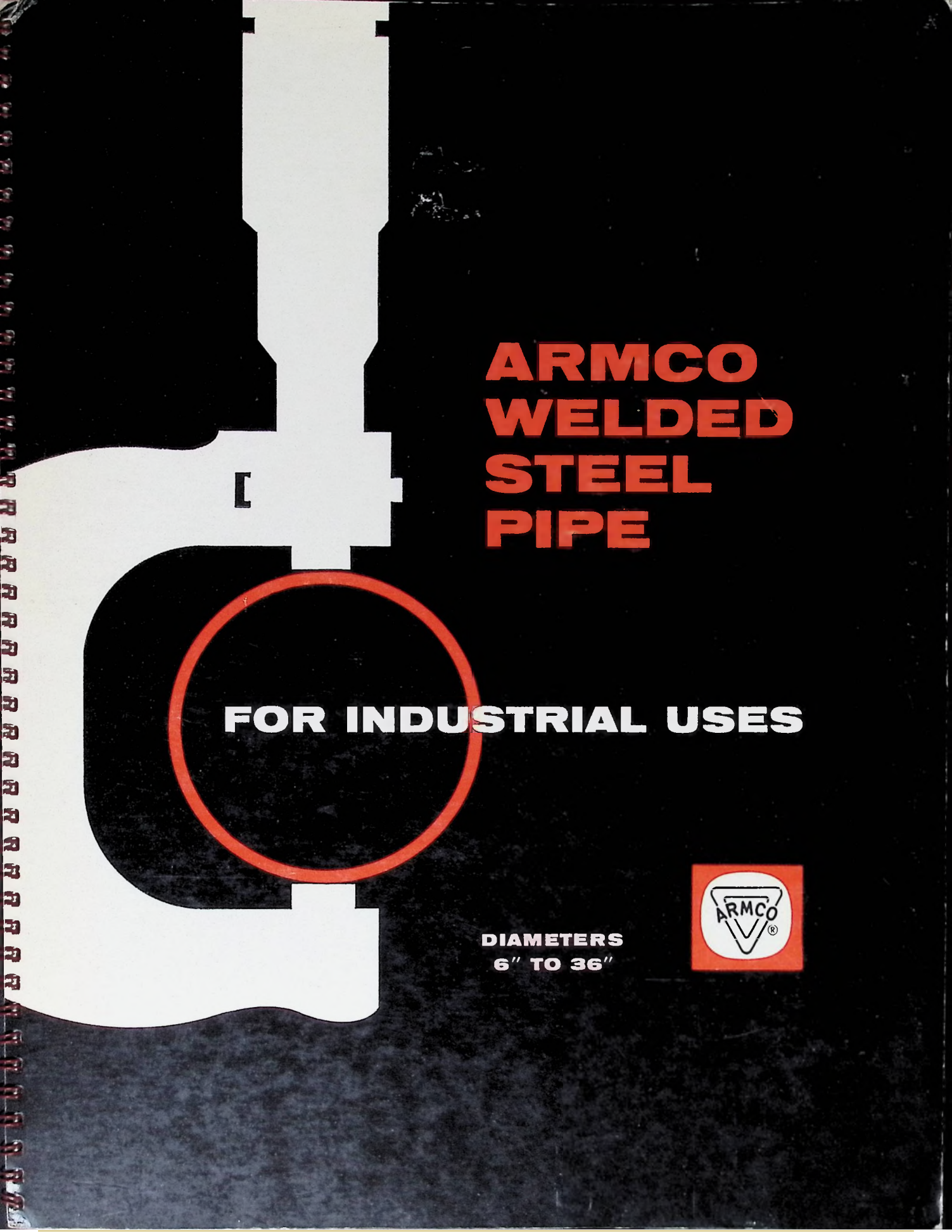
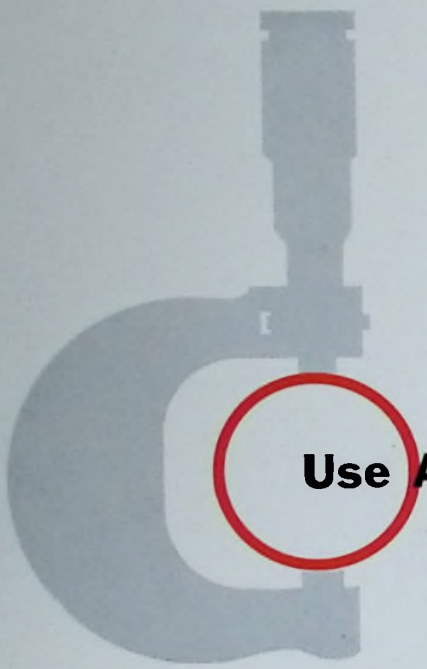


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Catalog 8558



Use Armco Pipe with confidence

One big reason for the consistently high quality of Armco Welded Steel Pipe is that Armco is both a steel producer and a pipe manufacturer. This means close control and inspection of all phases of production . . . from the raw iron ore to the finished pipe.

Millions of feet of Armco Pipe, successfully used in thousands of installations over a period of many years, are evidence of this high quality and durability. These installations include municipal water lines, foundation piling, dredge lines, oil and gas lines, plant piping, and many others shown in this catalog. Produced continuously on Armco-invented automatic machines, this pipe offers many advantages to industry.

This catalog describes these advantages and provides technical and design data on Armco Welded Steel Pipe. Information on design data for specific installations will be supplied upon request.

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Armco Drainage & Metal Products, Inc.

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Hydraulic materials handling

WHERE ARMCO WELDED STEEL PIPE IS USED IN INDUSTRY

Supply lines



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1. Factory piping

Air, water, gas, and steam lines
Cooling tower piping
Spray pond piping
Heat exchanger pipe

2. Process piping

Stock lines
White water lines
Waste lines
Water lines
Steam lines
Filtration plant piping
Special analysis dredge pipe

3. Water supply and waste disposal lines

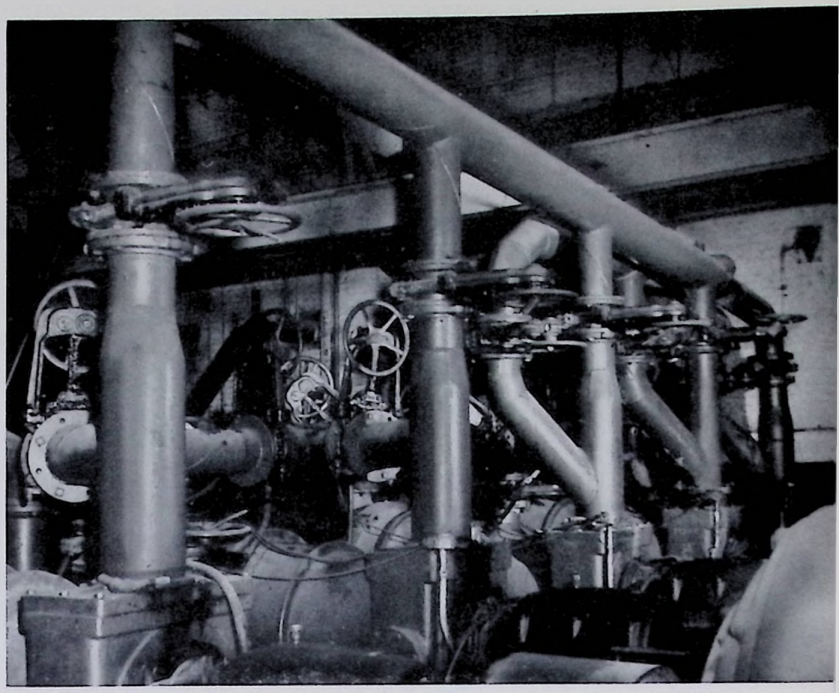
Supply lines
Equalizing mains
Underwater crossings
Bridge crossings
Water purification piping
Power house piping
  water lines
  air lines
  steam lines
Sewage disposal lines
Outfall sewers

4. Contractor's pipe

Foundation pipe
Air supplies
Water supplies
Waste lines
Placing concrete
Well-point headers

5. Base products

For units to be finished in manufacturer's plant . . . for example small tanks for compressor units



Plant piping

Water supply and treatment



Foundation piling



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High strength with ductility. Armco Pipe is sufficiently strong yet ductile enough for aerial crossings, underground and underwater crossings or other difficult installations.

Here are some of the reasons why Modern Industry Selects **ARMCO STEEL PIPE**

Ample Strength

You can specify the grade of steel to meet your particular requirements. Armco Pipe is made from steel of recognized welding quality in specified grades as shown on page 8. In addition, certain other ASTM steel grades can be supplied when quantities justify.

High Flow Capacity

Armco Welded Steel Pipe is smooth inside with little evidence of ridges, creases, or other obstructions that tend to retard the flow of fluids, cause turbulence, or impede the flow of transported materials.

Excellent Welds

Armco automatic machine welds, made by the submerged arc process, are as strong and resistant to corrosion as the pipe wall itself.

Adaptable to field fabrication. Only steels of high welding quality are used in Armco Pipe. Field-fabricated specials are easily made by experienced welders.



Uniform Wall Thickness

With Armco Pipe you are assured a high degree of uniformity of strength and wall thickness. The steel from which all sizes are made is held to the very close under-thickness tolerance of 0.01 inch.

Quality Closely Controlled

The quality of Armco Pipe is carefully controlled from iron ore to the finished pipe. Both sides of the steel coils or plates are inspected before forming into pipe. Tests are made during each stage of manufacture to insure high quality. In addition, each length of Armco Pipe must pass a rigid hydrostatic test before it leaves the mill.

Variety of Joints

Armco Pipe is supplied with ends prepared for the commonly used joints. These joints are shown on pages 20 to 23.

Standard or Special Fittings

Standard fittings such as tees, elbows, wyes, crosses, and reducers are available with Armco Pipe. Also special fittings can be fabricated to individual specifications in the Armco Fitting Shop. See pages 18 and 19.

Adaptable to Field Fabrication

Because of its uniform diameter and smooth interior, Armco Steel Pipe can easily be cut to special lengths and joined by butt welding. If desired, special fittings can be fabricated on the job. Since Armco Pipe is a welded product, only steels of the highest welding quality are used.

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Light weight for easy, low-cost handling. The high strength-to-weight ratio of Armco Pipe means low transportation and handling costs. This 50-foot length is part of a 5-mile industrial water supply line.

Variety of Coatings

You can obtain Armco Pipe with a wide variety of linings and protective coatings to meet your specific requirements. These are shown on pages 16 and 17.

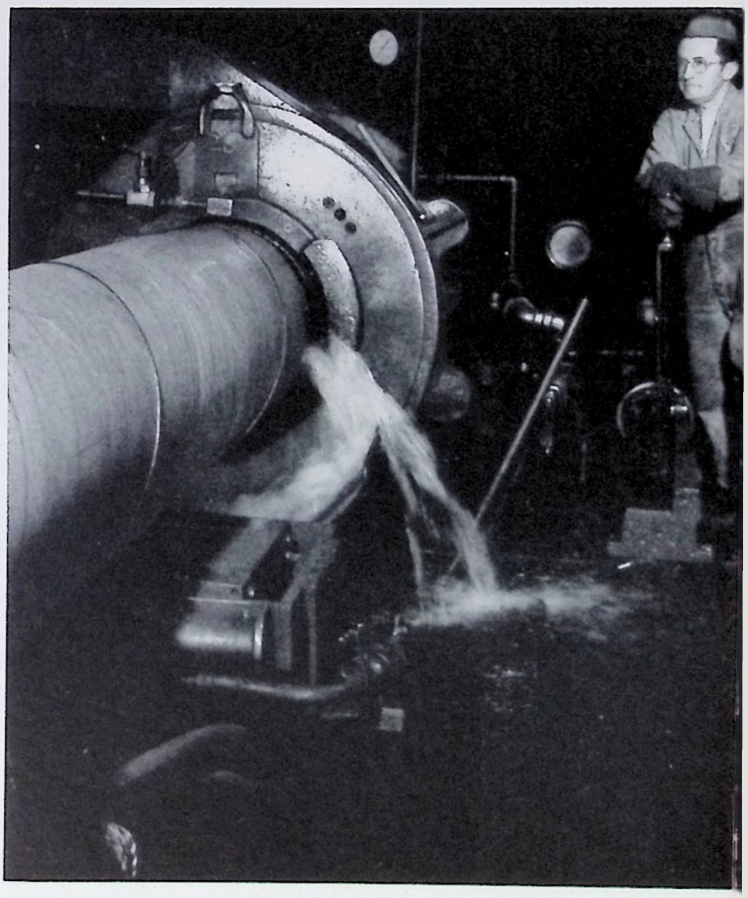
Lengths Up to 60 Feet

Armco Pipe is supplied in any length up to 60 feet. Where standard 60-foot sections can be used fewer joints are required, handling costs are lower. Long or short lengths of Armco Pipe may be hung with minimum clearance and the simplest of hanging fixtures.

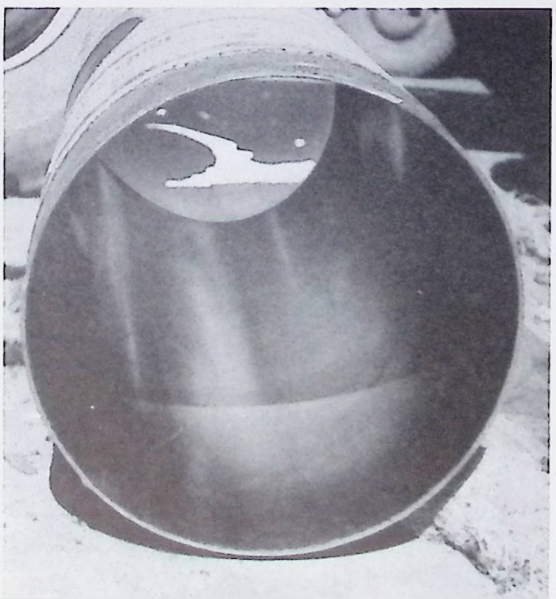
Economical Choice of Sizes

There are 20 standard diameters of Armco Pipe from 6 to 36 inches as shown in Table 6, pages 24 to 27. Wall thicknesses range from $\frac{7}{64}$ to $\frac{1}{2}$ inch. Intermediate wall thicknesses of 0.219″, 0.281″, and 0.438″ can also be supplied when quantities permit.

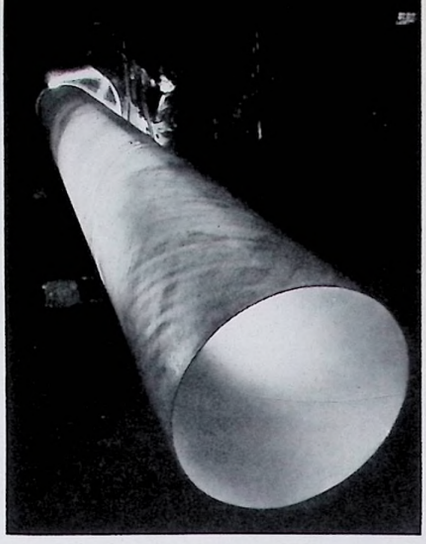
Rigidly tested. Each length of Armco Pipe must pass this rigid hydrostatic pressure test.



No loss of flow capacity after 17 years of water line service. This unretouched photo shows section of 24-inch-diameter Armco Pipe, 17 years old, that was removed to insert a tee fitting.



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HOW ARMCO PIPE IS MADE

Armco Welded Steel Pipe is made on automatic machines especially developed by Armco engineers to convert large coils of flat steel into pipe by a continuous process. The machine unrolls the coils, prepares the edges for welding, and spirally winds the cold steel into a continuous tube of the required diameter, with edges evenly butted. An automatic submerged-melt type electric arc welds the seam against a backing shoe as it leaves the forming element. This first pass or root weld is deposited flush or slightly above the surface of the pipe.

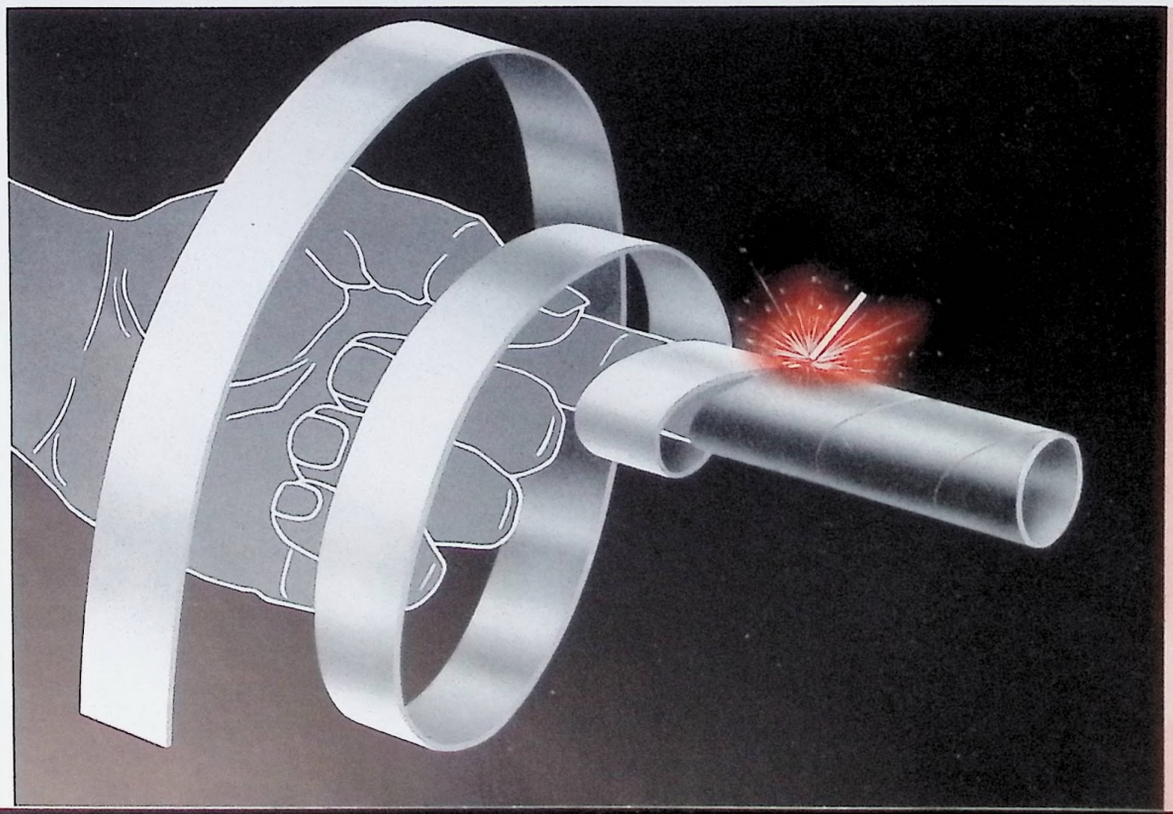
A second pass weld is deposited continuously over the root weld, penetrating to approximately one-half the wall thickness of the pipe (See figure 2). The pipe emerges from the machine and is cut to any desired length by an automatic cut-off device.

Welded Seam

The two-pass welding process used in making Armco Pipe is shown diagrammatically in Figure 3. This process produces a strong, dense weld, free from porosity. The second pass weld tends to heat-treat the root weld, resulting in a stronger, more ductile weld. In addition, the wide spread of the second weld provides additional face bead reinforcement.

Photomicrographs (Figure 2) show the nature of a

Figure 1. Armco Pipe is made by the Armco-developed continuous process on automatic machines.



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typical welded seam of Armco Pipe made by the two-pass submerged-arc welding process. The fine grain structure in the root weld indicates strong, tough, yet ductile properties. The junction zone and parent plate show grain patterns typical of submerged arc weld deposits made on quality open hearth or electric furnace steels.

Welding procedure used on the Armco Pipe machines is qualified in accordance with the American Welding Society Standard Qualification welding procedure, which includes written procedures covering each pipe machine and every pipe gage. The procedures cover weld, tensile, and bend tests for every pipe gage on every pipe machine.

The weld test specimens cut from Armco Pipe at right angles to the weld will meet all tests imposed in accordance with the requirements of the standard common-purpose steel pipe specifications. These specifications along with their required physical properties are listed on page 8.

The spiral method of forming Armco Pipe produces a cross section that is a commercially accurate circle. The finished pipe is the same size from end to end, and is straight even in long lengths. Manufacturing tolerances are given on pages 14 and 15.

