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American Water Works Association

**STANDARD PRACTICE
FOR THE SELECTION OF
ASBESTOS-CEMENT WATER PIPE**

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AMERICAN WATER WORKS ASSOCIATION
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2 Park Avenue, New York, N.Y. 10016

Prepared by
AWWA Committee on Asbestos-Cement Water Pipe

R. H. RITTER, *Chairman*

E. H. ALDRICH
F. G. DENSON
C. R. ERICKSON
J. E. FARRELL

W. R. GELSTON
R. H. JENSEN
K. A. McCORD
X. D. MURDEN

Producers
J. R. CRAN
C. R. MEEK

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Standard Practice for the Selection of Asbestos-Cement Water Pipe

Sec. 1—Scope

This handbook has been prepared so that design engineers may quickly determine the correct class of asbestos-cement pipe to use under various combinations of internal pressure and external loading. Curves are included in this handbook to expedite the selection of the correct pipe class. Detailed analyses of the various structural factors affecting pipe design and selection are treated under separate headings.

Pipe pressure designations of Class 100, Class 150, and Class 200 in this handbook refer to the similarly numbered classes specified in AWWA C400, "Standard for Asbestos-Cement Water Pipe."

For detailed specifications for the installation of asbestos-cement pipe, reference should be made to AWWA C603, "Standard for the Installation of Asbestos-Cement Pipe."

Sec. 2—Strength and Design Factors

The strength of asbestos-cement water pipe must be sufficient to withstand the combined forces of internal hydrostatic pressure and external loads. Furthermore, the conditions under which the pipe is installed have a direct relationship to its ability to resist these forces. Therefore, satisfactory pipe performance in field service requires that the bedding con-

ditions, as well as the internal and external forces acting on the pipe, be taken into consideration in selecting a class of pipe for any given installation. Finally, sound engineering practice requires that adequate safety factors be applied to strength requirements to insure performance under less than ideal conditions.

Research tests and the application of statistical analysis have shown that asbestos-cement pipe strength may be graphically illustrated by combined-loading parabolic curves. The combined-loading theory developed by the late W. J. Schlick¹ is used in this handbook as the basis for selection curves for asbestos-cement water pipe. External-load determinations for underground conduit used in this handbook are based on the data in Chapter 9 of the *Manual on Design and Construction of Sanitary and Storm Sewers*² produced jointly by ASCE and WPCF.

Sec. 3—Bedding Conditions

The bedding conditions described in Table 1 have been selected as representative of typical installation conditions encountered in the field. They are illustrated in Fig. A2.

Sec. 4—Combined-Loading Theory

Tests of asbestos-cement pipe under various combinations of internal pressure and external load applied in three-edge bearing (see Sec. 5), indi-

cate there is a relationship between the combined loads at the point of pipe fracture. This relationship can be represented by a parabolic curve, as shown in Fig. 1. The equation for the load pressure parabolic curve shown in Fig. 1 may be expressed as:

$$w = W \sqrt{\frac{P - p}{P}} \quad (1)$$

in which, P is the internal pressure, in pounds per square inch, that will burst the pipe when no external load

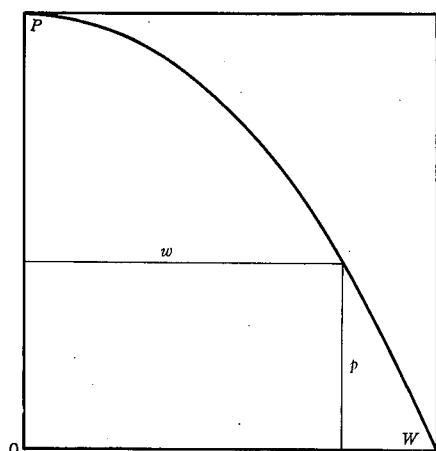


Fig. 1. Load Pressure Curve

P represents the internal pressure; W the external load.

exists; W is the external load, in pounds per lineal foot of pipe, in the three-edge bearing test, that will crush the pipe when no internal pressure exists; p is the internal pressure, in pounds per square inch which, in combination with some external load (w) applied in three-edge bearing, will fracture the pipe; and w is the external load, in pounds per lineal foot of pipe applied in three-edge bearing which, in combination with some internal pressure (p), will fracture the pipe.

