | 7.625 | 5.875 | .875 | 23.955 | 18.457 | 45.664 | 27.109 | 18.555 | 2.000 | 5.312 | 63.079 | 11.75 |
| 8 | 8.625 | 6.875 | .875 | 27.096 | 21.598 | 58.426 | 37.122 | 21.304 | 2.262 | 3.879 | 72.424 | 16.10 |

# Square Feet of Radiating Surface

For various lengths of pipe, per lineal foot
(On all lengths over one foot, figures are given to nearest tenth.)

| Length of Pipe in ft. | SIZE OF PIPE, IN INCHES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ¾ | 1 | 1¼ | 1½ | 2 | 2½ | 3 | 3½ | 4 | 5 | 6 |
| 1 | .275 | .346 | .434 | .494 | .622 | .753 | .916 | 1.047 | 1.175 | 1.455 | 1.739 |
| 2 | .5 | .7 | .9 | 1.0 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.9 | 3.5 |
| 3 | .8 | 1.0 | 1.3 | 1.5 | 1.9 | 2.3 | 2.7 | 3.1 | 3.5 | 4.4 | 5.2 |
| 4 | 1.1 | 1.4 | 1.7 | 2.0 | 2.5 | 3.0 | 3.6 | 4.2 | 4.7 | 5.8 | 7.0 |
| 5 | 1.4 | 1.7 | 2.2 | 2.4 | 3.1 | 3.8 | 4.6 | 5.2 | 5.8 | 7.3 | 7.7 |
| 6 | 1.6 | 2.1 | 2.6 | 2.9 | 3.7 | 4.5 | 5.5 | 6.3 | 7.0 | 8.7 | 10.5 |
| 7 | 1.9 | 2.4 | 3.0 | 3.4 | 4.4 | 5.3 | 6.4 | 7.3 | 8.2 | 10.2 | 12.1 |
| 8 | 2.2 | 2.8 | 3.5 | 3.9 | 5.0 | 6.0 | 7.3 | 8.4 | 9.4 | 11.6 | 13.9 |
| 9 | 2.5 | 3.1 | 3.9 | 4.4 | 5.6 | 6.8 | 8.2 | 9.4 | 10.6 | 13.1 | 15.7 |
| 10 | 2.7 | 3.5 | 4.3 | 4.9 | 6.2 | 7.5 | 9.1 | 10.5 | 11.8 | 14.6 | 17.4 |
| 11 | 3.0 | 3.8 | 4.8 | 5.4 | 6.8 | 8.3 | 10.0 | 11.5 | 12.9 | 16.0 | 19.1 |
| 12 | 3.3 | 4.1 | 5.2 | 5.9 | 7.5 | 9.0 | 11.0 | 12.6 | 14.1 | 17.4 | 20.9 |
| 13 | 3.6 | 4.5 | 5.6 | 6.4 | 8.1 | 9.8 | 11.9 | 13.6 | 15.3 | 18.9 | 22.6 |
| 14 | 3.8 | 4.8 | 6.1 | 6.9 | 8.7 | 10.5 | 12.8 | 14.7 | 16.5 | 20.3 | 24.3 |
| 15 | 4.1 | 5.2 | 6.5 | 7.4 | 9.3 | 11.3 | 13.7 | 15.7 | 17.6 | 21.8 | 26.1 |
| 16 | 4.4 | 5.5 | 6.9 | 7.9 | 10.0 | 12.0 | 14.6 | 16.7 | 18.8 | 23.2 | 27.8 |
| 17 | 4.7 | 5.9 | 7.4 | 8.4 | 10.6 | 12.8 | 15.5 | 17.8 | 20.0 | 24.7 | 29.5 |
| 18 | 5.0 | 6.2 | 7.8 | 8.9 | 11.2 | 13.5 | 16.5 | 18.8 | 21.2 | 26.2 | 31.3 |
| 19 | 5.2 | 6.6 | 8.3 | 9.4 | 11.8 | 14.3 | 17.4 | 19.9 | 22.3 | 27.6 | 33.1 |
| 20 | 5.5 | 6.9 | 8.7 | 9.9 | 12.5 | 15.0 | 18.3 | 20.9 | 23.5 | 29.1 | 34.8 |
| 25 | 6.9 | 8.6 | 10.9 | 12.3 | 15.6 | 18.8 | 22.9 | 26.2 | 29.3 | 36.3 | 43.5 |
| 30 | 8.3 | 10.4 | 13.0 | 14.8 | 18.7 | 22.5 | 27.5 | 31.4 | 35.3 | 43.6 | 52.1 |
| 35 | 9.6 | 12.1 | 15.2 | 17.3 | 21.8 | 26.3 | 32.0 | 36.6 | 41.1 | 50.9 | 60.8 |
| 40 | 11.0 | 13.8 | 17.4 | 19.8 | 24.9 | 30.1 | 36.6 | 41.9 | 47.0 | 58.2 | 69.5 |
| 45 | 12.4 | 15.6 | 19.5 | 22.2 | 28.0 | 33.8 | 41.2 | 47.1 | 52.9 | 65.5 | 78.2 |
| 50 | 13.8 | 17.3 | 21.7 | 24.7 | 31.1 | 37.6 | 45.8 | 52.3 | 58.7 | 72.7 | 87.0 |
| 55 | 15.2 | 19.0 | 23.9 | 27.1 | 34.3 | 41.3 | 50.4 | 57.6 | 64.6 | 80.1 | 95.6 |
| 60 | 16.6 | 20.8 | 26.0 | 29.6 | 37.3 | 45.2 | 55.0 | 62.8 | 70.5 | 87.3 | 104.3 |
| 65 | 18.0 | 22.6 | 28.2 | 32.1 | 40.5 | 48.8 | 59.5 | 68.0 | 76.4 | 94.5 | 112.9 |
| 70 | 19.4 | 24.2 | 30.4 | 34.6 | 43.5 | 52.7 | 64.1 | 73.3 | 82.3 | 101.9 | 121.7 |
| 75 | 20.7 | 26.0 | 32.6 | 37.1 | 46.6 | 56.5 | 68.7 | 78.5 | 88.1 | 109.1 | 130.4 |
| 80 | 22.0 | 27.7 | 34.7 | 39.6 | 49.8 | 60.2 | 73.3 | 83.8 | 94.0 | 116.4 | 139.1 |
| 85 | 23.4 | 29.4 | 36.9 | 42.0 | 53.4 | 63.9 | 77.8 | 89.0 | 99.9 | 123.7 | 147.9 |
| 90 | 24.8 | 31.1 | 39.1 | 44.5 | 56.0 | 67.8 | 82.4 | 94.2 | 105.8 | 130.9 | 156.5 |
| 95 | 26.2 | 32.9 | 41.2 | 46.9 | 59.6 | 71.5 | 87.2 | 99.5 | 111.6 | 138.2 | 165.2 |
| 100 | 27.5 | 34.6 | 43.4 | 49.4 | 62.2 | 75.3 | 91.6 | 104.7 | 117.5 | 145.5 | 173.9 |



# Total 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 Inches | Flanged Couplings | | 90° Ells | | Long Radius Ells | | Tees | | Crosses | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Area in Sq. Ft. | Pipe Length in Ft. | Area in Sq. Ft. | Pipe Length in Ft. | Area in Sq. Ft. | Pipe Length in Ft. | Area in Sq. Ft. | Pipe Length in Ft. | Area in Sq. Ft. | Pipe Length in 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 | 2.49 | 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 | 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 |

# Extra Heavy Fittings

| Pipe Size in Inches | Flanged Couplings | | 90° Ells | | Long Radius Ells | | Tees | | Crosses | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Area in Sq. Ft. | Pipe Length in Ft. | Area in Sq. Ft. | Pipe Length in Ft. | Area in Sq. Ft. | Pipe Length in Ft. | Area in Sq. Ft. | Pipe Length in Ft. | Area in Sq. Ft. | Pipe Length in Ft. |
| 1 | .44 | 1.27 | 1.02 | 2.95 | 1.08 | 3.15 | 1.58 | 4.58 | 2.07 | 6.02 |
| 1¼ | .51 | 1.17 | 1.10 | 2.52 | 1.34 | 3.08 | 1.93 | 4.43 | 2.53 | 5.82 |
| 1½ | .73 | 1.46 | 1.33 | 2.67 | 1.87 | 3.76 | 2.68 | 5.38 | 3.54 | 7.11 |
| 2 | .85 | 1.36 | 2.01 | 3.23 | 2.16 | 3.47 | 3.09 | 4.97 | 4.06 | 6.53 |
| 2½ | 1.11 | 1.46 | 2.57 | 3.41 | 2.76 | 3.67 | 4.05 | 5.38 | 5.17 | 6.87 |
| 3 | 1.48 | 1.62 | 3.49 | 3.81 | 3.74 | 4.08 | 5.33 | 5.82 | 6.95 | 7.58 |
| 3½ | 1.64 | 1.57 | 3.96 | 3.78 | 4.28 | 4.09 | 6.04 | 5.77 | 7.89 | 7.54 |
| 4 | 1.91 | 1.62 | 4.64 | 3.94 | 4.99 | 4.24 | 7.07 | 6.00 | 9.24 | 7.84 |
| 4½ | 2.04 | 1.56 | 5.02 | 3.83 | 5.46 | 4.17 | 7.72 | 5.90 | 10.07 | 7.69 |
| 5 | 2.18 | 1.50 | 5.47 | 3.76 | 6.02 | 4.13 | 8.52 | 5.85 | 10.97 | 7.53 |
| 6 | 2.78 | 1.60 | 6.99 | 4.03 | 7.76 | 4.48 | 10.64 | 6.14 | 13.75 | 7.93 |
| 7 | 3.46 | 1.73 | 8.62 | 4.32 | 9.73 | 4.87 | 12.33 | 6.18 | 16.83 | 8.43 |
| 8 | 3.77 | 1.67 | 9.76 | 4.32 | 11.09 | 4.91 | 14.74 | 6.53 | 18.97 | 8.41 |
| 9 | 4.44 | 1.76 | 11.44 | 4.54 | 13.17 | 5.23 | 17.23 | 6.84 | 22.10 | 8.77 |
| 10 | 5.20 | 1.85 | 13.58 | 4.82 | 15.60 | 5.54 | 20.41 | 7.25 | 26.26 | 9.32 |
| 12 | 6.71 | 2.01 | 17.73 | 5.31 | 18.76 | 5.62 | 26.65 | 7.99 | 34.11 | 10.22 |
| 14 | 8.30 | 2.26 | 22.31 | 6.08 | 25.70 | 7.02 | 33.63 | 9.18 | 43.15 | 11.75 |
| 16 | 10.05 | 2.40 | 27.18 | 6.48 | 31.73 | 7.58 | 40.94 | 9.78 | 52.35 | 12.50 |




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## Heat Losses from Horizontal Bare Iron Surfaces

In BTU's per sq. ft. of metal surface per hour per °F. temperature difference between metal and air.

| Pipe Size Inches | Area of Pipe Surface per lin. ft. | TEMPERATURE DIFFERENCE BETWEEN METAL AND AIR IN DEGREES F. | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 50° | 100° | 200° | 300° | 400° | 500° | 600° | 700° | 800° | 900° | 1000° | 1100° | 1200° |
| ½ | .220 | 2.48 | 2.70 | 3.21 | 3.84 | 4.57 | 5.41 | 6.31 | 7.25 | 8.22 | 9.23 | 10.20 | 11.20 | 12.20 |
| ¾ | .275 | 2.36 | 2.57 | 3.07 | 3.68 | 4.42 | 5.25 | 6.15 | 7.09 | 8.06 | 9.07 | 10.04 | 11.04 | 12.04 |
| 1 | .346 | 2.29 | 2.50 | 3.00 | 3.60 | 4.34 | 5.16 | 6.05 | 6.98 | 7.95 | 8.96 | 9.93 | 10.94 | 11.93 |
| 1¼ | .434 | 2.24 | 2.45 | 2.94 | 3.54 | 4.28 | 5.09 | 5.98 | 6.91 | 7.88 | 8.89 | 9.86 | 10.87 | 11.86 |
| 1½ | .494 | 2.20 | 2.41 | 2.90 | 3.50 | 4.23 | 5.03 | 5.92 | 6.86 | 7.83 | 8.84 | 9.81 | 10.82 | 11.81 |
| 2 | .622 | 2.15 | 2.35 | 2.85 | 3.45 | 4.16 | 4.98 | 5.84 | 6.77 | 7.74 | 8.76 | 9.73 | 10.72 | 11.73 |
| 2½ | .753 | 2.09 | 2.29 | 2.78 | 3.37 | 4.09 | 4.91 | 5.78 | 6.71 | 7.68 | 8.71 | 9.69 | 10.68 | 11.69 |
| 3 | .916 | 2.05 | 2.25 | 2.73 | 3.31 | 4.03 | 4.85 | 5.71 | 6.66 | 7.63 | 8.66 | 9.63 | 10.62 | 11.63 |
| 3½ | 1.047 | 2.02 | 2.22 | 2.69 | 3.27 | 3.98 | 4.80 | 5.67 | 6.62 | 7.59 | 8.62 | 9.59 | 10.58 | 11.59 |
| 4 | 1.175 | 2.00 | 2.19 | 2.66 | 3.24 | 3.95 | 4.77 | 5.64 | 6.58 | 7.55 | 8.58 | 9.55 | 10.54 | 11.55 |
| 4½ | 1.309 | 1.98 | 2.17 | 2.63 | 3.22 | 3.92 | 4.74 | 5.62 | 6.54 | 7.53 | 8.55 | 9.52 | 10.51 | 11.52 |
| 5 | 1.455 | 1.97 | 2.15 | 2.61 | 3.20 | 3.90 | 4.71 | 5.60 | 6.52 | 7.49 | 8.52 | 9.49 | 10.48 | 11.49 |
| 6 | 1.739 | 1.95 | 2.13 | 2.59 | 3.18 | 3.89 | 4.69 | 5.57 | 6.49 | 7.46 | 8.49 | 9.46 | 10.45 | 11.46 |
| 7 | 2.00 | 1.93 | 2.11 | 2.57 | 3.16 | 3.87 | 4.67 | 5.55 | 6.47 | 7.44 | 8.47 | 9.44 | 10.43 | 11.44 |
| 8 | 2.257 | 1.91 | 2.09 | 2.56 | 3.14 | 3.86 | 4.66 | 5.53 | 6.46 | 7.43 | 8.45 | 9.42 | 10.41 | 11.42 |
| 9 | 2.52 | 1.90 | 2.08 | 2.55 | 3.13 | 3.85 | 4.65 | 5.51 | 6.45 | 7.42 | 8.43 | 9.40 | 10.39 | 11.40 |
| 10 | 2.817 | 1.89 | 2.07 | 2.54 | 3.12 | 3.84 | 4.64 | 5.50 | 6.44 | 7.41 | 8.41 | 9.38 | 10.37 | 11.38 |
| 12 | 3.34 | 1.87 | 2.05 | 2.52 | 3.10 | 3.81 | 4.61 | 5.48 | 6.41 | 7.38 | 8.39 | 9.36 | 10.35 | 11.36 |
| 14 | 3.66 | 1.86 | 2.04 | 2.50 | 3.08 | 3.79 | 4.59 | 5.46 | 6.39 | 7.36 | 8.37 | 9.34 | 10.33 | 11.34 |
| 16 | 4.188 | 1.85 | 2.03 | 2.48 | 3.06 | 3.77 | 4.57 | 5.44 | 6.37 | 7.34 | 8.35 | 9.32 | 10.31 | 11.32 |
| 18 | —— | 1.84 | 2.02 | 2.47 | 3.05 | 3.75 | 4.55 | 5.42 | 6.35 | 7.32 | 8.33 | 9.30 | 10.29 | 11.30 |
| Flat | —— | 1.75 | 1.92 | 2.35 | 2.90 | 3.56 | 4.32 | 5.15 | 6.04 | 6.95 | 7.95 | 8.85 | 9.75 | 10.70 |