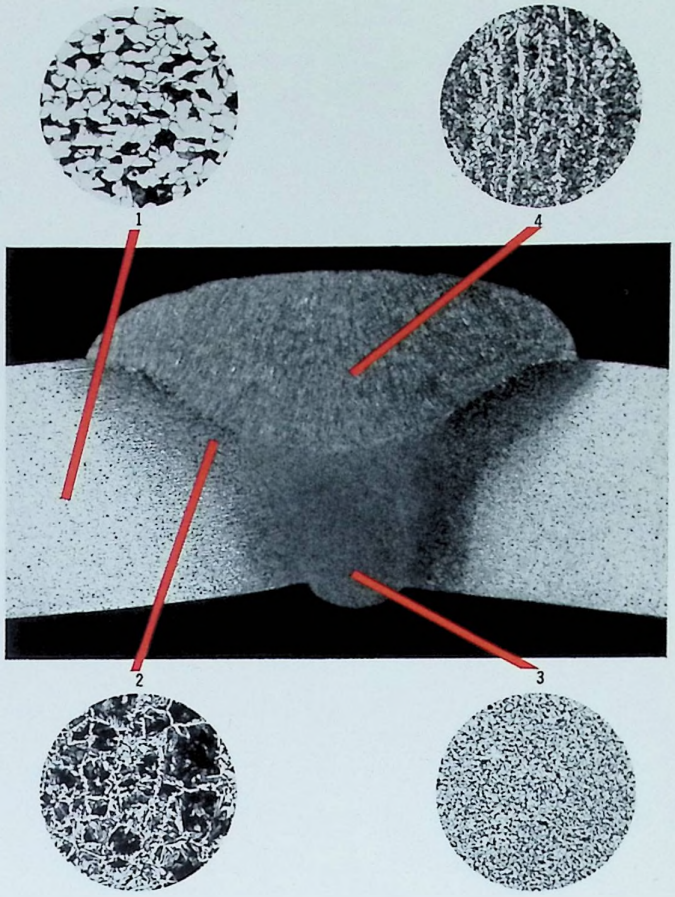
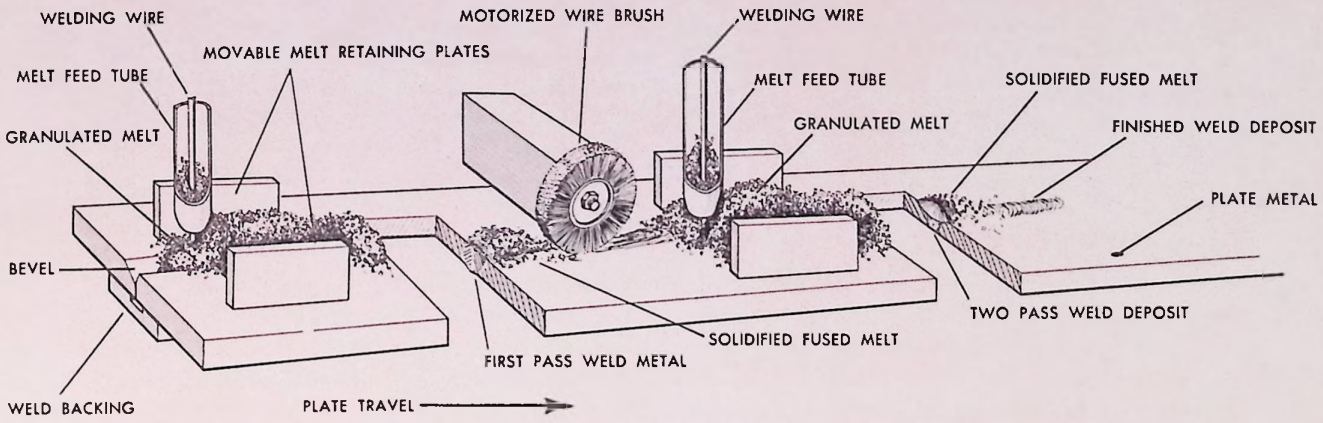
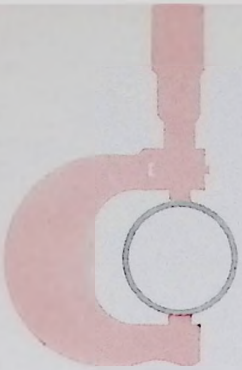


Figure 2. Photomicrographs showing grain structures in:
1. parent plate 2. junction zone 3. root weld deposit
4. cover weld deposit

Figure 3. Diagram of Armco Welding Process.



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Standard Specifications for Armco Pipe

The quality and grade of Armco Pipe are established by the requirements of any one of the following specifications.

1. ASTM Specification A-134, Electric-Fusion-Welded Steel Pipe, Size 16 Inches and Over.

Armco size range: **16 to 36 inch inclusive**
Steel (1): **Conforming to selected ASTM plate specification**

2. ASTM Specification A-139, Electric-Fusion-Welded Steel Pipe, Size 4 Inches and Over.

Armco size range: **6 to 36 inch inclusive**
Steel (1): **A-139 Grade B**
Tensile strength, min., psi 60,000
Yield point, min., psi 35,000

3. ASTM Specification A-211, Spiral Welded Steel or Iron Pipe.

Armco size range: **6 to 36 inch inclusive**
Steel (1): **A-139 Grade B**
Tensile Strength, min., psi 60,000
Yield point, min., psi 35,000

4. ASTM Specification A-252, Welded and Seamless Steel Pipe Piles.

Armco size range: **6 to 36 inch inclusive**
Steel (1): **A-252 Grade 2**
Tensile strength, min., psi 60,000
Yield point, min., psi 35,000

5. AWWA C-201 Standard for Electric-Fusion-Welded Steel Pipe, Size 30 Inches and Over.

Armco size range: **30 to 36 inch inclusive**
Steel (1): **ASTM A-283 Grade B**
Tensile strength, min., psi . . . . . 50,000 to 60,000
Yield point, min., psi 27,000

6. AWWA C-202 Standard for Steel Water Pipe, Size Less Than 30 Inches.

Armco size range: **6 to 28 inch inclusive**
Steel (1): **ASTM A-283 Grade B**
Tensile Strength, min., psi 48,000
Yield point, min., psi 30,000

7. Underwriters' Laboratories, Inc., Standard 888 for Steel Pipe Lines for Underground Water Service.

Armco size range: **6 to 36 inch inclusive**
Steel (1): **Standard 888**
Tensile strength, min., psi 48,000
Yield point, min., psi 30,000

NOTE: (1). Other steels may be obtained by special arrangement.

Compliance Certificate

When requested at the time of ordering, Armco will supply certified copies of reports of chemical analyses and physical properties of heats of steel, together with mill-tests report signifying compliance with specification requirements. See page 12.

Comparison with API Specification

For comparison purposes, the chemical and physical properties required by ASTM Specification A-139 Grade B to which Armco Pipe is made, and American Petroleum Institute Specifications for Line Pipe No. 5L Grade B are shown on page 9.

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CHEMICAL COMPOSITION

	API 5L Electric Welded Grade B	ASTM A-139 Grade B
Carbon (max.)	0.27	0.30 (1)
Manganese	1.35 (max.)	0.30-1.00
Phosphorus (max.)	0.04	0.04
Sulfur (max.)	0.05	0.05

TENSILE REQUIREMENTS

Yield strength	35,000	35,000
Tensile strength (psi)	60,000	60,000
Elongation (per cent in 2 inches)	(2)	(2)

NOTE: (1). The usual range in Armco Pipe is 0.20 to 0.30. The average is about 0.23.

NOTE: (2).

Wall thickness	Minimum Elongation, per cent in 2 inches*
.312 and over	30.00
.281	28.50
.250	27.00
.219	25.50
.188	24.00
.156	22.50
.125	21.00
.094	19.50
.062	18.00

*The computed minimum elongation values above are for each 1/32-inch decrease in wall thickness. Where the wall thickness lies between the two values shown above, the minimum elongation value shall be determined by the following formula:

$E = 48t + 15.00$

where E = per cent elongation in two inches
t = actual thickness of specimen in inches

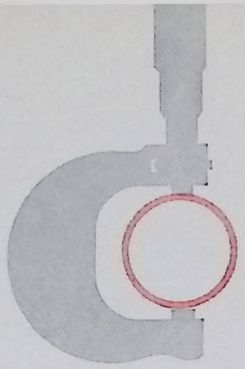
Table 1 PRODUCTION LIMITS ARMCO PIPE

WEIGHT PER FOOT OF UNCOATED PIPE

1	2	3	4	5	6	7	8	9	10	11	12
Outside Diameter Inches	Wall Thickness Inches[2]										
	.109	.141	.172	.188	.219	.250	.281	.312	.375	.438	.500
6	6.88	8.80	10.70	11.64	13.51						
6⅝	7.61	9.74	11.85	12.89	14.97						
8	9.22	11.80	14.36	15.64	18.18						
8⅝	9.95	12.74	15.20	16.90	19.64	22.36					
10	11.55	14.81	18.04	19.65	22.85	26.03					
10¾[1]	12.43	15.93	19.42	21.15	24.60	28.04	31.20				
12	13.89	17.81	21.71	23.65	27.52	31.37	35.20	39.01			
12¾	14.77	18.94	23.09	25.16	29.28	33.38	37.45	41.51			
14		20.82	25.38	27.66	32.20	36.71	41.21	45.68			
16		23.82	29.06	31.66	36.87	42.05	47.22	52.36	62.58		
18		26.82	32.73	35.67	41.54	47.39	53.22	59.03	70.59	82.15	
20		29.83	36.40	39.67	46.21	52.73	59.23	65.71	78.60	91.41	
22			40.07	43.68	50.88	58.07	65.24	72.38	86.61	100.75	114.81
24			43.74	47.68	55.56	63.41	71.25	79.06	94.62	110.10	125.49
26				51.69	60.23	68.75	77.25	85.73	102.63	119.44	136.17
28				55.69	64.90	74.09	83.26	92.41	110.64	128.79	146.85
30				59.70	69.58	79.43	89.27	99.08	118.65	138.13	157.53
32						84.77	95.28	105.76	126.66	147.48	168.21
34						90.11	101.28	112.43	134.67	156.82	178.89
36						95.45	107.29	119.11	142.68	166.17	189.57

1—10¾" O.D. pipe is made with a wall thickness of 0.279" instead of 0.281".
2—Other wall thicknesses within these production limits are available upon request.

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SPECIAL PROPERTIES AND CHARACTERISTICS OF ARMCO PIPE

In addition to meeting standard specifications, Armco Welded Steel Pipe offers you extra advantages.

Low residual welding stress

Armco Pipe has less residual welding stress than pipe made by other processing. The smaller the residual stresses in pipe the more strength remains to meet unforeseen or accidental overloads. A series of tests was made on Armco Pipe to determine residual stress due to forming and welding. Ring sections ½-inch long were cut from the pipe. These were then severed in the circumference at various points with reference to weld location. The amount of opening, or spring of the free edges, of the severed ring was used to determine the magnitude of locked-up stress. Typical test rings are shown in Figure 6. The stress was found to vary from a minimum of 100 psi to a maximum of 1,000 psi. The maximum is about 10% of similarly measured stresses in many commonly used standard pipes.

Resistance to shock

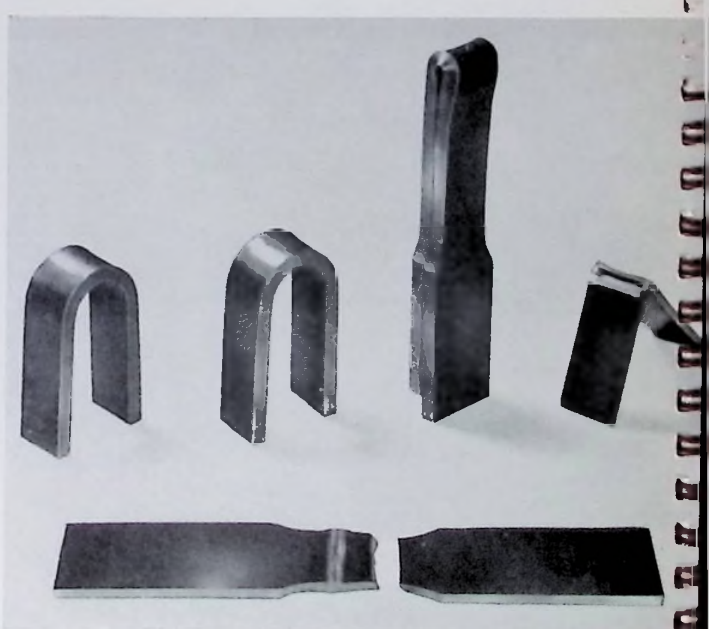
Shock does not rip Armco Pipe seams. This has been thoroughly demonstrated by the driving of thousands of Armco Foundation Pipe Piles. The heaviest of pile driving hammers were used without parting the welded seam. It has also been forcibly demonstrated by using dynamite. Figure 5 shows the result of exploding sufficient dynamite in 6-inch 0.219" wall pipe to practically sever the pipe. Rupture occurred in the pipe wall only at the point of explosion. Welds did not rip outside the general fracture zone.

Resistance to collapse

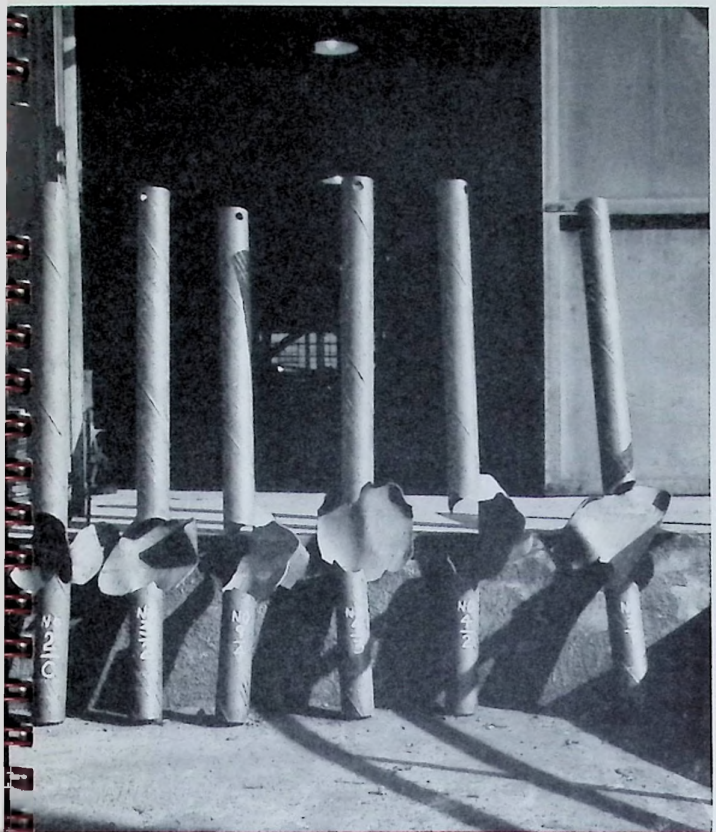
High resistance to collapse provides Armco Pipe with extra safety where the pipe is subjected to collapsing or crushing forces. (See Page 34 for more complete data.)

Average collapse pressures for Armco Pipe are tabulated in Column 19, Table 6, pages 24 to 27.

This higher and more consistent resistance to collapse exhibited by Armco Pipe is accounted for by its method of manufacture, its small out-of-roundness variation, the direction of rolling grain of the steel with relation to the pipe axis, the weld bead reinforcement, the freedom from high residual stress, the uniformity of wall thickness of pipe, and the physical properties of steel produced under close control of sheet and plate mill operation.



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ABOVE

Figure 5. Armco Pipe after dynamite test shows pipe wall severed only at point of explosion.

RIGHT

Figure 6. Typical test rings to determine locked-up stress in Armco Pipe show little out-of-roundness after rings are severed.

LEFT

Figure 4. Test specimens show sections of Armco Pipe after bending and tensile tests.

Special tests

Special tests made on Armco Pipe Steel that met requirements of ASTM Specifications A-139 Grade B (actual carbon 0.245, manganese 0.47) showed the following:

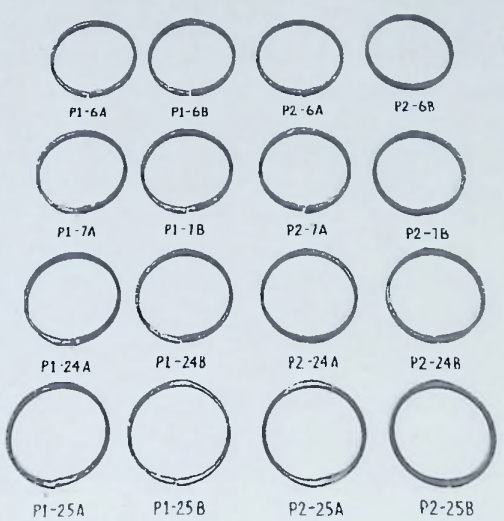
(a) Average hardness in "as rolled" condition—Brinell 150.

(b) In field welding, the steel may be cooled at any rate up to 130° F. per second through the critical range (Approximately 1100° to 1300° F.) without exceeding a Brinell of 200. This, according to the American Welding Society, is the desirable upper limit of hardness in welded joints that are not annealed or normalized.

(c) A welded joint may be quenched in water after it has cooled to 1250° F. (medium cherry) without exceeding a Brinell of 200.

Because of the excellent welding characteristics possessed by the steel in Armco Pipe, it may be field welded in minimum time using regular technique.

This is proved by the successful performance of thousands of field welds in Armco Pipe. Further proof is provided by thousands of fine splice welds in Armco Foundation Pipe where the heaviest pile driving blows must be absorbed by the welded joint without cracking or failing.



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ARMCO STANDARD MILL PRACTICE

Unless exceptions have been agreed upon by the purchaser and Armco, orders will be filled in accordance with Armco Standard Mill Practice.

Quality grade and compliance certificate

Pipe will be supplied to meet the requirements of one of the specifications given on page 8 as designated by the purchaser. If the order is of rolling quantity, and if the request is made at time of ordering, copies of certified mill test reports showing compliance will be provided.

If the purchaser does not specify quality or grade, pipe usually will be supplied in accordance with the requirements of ASTM Specification A-139 Grade B. However, when the purchaser does not specify, Armco may, at its option, supply pipe made in accordance with the requirements of other suitable specifications.

In general, certified mill test reports cannot be provided for pipe taken from mill stock.

Methods of making chemical analysis

Methods of analysis are in accordance with latest edition of "Methods of Chemical Analysis of Metals" published by the American Society for Testing Materials. Check analyses, when specified, are made in accordance with the latest edition of Steel Products Manual, Steel Tubular Products section, published by the American Iron and Steel Institute.

Carbon content when unspecified

Where carbon requirement is not covered by specification, Armco practice fixes carbon content at 0.30% maximum, unless otherwise specified by customer. Usual range is 0.20 to 0.30 per cent.

Tensile testing

Tensile testing required by specifications is conducted at room temperature in accordance with procedures established by the American Society for Testing Materials.

Hydrostatic testing

Unless otherwise required by specification, or by agreement between Armco and the purchaser, all pipe will be hydrostatically tested to the pressures shown in Column 14, Table 6, pages 24 to 27.

End finish

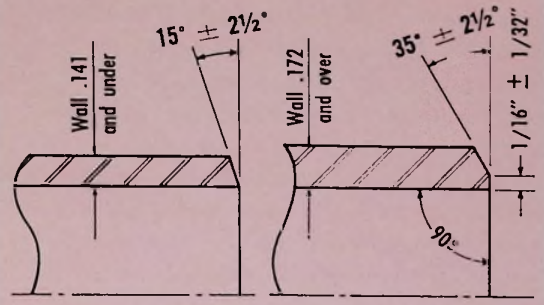
Armco Pipe is available with several standard end finishes which may be selected by the purchaser.

Orders for pipe specifying simply "plain ends," "ends for field welding" or "ends for Dresser Couplings" will be filled in accordance with Armco standards unless specifically designated otherwise by the purchaser at time of ordering.

To avoid misunderstanding, references in correspondence and in orders should be worded as follows.

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Figure 7—Armco Standard End Bevel.



1. Ends beveled for field welding with weld bead removed 6 inches

End facing to standard bevel profile is done by cutting tool in special machine. The standard bevel shown in Figure 7 is used unless otherwise designated on the order. Notice that the angle of bevel is measured from a plane perpendicular to the pipe axis. The mill weld bead is removed for a distance of 6 inches at the end of the pipe to permit the use of standard line-up clamps.

2. Ends beveled for field welding (special)

Same as End Finish No. 1 except weld bead is not removed at the ends of the pipe. This type of end finish is used on inventory stock pipe.

3. Ends flame cut

An automatic gas torch cuts the pipe as it leaves the pipe machine. The resulting cut is slightly beveled and fairly smooth. Burrs are removed by grinding.

4. Ends for Dresser couplings—8 inches

After flame cutting (End No. 3), the weld bead is removed for a distance of 8 inches from the end of the pipe. Ends are sufficiently smooth to provide a tight joint make-up using a rubber gasket type of coupling.