TABLE 1

Typical Field Installation Conditions

Bedding Condition (class)	Description
A	Gravel or sand base—backfill tamped
B	Same as A, but backfill not tamped
C	Pipe laid on earth mounds or pipe barrel on flat trench bottom with excavated coupling holes—backfill tamped
D	Same as C, but backfill not tamped

Sec. 5—Three-Edge Bearing Load Factors

A convenient method of testing pipe for crushing strength (W) is the three-edge-bearing method of loading (Fig. 2). Because the field supporting strength of a conduit is influenced by the bedding conditions and the lateral pressure acting against the sides of the conduit, it is necessary to apply a load factor to the three-edge-bearing loads in order to correlate them to the field loads. The relationship is expressed as the external load equals load factor times the three-edge-bearing load.

TABLE 2

Correlation of Bedding Conditions, Pipe Size, and Load Factors

Bedding Class	Pipe Size in.	Load Factor
A	4-12	1.7
	14-20	1.8
	24-36	2.0
B	4-36	1.5
C	4-12	1.3
	14-20	1.4
	24-36	1.5
D	4-36	1.1

Table 2 shows load factors to be applied for any one of the bedding conditions described in Table 1.

Sec. 6—Hydrostatic Pressures

The hydrostatic pressures to be considered in pipeline design are static operating pressure and surge pressure. The static pressure will be fixed by the particular field service condition. Ordinary surge pressure conditions are allowed for in this handbook by applying a safety factor of at least 4.0 to internal pressure in combined loading. Where exceptional surge pressures are a necessary specific consideration in design, a conservative basis for surge allowance determination is the method proposed by S. Logan Kerr.³

Kerr's method considers the fundamental relations affecting water hammer, including velocity of flow in the pipeline, length of the pipeline, time of valve operation or interruption of flow, and the pressure wave velocity. Water hammer allowance is determined by the formulas of Eq 2 and 3

$$h = 2.3 p = \frac{aV}{g} \quad (2)$$

In Eq 2, h is the water hammer allowance, in feet; p is the water hammer allowance, in pounds per square inch; a is the velocity of the pressure wave, in feet per second; g is the acceleration due to gravity (32.2 fps/sec); and V is the flow line velocity, in feet per second, cut off by the valve operation or other action in the critical time, or less.

$$a = \frac{4660}{\sqrt{1 + \frac{k}{E} \cdot \frac{d}{e}}} \quad (3)$$

In Eq 3, a is the pressure wave velocity in feet per second; k is the modulus of

compression of water, in pounds per square inch (290,000–300,000 psi); E is the modulus of elasticity of asbestos-cement pipe, in pounds per square inch (3,400,000 psi); d is the internal diameter, in inches; and e is the wall thickness, in inches.

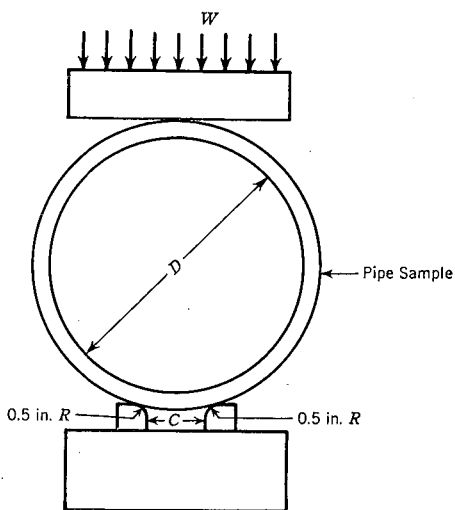


Fig. 2. Crushing Test Assembly

W represents load; R , approximately 0.5 in.—the radius of the bearings; D , the nominal diameter of the pipe; and C , the clear space between wooden supports. C should be 0.5 in. for diameters of 12 in. and under, 1 in. for 14–24 in. inclusive, and 2 in. for 30 in. and over.

Sec. 7—External Loads

External loads on conduit are of two types: those due to gravity earth loads and those due to superimposed loads, which may be static or moving.