## Effect of Wind Velocity on Bare or Insulated Surfaces

Ratio of heat loss to still air conditions

| Wind Velocity Miles per Hour | TEMPERATURE DIFFERENCE BETWEEN EXPOSED SURFACE AND AIR IN DEGREES F. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 100° | 200° | 300° | 400° | 500° | 600° | 700° | 800° | 900° |
| 2½ | 1.46 | 1.43 | 1.40 | 1.36 | 1.32 | 1.27 | 1.22 | 1.17 | 1.12 |
| 5 | 1.74 | 1.69 | 1.64 | 1.59 | 1.53 | 1.47 | 1.38 | 1.29 | 1.20 |
| 10 | 2.16 | 2.10 | 2.02 | 1.93 | 1.84 | 1.72 | 1.59 | 1.45 | 1.31 |
| 15 | 2.50 | 2.42 | 2.33 | 2.21 | 2.08 | 1.94 | 1.77 | 1.60 | 1.44 |
| 20 | 2.76 | 2.69 | 2.58 | 2.45 | 2.30 | 2.14 | 1.94 | 1.75 | 1.54 |
| 25 | 2.98 | 2.89 | 2.78 | 2.64 | 2.49 | 2.30 | 2.10 | 1.90 | 1.65 |
| 30 | 3.15 | 3.06 | 2.94 | 2.81 | 2.66 | 2.46 | 2.25 | 2.02 | 1.77 |
| 35 | 3.30 | 3.21 | 3.10 | 2.97 | 2.81 | 2.61 | 2.40 | 2.15 | 1.90 |

## Color Scale for Temperatures

| Color | Degrees Centigrade | Degrees Fahrenheit |
|---|---|---|
| Lowest visible red | 475 | 875 |
| Lowest visible red to dark red | 475 to 650 | 875 to 1200 |
| Dark red to cherry red | 650 to 750 | 1200 to 1375 |
| Cherry red to bright cherry red | 750 to 825 | 1375 to 1500 |
| Bright cherry red to orange | 825 to 900 | 1500 to 1650 |
| Orange to yellow | 900 to 1090 | 1650 to 2000 |
| Yellow to light yellow | 1090 to 1320 | 2000 to 2400 |
| Light yellow to white | 1320 to 1540 | 2400 to 2800 |
| White to dazzling white | 1540 and over | 2800 and over |



## Temperature End Points of American Pyrometric Cones

| No. of Cone | Degrees Fahrenheit | No. of Cone | Degrees Fahrenheit | No. of Cone | Degrees Fahrenheit |
|---|---|---|---|---|---|
| 022 | 1121 | 03 | 2039 | 17 | 2687 |
| 021 | 1139 | 02 | 2057 | 18 | 2714 |
| 020 | 1202 | 01 | 2093 | 19 | 2768 |
| 019 | 1220 | 1 | 2120 | 20 | 2786 |
| 018 | 1328 | 2 | 2129 | 23 | 2876 |
| 017 | 1418 | 3 | 2138 | 26 | 2903 |
| 016 | 1463 | 4 | 2174 | 27 | 2921 |
| 015 | 1481 | 5 | 2201 | 28 | 2939 |
| 014 | 1526 | 6 | 2246 | 29 | 2984 |
| 013 | 1580 | 7 | 2282 | 30 | 3002 |
| 012 | 1607 | 8 | 2300 | 31 | 3056 |
| 011 | 1661 | 9 | 2345 | 32 | 3092 |
| 010 | 1643 | 10 | 2381 | 32½ | 3131 |
| 09 | 1706 | 11 | 2417 | 33 | 3173 |
| 08 | 1742 | 12 | 2435 | 34 | 3200 |
| 07 | 1814 | 13 | 2462 | 35 | 3245 |
| 06 | 1859 | 14 | 2552 | 36 | 3290 |
| 05 | 1904 | 15 | 2615 | 37 | 3308 |
| 04 | 1940 | 16 | 2669 | 38 | 3335 |

## Comparative Thermal Values of Various Fuels Based on Their Respective Units of Weight or Volume

| | | Natural Gas 1,000 BTU/cu. ft. | Artificial Gas 550 BTU/cu. ft. | Blast Furnace Gas 100 BTU/cu. ft. | Producer Gas 150 BTU/cu. ft. | Coke Breeze 10,000 BTU/Lb. | Coke 12,000 BTU/Lb. | Coal 12,500 BTU/Lb. | Coal 13,000 BTU/Lb. | Coal 13,500 BTU/Lb. | Coal 14,000 BTU/Lb. | Fuel Oil 140,000 BTU/Gal. | Fuel Oil 145,000 BTU/Gal. | Fuel Oil 150,000 BTU/Gal. | Electric Current 3,412 BTU/KW. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1,000 cu. ft. | Natural Gas 1,000 BTU/cu. ft. | | 1,818 cu. ft. | 10,000 cu. ft. | 6,667 cu. ft. | 100 Lbs. | 83.4 Lbs. | 80 Lbs. | 77 Lbs. | 74 Lbs. | 71.5 Lbs. | 7.15 Gals. | 6.9 Gals. | 6.67 Gals. | 293 KW. |
| | Artificial Gas 550 BTU/cu. ft. | 550 cu. ft. | | 5,500 cu. ft. | 3,670 cu. ft. | 55 Lbs. | 45.8 Lbs. | 44 Lbs. | 42.3 Lbs. | 40.7 Lbs. | 39.3 Lbs. | 3.93 Gals. | 3.8 Gals. | 3.67 Gals. | 161 KW. |
| | Blast Furnace Gas 100 BTU/cu. ft. | 100 cu. ft. | 181.8 cu. ft. | | 667 cu. ft. | 10 Lbs. | 8.34 Lbs. | 8 Lbs. | 7.7 Lbs. | 7.4 Lbs. | 7.15 Lbs. | .715 Gals. | .69 Gals. | .667 Gals. | 29.3 KW. |
| | Producer Gas 150 BTU/cu. ft. | 150 cu. ft. | 273 cu. ft. | 1,500 cu. ft. | | 15 Lbs. | 12.5 Lbs. | 12 Lbs. | 11.55 Lbs. | 11.10 Lbs. | 10.70 Lbs. | 1.07 Gals. | 1.03 Gals. | 1.00 Gals. | 44 KW. |
| 2,000 Pounds | Coke Breeze 10,000 BTU/Lb. | 20,000 cu. ft. | 36,400 cu. ft. | 200,000 cu. ft. | 133,500 cu. ft. | | 1,667 Lbs. | 1,600 Lbs. | 1,540 Lbs. | 1,480 Lbs. | 1,430 Lbs. | 143 Gals. | 138 Gals. | 133 Gals. | 5,862 KW. |
| | Coke 12,000 BTU/Lb. | 24,000 cu. ft. | 43,700 cu. ft. | 240,000 cu. ft. | 160,000 cu. ft. | 2,400 Lbs. | | 1,920 Lbs. | 1,845 Lbs. | 1,780 Lbs. | 1,712 Lbs. | 171 Gals. | 166 Gals. | 160 Gals. | 7,031 KW. |
| | Coal 12,500 BTU/Lb. | 25,000 cu. ft. | 45,500 cu. ft. | 250,000 cu. ft. | 166,500 cu. ft. | 2,500 Lbs. | 2,080 Lbs. | | 1,925 Lbs. | 1,850 Lbs. | 1,785 Lbs. | 178 Gals. | 172 Gals. | 167 Gals. | 7,327 KW. |
| | Coal 13,000 BTU/Lb. | 26,000 cu. ft. | 47,300 cu. ft. | 260,000 cu. ft. | 173,200 cu. ft. | 2,600 Lbs. | 2,162 Lbs. | 2,080 Lbs. | | 1,925 Lbs. | 1,857 Lbs. | 185 Gals. | 179 Gals. | 173 Gals. | 7,618 KW. |
| | Coal 13,500 BTU/Lb. | 27,000 cu. ft. | 49,100 cu. ft. | 270,000 cu. ft. | 179,800 cu. ft. | 2,700 Lbs. | 2,250 Lbs. | 2,160 Lbs. | 2,075 Lbs. | | 1,930 Lbs. | 193 Gals. | 186 Gals. | 180 Gals. | 7,911 KW. |
| | Coal 14,000 BTU/Lb. | 28,000 cu. ft. | 50,800 cu. ft. | 280,000 cu. ft. | 186,500 cu. ft. | 2,800 Lbs. | 2,335 Lbs. | 2,240 Lbs. | 2,156 Lbs. | 2,075 Lbs. | | 200 Gals. | 193 Gals. | 187 Gals. | 8,206 KW. |
| One Gallon | Fuel Oil 140,000 BTU/Gal. | 140 cu. ft. | 255 cu. ft. | 1,400 cu. ft. | 934 cu. ft. | 14 Lbs. | 11.7 Lbs. | 11.2 Lbs. | 10.78 Lbs. | 10.38 Lbs. | 10 Lbs. | | .966 Gals. | .934 Gals. | 41 KW. |
| | Fuel Oil 145,000 BTU/Gal. | 145 cu. ft. | 264 cu. ft. | 1,450 cu. ft. | 966 cu. ft. | 14.5 Lbs. | 12.09 Lbs. | 11.6 Lbs. | 11.15 Lbs. | 10.72 Lbs. | 10.35 Lbs. | 1.03 Gals. | | .966 Gals. | 42.5 KW. |
| | Fuel Oil 150,000 BTU/Gal. | 150 cu. ft. | 273 cu. ft. | 1,500 cu. ft. | 1,000 cu. ft. | 15 Lbs. | 12.5 Lbs. | 12 Lbs. | 11.5 Lbs. | 11.1 Lbs. | 10.7 Lbs. | 1.07 Gals. | 1.032 Gals. | | 44 KW. |
| One KW. | Electric Current 3,412 BTU/KW. | 3,412 cu. ft. | 6.2 cu. ft. | 34 cu. ft. | 22.7 cu. ft. | .3412 Lbs. | .284 Lbs. | .273 Lbs. | .262 Lbs. | .252 Lbs. | .244 Lbs. | .0244 Gals. | .0235 Gals. | .0227 Gals. | |



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# Process Temperatures

## IRON AND STEEL MANUFACTURING

| | | | |
|---|---|---|---|
| Open Hearth | 2750—3150 | degrees | Fahrenheit |
| Pipe Welding: | | | |
| Butt | 2350—2650 | " | " |
| Lap | 1750—2650 | " | " |
| Bolt Heating | 2150—2350 | " | " |
| Ingot Heating | 1950—2250 | " | " |
| Slab Heating | 1950—2250 | " | " |
| Spike Heating | 1950—2250 | " | " |
| Bar and Shape | 1900—2250 | " | " |
| Sheet Mill | 1950—2150 | " | " |
| Flanging | 1800—2150 | " | " |
| Rod Mill | 1900—2150 | " | " |
| Soaking Pits | 1900—2150 | " | " |
| Sheet Furnaces | 1800—2150 | " | " |
| Blooming Mills | 1900—2100 | " | " |
| Annealing: | | | |
| Sheet | 1400—1650 | " | " |