5. Ends square cut

End facing in a plane perpendicular to the pipe axis is done by cutting tool in special machine.

6. Ends flanged

Pipe is flame cut and flanges attached by fillet welding at face and back of flange. Required flange must be specified as to material, class, and drilling template.

7. Ends for Flange Attachment in Field—Weld Bead removed 3 inches from ends

After square cutting (end finish No. 5) or after squaring ends by hand grinding, in the case of special analysis pipe, the weld bead is removed for a distance of 3 inches at the ends of the pipe.

8. Grooved adaptor ends

For Victaulic, Tite-Line and Gruvagrip Couplings a short section of standard steel pipe or welded band, of approximately Schedule 40 thickness, having a machined groove of required dimensions is butt-welded to or slipped over the end of Armco Pipe. Exposed ends of adaptors are tool cut. Pipe in the smaller sizes with this type of end should preferably be in 6⅝" OD, 8⅝" OD, 10¾" OD, or 12¾" OD rather than 6" OD, 8" OD, 10" OD, or 12" OD.

Mill priming

Unless otherwise specified by the purchaser, all line pipe will be shipped bare with no mill primer applied. However, certain standard pipe-line primers are readily available mill-applied on Armco Pipe when so specified. These are optional with the purchaser of the pipe and are listed below.

Pipe lengths prepared for field welding will not be prime coated for a short distance at the ends.

Only standard primer coats are given here. Information on types of heavy protective coatings, including hot-dipped galvanizing will be supplied on request.

1. Mill primer for bituminous field follower coat

   Specify: Coal Tar Pipeline Primer

   A single sprayed or brushed coat of coal tar base, or asphalt base, priming solution is applied to the outside of the pipe. These primers are recommended respectively where field applications of coal tar enamel or asphalt enamel are contemplated. *Unless a particular brand or primer is specified, a common coal tar base brand will be furnished.* This means that if an asphalt primer is required, it should be specified on the order, because an asphalt follower coat should not be applied over a coal tar primer.

   Note: Oil paints should not be used over coal tar or asphalt base primers because the underlying black coat will permeate and discolor subsequent coats of oil paints.

2. Mill primer for subsequent oil paint coat

   Specify: Red mill coat

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Red iron oxide synthetic enamel is applied to the outside of the pipe for protection during transit and installation. It is strictly for atmospheric use and not for underground exposure. *This pipe is* comparable with the ordinary "black" pipe of industry. The coating forms a good base for any of the common oil paints. It may be used on steam lines if desired since it is not affected by temperatures under 500° F.

Methods of loading and shipping

In loading Armco Pipe at the mill, every precaution is taken to securely bind pipe in cars in accordance with the requirements of loading specifications of the American Association of Railroads (AAR). However, if in spite of all precautions, damage results beyond the usual scuff marks, it may be necessary to make a claim against the carrier. This claim may be handled by Armco or by the purchaser. It cannot be handled without proper cooperation on the part of the contractor who is unloading the pipe. Note this especially. *Damage for which claim is to be made must be noted in writing on the freight bill by the local freight agent over his own signature before the car is unloaded.* This is a railroad requirement and a prerequisite to the establishment of any claim for damage.

Under certain circumstances and in some localities, pieces of pipe moving in less-carload quantities should be checked for size and length to avoid excessive freight charges. Therefore, on less-carload shipments it is best to consult the mill regarding freight costs.

It is not always possible to obtain a minimum car weight due to the bulk of the pipe when loading the larger diameters with the thinner wall thicknesses. This should be considered in estimating freight costs.

When orders cover several sizes of pipe in combination shipment, especially with the larger sizes, a loading problem may develop.

On request, Armco will aid in determining the best loading arrangement for such a mixture of pipe sizes to obtain lowest freight charges.



ARMCO STANDARD TOLERANCES AND PERMISSIBLE VARIATIONS

Unless otherwise specifically agreed upon by the agent or purchaser and Armco, pipe shall be accepted by inspectors when variations from the nominal dimensions do not exceed the following:

1. Diameter of pipe barrel at any point in a length

(As determined by circumferential measurement)

Size OD (ins.)	Tolerance *Over*	Tolerance *Under*
Over 6 to 8⅝ incl.	1/16"	1/32"
Over 8⅝ to 18 incl.	3/32"	1/32"
Over 18 to 24 incl.	1/8"	1/32"
Over 24 to 36 incl.	½%	½%

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2. Diameter of pipe ends

a. Sizes 10¾ inch OD and smaller shall not be more than 1/64-inch smaller than the nominal outside diameter for a distance of 4 inches from the end and shall permit the passing for a distance of 4 inches of a ring gage which has a bore 1/16-inch larger than the nominal outside diameter of the pipe.

b. Sizes over 10¾ inch OD to and including 36 inch OD shall not be more than 1/32-inch smaller than the nominal outside diameter for a distance of 4 inches from the end of the pipe and shall permit the passing for a distance of 4 inches of a ring gage which has a bore 3/32-inch larger than the nominal outside diameter of the pipe. The outside diameter may be measured with a diameter tape.

3. End Finish

a. Ends for field welding: Diameter tolerances shall be in accordance with those given in paragraph 2.

b. Ends for Dresser Couplings: Diameter tolerances shall be in accordance with those given in paragraph 2, except that the ring shall pass over the pipe a distance of 8 inches.

c. *Ends Flame Cut*

Out of Square tolerance:

6 inch OD through 12 inch OD inclusive: ⅛ inch, 12¾ inch OD through 36 inch OD inclusive: ¼ inch.

Note: This tolerance represents the maximum distance between any point on the end of the pipe barrel and a plane perpendicular to the pipe axis and passing through any other point on the end of the pipe barrel.

d. Ends of other types: Tolerances for ends other than those for field welding or for Dresser Couplings shall be fixed by agreement between the purchaser and Armco.

4. End bevel

All plain end pipe with beveled ends:

a. Wall thickness 0.172 inch and over:

Outside bevel: 35 degrees, plus 2½ degrees, minus 2½ degrees.

Width of flat at end of pipe: 1/16-inch, plus 1/32-inch, minus 1/32-inch.

b. Wall thickness less than 0.172 inch:

Outside bevel: 15 degrees, plus 2½ degrees, minus 2½ degrees.

Width of flat at end of pipe: None.

5. Wall thickness

Permissible variation:

Minus 0.01 inch.

Over-thickness governed by weight tolerance.

6. Weight

For single lengths of pipe:

Wall thickness 0.188 inch or less:

Plus 10 per cent.

Minus 5 per cent.

Wall thickness over 0.188 inch:

Plus 10 per cent.

Minus 3.5 per cent.

Carload weight:

Minus 1¾ per cent.

7. Length

Definite cut lengths, all sizes:

(a) 24 feet and under, plus ⅛-inch; minus ⅛-inch.

(b) Over 24 feet to 34 feet inclusive: plus 5/16-inch; minus 0 inch.

(c) Over 34 feet; plus 5/16-inch increased by 1/16-inch for each additional 10 feet of length over 34 feet; minus 0 inch.

Line pipe and pipe piling:

(a) Up to 50 feet, plus ½-inch, minus ½ inch.

(b) Over 50 feet, plus 1 inch, minus 1 inch.

8. Straightness

Pipe is supplied reasonably straight as common practice. When specific straightness requirements are necessary, the misalignment shall be determined using a 10 foot straight edge so placed that both ends are in contact with the pipe. The clearance between pipe and straight edge shall not exceed ⅛-inch. Out-of-roundness shall be considered in making this measurement.

9. Out-of-roundness

The difference between major and minor outside diameters shall not exceed 1 per cent of the nominal outside diameter. If the wall thickness-diameter ratio is such that the pipe barrel is flexed by its own weight, the pipe shall be rotated to four successive positions so that all measurements of the major and minor diameters are made twice in a vertical position. The average out-of-roundness shall be determined from these measurements.

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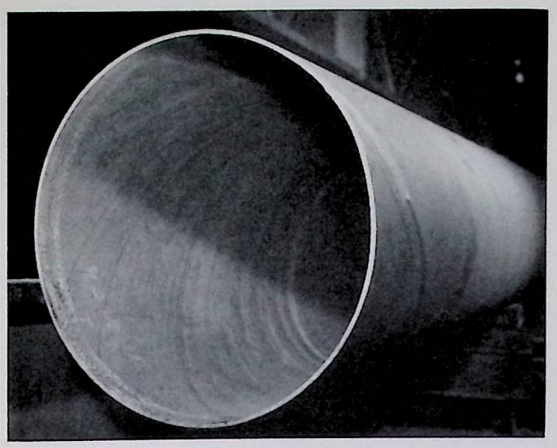
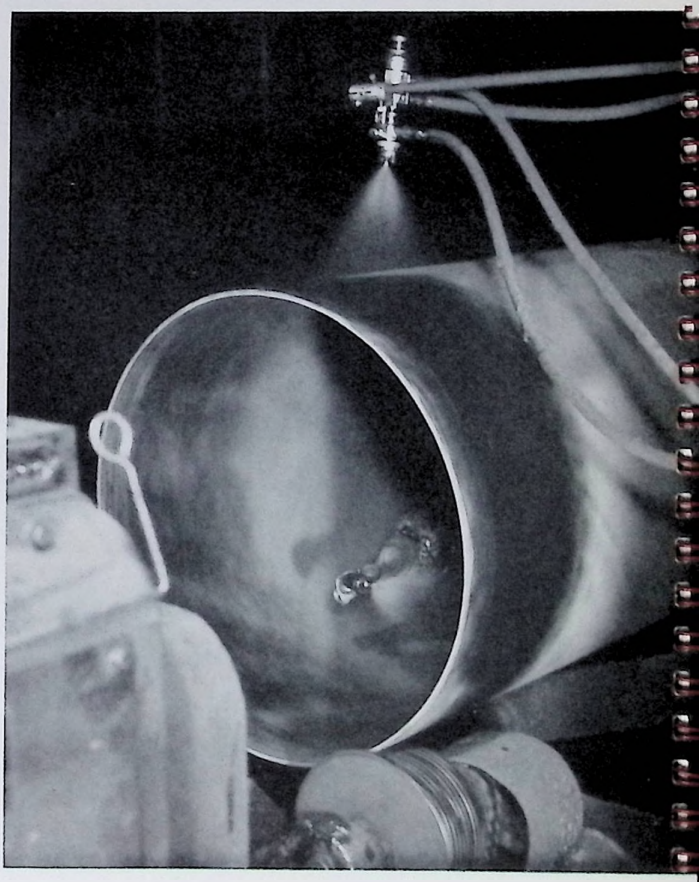


Figure 8. Shot-blasting in the Armco Coating Mill leaves the pipe with a clean, bare surface, slightly roughened to take the primer coat.

LININGS AND COATINGS FOR ARMCO PIPE



Pipe preparation

Before applying coal tar enamel primer, the bare pipe is completely dried and steel shot-blasted inside and out. Shot-blasting removes all scale, grease, rust, and other surface contaminants leaving the clean, bare pipe with a slightly roughened surface for the priming coat.

Bare pipe or mill-primed pipe can also be supplied for customer application of linings and coatings.

Primers

Primers are sprayed on the inside and/or outside of the pipe immediately after shot-blasting. The following primers are available on Armco Pipe:

1. *Synthetic red oxide enamel*—This primer provides pipe protection during shipment and installation. It forms a good base for any of the common oil paints. It is not recommended as a base for coal tar or asphalt coatings.

2. *Synthetic red lead primer*—This primer, conforming to AWWA Standard C-203, is used as a prime coat for oil based paints.

3. *Coal tar primer*—Used as primer for all coal tar linings and coatings. It is not recommended as a primer for oil-based paints.

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Outside Coatings

The following outside coating materials can be supplied on Armco Pipe:

1. Coal tar enamel coatings*
2. Asbestos-felt wrap*
3. Fibrous glass wrap*
4. Heavy kraft paper for heat reflection*
5. Water-resistant whitewash for heat reflections*
6. Asphaltum paint (may be specified on dredge pipe)

**Note*—Various combinations of these coatings may be specified to meet AWWA Standard C-203 and commonly accepted pipe line industry practice. For example, a complete protective coating could consist of the following: coal tar enamel primer; coal tar enamel coating; asbestos felt wrap; kraft paper wrapping. Many other combinations of these materials are also commonly specified.

Inside linings

The following inside lining materials are available on Armco Pipe:

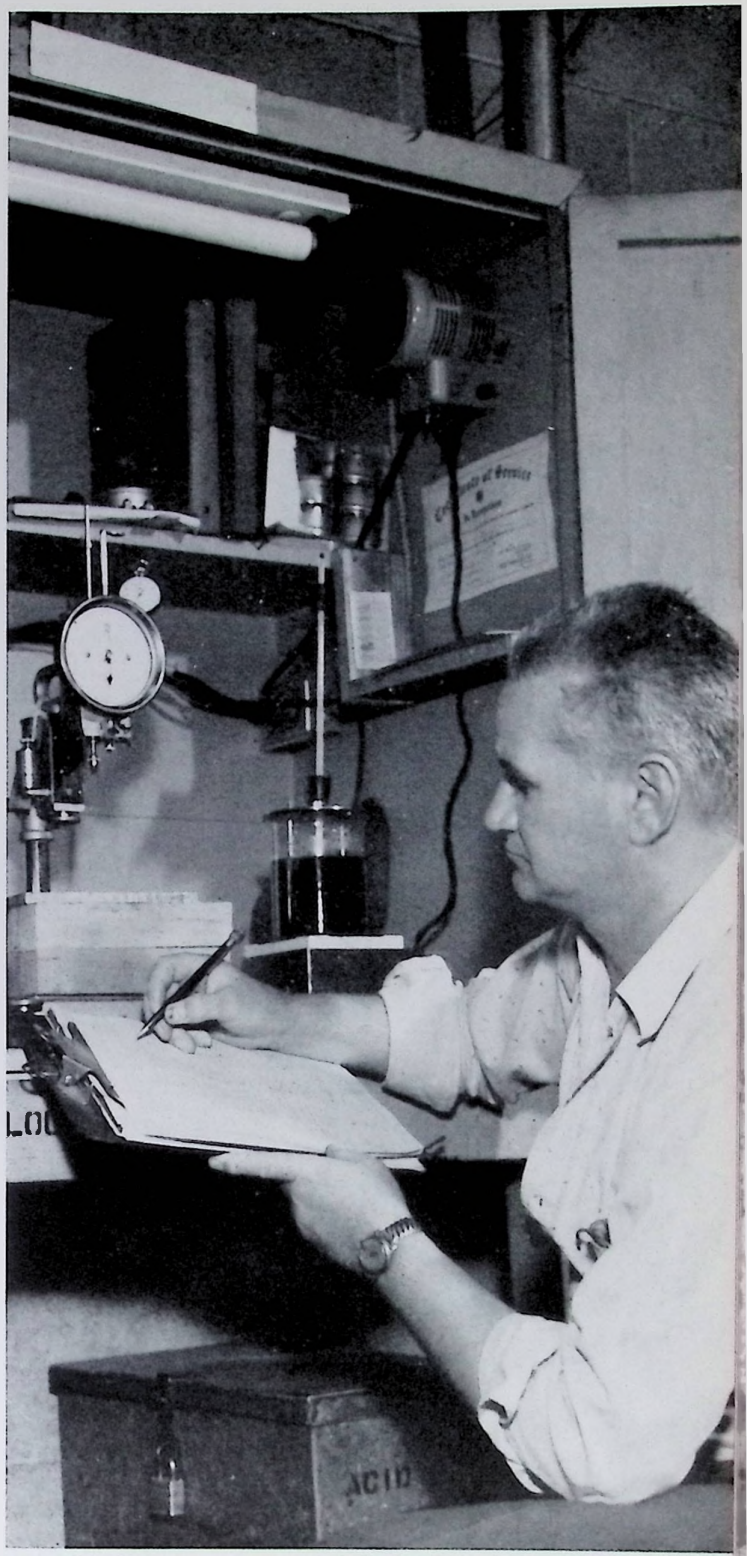
1. *Centrifugally spun coal tar enamel*—This lining, in accordance with AWWA Standard C-203, produces a smooth, glossy interior with a high flow capacity. It prevents tuberculation. Thickness of the lining is 3/32" plus or minus 1/32".

2. *Coal tar solution*—This material provides interior protection for use with non-aggressive waters.

Galvanizing

Armco Pipe can be supplied with a hot-dip galvanized coating in accordance with ASTM Specification C-123. After fabrication the pipe is cleaned, pickled, washed, and immersed in a bath of molten zinc to produce a galvanized coating weighing from 2 to 4 ounces per square foot of double exposed surface.

For long lengths or special or odd-shaped sections, allowances must be made for the size of the dipping vat. In some cases more than one immersion may be required. Each case is dealt with individually according to its own requirements.



LEFT:
Figure 9. Primer coat is sprayed on the inside and/or outside of the pipe while it is being spun. This provides a uniform base coat.

RIGHT:
Figure 10. Tests to control quality of linings and coatings are conducted at the Armco Coating Mill to maintain high standards of performance.

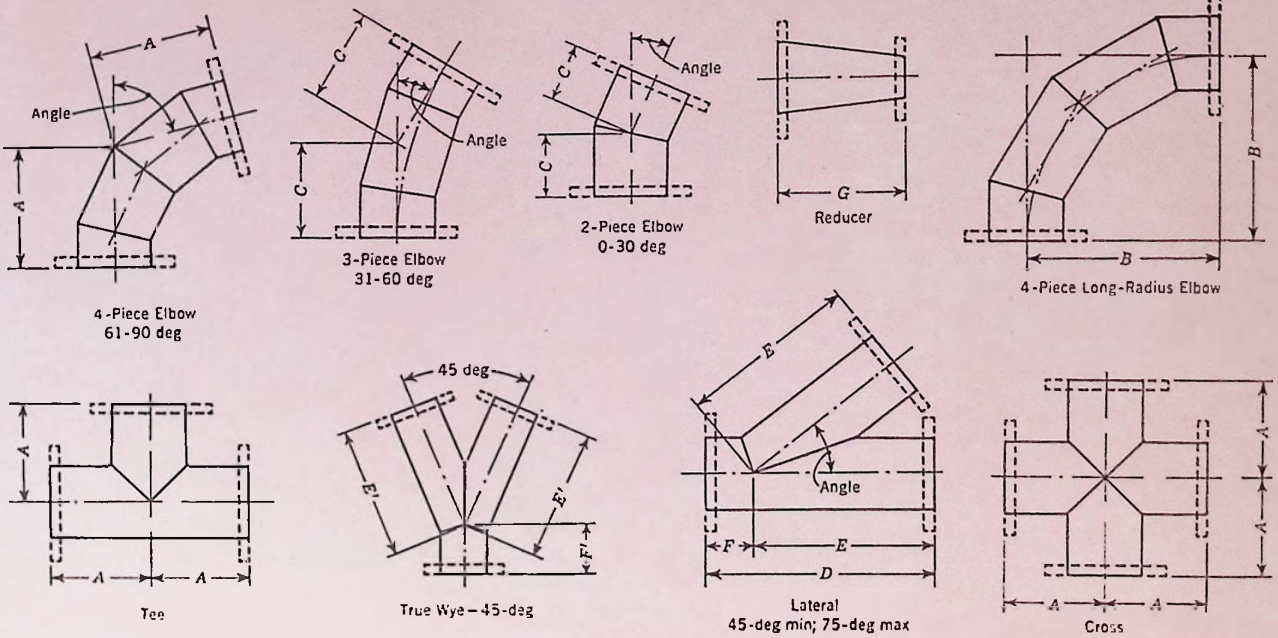
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Figure 11. Examples of special Armco Fittings. By using fittings fabricated to order, the designer has more flexibility in designing piping systems to meet specific needs.

STANDARD AND SPECIAL FITTINGS

Standard Fittings for Armco Pipe



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With Armco Welded Steel Pipe the problem of fittings is greatly simplified. Since Armco Pipe is a welded product, only steels of the highest welding quality are used. Standard or special fittings can be fabricated from Armco Pipe to meet individual plans.

Using Armco Pipe, an entire pipe layout may be designed with fittings integral with straight lengths of pipe. The number of joints is reduced. This not only eliminates the first cost of the joint, but also makes erection easier and reduces the possibility of joint leakage. Piping designed in this manner is easier to support or suspend than systems using a larger number of individual fittings.

Armco Fittings fabricated to order

Modern industry has found that Armco Fittings fabricated to order offer a practical way to save installation time and labor, reduce maintenance costs, and insure a perfect fit.

The Armco Fitting Shop is well equipped to fabricate unusual, special, or complicated piping systems. Layout plans of proposed piping may be submitted to Armco for price estimates or quotations.