The magnitude of gravity earth loads may be computed by using the theory developed by Anson Marston.⁴ Marston's theory, in general, states that the load on a buried conduit is equal to the weight of a prism of earth (called the interior prism) directly over the conduit, plus or minus the

TABLE 3

Impact Factors Caused by Moving Vehicles

Type of Traffic	Impact Factor (F)
Highway	1.50
Railway	1.75
Airfield runways, taxiways, aprons, or hardstands	1.00

frictional shearing forces transferred to that prism by the adjacent prisms of earth. The magnitude and direction of these frictional forces are a function of the amount of relative settlement occurring between the interior and adjacent earth prisms. The general form of Marston's equation is $W = CwB^2$ in which W is the vertical load, per lineal foot, acting on the conduit because of gravity earth loads; w is the weight of earth, in pounds per cubic foot; B is the trench or conduit width, depending on installation conditions; and C is a coefficient that includes the effect of: (1) the ratio of the height of the fill to the width of the trench or conduit, (2) the shearing

forces between the interior and adjacent earth prisms, (3) the direction and amount of relative settlement between interior and adjacent earth prisms for embankment conditions, and (4) the rigidity of conduit support for embankment conditions.

The selection curves included in this handbook were developed using the load-pressure formula, with the external load intercept being the crushing strength as tabulated in Table 2 of AWWA C400-65, "Standard for Asbestos-Cement Water Pipe," and the design point on the parabolic curve being that condition existing at a 5-ft depth of cover with the trench width assumed as pipe ID plus 2 ft, a bedding condition of Class C and a soil weight of 120 lb/cu ft. The external loads were based on the positive projecting conduit analysis because this analysis produced the governing load on the pipe at the conditions set forth above. The design point for each class of pipe is based on a safety factor of 4 times the pressure-pipe class and 2.5 times

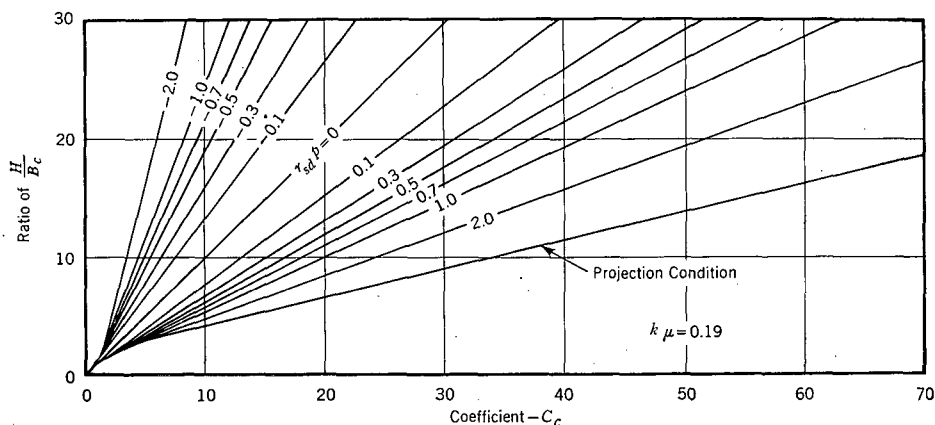


Fig. 3. Graph for Determining Load Coefficient Values

The graph shows a plot of load coefficient values C_c against values obtained by dividing the height of the fill above the conduit by the outside width of the conduit H/B_c .

the three-edge bearing equivalent of the trench load. Once the parabolic curve has been established through the external-load intercept and the control point, the equivalent depth of cover scale is correlated for the various bedding conditions utilizing either the trench load condition or the positive projecting-conduit load condition, whichever is the governing load condition.

Values for external loads may be determined by Marston's formula

$$W_e = C_e w (B_o)^2 \quad (4)$$

in which W_e is the load on the conduit, in pounds per lineal foot; w is the unit weight of the soil, in pounds per cubic foot; B_o is the outside width of conduit, in feet; and C_e is the load coefficient. (Tables of external loads, based on soil weight of 120 lb/cu ft, are presented in Table A1.)