## IRON AND STEEL PRODUCTS

| | | | |
|---|---|---|---|
| Welding | 2150—2850 | degrees | Fahrenheit |
| Drop Forging | 2200—2400 | " | " |
| Hardening: | | | |
| High Speed Steel | 1800—2300 | " | " |
| Steel Tools | 1400—2250 | " | " |
| Cyanide | 1400—1850 | " | " |
| Rivet Heating | 2000—2300 | " | " |
| Heat Treating | 800—1700 | " | " |
| Carbonizing | 1350—1700 | " | " |
| Annealing: | | | |
| Springs | 1500—1700 | " | " |
| High Carbon Steel | 1400—1550 | " | " |
| Malleable Castings | 1500—1750 | " | " |
| Steel Castings | 1300—1650 | " | " |
| Galvanizing: | | | |
| Nail | 800— 950 | " | " |
| Pipe | 800— 950 | " | " |
| Sheet | 800— 950 | " | " |

## IRON AND STEEL PRODUCTS—Continued

| | | | |
|---|---|---|---|
| Wire | 800— 950 | degrees | Fahrenheit |
| Tempering | 400— 700 | " | " |
| Foundry Core Ovens | 350— 650 | " | " |

## NON-FERROUS METAL PROCESSES

| | | | |
|---|---|---|---|
| Melting Monel Metal | 2800 | degrees | Fahrenheit |
| Melting Nickel | 2650 | " | " |
| Refining Copper | 2100—2650 | " | " |
| Melting Bronze | 1800—2350 | " | " |
| Melting Brass | 1650—2300 | " | " |
| Annealing Monel Metal | 1100—1480 | " | " |
| Annealing Nickel | 1100—1480 | " | " |
| Melting Aluminum | 1217 | " | " |
| Annealing Brass | 475—1050 | " | " |
| Annealing Copper | 450— 950 | " | " |
| Annealing Aluminum | 390— 850 | " | " |
| Melting Babbitt | 600— 850 | " | " |
| Melting Lead | 620 | " | " |
| Melting Solder | 400 | " | " |

## OTHER MANUFACTURING PROCESSES

| | | | |
|---|---|---|---|
| Cement Kilns | 2750—3000 | degrees | Fahrenheit |
| Glass Making | 2550—3000 | " | " |
| Porcelain Burning | 2600 | " | " |
| Brick Burning | 2450—2850 | " | " |
| China Glazing | 1500—1950 | " | " |
| Vitreous Enameling | 1400—1850 | " | " |
| Pigment Calcining | 1650 | " | " |
| Annealing Glass | 650—1550 | " | " |
| Roasting Coffee | 550— 700 | " | " |
| Varnish Making | 550 | " | " |
| Pie Baking | 500 | " | " |
| Bread Baking | 500 | " | " |
| Asphalt Melting | 350— 450 | " | " |
| Japanning Ovens | 300— 450 | " | " |
| Enameling Ovens | 250— 450 | " | " |
| Lithographing | 300 | " | " |

# Weights and Measures—United States or British Standard

### *Long Measure*

12 inches = 1 foot
3 feet = 1 yard
1,760 yards, or 5,280 feet = 1 mile
1,000 mils = 1 inch
5½ yards or 16½ feet = 1 rod

### *Square Measure*

144 sq. inches, or 183.35 circular inches = 1 sq. foot
9 sq. feet = 1 sq. yard
30¼ sq. yards, or 272¼ sq. feet = 1 sq. rod
10 sq. chains, or 160 sq. rods, or 4,840 sq. yards, or 43,560 sq. feet = 1 acre
640 acres = 1 sq. mile

### *Solid or Cubic Measure*

1,728 cu. inches = 1 cu. foot
27 cu. feet = 1 cu. yard
1 cord of wood = a pile, 4 × 4 × 8 feet = 128 cu. feet
1 perch of masonry = 16½ × 1½ × 1 foot = 24¾ cu. feet

### *Liquid Measure*

4 gills = 1 pint
2 pints = 1 quart
4 quarts = 1 gallon { U. S. 231 cu. inches / Eng. 277.274 cu. inches }
7.4805 gallons = 1 cu. foot
277.274 cu. inches = 1 British Imperial gallon

### *Dry Measure, U. S.*

2 pints = 1 quart
8 quarts = 1 peck
4 pecks = 1 bushel
2,150.42 cu. inches = 1 U. S. standard struck bushel
1.2445 cu. feet = 1 U. S. standard struck bushel
2,218.192 cu. inches = 1 British Imperial bushel
1.2837 cu. feet = 1 British Imperial bushel

### *Shipping Measure*

For measurement of cargo

1 U. S. shipping ton = 40 cu. ft. = { 31.16 Imp. bu. / 32.143 U. S. bu. }
1 British shipping ton = 42 cu. ft. = { 32.719 Imp. bu. / 33.75 U. S. bu. }

### *Measures of Weight, Avoirdupois*

16 drams, or 437.5 grains = 1 ounce, oz.
16 ounces, or 7,000 grains = 1 pound, lb.
28 pounds = 1 quarter, qr.
4 quarters = 1 hundredweight, cwt. = 112 lb.
20 hundredweight = 1 ton of 2,240 lbs. gross or long ton
2,000 pounds = 1 net, or short ton
2,204.6 pounds = 1 metric ton



# Metric and United States or British Equivalents

### *Measure of Length*

| Metric | | British and U. S. |
|---|---|---|
| 1 meter | = | 39.37 inches, or 3.28083 feet, or 1.09361 yards |
| 0.3048 meter | = | 1 foot |
| 1 centimeter | = | 0.3937 inch |
| 2.54 centimeters | = | 1 inch |
| 1 millimeter | = | 0.03937 inch, or 1-25 inch, nearly |
| 25.4 millimeters | = | 1 inch |
| 1 kilometer | = | 1,093.61 yards, or 0.62137 mile |

### *Surface*

| Metric | | British and U. S. |
|---|---|---|
| 1 sq. meter | = | 10.764 sq. feet / 1.196 sq. yards |
| 0.836 sq. meter | = | 1 sq. yard |
| 0.0929 sq. meter | = | 1 sq. foot |
| 1 sq. centimeter | = | 0.155 sq. inch |
| 6.452 sq. centimeters | = | 1 sq. inch |
| 1 sq. millimeter | = | 0.00155 sq. inch = 1973.5 circular millimeters |
| 645.2 sq. millimeters | = | 1 sq. inch |
| 1 centiare = 1 sq. meter | = | 10.764 sq. feet |
| 1 ARE = 1 sq. decameter | = | 1076.41 sq. feet |
| 1 sq. kilometer | = | 0.386109 sq. miles = 247.11 acres |
| 1 sq. myriameter | = | 38.6109 sq. miles |

### *Weight*

| Metric | | British and U. S. |
|---|---|---|
| 1 gram | = | 15.432 grains |
| 0.0648 gram | = | 1 grain |
| 28.35 gram | = | 1 ounce avoirdupois |
| 1 kilogram | = | 2.2046 pounds |
| 0.4536 kilogram | = | 1 pound |
| 1 tonne or metric ton | = | 0.9842 ton of 2,240 pounds / 19.68 cwts. |
| 1,000 kilograms | = | 2,204.6 pounds |

### *Weight—Continued*

1.016 metric tons / 1016 kilograms = 1 ton of 2,240 pounds

### *Volume*

| Metric | | British and U. S. |
|---|---|---|
| 1 cu. meter | = | 35.314 cu. feet / 1.308 cu. yards |
| 0.7645 cu. meter | = | 1 cu. yard |
| 0.02832 cu. meter | = | 1 cu. foot |
| 1 cu. decimeter | = | 61.023 cu. inches / 0.0353 cu. foot |
| 2832 cu. decimeters | = | 1 cu. foot |
| 1 cu. centimeter | = | 0.061 cu. inch |
| 16.387 cu. centimeters | = | 1 cu. inch |
| 1 cu. centimeter = 1 milliliter | = | 0.061 cu. inch |
| 1 centiliter | = | 0.610 cu. inch |
| 1 deciliter | = | 6.102 cu. inches |
| 1 liter = 1 cu. decimeter | = | 61.023 cu. inch = 1.05671 quarts, U. S. |
| 1 hectoliter or decistere | = | 3.5314 cu. ft. = 2.8375 bushels, U. S. |
| 1 stere, kiloliter or cubic meter | = | 1.308 cu. yards = 28.37 bushels, U. S. |

### *Capacity*

| Metric | | British and U. S. |
|---|---|---|
| 1 liter = 1 cu. decimeter | = | 61.023 cu. inches / 0.03531 cu. foot / 0.2642 gallon (American) / 2.202 pounds of water at 62° F. |
| 28.317 liters | = | 1 cu. foot |
| 4.543 liters | = | 1 gallon (British) |
| 3.785 liters | = | 1 gallon (American) |

# Decimal Equivalents of Fractions of One Inch

| | | | | | |
|---|---|---|---|---|---|
| 1/64 | .0156 | 17/64 | .2656 | 33/64 | .5156 | 49/64 | .7656 |
| 1/32 | .0312 | 9/32 | .2812 | 17/32 | .5312 | 25/32 | .7812 |
| 3/64 | .0468 | 19/64 | .2969 | 35/64 | .5469 | 51/64 | .7969 |
| 1/16 | .0625 | 5/16 | .3125 | 9/16 | .5625 | 13/16 | .8125 |
| 5/64 | .0781 | 21/64 | .3281 | 37/64 | .5781 | 53/64 | .8281 |
| 3/32 | .0937 | 11/32 | .3437 | 19/32 | .5937 | 27/32 | .8437 |
| 7/64 | .1093 | 23/64 | .3594 | 39/64 | .6094 | 55/64 | .8594 |
| 1/8 | .125 | 3/8 | .375 | 5/8 | .625 | 7/8 | .875 |
| 9/64 | .1406 | 25/64 | .3906 | 41/64 | .6406 | 57/64 | .8906 |
| 5/32 | .1562 | 13/32 | .4062 | 21/32 | .6562 | 29/32 | .9062 |
| 11/64 | .1718 | 27/64 | .4219 | 43/64 | .6719 | 59/64 | .9219 |
| 3/16 | .1875 | 7/16 | .4375 | 11/16 | .6875 | 15/16 | .9375 |
| 13/64 | .2031 | 29/64 | .4531 | 45/64 | .7031 | 61/64 | .9531 |
| 7/32 | .2187 | 15/32 | .4687 | 23/32 | .7187 | 31/32 | .9687 |
| 15/64 | .2344 | 31/64 | .4844 | 47/64 | .7344 | 63/64 | .9844 |
| 1/4 | .25 | 1/2 | .5 | 3/4 | .75 | 1 | 1.0 |



*Armstrong's Industrial Insulations (1951)*
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# Expansion of Bodies by Heat

The coefficient of linear expansion ($\varepsilon$) is the change in length, per unit of length, for a change of one degree of temperature. The coefficient of surface expansion is approximately two times the linear coefficient, and the coefficient of volume expansion, for solids, is approximately three times the linear coefficient.

A bar, free to move, will increase in length with an increase in temperature and will decrease in length with a decrease in temperature. The change in length will be $\varepsilon tl$, where $\varepsilon$ is the coefficient of linear expansion, t the change in temperature, and $l$ the length. If the ends of a bar are fixed, a change in temperature (t) will cause a change in the unit stress of $E\varepsilon t$, and in the total (stress of) $AE\varepsilon t$, where A is the cross sectional area of the bar and E the modulus of elasticity.

The following table gives the coefficient of linear expansion for 100°, or 100 times the value indicated above.

*Example:* A piece of medium steel is exactly 40 feet long at 60° F. Find the length at 90° F. assuming the ends free to move.

$$\text{Change of length} = \varepsilon tl = \frac{.00067 \times 30 \times 40}{100} = .00804 \text{ foot.}$$

The length at 90° F. is 40.00804 feet.