Designers have found that it is not necessary to fit together standard, unvariable, individual units of tees, wyes, elbows, laterals, and other accessories, each of which require a separate joint. By using Armco Steel Pipe, fittings can be made to order with the fewest number of joints.

Table 2 DIMENSIONS OF FITTINGS (all dimensions in inches)

Nominal Diameter Inches	Tee		Cross	Lateral** (45-75 deg.)		True Wye (45 deg.)		Elbows				Reducer
	Run A+A	Outlet A	A+A	Run D	Outlet E	E′	F′	Two-Piece (0-30 deg.) C	Three-Piece (31-60 deg.) C	Four-Piece (61-90 deg.) A	Four-Piece Long-Radius B	Cone G
6	16	8	16	18	14.5	8	3.5	5	5	8	11.5	9
8	18	9	18	22	17.5	9	4.5	5.5	5.5	9	14	11
10	22	11	22	25.5	20.5	11	5	6.5	6.5	11	16.5	12
12	24	12	24	30	24.5	12	5.5	7.5	7.5	12	19	14
14	28	14	28	33	27	14	6	7.5	7.5	14	21.5	16
16	30	15	30	36.5	30	15	6.5	8	8	15	24	18
18	33	16.5	33	39	32	16.5	7	8.5	8.5	16.5	26.5	19
20	36	18	36	43	35	18	8	9.5	9.5	18	29	20
22	40	20	40	46	37.5			10	10	20	31.5	22
24	44	22	44	49.5	40.5	22	9	11	11	22	34	24
30	50	25	50	59	49	25	10	15	15	25	41.5	30
36	56	28	56	84	60			18	18	28	49	36

*All dimensions conform to ASA B16.1 for cast iron pipe flanged fittings and AWWA Standard C-208 for steel water pipe flanged fittings Class 125.

**Except for laterals, mechanical couplings may be used with these fittings by adding 8" to each leg for sizes up to 30 inches and adding 10" to sizes 30" and over. Dimensions for mechanically-joined laterals will be supplied upon request.

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JOINTS FOR ARMCO PIPE

Flanged Joints

Armco flanges are the slip-on type. They are welded to the pipe at the end of the barrel inside and at the back of the flange outside. Armco supplies flanges of cast steel, forged steel, or steel ring without hub.

Unless otherwise specified, it is common practice to attach flanges with bolt holes straddling vertical and horizontal center lines. On all flanges attached to tees, wyes, elbows, or similar fittings, bolt holes will straddle the plane of the fitting unless otherwise specified.

Following are dimensions of some of the more common flanges used with Armco Pipe.

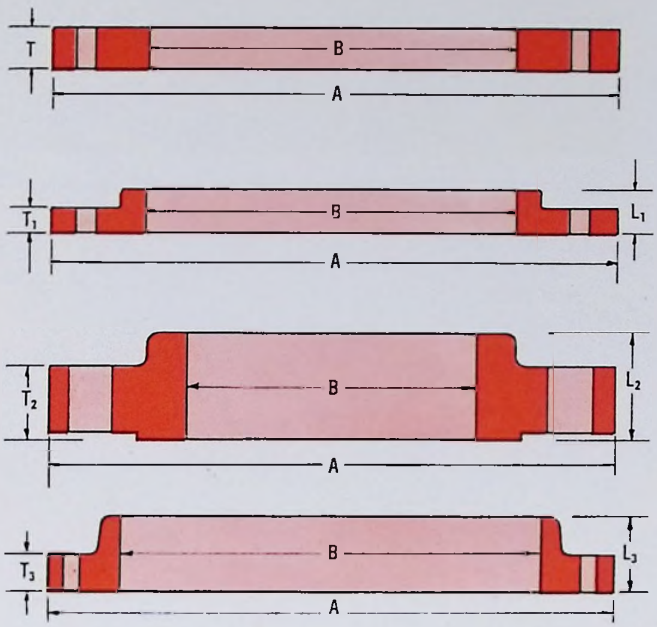


Figure 12. Steel ring, AWWA C-207, Class D

Water service rating at atmospheric temperature: sizes 6" to 12" incl. 175 psi; sizes larger than 12" 150 psi. These flanges have the same diameter and drilling as Class 125 cast iron flanges (ASA B16.1). In sizes 24" and smaller they also match the diameter and drilling of ASA B16.5 150 psi standard for steel flanges, designed for 1/16" thick cloth-inserted rubber gaskets extending to bolt holes.

Figure 13. Forged steel, light type

This is a light type forged steel flange to connect with fittings having 125 lb. American Standard cast iron flanges. This flange is flat faced and may be used with a full or part faced gasket.

Figure 14. Forged steel, 150 lb., ASA B 16.5

Primary service pressure rating is 150 psi. For complete pressure-temperature rating refer to American Standard ASA B16.5, 150-pound standard for steel flanges with standard facing.

Figure 15. Forged steel, 125 lb., large diameter

This flange has the same general dimensions and drilling as 125 lb. American Standard for cast iron (ASA B16.1) and has the same pressure ratings as cast iron flanges.

Table 3 DIMENSIONS OF SLIP-ON FLANGES (all dimensions in inches)

Pipe diameter (nominal OD)	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
"A" (OD)	11	13½	16	19	21	23½	25	27½	29½	32	34¼	36½	38¾	41¾	43¾	46
"B" (ID)																
"T" (thickness)	11/16	11/16	11/16	13/16	15/16	1	1 1/16	1 1/8	1 3/16	1 1/4	1 5/16	1 5/16	1 3/8	1 1/2	1 1/2	1 5/8
"T1" (thickness)	5/16	5/16	11/16	11/16	3/4	3/4	3/4	3/4	1	1	1	1	1	1 1/8	1 1/8	1 1/8
"T2" (thickness)	1	1 1/8	1 3/16	1 1/4	1 3/8	1 3/16	1 5/16	1 11/16		1 3/8						
"T3" (thickness)											2	2 1/16	2 1/8	2 1/4	2 5/16	2 3/8
"L1" (length)	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¾	1¾	1¾	1¾	1¾	1¾	1¾	1¾
"L2" (length)	1 5/16	1¾	1 15/16	2 3/16	2¼	2½	2 11/16	2⅞	3⅛	3¼						
"L3" (length)											3 3/8	3 7/16	3½	3 5/8	3 11/16	3¾
Drilling template																
Number of bolts	8	8	12	12	12	16	16	20	20	20	24	28	28	28	32	32
Bolt diameter	¾	¾	⅞	⅞	1	1	1⅛	1⅛	1¼	1¼	1¼	1¼	1¼	1½	1½	1½
Diam. bolt circle	9½	11¾	14¼	17	18¾	21¼	22¾	25	27¼	29½	31¾	34	36	38½	40½	42¾

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Other flanges

In addition to the above, Armco can supply the following flanges:

1. AWWA Standard C 207 Class B (similar to ASA B16b2 for 25 psi cast iron pipe flanges.)
2. Armco Spiral Pipe Standard (Light weight flange having outside diameter and thickness less than ASA Standards. Used on low pressure lines.)
3. 300 lb. American Standard B 16.5.
4. 250 lb. large diameter (Flanges have the same general dimensions and drilling as 250 lb. American Standard for cast iron B16b.)

Dresser Couplings

The welded seam is ground flush with the pipe barrel for approximately 8 inches from the end to accommodate the Dresser Coupling. This coupling may be used on high or low pressure lines or on lines operating under full vacuum. Gaskets may be obtained for use on hot or cold lines carrying water, air, gas, or gasoline or other contents. Type of service should be stated when ordering.

The Dresser Coupling safely permits deflection of the pipe at the joints. See page 35 for deflection data. No threading, beveling, exact pipe fitting and alignment, or other special pipe end preparation is required. The resilient gaskets absorb vibration, expansion-contraction and other pipe movement. The only joining tool required is a wrench.

Figure 16. Style 38 Dresser Coupling

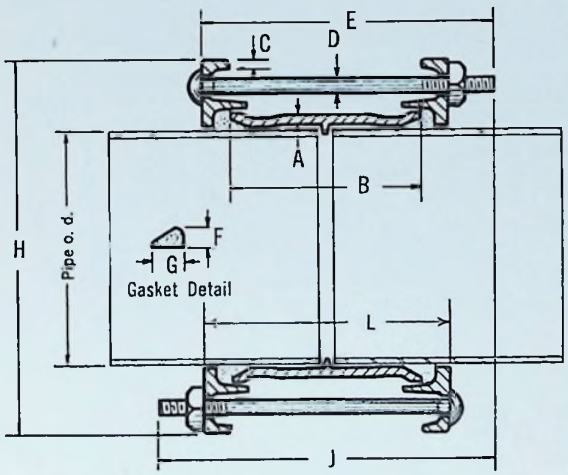


Table 4 Data and Dimensions of Style 38 Dresser Couplings for steel pipe

(see figure 16)

1	2	3	4	5	6	7	8	9
Steel Pipe OD	MIDDLE RING[1] Thickness and Length (A & B)	FOLLOWER RINGS Thickness (C)	BOLTS Number, Diameter and Length (D & E)	GASKETS Section Dimensions Thickness & Length (F & G)	OVERALL DIMENSIONS Diam. (H)	OVERALL DIMENSIONS Length (J)[2]	OVERALL DIMENSIONS Length (L)[2]	WORKING[4] PRESS. Lbs. per Sq. In. (Max.)
*6.000	.134 x 4	.134	4—½ x 6	⅜ x ⅞	9	7⅝	5¼	
6.000	¼ x 5	¼	6—⅝ x 8	½ x 1	9⅞	10⅛	6⅞	1126
6.000	¼ x 7	¼	6—⅝ x 10	½ x 1	9⅞	12⅛	8⅞	1126
*6.625	3/16 x 4	.134	4—½ x 6	⅜ x ⅞	9¾	7⅝	5¼	
6.625	¼ x 5	¼	6—⅝ x 8	½ x 1	10½	10⅛	6⅞	1029
6.625	¼ x 7	¼	6—⅝ x 10	½ x 1	10½	12⅛	8⅞	1029
*7.000	3/16 x 4	3/16	4—⅝ x 6½	⅜ x ⅞	10⅝	8⅛	5¾	
7.000	¼ x 5	¼	6—⅝ x 8	½ x 1	11	10⅛	6⅞	979
7.000	¼ x 7	¼	6—⅝ x 10	½ x 1	11	12⅛	8⅞	979
*8.000	3/16 x 4	.146	5—½ x 6	⅜ x ⅞	11	7⅝	5¼	
8.000	¼ x 5	¼	6—⅝ x 8	½ x 1	11⅞	10⅛	6⅞	866
8.000	¼ x 7	¼	6—⅝ x 10	½ x 1	11⅞	12⅛	8⅞	866
*8.625	3/16 x 4	.146	6—½ x 6	⅜ x ⅞	11⅝	7⅝	5¼	
8.625	¼ x 5	¼	6—⅝ x 8	½ x 1 1/16	12 1/16	10⅛	6⅞	807
8.625	¼ x 7	¼	6—⅝ x 10	½ x 1 1/16	12 1/16	12⅛	8⅞	807
8.625	5/16 x 5	5/16	6—⅝ x 8½	½ x 1 1/16	12 1/16	10⅞	7⅜	996
8.625	5/16 x 7	5/16	6—⅝ x 10½	½ x 1 1/16	12 1/16	12⅞	9⅜	996
*10.000	¼ x 5	3/16	8—⅝ x 7½	½ x 1	13⅜	9⅝	6⅜	
10.000	¼ x 5	¼	8—⅝ x 8	½ x 1	13⅜	10⅛	6⅞	703
10.000	¼ x 7	¼	8—⅝ x 10	½ x 1	13⅜	12⅛	8⅞	703
10.750	¼ x 5	¼	8—⅝ x 8	½ x 1 1/16	14⅜	10⅛	6⅞	657
10.750	¼ x 7	¼	8—⅝ x 10	½ x 1 1/16	14⅜	12⅛	8⅞	657
10.750	5/16 x 5	5/16	8—⅝ x 8½	½ x 1 1/16	14¾	10⅞	7⅜	813
10.750	5/16 x 7	5/16	8—⅝ x 10½	½ x 1 1/16	14¾	12⅞	9⅜	813
*12.000	¼ x 5	3/16	8—⅝ x 7½	½ x 1	15⅜	9⅝	6⅜	
12.000	¼ x 5	¼	8—⅝ x 8	½ x 1	16⅛	10⅛	6⅞	591
12.000	¼ x 7	¼	8—⅝ x 10	½ x 1	16⅛	12⅛	8⅞	591
12.750	¼ x 5	¼	8—⅝ x 8	½ x 1 1/16	16¾	10⅛	6⅞	558
12.750	¼ x 7	¼	8—⅝ x 10	½ x 1 1/16	16¾	12⅛	8⅞	558
15.750	5/16 x 5	5/16	8—⅝ x 8½	½ x 1 1/16	16⅞	10⅞	7⅜	691
12.750	5/16 x 7	5/16	8—⅝ x 10½	½ x 1 1/16	16⅞	12⅞	9⅜	691
14.000	¼ x 5	¼	8—⅝ x 8½	½ x 1 1/16	18	11⅛	7⅛	510
14.000	¼ x 7	¼	8—⅝ x 10½	½ x 1 1/16	18	13⅛	9⅛	510
14.000	5/16 x 5	5/16	8—⅝ x 8½	½ x 1 1/16	18⅛	10⅞	7⅜	633
14.000	5/16 x 7	5/16	8—⅝ x 10½	½ x 1 1/16	18⅛	12⅞	9⅜	633
16.000	¼ x 7	¼	10—⅝ x 10½	½ x 1 1/16	20	13⅛	9⅛	449
16.000	5/16 x 7	5/16	10—⅝ x 10½	½ x 1 1/16	20⅛	12⅞	9⅜	557
16.000	⅜ x 7	11/32	10—⅝ x 10½	⅝ x 1 3/16	20 7/16	12¾	9⅝	664
18.000	¼ x 7	¼	10—⅝ x 10½	½ x 1 1/16	22	13⅛	9⅛	401
18.000	5/16 x 7	5/16	10—⅝ x 10½	½ x 1 1/16	22 1/16	12⅞	9⅜	498
18.000	⅜ x 7	11/32	10—⅝ x 10½	⅝ x 1 3/16	22 7/16	12¾	9⅝	594
20.000	¼ x 7	¼	12—⅝ x 10½	½ x 1 1/16	24 1/16	13⅛	9⅛	362
20.000	5/16 x 7	5/16	12—⅝ x 10½	½ x 1 1/16	24 1/16	12⅞	9⅜	450
20.000	⅜ x 7	11/32	12—⅝ x 10½	⅝ x 1 3/16	24 1/16	12¾	9⅝	537
22.000	¼ x 7	¼	14—⅝ x 10	½ x 1 3/16	26	12⅜	9⅛	330
22.000	⅜ x 7	⅜	14—⅝ x 10½	⅝ x 1 3/16	27	12¾	9⅝	490
24.000	¼ x 7	¼	14—⅝ x 10	½ x 1 3/16	28	12⅜	9⅛	304
24.000	⅜ x 7	⅜	14—⅝ x 10½	⅝ x 1 3/16	29	12¾	9⅝	451
30.500	¼ x 7	¼	16—⅝ x 10	½ x 1 3/16	34 1/16	12⅜	9⅛	240
30.625	5/16 x 7	¼	16—⅝ x 10	½ x 1 3/16	34⅜	12⅜	9⅛	298
30.750	⅜ x 7	⅜	16—⅝ x 10½	⅝ x 1 3/16	35¾	12⅞	9½	354
31.000	½ x 7	⅜	16—⅝ x 10½	⅝ x 1 3/16	36	12⅞	9½	465
31.000	½ x 10	⅜	16—⅝ x 13½	⅝ x 1 3/16	36	15⅞	12⅜	465
36.500	¼ x 7	¼	18—⅝ x 10	½ x 1 7/16	40½	12⅜	9⅛	201
36.625	5/16 x 7	¼	18—⅝ x 10	½ x 1 7/16	40⅝	12⅜	9⅛	250
36.750	⅜ x 7	⅜	18—⅝ x 10½	⅝ x 1 3/16	41¾	12⅞	9½	298
37.000	½ x 7	⅜	18—⅝ x 10½	⅝ x 1 3/16	42	12⅞	9½	392
37.000	½ x 10	⅜	18—⅝ x 13½	⅝ x 1 3/16	42	15⅞	12⅜	392

* Indicates light pattern coupling for use with light wall steel pipe.
1. Middle rings thicker or longer than those listed can be supplied.
2. Dimension "J" (maximum) will be equal to dimension "E" plus ½" (approximate bolt head thickness) if all bolts are inserted from one side of the coupling.
3. Dimension "L" (overall length exclusive of bolts) is with bolts drawn up finger tight.
4. Working pressures shown were determined with Barlow's formula, using a working stress equal to one half the minimum yield of the middle ring material.

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Victaulic Couplings

The Victaulic Coupling is normally used with Armco Pipe having adapter bands. The coupling may be used on high or low pressure lines or vacuum lines. Gaskets may be obtained for use on hot or cold lines carrying water, air, steam, gas, or gasoline and other services. Type of service should be stated when ordering. The joint is mechanically locked and can therefore be used to advantage where end-pull is a factor.

Victaulic Couplings permit deflection of the pipe at joints. See page 35 for deflection data. The adapter bands are grooved and butt-welded to the ends of Armco Pipe. The bands must be made to conform to standard Victaulic Coupling dimensions. If standard OD Armco Pipe is ordered the band will be flush outside but slightly offset inside (Type I below). To make bands flush on the inside (Type II below) requires a special pipe diameter that is not a standard stock size. Slip-on adapters and shoulder-type adapters are also available. A variety of coupling sizes and adapter bands is available to meet specific requirements. Contact Armco for details.

Dimensions of some of the most common Victaulic Couplings and adapter bands are shown below.

Figure 17. Victaulic Coupling

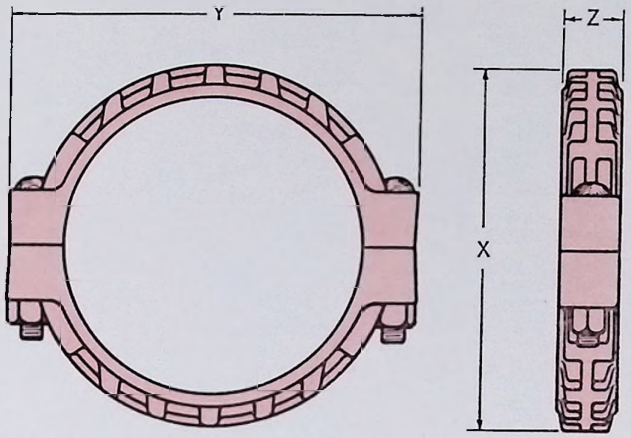


Figure 18. Adapter band

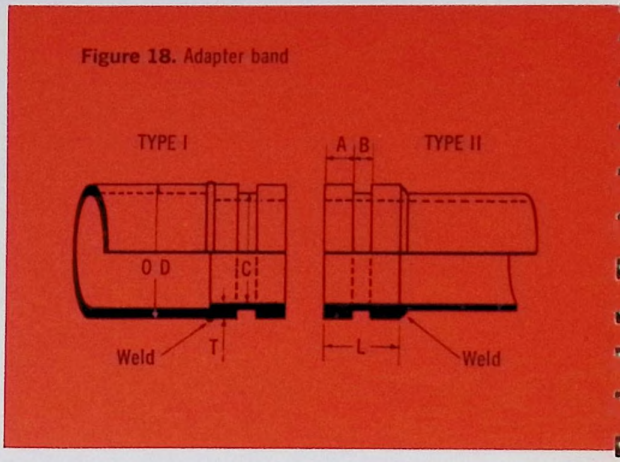


Table 5 Dimensions of Victaulic Couplings and Adapter Bands for Armco Steel Pipe

Pipe, size (nominal OD)	Coupling dimensions			Working pressure (psi)	End pull (pounds)	Adapter dimensions				
	"X"	"Y"	"Z"			"A"	"B"	"C"	"T"	"L" (min.)
6⅝	9	11⅛	2	1000	104,000	⅝	⅜	6.455	.280	2
8⅝	11⅜	13⅞	2⅜	800	146,000	¾	7/16	8.441	.277	2½
10¾	13½	16	2½	800	209,000	¾	½	10.562	.279	2½
12¾	15½	18	2½	800	243,000	¾	½	12.531	.330	2½
14	16⅝	18⅞	2⅜	300	231,000	15/16	½	13.781	.375	2½
16	19	21⅞	2⅞	300	302,000	15/16	½	15.781	.375	2½
18	21¼	24¾	3	300	254,000	1	½	17.781	.409	2½
20	23½	27⅛	3	300	282,000	1	½	19.781	.409	2½
24	27⅝	31	3⅛	300	362,000	1	9/16	23.656	.437	3

Notes: 1. All dimensions in inches.
2. Housings for 16 through 24 inches inclusive are in four parts.
3. Distance between the pipe ends in the coupling is ¼" maximum.