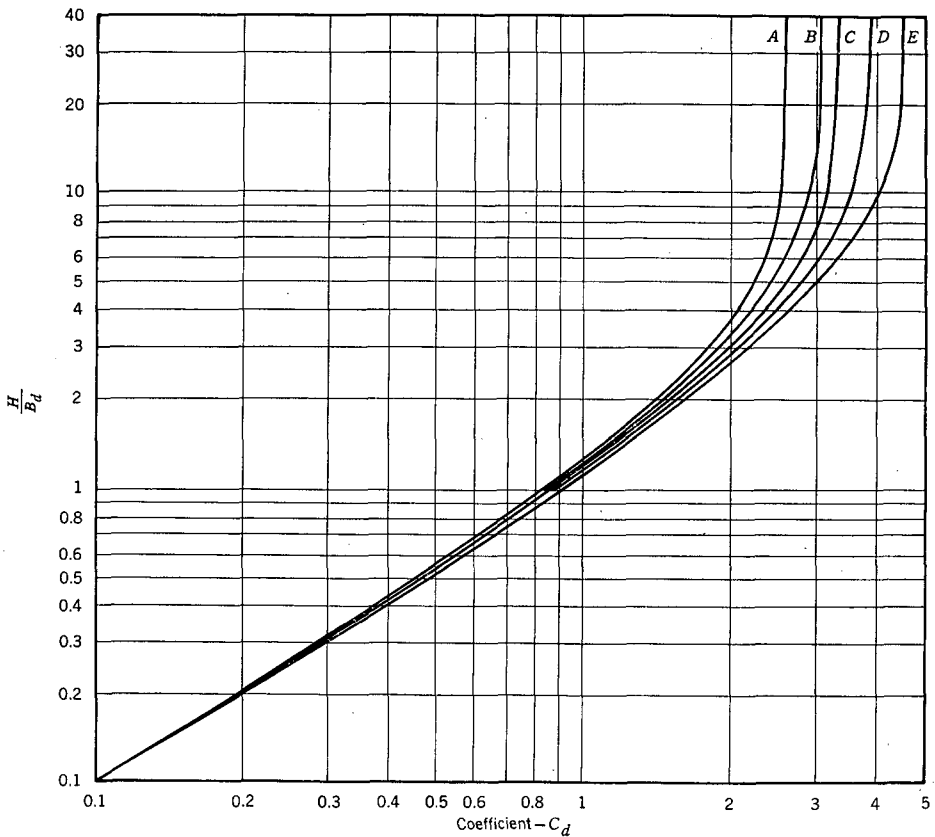


Fig. 4. Graph for Determining C_d Coefficients

Each of the above curves represent C_d values for k_u and k_u' . A represents 0.1924 for granular materials without cohesion; B is 0.165 maximum for sand and gravel; C is 0.150 maximum for saturated top soil; D, 0.13 maximum for ordinary clay; and E, 0.110 maximum for saturated clay. The symbol u' , is the coefficient of friction between the backfill material and the sides of the ditch.

In Marston's formula, the load coefficient, C_o , is a function of H/B_o , p , r_{sd} , u , k ; H is the height of the fill above the conduit; in feet; p is the projection ratio, that is, the ratio of the distance of the top of the conduit above the natural grade, to the width of the conduit; r_{sd} is the settlement ratio; μ is the coefficient of internal friction of the backfill material; and k is the Rankins ratio of lateral pressure to vertical pressure.

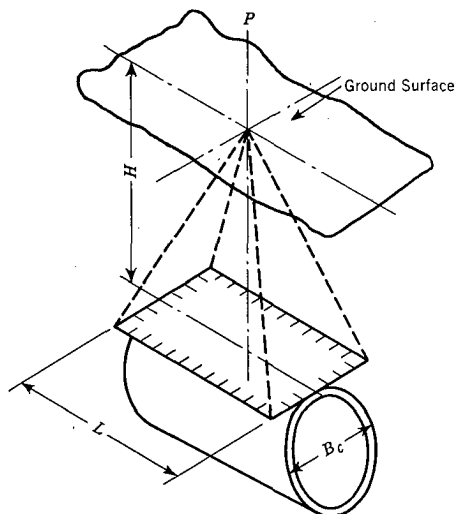


Fig. 5. Concentrated Superimposed Load

P represents the concentrated load; H , the height from the top of the conduit to the ground surface; B_o , the width of the conduit; and, L , the length of the conduit.

Based on a flat-bottomed, backfill-tamped trench, conservative values of $p = 1.0$, $r_{sd}p = 0.70$, and $ku = 0.192$ were used in the determination of external loads for the performance curves. C_o values may be determined from Fig. 3, which shows a plot of C_o against H/B_o ratios.