*Example:* A piece of medium steel is exactly 40 feet long and the ends are fixed. If the temperature increases 30° F., what is the resulting change in the unit stress?

$$\text{Change in unit stress} = E\varepsilon t = \frac{29{,}000{,}000 \times .00067 \times 30}{100} = 5830 \text{ lbs. per sq. in.}$$

## Coefficients of Expansion for 100 Degrees = $100\varepsilon$

| Substances | Linear Expansion | |
|---|---|---|
| | Centigrade | Fahrenheit |
| **METALS AND ALLOYS** | | |
| Aluminum, wrought | .00231 | .00128 |
| Brass | .00188 | .00104 |
| Bronze | .00181 | .00101 |
| Copper | .00168 | .00093 |
| Iron, cast, gray | .00106 | .00059 |
| Iron, wrought | .00120 | .00067 |
| Iron, wire | .00124 | .00069 |
| Lead | .00286 | .00159 |
| Nickel | .00126 | .00070 |
| Steel, cast | .00110 | .00061 |
| Steel, hard | .00132 | .00073 |
| Steel, medium | .00120 | .00067 |
| Steel, soft | .00110 | .00061 |
| Zinc, rolled | .00311 | .00173 |
| **STONE AND MASONRY** | | |
| Ashlar masonry | .00063 | .00035 |
| Brick masonry | .00055 | .00031 |
| Cement, portland | .00107 | .00059 |
| Concrete | .00143 | .00079 |
| Granite | .00084 | .00047 |
| Limestone | .00080 | .00044 |
| Marble | .00100 | .00056 |
| Plaster | .00166 | .00092 |
| Rubble masonry | .00063 | .00035 |
| Sandstone | .00110 | .00061 |
| Slate | .00104 | .00058 |
| **TIMBER** | | |
| Fir, Maple, Oak, Pine — parallel to fiber | .00037 | .00021 |
| | .00064 | .00036 |
| | .00049 | .00027 |
| | .00054 | .00030 |
| Fir, Maple, Oak, Pine — perpendicular to fiber | .0058 | .0032 |
| | .0048 | .0027 |
| | .0054 | .0030 |
| | .0034 | .0019 |

## Expansion of Water

MAXIMUM DENSITY = 1

| C° | Volume | C° | Volume | C° | Volume | C° | Volume | C° | Volume | C° | Volume |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1.000126 | 10 | 1.000257 | 30 | 1.004234 | 50 | 1.011877 | 70 | 1.022384 | 90 | 1.035829 |
| 4 | 1.000000 | 20 | 1.001732 | 40 | 1.007627 | 60 | 1.016954 | 80 | 1.029003 | 100 | 1.043116 |

Courtesy American Institute of Steel Construction



# Weights and Specific Gravities

| Substance | Weight Lb. per Cu. Ft. | Specific Gravity |
|---|---|---|
| **METALS, ALLOYS, ORES** | | |
| Aluminum, cast, hammered | 165 | 2.55–2.75 |
| Aluminum, bronze | 481 | 7.7 |
| Brass, cast, rolled | 534 | 8.4–8.7 |
| Bronze, 7.9 to 14% Sn | 509 | 7.4–8.9 |
| Copper, cast, rolled | 556 | 8.8–9.0 |
| Copper ore, pyrites | 262 | 4.1–4.3 |
| Gold, cast, hammered | 1205 | 19.25–19.3 |
| Iron, cast, pig | 450 | 7.2 |
| Iron, wrought | 485 | 7.6–7.9 |
| Iron, steel | 490 | 7.8–7.9 |
| Iron, spiegel-eisen | 468 | 7.5 |
| Iron, ferro-silicon | 437 | 6.7–7.3 |
| Iron ore, hematite | 325 | 5.2 |
| Iron ore, hematite in bank | 160–180 | ..... |
| Iron ore, hematite loose | 130–160 | ..... |
| Iron ore, limonite | 237 | 3.6–4.0 |
| Iron ore, magnetite | 315 | 4.9–5.2 |
| Iron slag | 172 | 2.5–3.0 |
| Lead | 710 | 11.37 |
| Lead ore, galena | 465 | 7.3–7.6 |
| Manganese | 475 | 7.2–8.0 |
| Manganese ore, pyrolusite | 259 | 3.7–4.6 |
| Mercury | 849 | 13.6 |
| Nickel | 565 | 8.9–9.2 |
| Nickel, monel metal | 556 | 8.8–9.0 |
| Platinum, cast, hammered | 1330 | 21.1–21.5 |
| Silver, cast, hammered | 656 | 10.4–10.6 |
| Tin, cast, hammered | 459 | 7.2–7.5 |
| Tin ore, cassiterite | 418 | 6.4–7.0 |
| Zinc, cast, rolled | 440 | 6.9–7.2 |
| Zinc ore, blende | 253 | 3.9–4.2 |
| **VARIOUS SOLIDS** | | |
| Cereals, oats, bulk | 32 | ..... |
| Cereals, barley, bulk | 39 | ..... |
| Cereals, corn, rye, bulk | 48 | ..... |
| Cereals, wheat, bulk | 48 | ..... |
| Hay and Straw, bales | 20 | ..... |
| Cotton, Flax, Hemp | 93 | 1.47–1.50 |
| Fats | 58 | 0.90–0.97 |
| Flour, loose | 28 | 0.40–0.50 |
| Flour, pressed | 47 | 0.70–0.80 |
| Glass, common | 156 | 2.40–2.60 |
| Glass, plate or crown | 161 | 2.45–2.72 |
| Glass, crystal | 184 | 2.90–3.00 |
| Leather | 59 | 0.86–1.02 |
| Paper | 58 | 0.70–1.15 |
| Potatoes, piled | 42 | ..... |
| Rubber, caoutchouc | 59 | 0.92–0.96 |
| Rubber goods | 94 | 1.0–2.0 |
| Salt, granulated, piled | 48 | ..... |
| Saltpeter | 67 | ..... |
| Starch | 96 | 1.53 |
| Sulphur | 125 | 1.93–2.07 |
| Wool | 82 | 1.32 |
| **TIMBER, U. S. SEASONED** | | |
| Moisture Content by Weight: | | |
| Seasoned timber 15 to 20% | | |
| Green timber up to 50% | | |
| Ash, white, red | 40 | 0.62–0.65 |
| Cedar, white, red | 22 | 0.32–0.38 |
| Chestnut | 41 | 0.66 |
| Cypress | 30 | 0.48 |
| Fir, Douglas spruce | 32 | 0.51 |
| Fir, eastern | 25 | 0.40 |
| Elm, white | 45 | 0.72 |
| Hemlock | 29 | 0.42–0.52 |
| Hickory | 49 | 0.74–0.84 |
| Locust | 46 | 0.73 |
| Maple, hard | 43 | 0.68 |
| Maple, white | 33 | 0.53 |
| Oak, chestnut | 54 | 0.86 |
| Oak, live | 59 | 0.95 |
| Oak, red, black | 41 | 0.65 |
| Oak, white | 46 | 0.74 |
| Pine, Oregon | 32 | 0.51 |
| Pine, red | 30 | 0.48 |
| Pine, white | 26 | 0.41 |
| Pine, yellow, longleaf | 44 | 0.70 |
| Pine, yellow, shortleaf | 38 | 0.61 |
| Poplar | 30 | 0.48 |
| Redwood, California | 26 | 0.42 |
| Spruce, white, black | 27 | 0.40–0.46 |
| Walnut, black | 38 | 0.61 |
| Walnut, white | 26 | 0.41 |
| **VARIOUS LIQUIDS** | | |
| Alcohol, 100% | 49 | 0.79 |
| Acids, muriatic 40% | 75 | 1.20 |
| Acids, nitric 91% | 94 | 1.50 |
| Acids, sulphuric 87% | 112 | 1.80 |
| Lye, soda 66% | 106 | 1.70 |
| Oils, vegetable | 58 | 0.91–0.94 |
| Oils, mineral, lubricants | 57 | 0.90–0.93 |
| Water, 4° C. max. density | 62.428 | 1.0 |
| Water, 100° C. | 59.830 | 0.9584 |
| Water, ice | 56 | 0.88–0.92 |
| Water, snow, fresh fallen | 8 | .125 |
| Water, sea water | 64 | 1.02–1.03 |
| **GASES** | | |
| Air, 0° C. 760 mm. | .08071 | 1.0 |
| Ammonia | .0478 | 0.5920 |
| Carbon dioxide | .1234 | 1.5291 |
| Carbon monoxide | .0781 | 0.9673 |
| Gas, illuminating | .028–.036 | 0.35–0.45 |
| Gas, natural | .038–.039 | 0.47–0.48 |
| Hydrogen | .00559 | 0.0693 |
| Nitrogen | .0784 | 0.9714 |
| Oxygen | .0892 | 1.1056 |

The specific gravities of solids and liquids refer to water at 4° C., those of gases to air at 0° C. and 760 mm. pressure. The weights per cubic foot are derived from average specific gravities, except where stated that weights are for bulk, heaped or loose material, etc.

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# Weights and Specific Gravities (Continued)

| Substance | Weight Lb. per Cu. Ft. | Specific Gravity |
|---|---|---|
| **ASHLAR MASONRY** | | |
| Granite, syenite, gneiss | 165 | 2.3–3.0 |
| Limestone, marble | 160 | 2.3–2.8 |
| Sandstone, bluestone | 140 | 2.1–2.4 |
| **MORTAR RUBBLE MASONRY** | | |
| Granite, syenite, gneiss | 155 | 2.2–2.8 |
| Limestone, marble | 150 | 2.2–2.6 |
| Sandstone, bluestone | 130 | 2.0–2.2 |
| **DRY RUBBLE MASONRY** | | |
| Granite, syenite, gneiss | 130 | 1.9–2.3 |
| Limestone, marble | 125 | 1.9–2.1 |
| Sandstone, bluestone | 110 | 1.8–1.9 |
| **BRICK MASONRY** | | |
| Pressed brick | 140 | 2.2–2.3 |
| Common brick | 120 | 1.8–2.0 |
| Soft brick | 100 | 1.5–1.7 |
| **CONCRETE MASONRY** | | |
| Cement, stone, sand | 144 | 2.2–2.4 |
| Cement, slag, etc. | 130 | 1.9–2.3 |
| Cement, cinder, etc. | 100 | 1.5–1.7 |
| **VARIOUS BUILDING MATERIALS** | | |
| Ashes, cinders | 40–45 | ..... |
| Cement, portland, loose | 90 | ..... |
| Cement, portland, set | 183 | 2.7–3.2 |
| Lime, gypsum, loose | 53–64 | ..... |
| Mortar, set | 103 | 1.4–1.9 |
| Slags, bank slag | 67–72 | ..... |
| Slags, bank screenings | 98–117 | ..... |
| Slags, machine slag | 96 | ..... |
| Slags, slag sand | 49–55 | ..... |
| **EARTH, ETC., EXCAVATED** | | |
| Clay, dry | 63 | ..... |
| Clay, damp, plastic | 110 | ..... |
| Clay and gravel, dry | 100 | ..... |
| Earth, dry, loose | 76 | ..... |
| Earth, dry, packed | 95 | ..... |
| Earth, moist, loose | 78 | ..... |
| Earth, moist, packed | 96 | ..... |
| Earth, mud, flowing | 108 | ..... |
| Earth, mud, packed | 115 | ..... |
| Riprap, limestone | 80–85 | ..... |
| Riprap, sandstone | 90 | ..... |
| Riprap, shale | 105 | ..... |
| Sand, gravel, dry, loose | 90–105 | ..... |
| Sand, gravel, dry, packed | 100–120 | ..... |
| Sand, gravel, dry, wet | 118–120 | ..... |
| **EXCAVATIONS IN WATER** | | |
| Sand or gravel | 60 | ..... |
| Sand or gravel and clay | 65 | ..... |
| Clay | 80 | ..... |
| River mud | 90 | ..... |
| Soil | 70 | ..... |
| Stone riprap | 65 | ..... |

| Substance | Weight Lb. per Cu. Ft. | Specific Gravity |
|---|---|---|
| **MINERALS** | | |
| Asbestos | 153 | 2.1–2.8 |
| Barytes | 281 | 4.50 |
| Basalt | 184 | 2.7–3.2 |
| Bauxite | 159 | 2.55 |
| Borax | 109 | 1.7–1.8 |
| Chalk | 137 | 1.8–2.6 |
| Clay, marl | 137 | 1.8–2.6 |
| Dolomite | 181 | 2.9 |
| Feldspar, orthoclase | 159 | 2.5–2.6 |
| Gneiss, serpentine | 159 | 2.4–2.7 |
| Granite, syenite | 175 | 2.5–3.1 |
| Greenstone, trap | 187 | 2.8–3.2 |
| Gypsum, alabaster | 159 | 2.3–2.8 |
| Hornblende | 187 | 3.0 |
| Limestone, marble | 165 | 2.5–2.8 |
| Magnesite | 187 | 3.0 |
| Phosphate rock, apatite | 200 | 3.2 |
| Porphyry | 172 | 2.6–2.9 |
| Pumice, natural | 40 | 0.37–0.90 |
| Quartz, flint | 165 | 2.5–2.8 |
| Sandstone, bluestone | 147 | 2.2–2.5 |
| Shale, slate | 175 | 2.7–2.9 |
| Soapstone, talc | 169 | 2.6–2.8 |
| **STONE, QUARRIED, PILED** | | |
| Basalt, granite, gneiss | 96 | ..... |
| Limestone, marble, quartz | 95 | ..... |
| Sandstone | 82 | ..... |
| Shale | 92 | ..... |
| Greenstone, hornblende | 107 | ..... |
| **BITUMINOUS SUBSTANCES** | | |
| Asphaltum | 81 | 1.1–1.5 |
| Coal, anthracite | 97 | 1.4–1.7 |
| Coal, bituminous | 84 | 1.2–1.5 |
| Coal, lignite | 78 | 1.1–1.4 |
| Coal, peat, turf, dry | 47 | 0.65–0.85 |
| Coal, charcoal, pine | 23 | 0.28–0.44 |
| Coal, charcoal, oak | 33 | 0.47–0.57 |
| Coal, coke | 75 | 1.0–1.4 |
| Graphite | 131 | 1.9–2.3 |
| Paraffine | 56 | 0.87–0.91 |
| Petroleum | 54 | 0.87 |
| Petroleum, refined | 50 | 0.79–0.82 |
| Petroleum, benzine | 46 | 0.73–0.75 |
| Petroleum, gasoline | 42 | 0.66–0.69 |
| Pitch | 69 | 1.07–1.15 |
| Tar, bituminous | 75 | 1.20 |
| **COAL AND COKE, PILED** | | |
| Coal, anthracite | 47–58 | ..... |
| Coal, bituminous, lignite | 40–54 | ..... |
| Coal, peat, turf | 20–26 | ..... |
| Coal, charcoal | 10–14 | ..... |
| Coal, coke | 23–32 | ..... |

The specific gravities of solids and liquids refer to water at 4° C., those of gases to air at 0° C. and 760 mm. pressure. The weights per cubic foot are derived from average specific gravities, except where stated that weights are for bulk, heaped or loose material, etc.