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High quality field-welded joints with Armco Pipe result from the high welding quality steel and the uniform diameter and wall thickness.

Welded Joints

When Armco Pipe is to be field welded, end facing to standard bevel profile is done by a cutting tool in special machines. The standard bevel shown in Figure 19 is used unless otherwise designated on the order. Notice that the angle of the bevel is measured from a plane perpendicular to the pipe axis. The mill weld bead is removed for a distance of 6 inches from the end of the pipe to permit the use of standard line-up clamps.

Connections for screw joint pipe

Standard threaded pipe may be connected to Armco Pipe in a variety of ways. A Thredolet, an extra-heavy half coupling, or half of a threaded pipe nipple may be welded directly to the pipe barrel at the mill. Also, standard pipe threads or corporation threads can be tapped into the side of Armco Pipe by using a reinforcing pad welded to the outside of the pipe. Flanged connections can also be used. The connecting screw joint pipe is then threaded into a screw flange matching the flange supplied on the pipe.

Threaded pipe connections in general should not exceed 6 inches, with 4 inches or less being the most desirable.

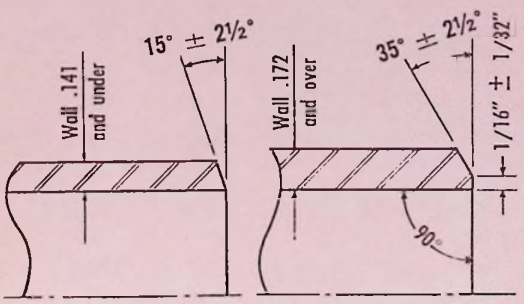
Miscellaneous joints

Armco Welded Steel Pipe can be supplied with special ends suitable for caulking into the bells of cast iron pipe, hub-end valves, etc. Details will be supplied when requested.

Mechanical couplings with Armco Pipe permit slight deflection at each joint.



Figure 19. Armco Standard End Bevel



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Table 6 DIMENSIONAL DATA AND PROPERTIES ARMCO WELDED STEEL PIPE

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Outside Diameter Inches	Inside Diameter Inches	WALL THICKNESS		WEIGHT OF PIPE			AREA OF			Section Modulus Inches³	Radius of Gyration Inches	INTERNAL PRESSURES IN POUNDS PER SQUARE INCH						External Pressure Average Collapse psi
												MILL TEST		THEORETICAL YIELD		THEORETICAL BURSTING		
		Decimal Inches	Fraction Inches	Uncoated Pounds per Foot	Tons per Mile	Feet per Ton	Inside Cross-Section (Sq. Ft.)	Outside Surface (Sq. Ft.)	Steel in Cross-Section (Sq. In.)			Grade A 22000 (1)	Grade B 28000 (2)	Grade A 30000	Grade B 35000	Grade A 50000	Grade B 60000	
6	5.782	.109	7/64	6.88	18.2	291.0	.182	1.57	2.017	2.93	2.083	800	1020	1090	1270	1820	2180	400
	5.718	.141	9/64	8.80	23.2	227.0	.178		2.595	3.70	2.072	1030	1320	1410	1640	2350	2820	830
	5.656	.172	11/64	10.70	28.2	187.0	.174		3.149	4.45	2.062	1260	1610	1720	2010	2870	3440	1410
6⅝	6.407	.109	7/64	7.61	20.1	263.0	.224	1.73	2.231	3.59	2.304	730	920	990	1150	1650	1980	300
	6.343	.141	9/64	9.74	25.7	205.0	.219		2.872	4.55	2.293	930	1190	1280	1490	2130	2550	630
	6.281	.172	11/64	11.85	31.3	169.0	.215		3.487	5.47	2.282	1140	1450	1560	1820	2600	3120	1100
	6.249	.188	3/16	12.89	34.0	155.0	.213		3.802	5.93	2.277	1250	1590	1700	1990	2840	3400	1370
	6.187	.219	7/32	14.97	39.5	134.0	.209		4.407	6.83	2.266	1450	1850	1980	2310	3300	3960	2000
8	7.782	.109	7/64	9.22	24.3	217.0	.330	2.09	2.702	5.28	2.790	600	760	820	950	1360	1640	170
	7.718	.141	9/64	11.80	31.2	169.0	.325		3.481	6.70	2.779	770	990	1060	1230	1760	2120	360
	7.656	.172	11/64	14.36	37.9	139.0	.320		4.230	8.10	2.768	950	1200	1290	1500	2150	2580	650
8⅝	8.407	.109	7/64	9.95	26.3	201.0	.385	2.26	2.916	6.15	3.011	560	710	760	880	1260	1520	140
	8.343	.141	9/64	12.74	33.6	157.0	.380		3.758	7.82	3.000	720	910	980	1140	1630	1960	290
	8.281	.172	11/64	15.20	40.1	132.0	.374		4.568	9.46	2.989	880	1120	1200	1400	1990	2390	520
	8.249	.188	3/16	16.90	44.6	118.0	.371		4.983	10.26	2.984	960	1220	1310	1530	2180	2620	670
	8.187	.219	7/32	19.64	51.8	102.0	.366		5.783	11.84	2.973	1120	1420	1520	1780	2540	3040	1040
	8.125	.250	1/4	22.36	59.0	89.4	.360		6.578	13.39	2.962	1280	1620	1740	2030	2900	3480	1450
10	9.782	.109	7/64	11.55	30.5	173.0	.522	2.62	3.387	8.32	3.497	480	610	650	760	1090	1310	90
	9.718	.141	9/64	14.81	39.1	135.0	.515		4.367	10.58	3.486	620	790	850	990	1410	1690	190
	9.656	.172	11/64	18.04	47.6	111.0	.509		5.311	12.82	3.475	760	960	1030	1200	1720	2060	340
10¾	10.532	.109	7/64	12.43	32.8	161.0	.605	2.81	3.644	9.64	3.762	450	570	610	710	1010	1220	80
	10.468	.141	9/64	15.93	42.1	126.0	.598		4.699	12.27	3.751	580	740	790	920	1310	1580	150
	10.406	.172	11/64	19.42	51.3	103.0	.591		5.716	14.87	3.740	700	900	960	1120	1600	1920	270
	10.374	.188	3/16	21.15	55.8	94.6	.587		6.238	16.15	3.735	770	980	1050	1220	1750	2100	350
	10.312	.219	7/32	24.60	64.9	81.3	.580		7.245	18.68	3.724	900	1140	1220	1430	2040	2440	550
	10.250	.250	1/4	28.04	74.0	71.3	.573		8.247	21.16	3.713	1020	1300	1400	1630	2320	2790	820
	10.192	.279	9/32	31.20	82.4	64.1	.566		9.242	23.60	3.703	1150	1450	1560	1820	2600	3120	1120
12	11.782	.109	7/64	13.89	36.7	144.0	.757	3.14	4.072	12.03	4.204	400	510	540	640	910	1090	60
	11.718	.141	9/64	17.81	47.0	112.0	.749		5.253	15.36	4.193	520	660	700	820	1170	1410	110
	11.656	.172	11/64	21.71	57.3	92.1	.741		6.391	18.62	4.182	630	800	860	1000	1430	1720	200

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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
12¾	12.532	.109	7/64	14.77	39.0	135.0	.856	3.34	4.329	13.61	4.470	380	480	510	600	850	1020	55
	12.468	.141	9/64	18.94	50.0	106.0	.848		5.585	17.37	4.458	490	620	660	770	1110	1330	95
	12.406	.172	11/64	23.09	61.0	86.6	.839		6.797	21.08	4.448	600	760	810	940	1350	1620	170
	12.374	.188	3/16	25.16	66.4	79.5	.835		7.419	22.91	4.442	650	830	880	1030	1410	1770	220
	12.312	.219	7/32	29.28	77.3	68.3	.827		8.621	26.53	4.431	760	960	1030	1200	1720	2060	340
	12.250	.250	1/4	33.38	88.1	59.9	.818		9.818	30.09	4.420	860	1100	1180	1370	1960	2350	500
	12.188	.281	9/32	37.45	98.9	53.4	.810		11.008	33.61	4.410	970	1230	1320	1540	2200	2640	700
	12.126	.312	5/16	41.51	109.6	48.2	.802		12.191	37.06	4.399	1080	1370	1470	1710	2450	2940	950
14	13.782	.109	7/64	16.23	42.8	123.0	1.036	3.67	4.757	16.45	4.911	340	440	470	550	780	940	45
	13.718	.141	9/64	20.82	55.0	96.1	1.027		6.139	21.00	4.900	440	560	600	700	1010	1210	75
	13.656	.172	11/64	25.38	67.0	78.8	1.017		7.472	25.50	4.889	540	690	740	860	1230	1480	130
	13.624	.188	3/16	27.66	73.0	72.3	1.013		8.158	27.72	4.884	590	750	810	940	1340	1610	160
	13.562	.219	7/32	32.20	85.0	62.1	1.003		9.482	32.13	4.873	690	880	940	1090	1560	1880	260
	13.500	.250	1/4	36.71	96.9	54.5	.994		10.799	36.48	4.862	790	1000	1070	1250	1790	2140	380
	13.438	.281	9/32	41.21	108.8	48.5	.985		12.111	40.44	4.852	880	1120	1200	1400	2010	2410	530
	13.376	.312	5/16	45.68	120.6	43.8	.976		13.417	44.98	4.841	980	1250	1340	1560	2230	2680	720
16	15.718	.141	9/64	23.82	62.9	84.0	1.348	4.19	7.025	27.54	5.607	390	490	530	620	880	1060	55
	15.656	.172	11/64	29.06	76.7	68.8	1.337		8.553	33.46	5.596	470	600	640	750	1070	1290	90
	15.624	.188	3/16	31.66	83.6	63.2	1.332		9.339	36.39	5.591	520	660	700	820	1170	1410	110
	15.562	.219	7/32	36.87	97.3	54.2	1.321		10.858	42.22	5.580	600	770	820	960	1370	1640	170
	15.500	.250	1/4	42.05	111.0	47.6	1.310		12.370	47.96	5.569	690	880	940	1090	1560	1880	260
	15.438	.281	9/32	47.22	124.7	42.4	1.300		13.877	53.64	5.558	770	980	1050	1230	1760	2110	360
	15.376	.312	5/16	52.36	138.2	38.2	1.289		15.377	59.24	5.548	860	1090	1170	1360	1950	2340	490
	15.250	.375	3/8	62.58	165.2	32.0	1.268		18.408	70.26	5.526	1030	1310	1410	1640	2340	2810	830
18	17.718	.141	9/64	26.82	70.8	74.6	1.712	4.71	7.911	34.96	6.314	340	440	470	550	780	940	45
	17.656	.172	11/64	32.73	86.4	61.1	1.700		9.633	42.50	6.304	420	540	570	670	960	1150	70
	17.624	.188	3/16	35.67	94.2	56.1	1.694		10.520	46.24	6.298	460	580	630	730	1040	1250	80
	17.562	.219	7/32	41.54	109.7	48.1	1.682		12.234	53.67	6.287	540	680	730	850	1220	1460	120
	17.500	.250	1/4	47.39	125.1	42.2	1.670		13.941	61.01	6.276	610	780	830	970	1390	1670	180
	17.438	.281	9/32	53.22	140.5	37.6	1.658		15.642	68.28	6.266	690	870	940	1090	1560	1870	260
	17.376	.312	5/16	59.03	155.8	33.9	1.647		17.337	75.47	6.255	760	970	1040	1210	1730	2080	350
	17.250	.375	3/8	70.59	186.4	28.3	1.623		20.764	89.62	6.233	920	1170	1250	1460	2080	2500	590
	17.124	.438	7/16	82.15	216.9	24.3	1.599		24.166	103.50	6.211	1020	1360	1460	1700	2430	2920	930
20	19.718	.141	9/64	29.83	78.8	67.0	2.121	5.24	8.797	43.26	7.022	310	390	420	490	700	840	35
	19.656	.172	11/64	36.40	96.1	54.9	2.107		10.714	52.62	7.010	380	480	520	600	860	1030	55
	19.624	.188	3/16	39.67	104.7	50.4	2.101		11.701	57.27	7.005	410	530	560	660	940	1130	65
	19.562	.219	7/32	46.21	122.0	43.3	2.087		13.610	66.51	6.994	480	610	660	770	1100	1320	90
	19.500	.250	1/4	52.73	139.2	37.9	2.074		15.512	75.65	6.983	550	700	750	870	1250	1500	130
	19.438	.281	9/32	59.23	156.4	33.8	2.061		17.408	84.71	6.972	620	790	840	980	1400	1680	190
	19.376	.312	5/16	65.71	173.5	30.4	2.047		19.298	93.67	6.962	690	870	940	1090	1560	1870	260
	19.250	.375	3/8	78.60	207.5	25.4	2.021		23.120	111.35	6.940	830	1050	1120	1310	1870	2250	440
	19.124	.438	7/16	91.41	241.3	21.9	1.995		26.918	128.69	6.918	960	1230	1310	1530	2190	2630	680

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Table 6 Continued from previous page

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Outside Diameter Inches	Inside Diameter Inches	WALL THICKNESS		WEIGHT OF PIPE			AREA OF			Section Modulus Inches³	Radius of Gyration Inches	INTERNAL PRESSURES IN POUNDS PER SQUARE INCH						External Pressure Average Collapse psi
												MILL TEST		THEORETICAL YIELD		THEORETICAL BURSTING		
		Decimal Inches	Fraction Inches	Uncoated Pounds per Foot	Tons per Mile	Feet per Ton	Inside Cross-Section (Sq. Ft.)	Outside Surface (Sq. Ft.)	Steel in Cross-Section (Sq. In.)			Grade A 22000 (1)	Grade B 28000 (2)	Grade A 30000	Grade B 35000	Grade A 50000	Grade B 60000	
22	21.718	.141	9/64	32.83	86.7	60.9	2.573	5.76	9.683	52.45	7.728	280	360	380	450	640	770	30
	21.656	.172	11/64	40.07	105.8	49.9	2.558		11.795	63.83	7.718	340	440	470	550	780	940	45
	21.624	.188	3/16	43.68	115.3	45.8	2.551		12.883	69.48	7.712	380	480	510	600	860	1030	55
	21.562	.219	7/32	50.88	134.3	39.3	2.536		14.986	80.72	7.701	440	560	600	700	1000	1200	75
	21.500	.250	1/4	58.07	153.3	34.4	2.521		17.082	91.85	7.690	500	640	680	800	1140	1360	100
	21.438	.281	9/32	65.24	172.2	30.7	2.507		19.173	102.89	7.680	560	720	770	900	1280	1540	140
	21.376	.312	5/16	72.38	191.1	27.6	2.492		21.258	113.84	7.669	630	790	850	990	1420	1700	190
	21.250	.375	3/8	86.61	228.7	23.1	2.463		25.476	135.44	7.647	750	960	1020	1190	1710	2050	330
	21.124	.438	7/16	100.75	266.0	19.9	2.434		29.670	156.67	7.625	880	1120	1200	1400	1990	2390	530
	21.000	.500	1/2	114.81	303.1	17.4	2.405		33.772	177.52	7.604	1000	1270	1360	1590	2270	2730	760
24	23.718	.141	9/64	35.83	94.6	55.8	3.068	6.28	10.569	62.52	8.436	260	330	350	410	590	700	23
	23.656	.172	11/64	43.74	115.5	45.7	3.052		12.876	76.11	8.425	320	400	430	500	720	860	26
	23.624	.188	3/16	47.68	125.9	41.9	3.044		14.064	82.86	8.419	340	440	470	550	780	940	45
	23.562	.219	7/32	55.56	146.7	36.0	3.028		16.362	96.30	8.408	400	510	550	640	910	1100	60
	23.500	.250	1/4	63.41	167.4	31.5	3.012		18.653	109.62	8.397	460	580	620	730	1040	1250	80
	23.438	.281	9/32	71.25	188.1	28.1	2.996		20.939	122.85	8.386	520	660	700	820	1170	1400	110
	23.376	.312	5/16	79.06	208.7	25.3	2.980		23.218	135.96	8.376	570	730	780	910	1300	1560	150
	23.250	.375	3/8	94.62	249.8	21.1	2.948		27.833	161.87	8.354	690	880	940	1090	1560	1880	260
	23.124	.438	7/16	110.10	290.7	18.2	2.917		32.422	187.37	8.332	880	1020	1100	1280	1830	2190	400
	23.000	.500	1/2	125.49	331.3	15.9	2.885		36.914	212.47	8.310	920	1170	1250	1460	2090	2500	590
26	25.624	.188	3/16	51.69	136.5	38.7	3.581	6.81	15.245	97.42	9.126	320	400	430	510	720	870	35
	25.562	.219	7/32	60.23	159.0	33.2	3.564		17.738	113.25	9.115	370	470	510	590	840	1010	50
	25.500	.250	1/4	68.75	181.5	29.1	3.547		20.224	128.95	9.104	420	540	580	670	960	1160	70
	25.438	.281	9/32	77.25	203.9	25.9	3.529		22.705	144.55	9.094	480	610	650	760	1080	1300	90
	25.376	.312	5/16	85.73	226.3	23.3	3.512		25.179	160.03	9.083	530	670	720	840	1200	1440	120
	25.250	.375	3/8	102.63	270.9	19.5	3.477		30.189	190.65	9.061	640	810	870	1010	1440	1730	200
	25.124	.438	7/16	119.44	315.3	16.7	3.443		35.174	220.82	9.039	740	940	1010	1180	1690	2020	320
	25.000	.500	1/2	136.17	359.5	14.7	3.409		40.055	250.54	9.017	850	1080	1160	1350	1920	2310	470

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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
28	27.624	.188	3/16	55.69	147.0	35.9	4.162	7.33	16.426	113.15	9.833	300	380	400	470	670	800	31
	27.562	.219	7/32	64.90	171.3	30.8	4.144		19.114	131.57	9.822	340	440	470	550	780	940	45
	27.500	.250	1/4	74.09	195.6	27.0	4.125		21.795	149.85	9.812	390	500	540	620	890	1070	60
	27.438	.281	9/32	83.26	219.8	24.0	4.106		24.470	168.02	9.801	440	560	600	700	1000	1200	75
	27.376	.312	5/16	92.41	244.0	21.6	4.087		27.139	186.06	9.790	490	620	670	780	1110	1340	95
	27.250	.375	3/8	110.64	292.1	18.1	4.050		32.545	221.78	9.768	590	750	800	940	1340	1610	160
	27.124	.438	7/16	128.79	340.0	15.5	4.013		37.926	257.00	9.746	690	880	940	1090	1560	1880	260
	27.000	.500	1/2	146.85	387.7	13.6	3.976		43.197	291.75	9.724	790	1000	1070	1250	1790	2140	380
30	29.624	.188	3/16	59.70	157.6	33.5	4.787	7.85	17.608	130.09	10.540	280	350	380	440	620	750	25
	29.562	.219	7/32	69.58	183.7	28.7	4.767		20.490	151.30	10.530	320	410	440	510	730	870	40
	29.500	.250	1/4	79.43	209.7	25.2	4.747		23.366	172.37	10.518	370	470	500	580	830	1000	50
	29.438	.281	9/32	89.27	235.7	22.4	4.726		26.236	193.31	10.508	410	520	560	650	940	1120	65
	29.376	.312	5/16	99.08	261.6	20.2	4.706		29.100	214.12	10.497	460	580	620	730	1040	1250	80
	29.250	.375	3/8	118.65	313.2	16.9	4.666		34.901	255.33	10.475	550	700	750	870	1250	1500	130
	29.124	.438	7/16	138.13	364.7	14.5	4.627		40.678	296.03	10.453	640	820	880	1020	1460	1750	210
	29.000	.500	1/2	157.53	415.9	12.7	4.587		46.339	336.20	10.431	730	930	1000	1160	1660	2000	310
32	31.624	.188	3/16	63.70	168.2	31.4	5.455	8.38	18.789	148.17	11.248	260	330	350	410	590	700	23
	31.562	.219	7/32	74.25	196.0	26.9	5.433		21.866	172.36	11.236	300	380	410	480	680	820	35
	31.500	.250	1/4	84.77	223.8	23.6	5.412		24.936	196.40	11.226	340	440	470	550	780	900	45
	31.438	.281	9/32	95.28	251.5	21.0	5.390		28.001	220.30	11.215	390	490	530	610	880	1050	55
	31.376	.312	5/16	105.76	279.2	18.9	5.369		31.060	244.06	11.204	430	540	580	680	970	1170	70
	31.250	.375	3/8	126.66	334.4	15.8	5.326		37.257	291.16	11.182	520	660	700	820	1170	1400	110
	31.124	.438	7/16	147.48	389.3	13.6	5.284		43.430	337.69	11.160	600	770	820	960	1370	1640	170
	31.000	.500	1/2	168.21	444.1	11.9	5.241		49.480	383.67	11.138	660	870	940	1090	1560	1870	260
34	33.624	.188	3/16	67.71	178.8	29.5	6.167	8.90	19.970	167.47	11.954	240	310	330	390	550	660	20
	33.562	.219	7/32	78.92	208.3	25.3	6.144		23.242	194.85	11.944	280	360	390	450	640	770	30
	33.500	.250	1/4	90.11	237.9	22.2	6.121		26.507	222.06	11.933	320	410	440	510	740	880	40
	33.438	.281	9/32	101.28	267.4	19.7	6.098		29.767	249.13	11.922	360	460	500	580	830	990	50
	33.376	.312	5/16	112.43	296.8	17.8	6.075		33.020	276.04	11.911	400	510	550	640	920	1100	60
	33.250	.375	3/8	134.67	355.5	14.9	6.030		39.614	329.42	11.889	490	620	660	770	1100	1320	90
	33.124	.438	7/16	156.82	414.0	12.8	5.985		46.182	382.21	11.867	570	720	770	900	1290	1540	150
	33.000	.500	1/2	178.89	472.3	11.2	5.940		52.622	434.40	11.845	650	820	880	1030	1470	1760	220
36	35.624	.188	3/16	71.71	189.3	27.9	6.922	9.42	21.151	187.88	12.662	230	290	310	370	520	630	18
	35.562	.219	7/32	83.59	220.7	23.9	6.898		24.618	218.63	12.651	270	340	360	430	610	730	25
	35.500	.250	1/4	95.45	252.0	21.0	6.874		28.078	249.21	12.640	310	390	420	490	700	840	30
	35.438	.281	9/32	107.29	283.2	18.6	6.850		31.532	279.63	12.629	340	440	470	550	780	940	40
	35.376	.312	5/16	119.11	314.5	16.8	6.825		34.981	309.89	12.618	380	490	520	610	870	1040	60
	35.250	.375	3/8	142.68	376.7	14.0	6.777		41.970	369.93	12.596	460	580	620	730	1040	1250	80
	35.124	.438	7/16	166.17	438.7	12.0	6.729		48.934	429.33	12.574	530	680	730	850	1220	1460	120
	35.000	.500	1/2	189.57	500.5	10.6	6.681		55.763	488.11	12.552	610	780	830	970	1390	1670	180

NOTES: (1) Grade A pipe is stressed to 22,000 psi.
(2) Grade B pipe is stressed to 28,000 psi.
(3) Test pressures other than those tabulated may be secured by special arrangement between the purchaser and Armco.