For values of H/B_o greater than 1.3, when $r_{sd}p = 0.70$, the graph is linear and values may be determined by the empirical equation

$$C_o = 1.892 \frac{H}{B_o} - 0.96. \quad (5)$$

Occasionally, a "trench condition" exists in which the width of the trench is less than two or three times the width of the conduit. In such cases, Marston's trench condition formula may be used for determinations of the gravity loads $W_a = C_a w (B_a)^2$, in which W_a is the vertical load, in pounds per lineal foot; B_a is the width of the trench; w is the weight of the backfill soil in pounds per cubic foot,

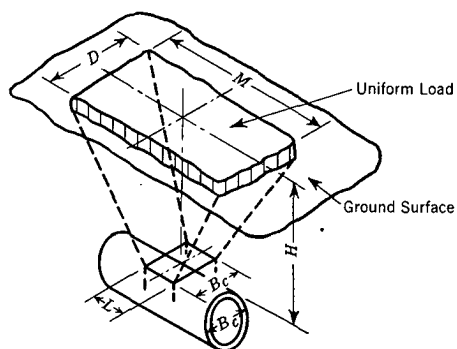


Fig. 6. Distributed Superimposed Load

D and M are the width and length, in feet, respectively, of the area over which the distributed load acts. The uniform load is lbs per sq ft acting on area $D \times M$.

and C_a is a load coefficient. (See Fig. 4 for values of C_a).

Where unusually heavy superimposed loads or impact loads are present, the solution of their magnitude may be computed for either a concentrated-load (such as a truck load) or a distributed-load condition. Normal truck and accompanying impact loads need not be considered when the depth of the cover is greater than 6 ft.

The magnitude of superimposed load produced by a concentrated load (see Fig. 5) is determined by use of the formula,

$$W_{sc} = C_s \frac{PF}{L} \quad (6)$$

in which W_{sc} is the load on the conduit, in pounds per lineal foot; P is the concentrated load, in pounds; F is the impact factor used to allow for the effects of dynamic loads due to moving vehicles (see Table 3); C_s is a load coefficient, a function of $B_c/2H$ and $L/2H$ (see Tables 4 and 5); B_c is the width of the conduit, in feet (OD of the pipe); H is the height

from the top of the conduit to the ground surface, in feet; and L is the effective length of the conduit, in feet. L is 3 ft for conduits greater than 3 ft in length, but is the actual length of conduit for conduits 3 ft long or less.

In the case of a distributed superimposed load, the formula may be rewritten in the form of,

$$W_{sd} = C_{sp} FB_c \quad (7)$$

in which W_{sd} is the load on the conduit, in pounds per lineal foot (see

TABLE 4

Values of Load Coefficients for Concentrated and Distributed Superimposed Loads Centered Vertically over Conduit

$D/2H$ or $B_c/2H$	$\frac{M}{2H}$ or $\frac{L}{2H}$													
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.5	2.0	5.0
0.1	0.019	0.037	0.053	0.067	0.079	0.089	0.097	0.103	0.108	0.112	0.117	0.121	0.124	0.128
0.2	0.037	0.072	0.103	0.131	0.155	0.174	0.189	0.202	0.211	0.219	0.229	0.238	0.244	0.248
0.3	0.053	0.103	0.149	0.190	0.224	0.252	0.274	0.292	0.306	0.318	0.333	0.345	0.355	0.360
0.4	0.067	0.131	0.190	0.241	0.284	0.320	0.349	0.373	0.391	0.405	0.425	0.440	0.454	0.460
0.5	0.079	0.155	0.224	0.284	0.336	0.379	0.414	0.441	0.463	0.481	0.505	0.525	0.540	0.548
0.6	0.089	0.174	0.252	0.320	0.379	0.428	0.467	0.499	0.524	0.544	0.572	0.596	0.613	0.624
0.7	0.097	0.189	0.274	0.349	0.414	0.467	0.511	0.546	0.584	0.597	0.628	0.650	0.674	0.688
0.8	0.103	0.202	0.292	0.373	0.441	0.499	0.546	0.584	0.615	0.639	0.674	0.703	0.725	0.740
0.9	0.108	0.211	0.306	0.391	0.463	0.524	0.574	0.615	0.647	0.673	0.711	0.742	0.766	0.784
1.0	0.112	0.219	0.318	0.405	0.481	0.544	0.597	0.639	0.673	0.701	0.740	0.774	0.800	0.816
1.2	0.117	0.229	0.333	0.425	0.505	0.572	0.628	0.674	0.711	0.740	0.783	0.820	0.849	0.868
1.5	0.121	0.238	0.345	0.440	0.525	0.596	0.650	0.703	0.742	0.774	0.820	0.861	0.894	0.916
2.0	0.124	0.244	0.355	0.454	0.540	0.613	0.674	0.725	0.766	0.800	0.849	0.894	0.930	0.956