# Wire and Sheet Metal Gages in Decimals of an Inch

| Name of Gage | United States Standard Gage* | | American Steel & Wire Co. and John A. Roebling Sons Co. | American or Brown & Sharpe Wire Gage | New Birmingham Standard Sheet & Hoop Gage | British Imperial or English Legal Standard Wire Gage | Birmingham or Stubs Iron Wire Gage | Name of Gage |
|---|---|---|---|---|---|---|---|---|
| Principal Use | Uncoated Steel Sheets and Light Plates | | Steel Wire except Music Wire | Non-Ferrous Sheets and Wire | Iron and Steel Sheets and Hoops | Wire | Strips, Bands, Hoops and Wire | Principal Use |
| Gage No. | Weight Lb. per Sq. Ft. | Approx. Thickness Inches | Thickness, Inches | | | | | Gage No. |
| 7/0's | 20.00 | .4902 | .4900 | | .6666 | .500 | | 7/0's |
| 6/0's | 18.75 | .4596 | .4615 | .5800 | .625 | .464 | | 6/0's |
| 5/0's | 17.50 | .4289 | .4305 | .5165 | .5883 | .432 | .500 | 5/0's |
| 4/0's | 16.25 | .3983 | .3938 | .4600 | .5416 | .400 | .454 | 4/0's |
| 3/0's | 15.00 | .3676 | .3625 | .4096 | .500 | .372 | .425 | 3/0's |
| 2/0's | 13.75 | .3370 | .3310 | .3648 | .4452 | .348 | .380 | 2/0's |
| 0 | 12.50 | .3064 | .3065 | .3249 | .3964 | .324 | .340 | 0 |
| 1 | 11.25 | .2757 | .2830 | .2893 | .3532 | .300 | .300 | 1 |
| 2 | 10.625 | .2604 | .2625 | .2576 | .3147 | .276 | .284 | 2 |
| 3 | 10.00 | .2451 | .2437 | .2294 | .2804 | .252 | .259 | 3 |
| 4 | 9.375 | .2298 | .2253 | .2043 | .250 | .232 | .238 | 4 |
| 5 | 8.75 | .2145 | .2070 | .1819 | .2225 | .212 | .220 | 5 |
| 6 | 8.125 | .1991 | .1920 | .1620 | .1981 | .192 | .203 | 6 |
| 7 | 7.50 | .1838 | .1770 | .1443 | .1764 | .176 | .180 | 7 |
| 8 | 6.875 | .1685 | .1620 | .1285 | .1570 | .160 | .165 | 8 |
| 9 | 6.25 | .1532 | .1483 | .1144 | .1398 | .144 | .148 | 9 |
| 10 | 5.625 | .1379 | .1350 | .1019 | .1250 | .128 | .134 | 10 |
| 11 | 5.00 | .1225 | .1205 | .0907 | .1113 | .116 | .120 | 11 |
| 12 | 4.375 | .1072 | .1055 | .0808 | .0991 | .104 | .109 | 12 |
| 13 | 3.75 | .0919 | .0915 | .0720 | .0882 | .092 | .095 | 13 |
| 14 | 3.125 | .0766 | .0800 | .0641 | .0785 | .080 | .083 | 14 |
| 15 | 2.8125 | .0689 | .0720 | .0571 | .0699 | .072 | .072 | 15 |
| 16 | 2.50 | .0613 | .0625 | .0508 | .0625 | .064 | .065 | 16 |
| 17 | 2.25 | .0551 | .0540 | .0453 | .0556 | .056 | .058 | 17 |
| 18 | 2.00 | .0490 | .0475 | .0403 | .0495 | .048 | .049 | 18 |
| 19 | 1.75 | .0429 | .0410 | .0359 | .0440 | .040 | .042 | 19 |
| 20 | 1.50 | .0368 | .0348 | .0320 | .0392 | .036 | .035 | 20 |
| 21 | 1.375 | .0337 | .0318 | .0285 | .0349 | .032 | .032 | 21 |
| 22 | 1.25 | .0306 | .0286 | .0253 | .0313 | .028 | .028 | 22 |
| 23 | 1.125 | .0276 | .0258 | .0226 | .0278 | .024 | .025 | 23 |
| 24 | 1.00 | .0245 | .0230 | .0201 | .0248 | .022 | .022 | 24 |
| 25 | .875 | .0214 | .0204 | .0179 | .0220 | .020 | .020 | 25 |
| 26 | .75 | .0184 | .0181 | .0159 | .0196 | .018 | .018 | 26 |
| 27 | .6875 | .0169 | .0173 | .0142 | .0175 | .0164 | .016 | 27 |
| 28 | .625 | .0153 | .0162 | .0126 | .0156 | .0148 | .014 | 28 |
| 29 | .5625 | .0138 | .0150 | .0113 | .0139 | .0136 | .013 | 29 |
| 30 | .50 | .0123 | .0140 | .0100 | .0123 | .0124 | .012 | 30 |
| 31 | .4375 | .0107 | .0132 | .0089 | .0110 | .0116 | .010 | 31 |
| 32 | .4062 | .0100 | .0128 | .0080 | .0098 | .0108 | .009 | 32 |
| 33 | .375 | .0092 | .0118 | .0071 | .0087 | .0100 | .008 | 33 |
| 34 | .3438 | .0084 | .0104 | .0063 | .0077 | .0092 | .007 | 34 |
| 35 | .3125 | .0077 | .0095 | .0056 | .0069 | .0084 | .005 | 35 |
| 36 | .2812 | .0069 | .0090 | .0050 | .0061 | .0076 | .004 | 36 |
| 37 | .2656 | .0065 | .0085 | .0045 | .0054 | .0068 | | 37 |
| 38 | .25 | .0061 | .0080 | .0040 | .0048 | .0060 | | 38 |
| 39 | .2344 | .0057 | .0075 | .0035 | .0043 | .0052 | | 39 |
| 40 | .2188 | .0054 | .0070 | .0031 | .0039 | .0048 | | 40 |

*U. S. Standard Gage is officially a weight gage (in ounces per sq. ft.) based on wrought iron at 480 lb. per cu. ft. The values tabulated above give the thickness of steel (at 489.6 lb. per cu. ft.) that will approximate the respective weights. The other gages are officially thickness gages.

Plates—Over 6″ to 48″ wide, $\frac{1}{4}$″ and thicker; over 48″ wide, $\frac{3}{16}$″ and thicker.
Sheets—24″ to 48″ wide, under $\frac{1}{4}$″ thick; over 48″ wide, under $\frac{3}{16}$″ thick.
Strip—23$\frac{15}{16}$″ and narrower, under $\frac{1}{4}$″ thick.

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*Armstrong's Industrial Insulations (1951)*
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## Decimals of a Foot for Each 32nd of an Inch

| Inch | 0″ | 1″ | 2″ | 3″ | 4″ | 5″ | 6″ | 7″ | 8″ | 9″ | 10″ | 11″ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | .0833 | .1667 | .2500 | .3333 | .4167 | .5000 | .5833 | .6667 | .7500 | .8333 | .9167 |
| 1/32 | .0026 | .0859 | .1693 | .2526 | .3359 | .4193 | .5026 | .5859 | .6693 | .7526 | .8359 | .9193 |
| 1/16 | .0052 | .0885 | .1719 | .2552 | .3385 | .4219 | .5052 | .5885 | .6719 | .7552 | .8385 | .9219 |
| 3/32 | .0078 | .0911 | .1745 | .2578 | .3411 | .4245 | .5078 | .5911 | .6745 | .7578 | .8411 | .9245 |
| 1/8 | .0104 | .0938 | .1771 | .2604 | .3438 | .4271 | .5104 | .5938 | .6771 | .7604 | .8438 | .9271 |
| 5/32 | .0130 | .0964 | .1797 | .2630 | .3464 | .4297 | .5130 | .5964 | .6797 | .7630 | .8464 | .9297 |
| 3/16 | .0156 | .0990 | .1823 | .2656 | .3490 | .4323 | .5156 | .5990 | .6823 | .7656 | .8490 | .9323 |
| 7/32 | .0182 | .1016 | .1849 | .2682 | .3516 | .4349 | .5182 | .6016 | .6849 | .7682 | .8516 | .9349 |
| 1/4 | .0208 | .1042 | .1875 | .2708 | .3542 | .4375 | .5208 | .6042 | .6875 | .7708 | .8542 | .9375 |
| 9/32 | .0234 | .1068 | .1901 | .2734 | .3568 | .4401 | .5234 | .6068 | .6901 | .7734 | .8568 | .9401 |
| 5/16 | .0260 | .1094 | .1927 | .2760 | .3594 | .4427 | .5260 | .6094 | .6927 | .7760 | .8594 | .9427 |
| 11/32 | .0286 | .1120 | .1953 | .2786 | .3620 | .4453 | .5286 | .6120 | .6953 | .7786 | .8620 | .9453 |
| 3/8 | .0313 | .1146 | .1979 | .2812 | .3646 | .4479 | .5313 | .6146 | .6979 | .7813 | .8646 | .9479 |
| 13/32 | .0339 | .1172 | .2005 | .2839 | .3672 | .4505 | .5339 | .6172 | .7005 | .7839 | .8672 | .9505 |
| 7/16 | .0365 | .1198 | .2031 | .2865 | .3698 | .4531 | .5365 | .6198 | .7031 | .7865 | .8698 | .9531 |
| 15/32 | .0391 | .1224 | .2057 | .2891 | .3724 | .4557 | .5391 | .6224 | .7057 | .7891 | .8724 | .9557 |
| 1/2 | .0417 | .1250 | .2083 | .2917 | .3750 | .4583 | .5417 | .6250 | .7083 | .7917 | .8750 | .9583 |
| 17/32 | .0443 | .1276 | .2109 | .2943 | .3776 | .4609 | .5443 | .6276 | .7109 | .7943 | .8776 | .9609 |
| 9/16 | .0469 | .1302 | .2135 | .2969 | .3802 | .4635 | .5469 | .6302 | .7135 | .7969 | .8802 | .9635 |
| 19/32 | .0495 | .1328 | .2161 | .2995 | .3828 | .4661 | .5495 | .6328 | .7161 | .7995 | .8828 | .9661 |
| 5/8 | .0521 | .1354 | .2188 | .3021 | .3854 | .4688 | .5521 | .6354 | .7188 | .8021 | .8854 | .9688 |
| 21/32 | .0547 | .1380 | .2214 | .3047 | .3880 | .4714 | .5547 | .6380 | .7214 | .8047 | .8880 | .9714 |
| 11/16 | .0573 | .1406 | .2240 | .3073 | .3906 | .4740 | .5573 | .6406 | .7240 | .8073 | .8906 | .9740 |
| 23/32 | .0599 | .1432 | .2266 | .3099 | .3932 | .4766 | .5599 | .6432 | .7266 | .8099 | .8932 | .9766 |
| 3/4 | .0625 | .1458 | .2292 | .3125 | .3958 | .4792 | .5625 | .6458 | .7292 | .8125 | .8958 | .9792 |
| 25/32 | .0651 | .1484 | .2318 | .3151 | .3984 | .4818 | .5651 | .6484 | .7318 | .8151 | .8984 | .9818 |
| 13/16 | .0677 | .1510 | .2344 | .3177 | .4010 | .4844 | .5677 | .6510 | .7344 | .8177 | .9010 | .9844 |
| 27/32 | .0703 | .1536 | .2370 | .3203 | .4036 | .4870 | .5703 | .6536 | .7370 | .8203 | .9036 | .9870 |
| 7/8 | .0729 | .1563 | .2396 | .3229 | .4063 | .4896 | .5729 | .6563 | .7396 | .8229 | .9063 | .9896 |
| 29/32 | .0755 | .1589 | .2422 | .3255 | .4089 | .4922 | .5755 | .6589 | .7422 | .8255 | .9089 | .9922 |
| 15/16 | .0781 | .1615 | .2448 | .3281 | .4115 | .4948 | .5781 | .6615 | .7448 | .8281 | .9115 | .9948 |
| 31/32 | .0807 | .1641 | .2474 | .3307 | .4141 | .4974 | .5807 | .6641 | .7474 | .8307 | .9141 | .9974 |

Courtesy American Institute of Steel Construction



## Useful Formulae

| | | | | |
|---|---|---|---|---|
| $\pi = 3.1415926536$ | $\frac{\pi}{4} = 0.7854$ | $\frac{1}{\pi} = 0.31831$ | $\pi^2 = 9.96960$ | $\sqrt{\pi} = 1.77245$ |
| $\frac{2}{\pi} = 1.5708$ | $\frac{\pi}{12} = 0.2618$ | $\frac{1}{\pi^2} = 0.10132$ | $\pi^3 = 31.00628$ | $\sqrt{\frac{1}{\pi}} = 0.56419$ |
| $\frac{\pi}{3} = 1.0472$ | $\frac{\pi}{64} = 0.04909$ | | $\log. \pi = 0.4971499$ | $\log. \sqrt{\pi} = 0.2485749$ |

$$\text{Diameter} = \frac{226 \times \text{Circumference}}{710}$$

$$\text{Circumference} = \frac{710 \times \text{Diameter}}{226}$$

$$\text{Diameter} = \frac{99 \times \text{Side Inscribed Square}}{70}$$

$$\text{Side Inscribed Square} = \frac{70 \times \text{Diameter}}{99}$$

$$\text{Diameter} = \frac{70 \times \text{Side of Equal Square}}{79}$$

$$\text{Side of Equal Square} = \frac{79 \times \text{Diameter}}{70}$$

$$\text{Circumference} = \frac{39 \times \text{Side of Equal Square}}{11}$$

$$\text{Side of Equal Square} = \frac{11 \times \text{Circumference}}{39}$$

$$\text{Diagonal of Square} = \frac{99 \times \text{Side of Square}}{70}$$

$$\text{Side of Square} = \frac{70 \times \text{Diagonal of Square}}{99}$$

$$\text{Area of Circle} = \frac{322 \times \text{Area of Inscribed Square}}{205}$$

$$\text{Atmospheres} = \frac{23 \times \text{Feet of Water}}{780}$$

$$\text{Feet of Water} = \frac{780 \times \text{Atmosphere}}{23}$$

$$\text{Pounds per Sq. Inch} = \frac{29 \times \text{Feet of Water}}{67}$$

$$\text{Feet of Water} = \frac{67 \times \text{Pounds per Sq. Inch}}{29}$$

$$\text{Pounds per Sq. Foot} = \frac{51 \times \text{Kilograms per Sq. Meter}}{249}$$

$$\text{Kilograms per Sq. Meter} = \frac{249 \times \text{Pounds per Sq. Foot}}{51}$$

$$\text{Inches of Mercury} = \frac{57 \times \text{Pounds per Sq. Inch}}{28}$$

$$\text{Pounds per Sq. Inch} = \frac{28 \times \text{Inches of Mercury}}{57}$$

$$\text{Inches of Water} = \frac{720 \times \text{Pounds per Sq. Inch}}{26}$$

$$\text{Pounds per Sq. Inch} = \frac{26 \times \text{Inches of Water}}{720}$$

$$\text{Feet of Water} = \frac{60 \times \text{Pounds per Sq. Inch}}{26}$$

$$\text{Pounds per Sq. Inch} = \frac{26 \times \text{Feet of Water}}{60}$$

$$\text{Inches of Mercury} = \frac{15 \times \text{Feet of Water}}{17}$$

$$\text{Feet of Water} = \frac{17 \times \text{Inches of Mercury}}{15}$$



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# Psychrometric Chart for Normal Temperatures