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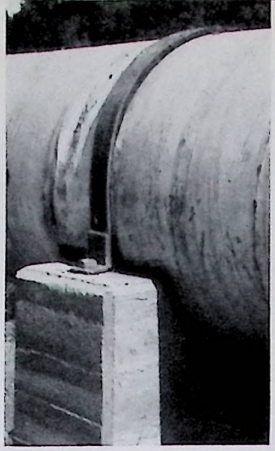


Figure 20. Armco Pipe supported on concrete saddle.

DETERMINING PIPE WALL THICKNESS

General Considerations

The wall thickness of steel pipe is determined by considering the factors listed below. The thickness selected will be that meeting the most severe requirement. The data given here should be supplemented with additional data from listed or other references.

Internal pressures

Static pressure

The static pressure used in design should be that fixed by service conditions. If the service pressure is less than 100 psi, a design based on 100 psi minimum pressure is sometimes used to determine the wall thickness. In a pumping line, the pressure at the outlet and the loss due to friction must be considered when determining static pressure.

Internal pressure for nominal wall thickness Armco Pipe, as calculated using the Barlow formula, and the stated stresses, is given in Table 6 pages 24 to 27.

Surge pressures

Surge pressure should be considered in determining wall thickness. The user is referred to other data published on this subject.[1]

Formulas for thickness

The wall thickness/diameter ratios of Armco Steel Pipe are such that the formulas for thin wall pipe rather than thick wall pipe apply.

Under-thickness tolerance

The acceptable under-thickness tolerance is fixed by the pipe specification selected to govern the manufacture of the pipe. Except in the cases of high pressure lines designed with great precision, the under-thickness tolerance is frequently ignored unless the installation is being made under a set of governing codes or regulations that require it to be considered in design. In low pressure installations, it is usually an insignificant factor in a group of many estimated factors.

Allowable working stresses

Unless governing codes or regulations specify otherwise, it is common good practice to set the maximum allowable working stress at 50 to 60 per cent of the specified minimum yield of the steel used. The allowable stresses given on page 30 are specified in the American Standard Code for Pressure Piping; ASA B-31.1—1955 for ASTM Designation A-139 Grade B to which Armco Pipe is made.

Corrosion allowance

A fixed corrosion allowance set by rule-of-thumb usually is not a satisfactory solution to a corrosion problem. It may be preferable to use the required nominal wall thickness pipe and then apply the proper protective coating for the conditions encountered if such coating is available. Some codes and regulations specify fixed corrosion allowances.

External Pressures

Uniform outside pressure

Uniform pressures acting radially, such as caused by air, water or other fluids, tend to collapse steel pipe. The ultimate average resistance of Armco Pipe under such a condition is tabulated in column 19, Table 6, pages 24 to 27. When modified by a suitable safety factor (1.5 or 2.0) these figures may be used for Armco Pipe designed to resist vacuum pressure inside or uni-

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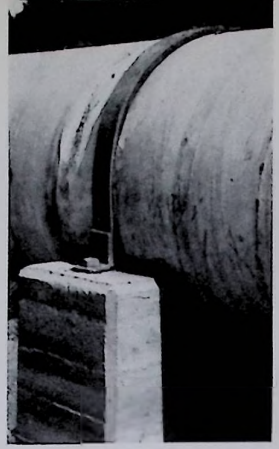


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form outside pressure caused by other fluids.

See other design data for stiffened pipe.[2]

Earth pressures

Steel pipe that is placed in a trench and covered with earth, or placed in an earth fill is subjected to a loading that is not uniformly radial and that is not like the collapsing pressure caused by outside *fluid* pressure. The loading is of such character, and is resisted in such manner that steel pipe of commonly used thickness placed and backfilled with reasonable care, covered to a depth at least equal to the pipe diameter *is virtually uncrushable* under earth loads, dead loads, or live loads usually encountered.

Earth pressures are resisted by a composite action of the pipe and the surrounding earth envelope. Under earth load, a flexible steel pipe tends to lessen its vertical diameter and increase its horizontal diameter due to the weight of the earth cover and live loads if any. Basic principles and methods of calculation have been published and should be consulted for full information.[3] Vertical deflection is rarely a problem with steel pipe 36 inches in diameter or smaller with the wall thicknesses commonly used.

Special physical loading

Pipe on saddle supports

The ability of steel pipe to support itself on saddles has been grossly under-estimated in most cases. For reference, see other data for the design of saddle supported pipe.[4]

Pipe on ring girders

The use of ring girder supports for large diameter pipe is increasing. This type of support for above-ground pipe lines may offer economies, especially for thin wall, large diameter steel pipe. Design data have been published.[1]

Practical considerations

The following factors may be listed among practical considerations in pipe line design: (1) the designer's experience or preference; (2) an organization practice or policy based on its experience; (3) a special set of circumstances surrounding a particular installation such as high hazard of operation or exposure to destructive elements; (4) the necessity to economize on costs; and (5) the minimum practical thickness for handling and installing if other factors do not govern.

Footnote references

1. Manual for Design and Installation of Steel Water Pipe, American Water Works Association, New York, N. Y.

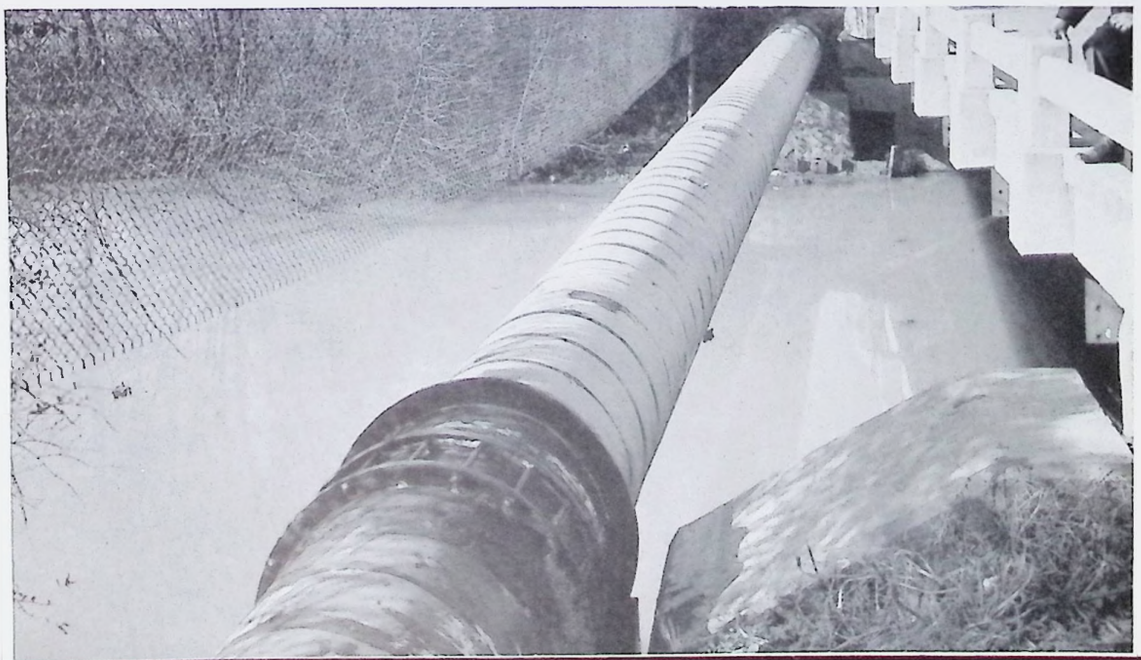
2. ASME Boiler and Pressure Vessel Code Section VIII, Unfired Pressure Vessels, American Society of Mechanical Engineers, N. Y., N. Y.

*3. Barnard, Russell E., Design and Deflection Control of Buried Steel Pipe Supporting Earth Loads and Live Loads, Proceedings Vol. 57, 1233, 1957, American Society of Testing Materials, Philadelphia, Pa.

*4. Barnard, Russell E., Design Standards for Steel Water Pipe.

* Available from Armco Drainage & Metal Products, Inc.

Figure 21. Armco Pipe with ring girder supports.



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form outside pressure caused by other fluids.

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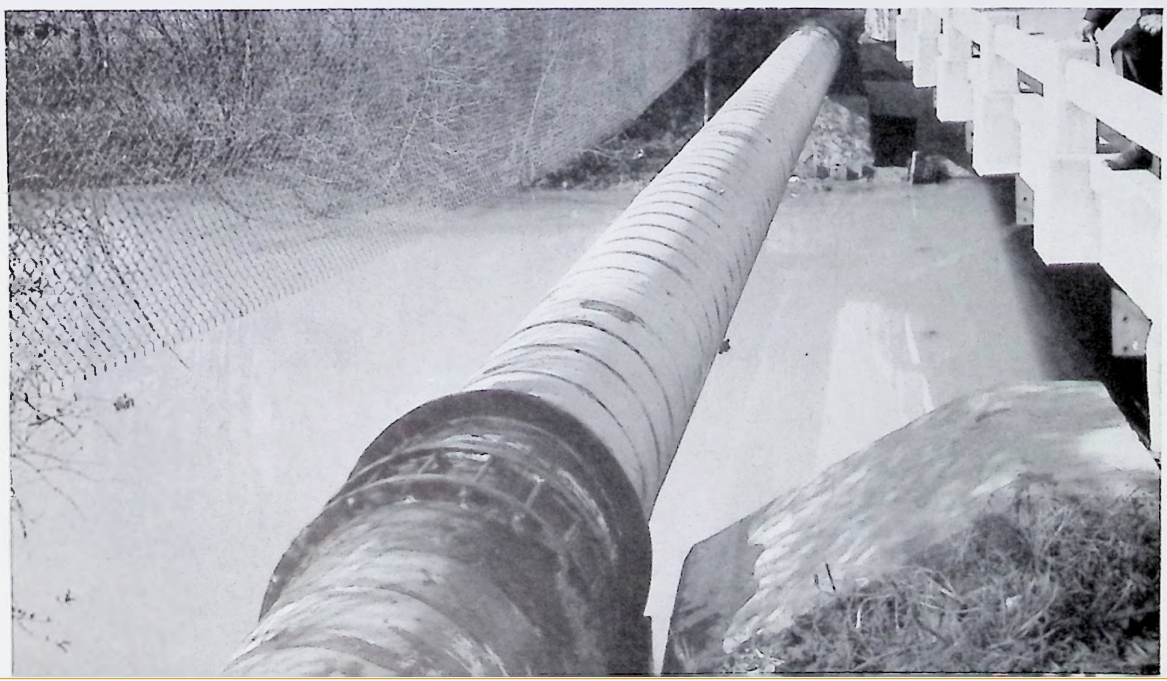
2. ASME Boiler and Pressure Vessel Code Section VIII, Unfired Pressure Vessels, American Society of Mechanical Engineers, N. Y., N. Y.

*3. Barnard, Russell E., Design and Deflection Control of Buried Steel Pipe Supporting Earth Loads and Live Loads, Proceedings Vol. 57, 1233, 1957, American Society of Testing Materials, Philadelphia, Pa.

*4. Barnard, Russell E., Design Standards for Steel Water Pipe.

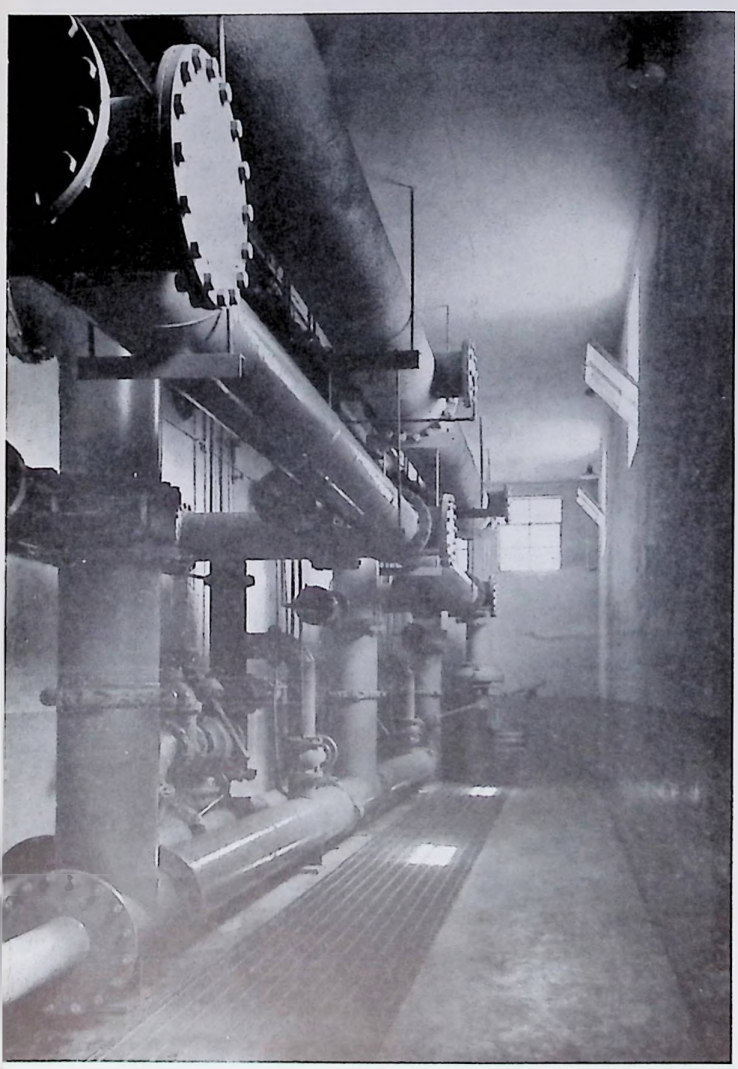
* Available from Armco Drainage & Metal Products, Inc.

Figure 21. Armco Pipe with ring girder supports.



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Pressure Design Data FOR ARMCO PIPE



ASA Code for Pressure Piping

Armco Welded Steel Pipe made in accordance with the requirements of ASTM Designation A-139 is sanctioned for use in the 1955 Code for Pressure Piping with allowable stresses for Grade B (60,000 psi min. tensile strength) as follows:

ASA B-31.1—1955

SECTION 1

Power Piping Systems

* For temperature (F) 20° to 650°	S = 12,000
* For temperatures not to exceed 700°	S = 11,350
* For temperatures not to exceed 750°	S = 9,950

Maximum temperature 450°
Maximum pressure 250 psi
* Stresses listed in Table 2A of the code.

SECTION 2

Industrial Gas and Air Piping Systems

For temperatures (F) not to exceed 100°	S = 16,800
For Temperatures (F) not to exceed 450°	S = 14,550

Maximum temperature 450°

SECTION 3

Refinery and Oil Transportation Piping Systems

DIVISION A

For temperatures (F) 20° to 100°	S = 15,000
For temperatures not to exceed 200°	S = 14,350
For temperatures not to exceed 300°	S = 13,650

Maximum temperature 300°

DIVISION B

For temperature at 100° (F)	S = 23,000

SECTION 4

District Heating

For temperatures (F) not to exceed 500°	S = 12,000

ASA B-31.1.8—1955

SECTION 8

Gas Transmission and Distribution Systems

Design as specified in the code, using longitudinal joint factor "E" = 0.80

ASME Boiler and Pressure Vessel Code

Sec. VIII—Unfired Pressure Vessels

Armco Welded Steel Pipe made in accordance with the requirements of ASTM A-139 is sanctioned for use in unfired pressure vessels under certain regulations. Data will be furnished on request.

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Thermal Expansion OF STEEL PIPE

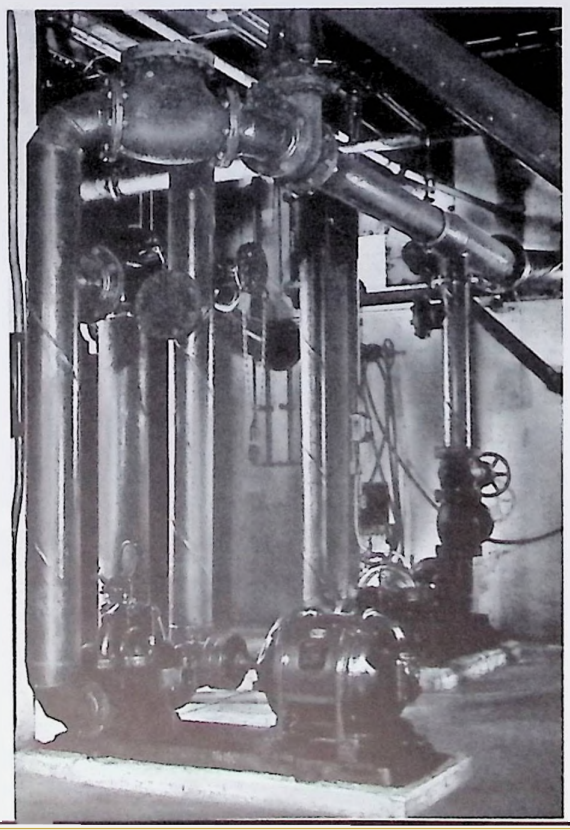
Within the general range of atmospheric and underground temperatures, steel pipe expands approximately ¾-inch per 100 degrees (F) temperature rise. The following table gives the total expansion in inches for 100 feet of steel pipe for various temperatures above 70 degrees (F).

Table 7

Linear thermal expansion of steel pipe

Temperature Fahrenheit	Linear Expansion (inches)
70	0.00
200	0.99
300	1.82
400	2.70
500	3.62
600	4.60
700	5.63
800	6.70

Flow of Fluids IN ARMCO PIPE



The subject of flow of fluids in pipe is not within the scope of this catalog. Various formulas for the calculation of flow are used by different designers. The formula to be used in a given case usually is selected by the designer on the basis of his familiarity and experience with it.