TABLE 5

Values of Load Coefficients C_s for Concentrated Superimposed Loads Centered Vertically Over Conduit

Pipe Size in.	Depth of Cover—ft										
	2	2.5	3	4	5	6	8	10	12	16	20
4	0.105	0.076	0.055	0.033	0.022	0.016	0.009	0.006	0.004	0.002	0.0015
6	0.147	0.106	0.078	0.046	0.031	0.023	0.013	0.008	0.006	0.003	0.002
8	0.191	0.137	0.102	0.061	0.041	0.029	0.017	0.010	0.008	0.004	0.003
10	0.237	0.174	0.129	0.078	0.052	0.037	0.022	0.013	0.009	0.006	0.0035
12	0.279	0.202	0.153	0.092	0.062	0.044	0.025	0.016	0.011	0.007	0.004
14	0.317	0.232	0.175	0.106	0.071	0.050	0.030	0.018	0.013	0.008	0.005
16	0.354	0.259	0.197	0.121	0.081	0.057	0.034	0.021	0.015	0.009	0.0055
18	0.391	0.289	0.221	0.136	0.092	0.066	0.038	0.025	0.017	0.010	0.006
20	0.422	0.316	0.241	0.150	0.102	0.073	0.042	0.027	0.019	0.011	0.007
24	0.478	0.362	0.280	0.177	0.120	0.087	0.050	0.033	0.022	0.013	0.008
30	0.543	0.423	0.332	0.213	0.147	0.106	0.062	0.041	0.029	0.016	0.010
36	0.590	0.470	0.375	0.248	0.171	0.124	0.073	0.049	0.035	0.020	0.012

Fig. 6); p is the intensity of distributed load, in pounds per square foot; F is the impact factor (see Table 3); B_o is the width of conduit, in feet; C_s is a load coefficient, a function of $D/2H$ and $M/2H$ (see Table 4); H is the height from the top of the conduit to the ground surface, in feet; and D and M are the width and length, respectively, of the area over which the distributed load acts, in feet.

Sec. 8—Safety Factors

In developing the selection curves, a safety factor of 4.0 was applied to internal pressures; and a safety factor of 2.5 was applied to external loads.

Furthermore, pipe selected from the curves will have a safety factor of at least 2.5 for internal pressure when combined with a safety factor of 2.5 for resisting an external load consisting of the total equivalent earth load plus a 10,000-lb wheel load and impact load.

Under impact loading conditions, the 2.5 safety factor for internal pressure represents good design practice, for it is unlikely that internal surge pressure would occur at the same instant as external impact.

Sec. 9—Selection Curves

The selection curves for pipe sizes 4–36 in. are based on combined-loading theory.

The curves may be conveniently used by entering them through the depth of cover and bedding condition scales. The scales are correlated to the three-edge bearing equivalents of the design external loads with a safety factor of 2.5. Where there is an external loading condition different from that due only to depth of cover, however, or where conditions warrant a

change in the safety factor, the equivalent external load should be determined and the selection curve entered at the proper value on the design external load scale.

The field supporting strength listed for pipe so selected has been proved conservative during many years of performance under various field conditions.

The application of the curves to design is shown in the following problem:

Required: A 6-in. pipe to operate at a pressure of 120 psi at 8 ft depth of cover. Bedding condition Class C, soil weight 120 lb/cu ft.

Solution: Enter the selection curve for 6-in. pipe at bedding condition Class C, 8 ft cover. The intersection of the 8-ft cover line with the 120 psi operating pressure line falls between pipe Classes 100 and 150. Use 6 in. Class 150.

The intersection of the 8 ft cover line with the Class 150 curve is at 135 psi operating pressure, or 550 psi design pressure. Therefore, the pressure safety factor equals $550/120 = 4.6$, with a safety factor of 2.5 for external load.

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APPENDIX

Data developed for the preparation of the selection curves are included in this appendix. Figures illustrating the various bedding conditions and the earth load conditions used in the preparation of the selection curves are included.

In the table of design internal pressure and design external-load intercepts, the external loads are the crushing loads that the pipe must be able to support without failure as specified in AWWA C400—"Standard for Asbestos-Cement Water Pipe." The tables of design external load (w) for various field bedding conditions and depths of cover show the calculated loads for Class 150 pipe. For Class 100 pipe, similar calculated loads would be less than those shown in the

tables, and for Class 200 pipe, the loads would be greater. The maximum variation would be less than 5 per cent.