## ADDITIVE CORRECTIONS TO VALUES OF W', W AND Σ FOR DEVIATIONS IN BAROMETRIC PRESSURE FROM 29.92 IN. HG.

| | APPROXIMATE ALTITUDE IN FEET | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | −900 | | 900 | | 1800 | | 2700 | | 3700 | | 4800 | | 5900 | |
| | ΔP = +1 | | ΔP = −1 | | ΔP = −2 | | ΔP = −3 | | ΔP = −4 | | ΔP = −5 | | ΔP = −6 | |
| t', °F | ΔW' | ΔΣ | ΔW' | ΔΣ | ΔW' | ΔΣ | ΔW' | ΔΣ | ΔW' | ΔΣ | ΔW' | ΔΣ | ΔW' | ΔΣ |
| 32 | − 0.9 | −0.14 | 0.9 | 0.14 | 1.9 | 0.29 | 3.0 | 0.45 | 4.1 | 0.63 | 5.3 | 0.82 | 6.7 | 1.03 |
| 33 | − 0.9 | −0.14 | 1.0 | 0.15 | 2.0 | 0.31 | 3.1 | 0.47 | 4.3 | 0.66 | 5.6 | 0.86 | 7.0 | 1.07 |
| 34 | − 0.9 | −0.14 | 1.0 | 0.15 | 2.1 | 0.32 | 3.2 | 0.49 | 4.5 | 0.68 | 5.8 | 0.89 | 7.3 | 1.12 |
| 35 | − 1.0 | −0.15 | 1.0 | 0.16 | 2.2 | 0.33 | 3.4 | 0.52 | 4.7 | 0.71 | 6.1 | 0.93 | 7.6 | 1.16 |
| 36 | − 1.0 | −0.15 | 1.1 | 0.17 | 2.3 | 0.35 | 3.5 | 0.54 | 4.8 | 0.74 | 6.3 | 0.97 | 7.9 | 1.21 |
| 37 | − 1.0 | −0.16 | 1.1 | 0.17 | 2.4 | 0.37 | 3.6 | 0.56 | 5.0 | 0.77 | 6.6 | 1.01 | 8.2 | 1.26 |
| 38 | − 1.1 | −0.17 | 1.2 | 0.18 | 2.4 | 0.38 | 3.8 | 0.58 | 5.2 | 0.80 | 6.8 | 1.05 | 8.5 | 1.31 |
| 39 | − 1.1 | −0.17 | 1.2 | 0.19 | 2.5 | 0.39 | 3.9 | 0.61 | 5.4 | 0.83 | 7.1 | 1.09 | 8.9 | 1.36 |
| 40 | − 1.2 | −0.18 | 1.3 | 0.20 | 2.6 | 0.40 | 4.1 | 0.63 | 5.7 | 0.87 | 7.4 | 1.13 | 9.2 | 1.41 |
| 41 | − 1.2 | −0.19 | 1.3 | 0.20 | 2.7 | 0.41 | 4.3 | 0.65 | 5.9 | 0.90 | 7.7 | 1.18 | 9.6 | 1.47 |
| 42 | − 1.3 | −0.20 | 1.4 | 0.21 | 2.8 | 0.43 | 4.4 | 0.67 | 6.1 | 0.93 | 8.0 | 1.23 | 10.0 | 1.53 |
| 43 | − 1.3 | −0.20 | 1.4 | 0.22 | 2.9 | 0.45 | 4.6 | 0.70 | 6.4 | 0.97 | 8.4 | 1.28 | 10.4 | 1.59 |
| 44 | − 1.4 | −0.21 | 1.5 | 0.23 | 3.1 | 0.47 | 4.8 | 0.73 | 6.6 | 1.01 | 8.7 | 1.33 | 10.8 | 1.65 |
| 45 | − 1.4 | −0.22 | 1.5 | 0.23 | 3.2 | 0.49 | 5.0 | 0.76 | 6.9 | 1.05 | 9.0 | 1.38 | 11.2 | 1.71 |
| 46 | − 1.5 | −0.23 | 1.6 | 0.24 | 3.3 | 0.50 | 5.2 | 0.79 | 7.2 | 1.09 | 9.4 | 1.43 | 11.7 | 1.78 |
| 47 | − 1.6 | −0.24 | 1.7 | 0.25 | 3.4 | 0.52 | 5.4 | 0.82 | 7.5 | 1.13 | 9.7 | 1.48 | 12.1 | 1.85 |
| 48 | − 1.6 | −0.25 | 1.7 | 0.26 | 3.6 | 0.54 | 5.6 | 0.85 | 7.7 | 1.17 | 10.1 | 1.54 | 12.6 | 1.92 |
| 49 | − 1.7 | −0.26 | 1.8 | 0.27 | 3.7 | 0.56 | 5.8 | 0.88 | 8.0 | 1.22 | 10.4 | 1.59 | 13.1 | 1.99 |
| 50 | − 1.8 | −0.27 | 1.9 | 0.28 | 3.9 | 0.59 | 6.0 | 0.92 | 8.3 | 1.27 | 10.9 | 1.65 | 13.6 | 2.06 |
| 51 | − 1.8 | −0.28 | 1.9 | 0.29 | 4.0 | 0.61 | 6.3 | 0.96 | 8.7 | 1.32 | 11.3 | 1.71 | 14.1 | 2.14 |
| 52 | − 1.9 | −0.29 | 2.0 | 0.30 | 4.2 | 0.64 | 6.5 | 0.99 | 9.0 | 1.37 | 11.7 | 1.78 | 14.6 | 2.22 |
| 53 | − 2.0 | −0.30 | 2.1 | 0.32 | 4.3 | 0.66 | 6.7 | 1.03 | 9.4 | 1.43 | 12.2 | 1.85 | 15.2 | 2.31 |
| 54 | − 2.0 | −0.31 | 2.2 | 0.33 | 4.5 | 0.68 | 7.0 | 1.07 | 9.7 | 1.48 | 12.7 | 1.92 | 15.8 | 2.40 |
| 55 | − 2.1 | −0.32 | 2.3 | 0.34 | 4.7 | 0.71 | 7.3 | 1.11 | 10.1 | 1.53 | 13.1 | 1.99 | 16.4 | 2.50 |
| 56 | − 2.2 | −0.33 | 2.3 | 0.35 | 4.8 | 0.73 | 7.6 | 1.15 | 10.5 | 1.59 | 13.7 | 2.07 | 17.1 | 2.59 |
| 57 | − 2.3 | −0.35 | 2.4 | 0.36 | 5.0 | 0.76 | 7.9 | 1.20 | 10.9 | 1.65 | 14.2 | 2.15 | 17.8 | 2.69 |
| 58 | − 2.4 | −0.36 | 2.5 | 0.38 | 5.2 | 0.79 | 8.2 | 1.24 | 11.3 | 1.71 | 14.8 | 2.23 | 18.4 | 2.78 |
| 59 | − 2.5 | −0.37 | 2.6 | 0.39 | 5.4 | 0.82 | 8.5 | 1.28 | 11.7 | 1.77 | 15.3 | 2.31 | 19.1 | 2.88 |
| 60 | − 2.5 | −0.38 | 2.7 | 0.41 | 5.6 | 0.85 | 8.8 | 1.33 | 12.2 | 1.84 | 15.8 | 2.39 | 19.8 | 2.99 |
| 61 | − 2.6 | −0.39 | 2.8 | 0.42 | 5.9 | 0.89 | 9.1 | 1.38 | 12.6 | 1.91 | 16.4 | 2.48 | 20.6 | 3.10 |
| 62 | − 2.7 | −0.41 | 2.9 | 0.44 | 6.1 | 0.92 | 9.5 | 1.43 | 13.1 | 1.98 | 17.0 | 2.57 | 21.3 | 3.22 |
| 63 | − 2.8 | −0.42 | 3.0 | 0.46 | 6.3 | 0.95 | 9.8 | 1.48 | 13.6 | 2.05 | 17.7 | 2.67 | 22.1 | 3.35 |
| 64 | − 2.9 | −0.44 | 3.2 | 0.48 | 6.5 | 0.98 | 10.2 | 1.53 | 14.1 | 2.13 | 18.3 | 2.77 | 23.0 | 3.48 |
| 65 | − 3.1 | −0.46 | 3.3 | 0.50 | 6.8 | 1.02 | 10.6 | 1.59 | 14.6 | 2.21 | 19.0 | 2.87 | 23.8 | 3.60 |
| 66 | − 3.2 | −0.48 | 3.4 | 0.51 | 7.0 | 1.06 | 11.0 | 1.65 | 15.2 | 2.29 | 19.7 | 2.98 | 24.7 | 3.73 |
| 67 | − 3.3 | −0.50 | 3.5 | 0.53 | 7.3 | 1.10 | 11.4 | 1.72 | 15.8 | 2.38 | 20.5 | 3.09 | 25.6 | 3.86 |
| 68 | − 3.4 | −0.51 | 3.7 | 0.55 | 7.5 | 1.14 | 11.8 | 1.78 | 16.3 | 2.46 | 21.2 | 3.20 | 26.6 | 4.01 |
| 69 | − 3.5 | −0.53 | 3.8 | 0.57 | 7.8 | 1.18 | 12.3 | 1.85 | 16.9 | 2.55 | 22.0 | 3.32 | 27.6 | 4.15 |
| 70 | − 3.7 | −0.55 | 3.9 | 0.59 | 8.1 | 1.22 | 12.7 | 1.91 | 17.5 | 2.64 | 22.8 | 3.44 | 28.6 | 4.29 |
| 71 | − 3.8 | −0.57 | 4.1 | 0.61 | 8.4 | 1.26 | 13.1 | 1.98 | 18.2 | 2.74 | 23.7 | 3.56 | 29.6 | 4.45 |
| 72 | − 3.9 | −0.59 | 4.2 | 0.63 | 8.7 | 1.31 | 13.6 | 2.05 | 18.9 | 2.84 | 24.5 | 3.69 | 30.7 | 4.62 |
| 73 | − 4.1 | −0.61 | 4.4 | 0.66 | 9.1 | 1.36 | 14.1 | 2.12 | 19.6 | 2.95 | 25.4 | 3.83 | 31.8 | 4.79 |
| 74 | − 4.2 | −0.63 | 4.5 | 0.68 | 9.4 | 1.41 | 14.6 | 2.19 | 20.3 | 3.05 | 26.4 | 3.96 | 33.0 | 4.96 |
| 75 | − 4.4 | −0.66 | 4.7 | 0.71 | 9.7 | 1.46 | 15.1 | 2.27 | 21.0 | 3.15 | 27.3 | 4.10 | 34.2 | 5.13 |
| 76 | − 4.5 | −0.68 | 4.9 | 0.73 | 10.1 | 1.51 | 15.7 | 2.35 | 21.7 | 3.25 | 28.3 | 4.24 | 35.4 | 5.31 |
| 77 | − 4.7 | −0.70 | 5.0 | 0.76 | 10.4 | 1.56 | 16.2 | 2.43 | 22.4 | 3.36 | 29.3 | 4.39 | 36.7 | 5.50 |
| 78 | − 4.9 | −0.73 | 5.2 | 0.78 | 10.8 | 1.62 | 16.8 | 2.52 | 23.2 | 3.48 | 30.4 | 4.55 | 38.0 | 5.70 |
| 79 | − 5.0 | −0.75 | 5.4 | 0.81 | 11.2 | 1.67 | 17.4 | 2.61 | 24.1 | 3.61 | 31.5 | 4.71 | 39.4 | 5.90 |
| 80 | − 5.2 | −0.78 | 5.6 | 0.84 | 11.6 | 1.73 | 18.0 | 2.70 | 25.0 | 3.74 | 32.6 | 4.87 | 40.8 | 6.11 |
| 81 | − 5.4 | −0.81 | 5.8 | 0.87 | 12.0 | 1.79 | 18.7 | 2.79 | 25.9 | 3.88 | 33.7 | 5.04 | 42.3 | 6.32 |
| 82 | − 5.6 | −0.84 | 6.0 | 0.90 | 12.5 | 1.86 | 19.3 | 2.89 | 26.8 | 4.01 | 34.9 | 5.22 | 43.8 | 6.54 |
| 83 | − 5.8 | −0.87 | 6.2 | 0.93 | 12.9 | 1.92 | 20.0 | 2.99 | 27.8 | 4.15 | 36.2 | 5.41 | 45.3 | 6.77 |
| 84 | − 6.0 | −0.90 | 6.4 | 0.96 | 13.3 | 1.99 | 20.7 | 3.10 | 28.8 | 4.29 | 37.5 | 5.60 | 47.0 | 7.01 |
| 85 | − 6.2 | −0.93 | 6.7 | 1.00 | 13.8 | 2.06 | 21.5 | 3.21 | 29.8 | 4.44 | 38.9 | 5.80 | 48.6 | 7.25 |
| 86 | − 6.4 | −0.96 | 6.9 | 1.03 | 14.2 | 2.13 | 22.3 | 3.32 | 30.9 | 4.60 | 40.2 | 6.00 | 50.4 | 7.51 |
| 87 | − 6.7 | −1.00 | 7.1 | 1.06 | 14.7 | 2.20 | 23.0 | 3.43 | 32.0 | 4.76 | 41.7 | 6.21 | 52.2 | 7.78 |
| 88 | − 6.9 | −1.03 | 7.4 | 1.10 | 15.3 | 2.28 | 23.9 | 3.55 | 33.1 | 4.93 | 43.1 | 6.43 | 54.1 | 8.06 |
| 89 | − 7.1 | −1.06 | 7.6 | 1.13 | 15.8 | 2.36 | 24.7 | 3.68 | 34.3 | 5.10 | 44.7 | 6.66 | 56.0 | 8.35 |
| 90 | − 7.4 | −1.10 | 7.9 | 1.17 | 16.4 | 2.44 | 25.6 | 3.81 | 35.5 | 5.28 | 46.3 | 6.89 | 58.0 | 8.64 |
| 91 | − 7.6 | −1.13 | 8.2 | 1.21 | 17.0 | 2.53 | 26.5 | 3.94 | 36.8 | 5.47 | 47.9 | 7.13 | 60.0 | 8.94 |
| 92 | − 7.9 | −1.17 | 8.5 | 1.26 | 17.6 | 2.62 | 27.4 | 4.08 | 38.1 | 5.66 | 49.6 | 7.38 | 62.2 | 9.25 |
| 93 | − 8.2 | −1.22 | 8.8 | 1.31 | 18.2 | 2.71 | 28.4 | 4.22 | 39.4 | 5.86 | 51.4 | 7.64 | 64.4 | 9.57 |
| 94 | − 8.5 | −1.27 | 9.1 | 1.35 | 18.8 | 2.80 | 29.4 | 4.37 | 40.8 | 6.07 | 53.2 | 7.91 | 66.6 | 9.90 |
| 95 | − 8.8 | −1.31 | 9.4 | 1.40 | 19.5 | 2.90 | 30.4 | 4.52 | 42.2 | 6.28 | 55.0 | 8.19 | 69.0 | 10.25 |
| 96 | − 9.1 | −1.35 | 9.8 | 1.45 | 20.2 | 3.00 | 31.5 | 4.68 | 43.7 | 6.50 | 57.0 | 8.48 | 71.5 | 10.62 |
| 97 | − 9.4 | −1.40 | 10.1 | 1.50 | 21.0 | 3.11 | 32.6 | 4.85 | 45.3 | 6.73 | 59.0 | 8.77 | 74.0 | 10.99 |
| 98 | − 9.7 | −1.44 | 10.4 | 1.55 | 21.7 | 3.21 | 33.7 | 5.02 | 46.9 | 6.96 | 61.1 | 9.07 | 76.6 | 11.36 |
| 99 | −10.1 | −1.49 | 10.8 | 1.60 | 22.4 | 3.32 | 34.9 | 5.19 | 48.5 | 7.20 | 63.2 | 9.38 | 79.3 | 11.76 |
| 100 | −10.4 | −1.54 | 11.1 | 1.65 | 23.2 | 3.43 | 36.1 | 5.37 | 50.2 | 7.44 | 65.5 | 9.70 | 82.1 | 12.18 |