Some formulas are empirical or "conventional" such as the Hazen-Williams Formula for the flow of water in pipes. Data for calculations using the Hazen-Williams Formula are available.[4] The user is also referred to data on other "conventional" formulas.[1]

Formulas based on the fluid-mechanics approach may be termed "universal" formulas since they apply to the flow of fluids having a variety of viscosities and temperatures. Useful data relative to "universal" formulas may be found in the references. [1] [5]

Data on flow through fittings and valves are included in the references.[1] [4] [5]

1. Manual for Design and Installation of Steel Water Pipe, American Water Works Association, New York, N. Y.

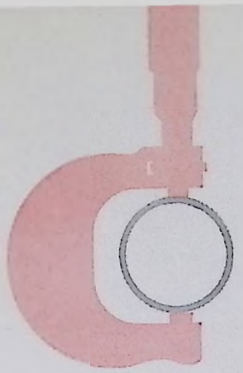
*4. Barnard, Russell E., Design Standards for Steel Water Pipe

5. Pipe Friction Manual, Hydraulic Institute, New York, N. Y.

*Available from Armco Drainage & Metal Products, Inc.

High flow capacity and low friction loss make Armco Pipe especially valuable in pumping installations.

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DEFLECTION OF STEEL PIPE IN BEAM ACTION

When designing free spans of pipe it may be desirable to determine the theoretical deflection in order to judge flexibility, or ascertain that the deflection does not exceed a desirable upper limit.

Freely supported pipe sometimes must be laid so that it will drain fully and contain no pockets between supports. The deflection or sag between supports must be found to determine the necessary grade.

In any given case the deflection is influenced by conditions of installation. The pipe may be a single span or may be continuous over several supports. The ends may act as though free or may act as though fixed. The pipe may carry gas or liquid and in addition to its own weight and that of its contents, may carry the weight of insulation or other uniform load. Concentrated loads such as valves and fittings may be present between supports.

The maximum theoretical deflection can be determined using Eq. 1. This is the standard formula found in text books for uniformly distributed load and free ends except for some changes in unit designation. It can be used for concentrated loads at the center of the span, and for other end conditions by applying a correction factor as described later.

$$y = 22.5\ WL^3/EI \qquad \text{Eq. 1}$$

where y = maximum deflection at center of span (ins.)
W = total load on span (lbs.)
L = length of span (ft.)
E = modulus of elasticity (psi) (30,000,000 for steel pipe)
I = moment of inertia of pipe (in.^{4})

Values of I may be computed by multiplying ½ × OD (Col. 1, Table 6, Page 24) × Section Modulus (Col. 11, Table 6, Page 24).

Tests conducted to determine the deflection of horizontal standard weight pipe lines filled with water[6] have indicated that the deflection of pipe larger than 2 inches supported at greater than 10 foot intervals is less than that determined theoretically for a uniformly loaded pipe fixed at both ends. The deflection of smaller pipe approached the theoretical for free ends.

6. Spacing of Pipe Supports, in Catalog 41, Crane Co., Chicago, Illinois

The following methods of calculating deflection are based on the common formulas found in text books for the cases given.

Determining deflection

Maximum deflection in a given case can be calculated by first assuming that the load is uniformly distributed and the ends are free. This is Case 1 below. Later this result can be modified if the load is concentrated, or the ends are fixed. These are Cases 2, 3 and 4 below. The deflection for Case 1 may be calculated using Eq. 1. Note that in Cases 1 and 2 the load W is the total uniformly distributed load on the span but in Cases 3 and 4 it is the load concentrated at the center of the span.

These four most commonly encountered conditions with their corresponding deflection factors are as follows:

Case 1. If the load W is *uniformly distributed* and the ends are *free*, the deflection is as calculated using Eq. 1.

Case 2. If the load W is *uniformly distributed* but the ends are *fixed*, the deflection is ⅕ that for Case 1.

Case 3. If the load W is *concentrated* at the center, and the ends are *free*, the deflection is 1⅗ times that for Case 1.

Case 4. If the load W is *concentrated* at the center, and the ends are *fixed*, the deflection is 2/5 that for Case 1.

The deflections caused by different loads are additive. Therefore, if a uniformly loaded pipe span contains a concentrated load, the calculated deflection for the concentrated load is added to that for the uniform load and the total sag in the pipe is the sum of the two deflections.

Gradient of supported pipe lines to prevent pocketing

If intermittently supported pipe lines are to drain freely, they must contain no sag pockets. To eliminate pockets each downstream support level must be lower than its

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upstream neighbor by an amount which is dependent upon the sag of the pipe between them. A practical average gradient of support elevations to meet this requirement may be found by using the following formula:[7]

$$G = \frac{L}{4y} \qquad \text{Eq. 2}$$

where G = grade (1 in. in G feet)
L = span (ft.)
y = deflection (ins.)

Example: If the deflection of an insulated 20 inch OD, 0.375 inch wall pipe carrying steam is 0.4 inches in a simple free-ended 50 foot span, what should be the grade of a series of 50 foot spans to allow drainage?

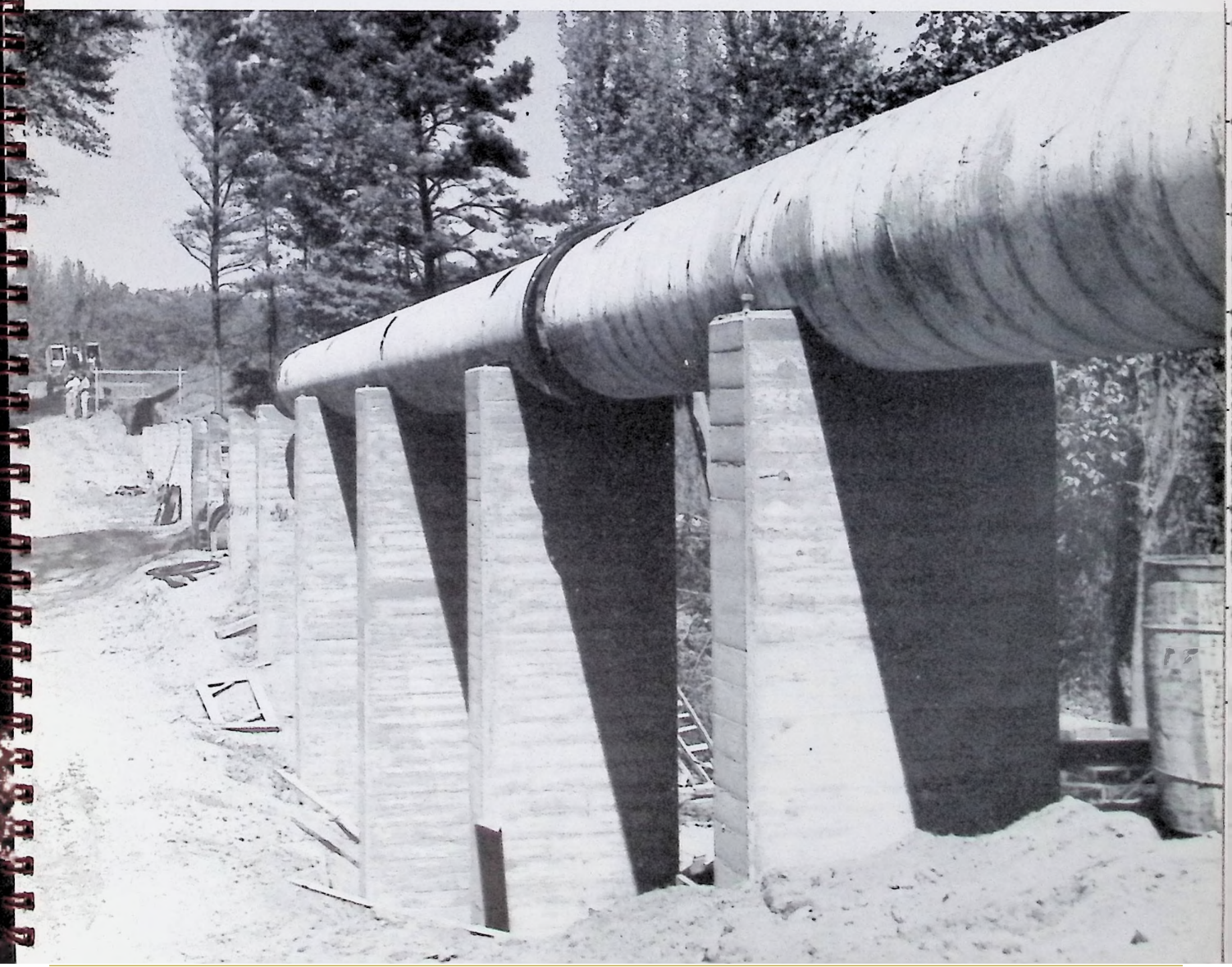
7. Crocker, Sabin. Piping Handbook, McGraw-Hill Book Company, New York, New York

Solution: $G = \frac{50}{4(0.4)} = 31$

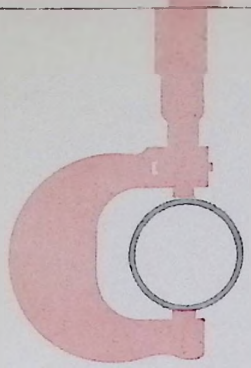
The grade therefore is 1 inch in 31 feet.

It has been suggested[6] that in the interest of satisfactory operation, it is well to double the calculated theoretical deflection when determining the slope of the pipe line gradient. If this were done in the preceding example, the grade used would be 1 inch in 15.5 feet.

The difference in elevation between a downstream support and its upstream neighbor must be four times the theoretical deflection of the pipe between them to establish the grade according to Eq. 2. The elevation difference is eight times the deflection if the suggestion in the preceding paragraph is followed.



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COLLAPSE RESISTANCE OF ARMCO PIPE

Certain isolated tests of Armco Welded Steel Pipe were conducted to determine its beam strength and resistance to uniform fluid pressure acting radially outside the pipe. These tests revealed strength greater than indicated by commonly accepted formulas. Therefore, it was decided to investigate the collapse strength, to determine a collapse pressure formula applicable to this particular product. To make the test results useful from a practical standpoint, specimen pipes were taken at random from regular stock.

Two types of commonly accepted collapse testing—open end and closed end—were used and results obtained by each method were compared.

Pipe specimens were selected from three different grades of stock material having different physical and chemical properties to determine effect of these factors upon collapse of the pipe. Ultimate tensile strength, yield strength, and elongation of each collapsed pipe were determined and chemical analyses were made on some.

A sufficient variety of wall thickness-diameter combinations was selected to cover the range without requiring too much interpolation or extrapolation when determining collapse formulas. Data were examined statistically to obtain greatest possible information from tests.

Results of tests and conclusions

Collapsing pressure on the pipe causes elastic failure or plastic failure, depending on diameter-wall thickness ratio.

Results of tests indicate that plastic failure for Armco Pipe probably occurs when the D/t ratios are less than 50; and elastic failure occurs when the D/t ratio is more than 50.

The data obtained also indicate that when the D/t ratio is 70 or greater, the actual average resistance of Armco Pipe is greater than indicated by the theoretical unmodified elastic formula for ordinary tubes. This excess strength may be attributed directly to the method of manufacture. The rolling direction of the steel from which the pipe is made spirals around the pipe axis. This produces a pipe with a cross section that is a commercially accurate circle, free from ridges and irregularities that might be formed by longitudinal rolling. Such irregularities could seriously impair collapse strength.

Formulas for average collapse pressure of Armco Pipe

Equations giving *average* collapsing pressure of Armco Pipe derived from test results are as follows:

Bracket 1 $D/t = 25$ to 40

$$P_A = \frac{9{,}447{,}000}{(D/t)^{2.48}} \qquad \text{Eq. 3}$$

Bracket 2 $D/t = 40$ to 90

$$P_A = \frac{46{,}189{,}000}{(D/t)^{2.91}} \qquad \text{Eq. 4}$$

Bracket 3 $D/t = 90$ and over

$$P_A = \frac{1{,}892{,}400}{(D/t)^{2.20}} \qquad \text{Eq. 5}$$

Where:

P_A = *Average* collapsing pressure (psi)
D = Outside diameter of pipe (inches)
t = Wall thickness of pipe (inches)

Test data were examined statistically. This study showed that the statistical minimum collapse pressure for Armco Pipe (based on three times the standard deviation) is 85 per cent of the average collapse pressure.

In general, the tests show that for Armco Pipe:

(1) Collapse strength for D/t ratios greater than 70 is up to 20 per cent higher than the theory of elastic collapse indicates for smooth wall pipe.

(2) Minimum collapse pressure for both elastic and plastic failure (computed statistically) is appreciably higher than experiments on other types of pipe would indicate. This is due to uniformity of product and performance.

The *average* collapse pressure for Armco Pipe, calculated using Eq. 3, 4 and 5, is given in Column 19, Table 6, Page 24. The *statistical* minimum collapse pressure would be 85 per cent of this tabular value.

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FIELD CURVES USING ARMCO PIPE

Dresser Couplings

When Dresser Couplings are used with Armco Pipe, small deflection angles are possible at each joint. The resulting radius of curve and deflection of the pipe is given in Table 8. If installation conditions require sharper curves than possible with 40-foot lengths, a few shorter lengths may be used instead of inserting fabricated elbows. Both horizontal and vertical deflection should be considered.

With deflections at Dresser Couplings as indicated in Table 8, it is not necessary to tie pipe sections together mechanically if the line is buried. On exposed lines provision must be made for anchoring pipe sections at frequent intervals to take care of thrust. Also at abrupt bends where couplings are placed on the legs of elbows, side or end thrust should be calculated and proper support provided.

On installations where end pull may be expected, it is customary to tie pipe sections together mechanically around Dresser Couplings so that no tension will be transmitted through the coupling. Sufficient lugs and bolts should be used depending upon internal pressure, longitudinal pull, and other conditions encountered in each installation.

Table 8 Radius of curve and deflection of pipe with Dresser Couplings

Radius of Curve and Deflection of Pipe in Feet*
(Standard Dresser Couplings and straight sections of pipe)

LENGTH of pipe section (feet)	†RADIUS OF CURVE (feet) for varying degrees deflection in each coupling						DEFLECTION OF PIPE (feet) for varying degrees deflection in each coupling						LENGTH of pipe section (feet)
	1°	2°	3°	4°	5°	6°	1°	2°	3°	4°	5°	6°	
6	344	172	115	84	66	57	0′ 1¼″	0′ 2½″	0′ 3¾″	0′ 5″	0′ 6¼″	0′ 7½″	6
12	687	344	229	172	138	114	0′ 2½″	0′ 5″	0′ 7½″	0′ 10″	1′ ⅝″	1′ 3″	12
16	916	458	306	229	183	153	0′ 3⅜″	0′ 6¾″	0′ 10″	1′ 1½″	1′ 4¾″	1′ 8″	16
18	1031	516	344	258	206	172	0′ 3¾″	0′ 7½″	0′ 11¼″	1′ 3⅛″	1′ 6⅞″	1′ 10½″	18
20	1145	573	382	286	229	191	0′ 4¼″	0′ 8⅜″	1′ ⅝″	1′ 4¾″	1′ 8⅞″	2′ 1″	20
30	1718	860	573	430	344	286	0′ 6¼″	1′ ⅝″	1′ 6⅞″	2′ 1″	2′ 7⅜″	3′ 1⅝″	30
40*	2291	1146	764	573	458	382	0′ 8⅜″	1′ 4¾″	2′ 1″	2′ 9½″	3′ 5⅞″	4′ 2⅛″	40*

*To find radius or deflection of pipe (in feet) for any pipe length not shown, divide the bottom row of figures by 40 and multiply by the length of the section.
†Smaller radius curves can always be made by cutting or using pipe of shorter lengths.
Notes: 1. The angle of deflection between successive pipe center lines obtained at each joint is approximately 4° for pipe sizes up to and including 24″, and 3° for 30″ and 36″ pipe.
2. Pipe lengths are considered as chords and each field joint as a point on the curve.

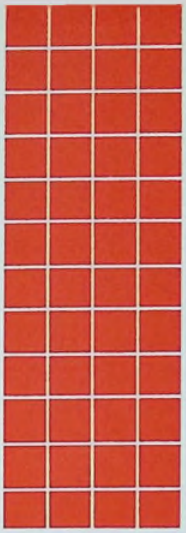
Table 9 Pipe deflection with Victaulic Couplings

Pipe OD	Maximum deflection degrees in one coupling	Maximum deflection inches pipe length	
		20′	40′
6⅝	2°-10′	9.1	18.2
8⅝	1°-40′	7.0	14.0
10¾	1°-20′	5.6	11.2
12¾	1°-7′	4.7	9.4
14	1°-2′	4.3	8.6
16	0°-54′	3.8	7.6
18	0°-48′	3.3	6.6
20	0°-43′	3.0	6.0
24	0°-36′	2.5	5.0

Victaulic Couplings

Victaulic Couplings permit small deflection angles at each joint. The angle of deflection and amount of deflection for a 20-foot pipe length and a 40-foot length are given in Table 9. Several shorter pipe lengths may be inserted in the line for greater deflection. Victaulic Couplings will withstand longitudinal pull. The permissible end pull on various size Victaulic Couplings is shown in Table 5, page 22.

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Tables of useful data
FOR THE DESIGNER

Table 10 CIRCUMFERENCES AND AREAS OF CIRCLES

Diameter in Feet and Inches	Circumference in Feet and Inches	Area in Square Feet	Diameter in Feet and Inches	Circumference in Feet and Inches	Area in Square Feet	Diameter in Feet and Inches	Circumference in Feet and Inches	Area in Square Feet	Diameter in Feet and Inches	Circumference in Feet and Inches	Area in Square Feet
0- 1	0- 3⅛	.0055	2- 3	7- 0⅞	3.976	4-11	15- 5⅜	18.99	7- 7	23- 9⅞	45.17
0- 1¼	0- 3⅞	.0085	2- 4	7- 4	4.276	5- 0	15- 8½	19.63	7- 8	24- 1	46.16
0- 1½	0- 4¾	.0123	2- 5	7- 7⅛	4.587	5- 1	15-11⅝	20.29	7- 9	24- 4⅛	47.17
0- 1¾	0- 5½	.0167	2- 6	7-10¼	4.909	5- 2	16- 2¾	20.97	7-10	24- 7¼	48.19
0- 2	0- 6¼	.0218	2- 7	8- 1⅜	5.241	5- 3	16- 5⅞	21.65	7-11	24-10½	49.22
0- 2½	0- 7⅞	.0341	2- 8	8- 4½	5.585	5- 4	16- 9	22.34	8- 0	25- 1⅝	50.27
0- 3	0- 9⅜	.0491	2- 9	8- 7⅝	5.940	5- 5	17- 0¼	23.04	8- 1	25- 4¾	51.32
0- 3½	0-11	.0668	2-10	8-10⅞	6.305	5- 6	17- 3⅜	23.76	8- 2	25- 7⅞	52.38
0- 4	1- 0⅝	.0873	2-11	9- 2	6.681	5- 7	17- 6½	24.48	8- 3	25-11	53.46
0- 4½	1- 2⅛	.1105	3- 0	9- 5⅛	7.069	5- 8	17- 9⅝	25.22	8- 4	26- 2⅛	54.54
0- 5	1- 3¾	.1364	3- 1	9- 8¼	7.467	5- 9	18- 0¾	25.97	8- 5	26- 5¼	55.64
0- 6	1- 6⅞	.1963	3- 2	9-11⅜	7.876	5-10	18- 3⅞	26.73	8- 6	26- 8½	56.75
0- 7	1-10	.2673	3- 3	10- 2½	8.296	5-11	18- 7	27.49	8- 7	26-11⅝	57.86
0- 8	2- 1⅛	.3491	3- 4	10- 5⅝	8.727	6- 0	18-10¼	28.27	8- 8	27- 2¾	58.99
0- 9	2- 4¼	.4418	3- 5	10- 8¾	9.168	6- 1	19- 1⅜	29.07	8- 9	27- 5⅞	60.13
0-10	2- 7⅜	.5454	3- 6	10-12	9.621	6- 2	19- 4½	29.87	8-10	27- 9	61.28
0-11	2-10½	.6600	3- 7	11- 3⅛	10.08	6- 3	19- 7⅝	30.68	8-11	28- 0⅛	62.44
1- 0	3- 1¾	.7854	3- 8	11- 6¼	10.56	6- 4	19-10¾	31.50	9- 0	28- 3¼	63.62
1- 1	3- 4⅞	.9218	3- 9	11- 9⅜	11.04	6- 5	20- 1⅞	32.34	9- 1	28- 6⅜	64.80
1- 2	3- 8	1.069	3-10	12- 0½	11.54	6- 6	20- 5	33.18	9- 2	28- 9⅝	66.00
1- 3	3-11⅛	1.227	3-11	12- 3⅝	12.05	6- 7	20- 8⅛	34.04	9- 3	29- 0¾	67.20
1- 4	4- 2¼	1.396	4- 0	12- 6¾	12.57	6- 8	20-11⅜	34.91	9- 4	29- 3⅞	68.42
1- 5	4- 5⅜	1.576	4- 1	12- 9⅞	13.10	6- 9	21- 2½	35.78	9- 5	29- 7	69.64
1- 6	4- 8½	1.767	4- 2	13- 1⅛	13.64	6-10	21- 5⅝	36.67	9- 6	29-10⅛	70.88
1- 7	4-11¾	1.969	4- 3	13- 4¼	14.19	6-11	21- 8¾	37.57	9- 7	30- 1¼	72.13
1- 8	5- 2⅞	2.182	4- 4	13- 7⅜	14.75	7- 0	21-11⅞	38.48	9- 8	30- 4⅜	73.39
1- 9	5- 6	2.405	4- 5	13-10½	15.32	7- 1	22- 3	39.41	9- 9	30- 7⅝	74.66
1-10	5- 9⅛	2.640	4- 6	14- 1⅝	15.90	7- 2	22- 6⅛	40.34	9-10	30-10¾	75.94
1-11	6- 0¼	2.885	4- 7	14- 4¾	16.50	7- 3	22- 9⅜	41.28	9-11	31- 1⅞	77.24
2- 0	6- 3⅜	3.142	4- 8	14- 7⅞	17.10	7- 4	23- 0½	42.24	10- 0	31- 5	78.54
2- 1	6- 6½	3.409	4- 9	14-11⅛	17.72	7- 5	23- 3⅝	43.20			
2- 2	6- 9⅝	3.687	4-10	15- 2¼	18.35	7- 6	23- 6¾	44.18			