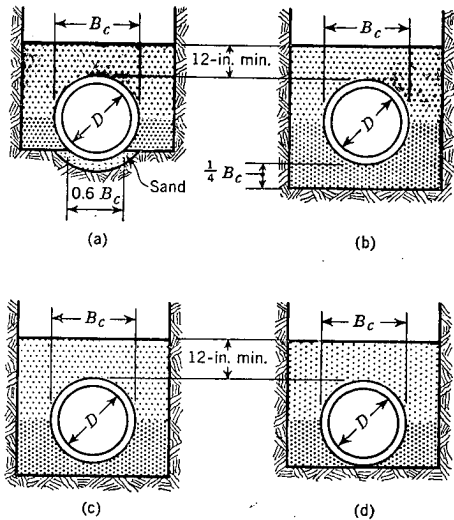


Fig. A2. Bedding Conditions Illustrated

Class A bedding conditions are shown in (a) and (b). Class C conditions are shown in (c) and (d). In all four diagrams, the lightly shaded area represents approved backfill, not frozen and free from lumps, large stones, boulders, or other unsuitable substances. The heavily shaded areas represent approved backfill, carefully tamped in 4 in. layers. In (a), a minimum of 2 in. of sand is placed in a shaped bottom under the pipe. In (b), the pipe is bedded in a gravel base. In (c), the pipe barrel rests on earth mounds. In (d), the pipe barrel is resting on the flat bottom of the trench. Class B condition is the same as Class A, and Class D is the same as Class C except that the backfill is not tamped in B or D

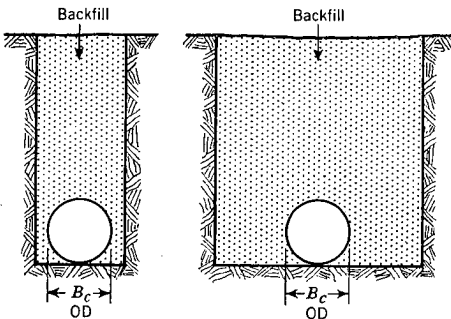


Fig. A1. Earth Load Conditions

Diagram (a) illustrates trench conduit conditions; that is, the trench width is less than two or three times B_c . Diagram (b) shows a positive projecting conduit condition; that is, the trench width is greater than two or three times B_c .

The shaded area represents backfill.

TABLE A1

Determination of Design External Load (w) Applied in 3-Edge Bearing

Pipe Size in.	1	2	3	1	2	3	1	2	3
	Ex- ternal Load lb	Equivalent Three-Edge Bearing Load (Col. 1) (Load Factor)	External Load Applied in Three-Edge Bearing (Col. 2 $\times$ 2.5 Factor of Safety)	Ex- ternal Load lb	Equivalent Three-Edge Bearing Load (Col. 1) (Load Factor)	External Load Applied in Three-Edge Bearing (Col. 2 $\times$ 2.5 Factor of Safety)	Ex- ternal Load lb	Equivalent Three-Edge Bearing Load (Col. 1) (Load Factor)	External Load Applied in Three-Edge Bearing (Col. 2 $\times$ 2.5 Factor of Safety)

Class A Bedding Condition

	2.5 ft of Cover			5 ft of Cover			8 ft of Cover		
4	219	129	323	458	269	673	744	438	1,095
6	297	175	438	634	373	933	1,041	612	1,530
8	371	218	545	814	479	1,198	1,344	790	1,975
10	450	264	660	1,012	595	1,488	1,688	993	2,483
12	507	298	745	1,174	691	1,728	1,975	1,162	2,905
14	559	311	778	1,336	742	1,855	2,267	1,259	3,148
16	604	335	838	1,484	825	2,063	2,398	1,332	3,330
18	643	357	893	1,644	914	2,285	2,528	1,404	3,510
20	670	372	930	1,779	988	2,470	2,712	1,506	3,765
24	802	401	1,002	2,022	1,011	2,528	3,014	1,507	3,768
30	887	444	1,110	2,328	1,164	2,910	3,451	1,725	4,313
36	976	488	1,220	2,552	1,276	3,190	3,990	1,995	4,988