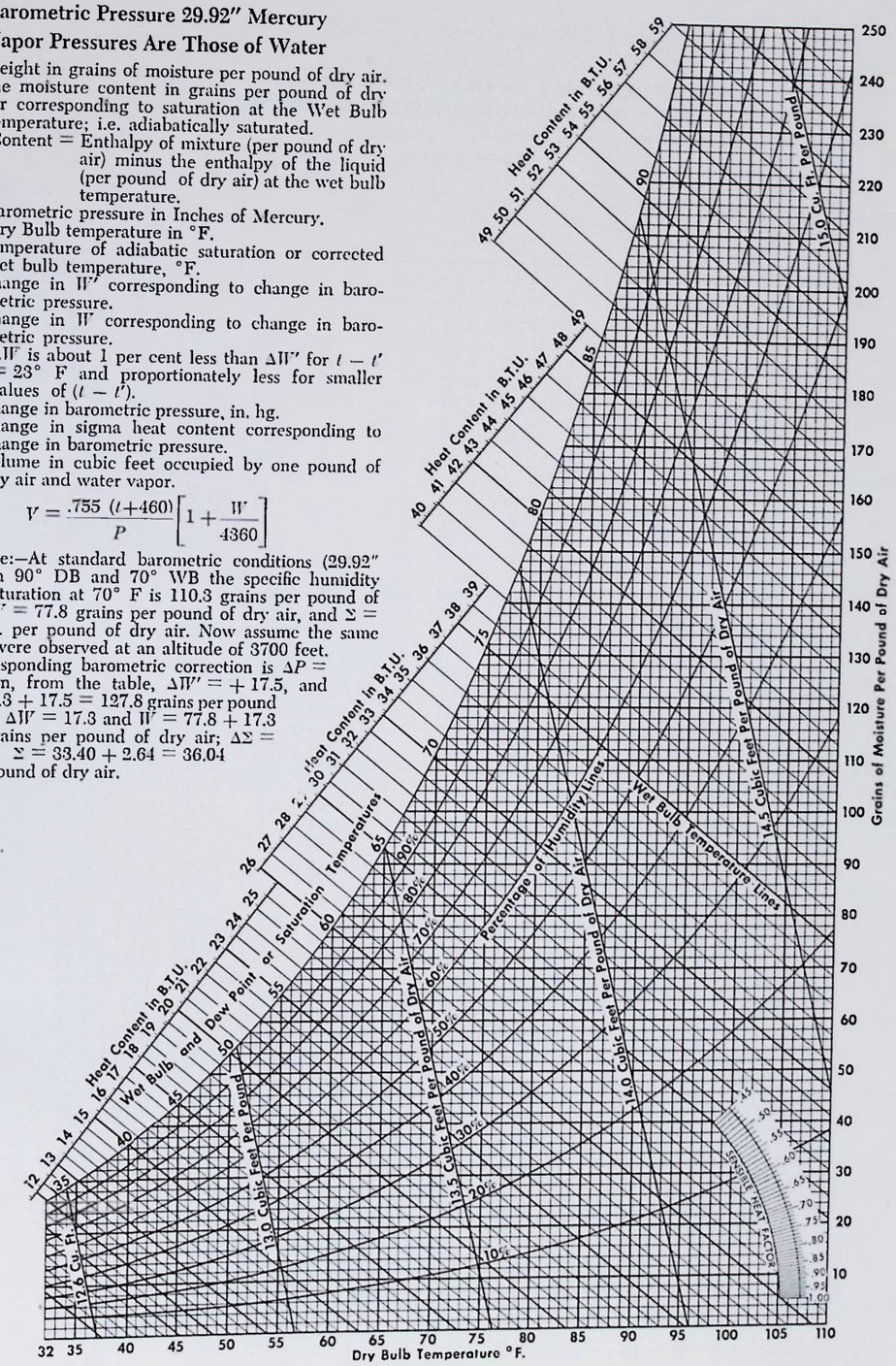


**Barometric Pressure 29.92" Mercury Vapor Pressures Are Those of Water**

$W$ = weight in grains of moisture per pound of dry air.
$W''$ = the moisture content in grains per pound of dry air corresponding to saturation at the Wet Bulb temperature; i.e. adiabatically saturated.
Σ Heat Content = Enthalpy of mixture (per pound of dry air) minus the enthalpy of the liquid (per pound of dry air) at the wet bulb temperature.
$P$ = Barometric pressure in Inches of Mercury.
$t$ = Dry Bulb temperature in °F.
$t'$ = temperature of adiabatic saturation or corrected wet bulb temperature, °F.
$\Delta W''$ = change in $W''$ corresponding to change in barometric pressure.
$\Delta W$ = change in $W$ corresponding to change in barometric pressure.
Note.—$\Delta W$ is about 1 per cent less than $\Delta W''$ for $t - t' = 23°$ F and proportionately less for smaller values of $(t - t')$.
$\Delta P$ = change in barometric pressure, in. hg.
$\Delta\Sigma$ = change in sigma heat content corresponding to change in barometric pressure.
$V$ = volume in cubic feet occupied by one pound of dry air and water vapor.

$$V = \frac{.755\ (t+460)}{P}\left[1 + \frac{W}{4360}\right]$$

Example:—At standard barometric conditions (29.92" HG.) with 90° DB and 70° WB the specific humidity $W''$ for saturation at 70° F is 110.3 grains per pound of dry air, $W$ = 77.8 grains per pound of dry air, and Σ = 33.40 btu. per pound of dry air. Now assume the same readings were observed at an altitude of 3700 feet. The corresponding barometric correction is $\Delta P$ = − 4. Then, from the table, $\Delta W'' = +17.5$, and $W'' = 110.3 + 17.5 = 127.8$ grains per pound of dry air; $\Delta W = 17.3$ and $W = 77.8 + 17.3 = 95.1$ grains per pound of dry air; $\Delta\Sigma = 2.64$ and $\Sigma = 33.40 + 2.64 = 36.04$ btu. per pound of dry air.






*Armstrong's Industrial Insulations (1951)*
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# Psychrometric Chart for Low Temperatures