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Table 11

PRESSURE IN POUNDS PER SQUARE INCH FOR GIVEN HEADS OF WATER

Head ft.	Pressure psi	Head ft.	Pressure psi	Head ft.	Pressure psi	Head ft.	Pressure psi
1	0.43	26	11.26	51	22.08	76	32.91
2	0.87	27	11.69	52	22.52	77	33.34
3	1.30	28	12.12	53	22.95	78	33.77
4	1.73	29	12.56	54	23.38	79	34.21
5	2.16	30	12.99	55	23.81	80	34.64
6	2.60	31	13.42	56	24.25	81	35.07
7	3.03	32	13.86	57	24.68	82	35.51
8	3.46	33	14.29	58	25.11	83	35.94
9	3.90	34	14.72	59	25.55	84	36.37
10	4.33	35	15.15	60	25.98	85	36.80
11	4.76	36	15.59	61	26.41	86	37.24
12	5.20	37	16.02	62	26.85	87	37.67
13	5.63	38	16.45	63	27.28	88	38.10
14	6.06	39	16.89	64	27.71	89	38.54
15	6.49	40	17.32	65	28.14	90	38.97
16	6.93	41	17.75	66	28.58	91	39.40
17	7.36	42	18.19	67	29.01	92	39.84
18	7.79	43	18.62	68	29.44	93	40.27
19	8.23	44	19.05	69	29.88	94	40.70
20	8.66	45	19.48	70	30.31	95	41.13
21	9.09	46	19.92	71	30.74	96	41.57
22	9.53	47	20.35	72	31.18	97	42.00
23	9.96	48	20.78	73	31.61	98	42.43
24	10.39	49	21.22	74	32.04	99	42.87
25	10.82	50	21.65	75	32.47	100	43.35

Table 12

STEEL PLATES, THEORETICAL WEIGHT PER SQUARE FOOT

Size in Inches	Wt. per Square Ft. Lbs.	Size in Inches	Wt. per Square Ft. Lbs.
3/16	7.65	2 1/8	102.00
1/4	10.20	2 1/4	112.20
5/16	12.75	3	122.40
3/8	15.30	3 1/4	132.60
7/16	17.86	3 1/2	142.80
1/2	20.40	3 3/4	153.00
9/16	22.96	4	163.20
5/8	25.50	4 1/4	173.40
3/4	30.60	4 1/2	183.60
7/8	35.70	5	204.00
1	40.80	5 1/2	224.40
1 1/8	45.90	6	244.80
1 1/4	51.00	6 1/2	265.20
1 3/8	56.10	7	285.60
1 1/2	61.20	7 1/2	306.00
1 5/8	66.30	8	326.40
1 3/4	71.40	9	367.20
2	81.60	10	408.00
2 1/8	91.80		

Table 13

ADDITIVE VALUES FOR COMPUTING SLOPE FROM HORIZONTAL DISTANCE

Slope Designation			Value to Be Added per Foot of Horizontal Distance
Rise or Fall—ft.			
Per Horiz. Foot	Per 100 ft. Horiz.*	Angle of Slope	
0.0100	1.00	0° 34.4′	0.000050
0.0200	2.00	1° 08.8′	0.000200
0.0300	3.00	1° 43.1′	0.000450
0.0400	4.00	2° 17.4′	0.000800
0.0500	5.00	2° 52.8′	0.001249
0.0600	6.00	3° 26.0′	0.001798
0.0700	7.00	4° 00.2′	0.002447
0.0800	8.00	4° 34.4′	0.003195
0.0900	9.00	5° 08.6′	0.003990
0.1000	10.00	5° 42.6′	0.004988
0.1100	11.00	6° 16.6′	0.006032
0.1200	12.00	6° 50.6′	0.007174
0.1300	13.00	7° 24.4′	0.008415
0.1400	14.00	7° 58.2′	0.009752
0.1500	15.00	8° 31.8′	0.011187
0.1600	16.00	9° 05.4′	0.012719
0.1700	17.00	9° 38.9′	0.014347
0.1800	18.00	10° 12.2′	0.016071
0.1900	19.00	10° 45.5′	0.017890
0.2000	20.00	11° 18.6′	0.019804
0.2100	21.00	11° 51.6′	0.021812
0.2200	22.00	12° 24.5′	0.023914
0.2300	23.00	12° 57.2′	0.026109
0.2400	24.00	13° 29.7′	0.028399
0.2500	25.00	14° 02.2′	0.030776
0.2600	26.00	14° 34.5′	0.033247
0.2700	27.00	15° 06.6′	0.035808
0.2800	28.00	15° 38.5′	0.038460
0.2900	29.00	16° 10.3′	0.041201
0.3000	30.00	16° 42.0′	0.044031
0.3100	31.00	17° 13.4′	0.046948
0.3200	32.00	17° 44.7′	0.049952
0.3300	33.00	18° 15.8′	0.053043

* Also per cent grade.

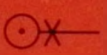
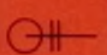
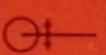
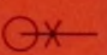
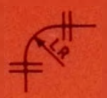
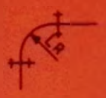
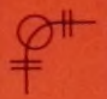
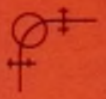
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Table 14 DECIMAL EQUIVALENTS OF AN INCH AND OF A FOOT

Fractions of Inch or Foot		Inch Equivalents to Foot Fractions	Fractions of Inch or Foot		Inch Equivalents to Foot Fractions	Fractions of Inch or Foot		Inch Equivalents to Foot Fractions	Fractions of Inch or Foot		Inch Equivalents to Foot Fractions
	.0052	1/16		.2552	3 1/16		.5052	6 1/16		.7552	9 1/16
	.0104	1/8		.2604	3 1/8		.5104	6 1/8		.7604	9 1/8
1/64	.015625	3/16	17/64	.265625	3 3/16	33/64	.515625	6 3/16	49/64	.765625	9 3/16
	.0208	1/4		.2708	3 1/4		.5208	6 1/4		.7708	9 1/4
	.0260	5/16		.2760	3 5/16		.5260	6 5/16		.7760	9 5/16
1/32	.03125	3/8	9/32	.28125	3 3/8	17/32	.53125	6 3/8	25/32	.78125	9 3/8
	.0365	7/16		.2865	3 7/16		.5365	6 7/16		.7865	9 7/16
	.0417	1/2		.2917	3 1/2		.5417	6 1/2		.7917	9 1/2
3/64	.046875	9/16	19/64	.296875	3 9/16	35/64	.546875	6 9/16	51/64	.796875	9 9/16
	.0521	5/8		.3021	3 5/8		.5521	6 5/8		.8021	9 5/8
	.0573	11/16		.3073	3 11/16		.5573	6 11/16		.8073	9 11/16
1/16	.0625	3/4	5/16	.3125	3 3/4	9/16	.5625	6 3/4	13/16	.8125	9 3/4
	.0677	13/16		.3177	3 13/16		.5677	6 13/16		.8177	9 13/16
	.0729	7/8		.3229	3 7/8		.5729	6 7/8		.8229	9 7/8
5/64	.078125	15/16	21/64	.328125	3 15/16	37/64	.578125	6 15/16	53/64	.828125	9 15/16
	.0833	1		.3333	4		.5833	7		.8333	10
	.0885	1 1/16		.3385	4 1/16		.5885	7 1/16		.8385	10 1/16
3/32	.09375	1 1/8	11/32	.34375	4 1/8	19/32	.59375	7 1/8	27/32	.84375	10 1/8
	.0990	1 3/16		.3490	4 3/16		.5990	7 3/16		.8490	10 3/16
	.1042	1 1/4		.3542	4 1/4		.6042	7 1/4		.8542	10 1/4
7/64	.109375	1 5/16	23/64	.359375	4 5/16	39/64	.609375	7 5/16	55/64	.859375	10 5/16
	.1146	1 3/8		.3646	4 3/8		.6146	7 3/8		.8646	10 3/8
	.1198	1 7/16		.3698	4 7/16		.6198	7 7/16		.8698	10 7/16
1/8	.1250	1 1/2	3/8	.3750	4 1/2	5/8	.6250	7 1/2	7/8	.8750	10 1/2
	.1302	1 9/16		.3802	4 9/16		.6302	7 9/16		.8802	10 9/16
	.1354	1 5/8		.3854	4 5/8		.6354	7 5/8		.8854	10 5/8
9/64	.140625	1 11/16	25/64	.390625	4 11/16	41/64	.640625	7 11/16	57/64	.890625	10 11/16
	.1458	1 3/4		.3958	4 3/4		.6458	7 3/4		.8958	10 3/4
	.1510	1 13/16		.4010	4 13/16		.6510	7 13/16		.9010	10 13/16
5/32	.15625	1 7/8	13/32	.40625	4 7/8	21/32	.65625	7 7/8	29/32	.90625	10 7/8
	.1615	1 13/16		.4115	4 15/16		.6615	7 15/16		.9115	10 15/16
	.1667	2		.4167	5		.6667	8		.9167	11
11/64	.171875	2 1/16	27/64	.421875	5 1/16	43/64	.671875	8 1/16	59/64	.921875	11 1/16
	.1771	2 1/8		.4271	5 1/8		.6771	8 1/8		.9271	11 1/8
	.1823	2 3/16		.4323	5 3/16		.6823	8 3/16		.9323	11 3/16
3/16	.1875	2 1/4	7/16	.4375	5 1/4	11/16	.6875	8 1/4	15/16	.9375	11 1/4
	.1927	2 5/16		.4427	5 5/16		.6927	8 5/16		.9427	11 5/16
	.1979	2 3/8		.4479	5 3/8		.6979	8 3/8		.9479	11 3/8
13/64	.203125	2 7/16	29/64	.453125	5 7/16	45/64	.703125	8 7/16	61/64	.953125	11 7/16
	.2083	2 1/2		.4583	5 1/2		.7083	8 1/2		.9583	11 1/2
	.2135	2 9/16		.4635	5 9/16		.7135	8 9/16		.9635	11 9/16
7/32	.21875	2 5/8	15/32	.46875	5 5/8	23/32	.71875	8 5/8	31/32	.96875	11 5/8
	.2240	2 11/16		.4740	5 11/16		.7240	8 11/16		.9740	11 11/16
	.2292	2 3/4		.4792	5 3/4		.7292	8 3/4		.9792	11 3/4
15/64	.234375	2 13/16	31/64	.484375	5 13/16	47/64	.734375	8 13/16	63/64	.984375	11 13/16
	.2396	2 7/8		.4896	5 7/8		.7396	8 7/8		.9896	11 7/8
	.2448	2 15/16		.4948	5 15/16		.7448	8 15/16		.9948	11 15/16
1/4	.2500	3	1/2	.5000	6	3/4	.7500	9	1	1.0000	12

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STANDARD DRAWING SYMBOLS, AMERICAN STANDARDS ASSOCIATION

ITEM	FLANGED	DRESSER	WELDED	ITEM	FLANGED	DRESSER	WELDED
Joint				Reducing Elbow			
Elbow—90 deg				Tee			
Elbow—45 deg				Tee—Outlet Up			
Elbow—Turned Up				Tee—Outlet Down			
Elbow—Turned Down				Side Outlet Tee Outlet Up			
Elbow—Long Radius				Side Outlet Tee Outlet Down			
Side Outlet Elbow—Outlet Down				Cross			
Side Outlet Elbow—Outlet Up				Reducer			
Base Elbow				Eccentric Reducer			
Double Branch Elbow				Lateral			
Single Sweep Tee				Gate Valve			
Double Sweep Tee				Expansion Joint Flanged			

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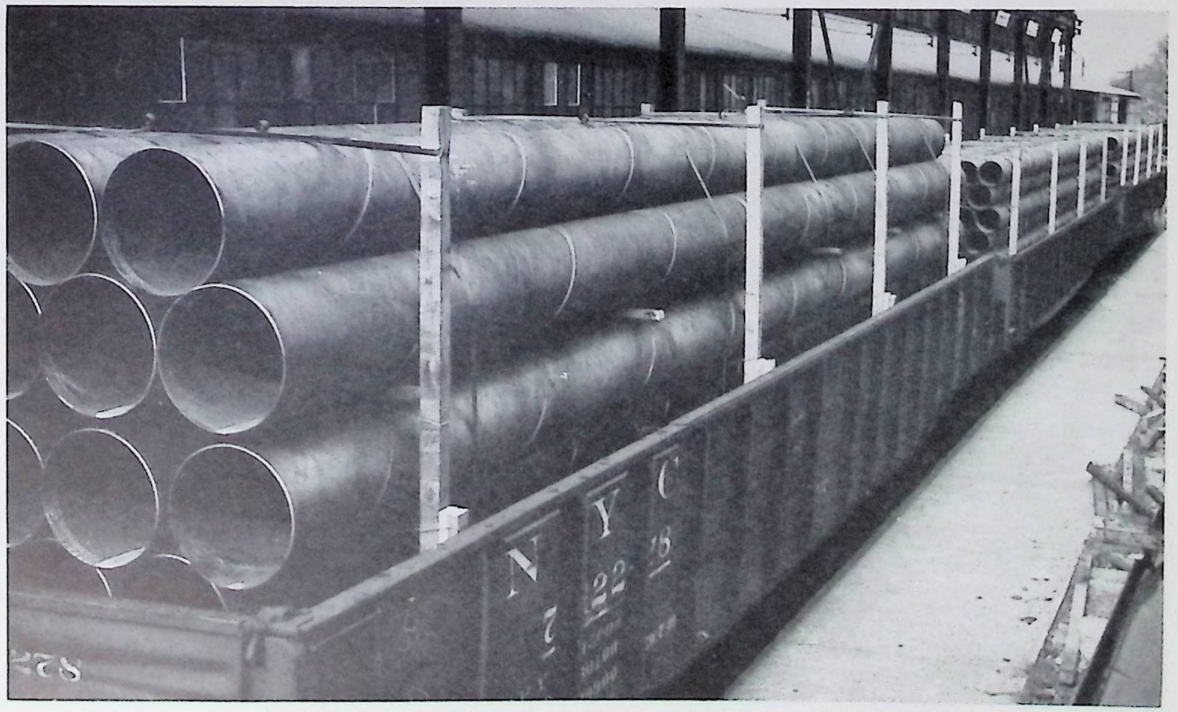
HOW TO ORDER

Armco Welded Steel Pipe for Industrial Use

When you supply all essential information at the time you place your order, further correspondence concerning your order is usually unnecessary. This permits Armco to give you better service. The following information is required:

1. Diameter of pipe (see limits, Page 9).
2. Wall thickness (see limits, Page 9).
3. Number of pieces and lengths.
4. Specification (see Page 8).
5. Type of joint (see Pages 20 to 23).
6. Type of coating and/or lining (see Pages 16 and 17).
7. Purpose of line and maximum operating pressure.
8. Maximum operating temperature (if steam line, designate degrees of super heat, if any).
9. Fittings. For standard fittings see Page 18. For specials, supply description or sketch.
10. Time delivery is desired.
11. Shipping information:
    - Name and address of purchaser
    - Name of consignee
    - Shipping destination
    - Routing, if any special preference

Note: Bolts and gaskets are *not supplied* by Armco unless specifically requested.



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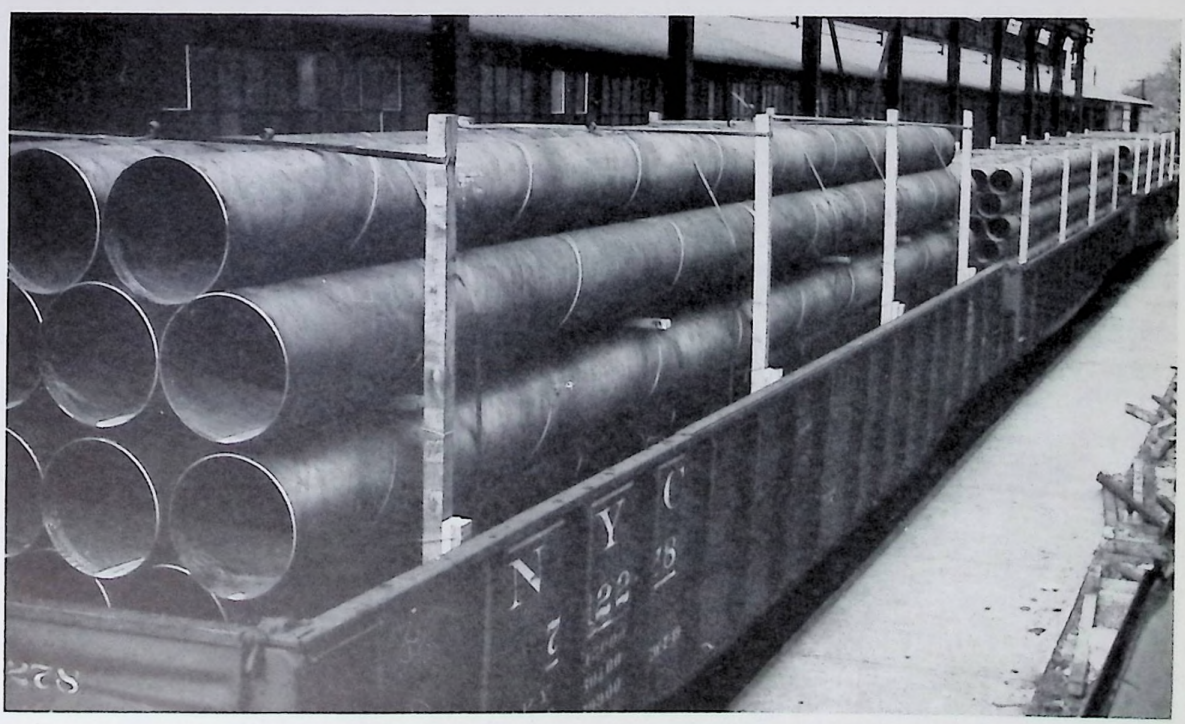
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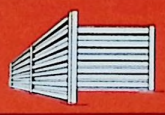
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A FULL LINE OF ARMCO PRODUCTS FOR INDUSTRIAL CONSTRUCTION

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Check this condensed guide to Armco Products. Then let us tell you how their many advantages can benefit you. Write us about your specific needs.

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Armco Water Control Gates		For water control in waste treatment and disposal, water treatment, and reclamation installations
Armco Corrugated Metal Pipe		For drains, culverts, sewers, conduits
Armco Asbestos-Bonded Pipe		For culverts, sewers, conduits under severe corrosive conditions
Armco Paved-Invert Pipe		For culverts and sewers under severe erosive conditions
Armco Smooth-Flo Sewer Pipe		For sewer or waste disposal installations requiring highest flow capacity
Armco Pipe-Arch		For sewers, culverts, conduits under limited headroom
Armco Multi-Plate		For drainage or conduits requiring large diameter openings, also available in Pipe-Arch and arch shape
Flex-Beam Guardrail		For parking lots, in-plant protection against traffic; as a safety device along highways and bridges
Armco Bin-Type Retaining Walls		For unstable slopes, shore and bank protection, limited right-of-ways
Armco Steel Sheeting		For trenches, cofferdams, foundations
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