**ADDITIVE CORRECTIONS TO VALUES OF W', W AND Σ FOR DEVIATIONS IN BAROMETRIC PRESSURE FROM 29.92 IN. HG.**

| | APPROXIMATE ALTITUDE IN FEET | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | −900 | | 900 | | 1800 | | 2700 | | 3700 | | 4800 | | 5900 | |
| | ΔP = +1 | | ΔP = −1 | | ΔP = −2 | | ΔP = −3 | | ΔP = −4 | | ΔP = −5 | | ΔP = −6 | |
| t', °F | ΔW | ΔΣ | ΔW | ΔΣ | ΔW | ΔΣ | ΔW | ΔΣ | ΔW | ΔΣ | ΔW | ΔΣ | ΔW | ΔΣ |
| −40 | −0.00 | 0.00 | 0.01 | 0.00 | 0.04 | 0.01 | 0.07 | 0.01 | 0.09 | 0.02 | 0.11 | 0.02 | 0.14 | 0.02 |
| −35 | −0.01 | 0.00 | 0.02 | 0.00 | 0.05 | 0.01 | 0.08 | 0.01 | 0.12 | 0.02 | 0.15 | 0.03 | 0.19 | 0.03 |
| −30 | −0.03 | −0.01 | 0.03 | −0.01 | 0.08 | 0.01 | 0.11 | 0.02 | 0.16 | 0.03 | 0.20 | 0.04 | 0.26 | 0.05 |
| −25 | −0.04 | −0.01 | 0.04 | −0.01 | 0.11 | 0.02 | 0.17 | 0.03 | 0.21 | 0.04 | 0.27 | 0.05 | 0.35 | 0.06 |
| −20 | −0.06 | −0.01 | 0.06 | −0.01 | 0.15 | 0.02 | 0.23 | 0.04 | 0.28 | 0.05 | 0.37 | 0.06 | 0.46 | 0.08 |
| −15 | −0.08 | −0.02 | 0.08 | −0.01 | 0.20 | 0.03 | 0.31 | 0.05 | 0.38 | 0.07 | 0.49 | 0.08 | 0.61 | 0.11 |
| −10 | −0.11 | −0.02 | 0.11 | −0.02 | 0.24 | 0.04 | 0.40 | 0.06 | 0.50 | 0.09 | 0.65 | 0.11 | 0.81 | 0.14 |
| − 5 | −0.14 | −0.02 | 0.14 | −0.02 | 0.31 | 0.05 | 0.50 | 0.08 | 0.65 | 0.11 | 0.85 | 0.15 | 1.06 | 0.18 |
| 0 | −0.17 | −0.03 | 0.17 | 0.03 | 0.37 | 0.07 | 0.60 | 0.11 | 0.84 | 0.15 | 1.10 | 0.19 | 1.38 | 0.22 |
| 1 | −0.2 | −0.03 | 0.2 | 0.04 | 0.4 | 0.07 | 0.6 | 0.11 | 0.9 | 0.16 | 1.1 | 0.20 | 1.4 | 0.23 |
| 2 | −0.2 | −0.03 | 0.2 | 0.04 | 0.4 | 0.08 | 0.7 | 0.12 | 0.9 | 0.17 | 1.2 | 0.21 | 1.4 | 0.25 |
| 3 | −0.2 | −0.03 | 0.2 | 0.04 | 0.5 | 0.08 | 0.7 | 0.13 | 1.0 | 0.17 | 1.2 | 0.22 | 1.5 | 0.26 |
| 4 | −0.2 | −0.04 | 0.2 | 0.04 | 0.5 | 0.09 | 0.8 | 0.13 | 1.0 | 0.18 | 1.3 | 0.23 | 1.6 | 0.28 |
| 5 | −0.2 | −0.04 | 0.2 | 0.04 | 0.5 | 0.09 | 0.8 | 0.14 | 1.1 | 0.19 | 1.4 | 0.24 | 1.7 | 0.29 |
| 6 | −0.2 | −0.04 | 0.3 | 0.05 | 0.5 | 0.09 | 0.8 | 0.15 | 1.2 | 0.20 | 1.4 | 0.25 | 1.8 | 0.31 |
| 7 | −0.3 | −0.04 | 0.3 | 0.05 | 0.6 | 0.10 | 0.9 | 0.15 | 1.2 | 0.21 | 1.5 | 0.26 | 1.9 | 0.32 |
| 8 | −0.3 | −0.05 | 0.3 | 0.05 | 0.6 | 0.10 | 0.9 | 0.16 | 1.3 | 0.23 | 1.6 | 0.28 | 2.0 | 0.34 |
| 9 | −0.3 | −0.05 | 0.3 | 0.05 | 0.6 | 0.11 | 1.0 | 0.17 | 1.4 | 0.24 | 1.7 | 0.29 | 2.1 | 0.37 |
| 10 | −0.3 | −0.05 | 0.3 | 0.05 | 0.7 | 0.11 | 1.0 | 0.18 | 1.4 | 0.25 | 1.8 | 0.30 | 2.2 | 0.39 |
| 11 | −0.3 | −0.05 | 0.3 | 0.05 | 0.7 | 0.12 | 1.1 | 0.19 | 1.5 | 0.26 | 1.9 | 0.32 | 2.4 | 0.41 |
| 12 | −0.3 | −0.06 | 0.4 | 0.06 | 0.7 | 0.13 | 1.1 | 0.20 | 1.6 | 0.27 | 2.0 | 0.34 | 2.5 | 0.44 |
| 13 | −0.3 | −0.06 | 0.4 | 0.06 | 0.8 | 0.13 | 1.2 | 0.21 | 1.7 | 0.29 | 2.1 | 0.36 | 2.7 | 0.46 |
| 14 | −0.4 | −0.06 | 0.4 | 0.07 | 0.8 | 0.14 | 1.2 | 0.22 | 1.7 | 0.30 | 2.2 | 0.38 | 2.8 | 0.49 |
| 15 | −0.4 | −0.07 | 0.4 | 0.07 | 0.8 | 0.15 | 1.3 | 0.23 | 1.8 | 0.32 | 2.3 | 0.40 | 3.0 | 0.52 |
| 16 | −0.4 | −0.07 | 0.4 | 0.07 | 0.9 | 0.15 | 1.4 | 0.24 | 1.9 | 0.33 | 2.5 | 0.43 | 3.1 | 0.54 |
| 17 | −0.4 | −0.07 | 0.4 | 0.08 | 0.9 | 0.16 | 1.5 | 0.26 | 2.0 | 0.35 | 2.7 | 0.45 | 3.3 | 0.57 |
| 18 | −0.4 | −0.08 | 0.5 | 0.08 | 1.0 | 0.17 | 1.5 | 0.27 | 2.1 | 0.36 | 2.8 | 0.48 | 3.5 | 0.61 |
| 19 | −0.5 | −0.08 | 0.5 | 0.09 | 1.0 | 0.18 | 1.6 | 0.28 | 2.2 | 0.38 | 3.0 | 0.51 | 3.7 | 0.64 |
| 20 | −0.5 | −0.08 | 0.5 | 0.09 | 1.1 | 0.19 | 1.7 | 0.29 | 2.3 | 0.40 | 3.1 | 0.53 | 3.8 | 0.67 |
| 21 | −0.5 | −0.09 | 0.5 | 0.10 | 1.1 | 0.20 | 1.8 | 0.30 | 2.4 | 0.42 | 3.2 | 0.56 | 4.0 | 0.70 |
| 22 | −0.5 | −0.09 | 0.6 | 0.10 | 1.2 | 0.21 | 1.8 | 0.32 | 2.6 | 0.44 | 3.4 | 0.59 | 4.2 | 0.73 |
| 23 | −0.6 | −0.10 | 0.6 | 0.10 | 1.2 | 0.22 | 1.9 | 0.34 | 2.7 | 0.47 | 3.5 | 0.62 | 4.5 | 0.79 |
| 24 | −0.6 | −0.10 | 0.6 | 0.11 | 1.3 | 0.23 | 2.0 | 0.35 | 2.8 | 0.49 | 3.7 | 0.65 | 4.7 | 0.81 |
| 25 | −0.6 | −0.11 | 0.7 | 0.11 | 1.4 | 0.24 | 2.1 | 0.37 | 3.0 | 0.52 | 3.9 | 0.68 | 4.9 | 0.85 |
| 26 | −0.7 | −0.11 | 0.7 | 0.12 | 1.4 | 0.25 | 2.2 | 0.39 | 3.1 | 0.54 | 4.1 | 0.71 | 5.2 | 0.90 |
| 27 | −0.7 | −0.12 | 0.7 | 0.13 | 1.5 | 0.26 | 2.3 | 0.41 | 3.2 | 0.57 | 4.3 | 0.75 | 5.4 | 0.94 |
| 28 | −0.7 | −0.13 | 0.8 | 0.13 | 1.6 | 0.27 | 2.5 | 0.43 | 3.4 | 0.59 | 4.5 | 0.78 | 5.6 | 0.98 |
| 29 | −0.8 | −0.13 | 0.8 | 0.14 | 1.7 | 0.29 | 2.6 | 0.45 | 3.6 | 0.62 | 4.7 | 0.82 | 5.9 | 1.03 |
| 30 | −0.8 | −0.14 | 0.8 | 0.15 | 1.7 | 0.30 | 2.7 | 0.47 | 3.7 | 0.65 | 4.9 | 0.85 | 6.1 | 1.07 |
| 31 | −0.8 | −0.14 | 0.9 | 0.16 | 1.8 | 0.32 | 2.8 | 0.49 | 3.9 | 0.68 | 5.1 | 0.89 | 6.4 | 1.12 |
| 32 | −0.9 | −0.15 | 0.9 | 0.16 | 1.9 | 0.33 | 3.0 | 0.52 | 4.1 | 0.71 | 5.3 | 0.92 | 6.7 | 1.16 |
| 33 | −0.9 | −0.16 | 1.0 | 0.17 | 2.0 | 0.35 | 3.1 | 0.54 | 4.3 | 0.74 | 5.6 | 0.96 | 7.0 | 1.21 |
| 34 | −0.9 | −0.16 | 1.0 | 0.17 | 2.1 | 0.36 | 3.2 | 0.56 | 4.5 | 0.78 | 5.8 | 1.01 | 7.3 | 1.27 |
| 35 | −1.0 | −0.17 | 1.0 | 0.18 | 2.2 | 0.38 | 3.4 | 0.58 | 4.7 | 0.81 | 6.1 | 1.06 | 7.6 | 1.32 |
| 36 | −1.0 | −0.18 | 1.1 | 0.19 | 2.3 | 0.39 | 3.5 | 0.61 | 4.8 | 0.84 | 6.3 | 1.09 | 7.9 | 1.37 |
| 37 | −1.0 | −0.18 | 1.1 | 0.20 | 2.4 | 0.41 | 3.6 | 0.63 | 5.0 | 0.87 | 6.6 | 1.14 | 8.2 | 1.42 |
| 38 | −1.1 | −0.19 | 1.2 | 0.20 | 2.4 | 0.42 | 3.8 | 0.66 | 5.2 | 0.91 | 6.8 | 1.18 | 8.5 | 1.48 |
| 39 | −1.1 | −0.20 | 1.2 | 0.21 | 2.5 | 0.44 | 3.9 | 0.68 | 5.4 | 0.94 | 7.1 | 1.23 | 8.9 | 1.53 |
| 40 | −1.2 | −0.20 | 1.3 | 0.22 | 2.6 | 0.46 | 4.1 | 0.71 | 5.7 | 0.98 | 7.4 | 1.27 | 9.2 | 1.58 |



**Barometric Pressure 29.92" Mercury**

**Vapor Pressures Are Those of Ice**

$W$ = weight in grains of moisture per pound of dry air.

$W'$ = the moisture content in grains per pound of dry air corresponding to saturation at the Wet Bulb temperature; i.e. adiabatically saturated.

Σ Heat Content = Enthalpy of mixture (per pound of dry air) minus the enthalpy of the liquid (per pound of dry air) at the wet bulb temperature.

$P$ = Barometric pressure in Inches of Mercury.

$t$ = Dry Bulb temperature in °F.

$t'$ = temperature of adiabatic saturation or corrected wet bulb temperature, °F.

$\Delta W'$ = change in $W'$ corresponding to change in barometric pressure.

$\Delta W$ = change in $W$ corresponding to change in barometric pressure.

Note.—Within the temperature range covered by this chart the values of $\Delta W$ and $\Delta W'$ may be considered the same.

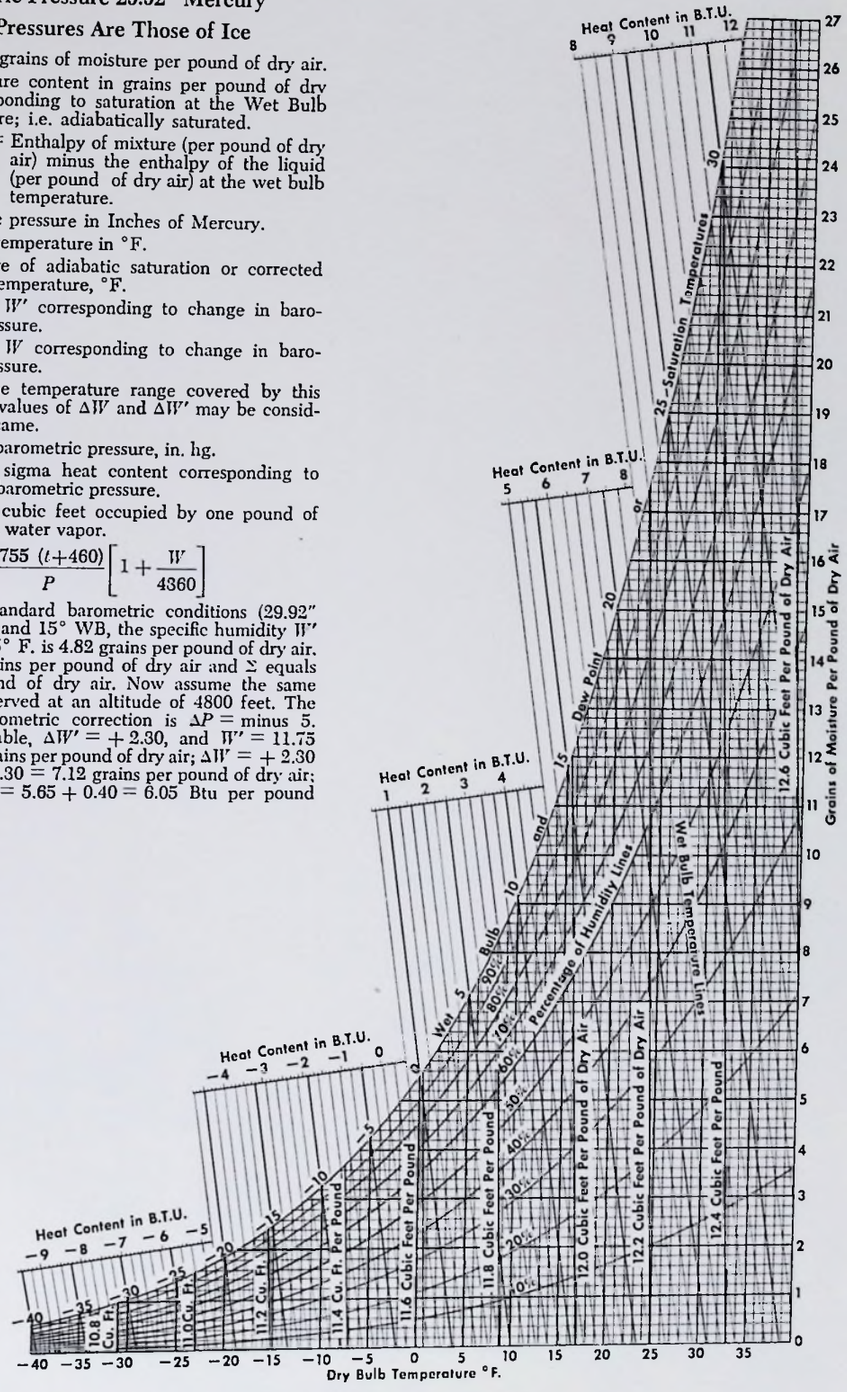
$\Delta P$ = change in barometric pressure, in. hg.

$\Delta \Sigma$ = change in sigma heat content corresponding to change in barometric pressure.

$V$ = volume in cubic feet occupied by one pound of dry air and water vapor.

$$V = \frac{.755\ (t+460)}{P}\left[1+\frac{W}{4360}\right]$$

Example:—At standard barometric conditions (29.92" Hg.) with 20° DB and 15° WB, the specific humidity $W'$ for saturation at 15° F. is 4.82 grains per pound of dry air. $W$ equals 4.82 grains per pound of dry air and Σ equals 5.65 Btu per pound of dry air. Now assume the same readings were observed at an altitude of 4800 feet. The corresponding Barometric correction is $\Delta P$ = minus 5. Then, from the table, $\Delta W' = +2.30$, and $W' = 11.75 + 2.30 = 14.05$ grains per pound of dry air; $\Delta W = +2.30$ and $W = 4.82 + 2.30 = 7.12$ grains per pound of dry air; $\Delta \Sigma = 0.40$ and $\Sigma = 5.65 + 0.40 = 6.05$ Btu per pound of dry air.







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