	12 ft of Cover			16 ft of Cover			20 ft of Cover		
4	1,127	663	1,658	1,510	888	2,220	1,893	1,113	2,783
6	1,584	932	2,330	2,124	1,249	3,123	2,550	1,500	3,750
8	2,051	1,206	3,015	2,602	1,531	3,828	2,816	1,656	4,140
10	2,451	1,441	3,603	2,835	1,668	4,170	3,076	1,809	4,523
12	2,678	1,575	3,938	3,078	1,811	4,528	3,402	2,001	5,003
14	2,886	1,603	4,008	3,367	1,870	4,675	3,727	2,070	5,175
16	3,130	1,738	4,345	3,663	2,035	5,088	4,063	2,257	5,643
18	3,337	1,853	4,633	3,969	2,205	5,513	4,336	2,409	6,023
20	3,551	1,972	4,930	4,277	2,376	5,940	4,680	2,600	6,500
24	4,032	2,016	5,040	4,800	2,400	6,000	5,376	2,688	6,720
30	4,666	2,333	5,833	5,589	2,794	6,985	6,318	3,159	7,898
36	5,400	2,700	6,750	6,450	3,225	8,063	7,500	3,750	9,375

Class B Bedding Condition

	2.5 ft of Cover			5 ft of Cover			8 ft of Cover		
4	219	146	365	458	305	763	744	496	1,240
6	297	198	495	634	423	1,058	1,041	694	1,735
8	371	248	620	814	542	1,355	1,344	896	2,240
10	450	300	750	1,012	674	1,685	1,688	1,126	2,815
12	507	338	845	1,174	783	1,958	1,975	1,317	3,293
14	559	373	933	1,336	890	2,225	2,267	1,512	3,780
16	604	402	1,005	1,484	989	2,473	2,398	1,598	3,995
18	643	428	1,070	1,644	1,096	2,740	2,528	1,685	4,213
20	670	447	1,118	1,779	1,186	2,965	2,712	1,808	4,520
24	734	489	1,223	2,022	1,348	3,370	3,014	2,009	5,023
30	887	592	1,480	2,328	1,552	3,880	3,451	2,300	5,750
36	976	651	1,628	2,552	1,701	4,253	3,990	2,660	6,650

TABLE A1—*Determination of Design External Load (w) Applied in 3-Edge Bearing (contd.)*

Pipe Size in.	1	2	3	1	2	3	1	2	3
	Ex- ternal Load lb	Equivalent Three-Edge Bearing Load (Col. 1 Load Factor)	External Load Applied in Three-Edge Bearing (Col. 2 × 2.5 Factor of Safety)	Ex- ternal Load lb	Equivalent Three-Edge Bearing Load (Col. 1 Load Factor)	External Load Applied in Three-Edge Bearing (Col. 2 × 2.5 Factor of Safety)	Ex- ternal Load lb	Equivalent Three-Edge Bearing Load (Col. 1 Load Factor)	External Load Applied in Three-Edge Bearing (Col. 2 × 2.5 Factor of Safety)

Class B Bedding Condition (contd.)

	12 ft of Cover			16 ft of Cover			20 ft of Cover		
4	1,127	751	1,878	1,510	1,007	2,518	1,827	1,218	3,045
6	1,584	1,056	2,640	2,124	1,416	3,540	2,550	1,700	4,250
8	2,051	1,367	3,418	2,602	1,735	4,338	2,816	1,877	4,693
10	2,451	1,634	4,085	2,835	1,890	4,725	3,076	2,050	5,125
12	2,678	1,785	4,463	3,078	2,052	5,130	3,402	2,268	5,670
14	2,886	1,924	4,810	3,367	2,244	5,610	3,727	2,485	6,213
16	3,130	2,086	5,215	3,663	2,442	6,105	4,063	2,708	6,770
18	3,337	2,224	5,560	3,969	2,646	6,615	4,336	2,891	7,228
20	3,551	2,367	5,918	4,277	2,851	7,128	4,680	3,120	7,800
24	4,032	2,688	6,720	4,800	3,200	8,000	5,376	3,584	8,960
30	4,666	3,110	7,775	5,589	3,726	9,315	6,318	4,212	10,530
36	5,400	3,600	9,000	6,450	4,300	10,750	7,500	5,000	12,500

Class C Bedding Condition

	2.5 ft of Cover			5 ft of Cover			8 ft of Cover		
4	219	168	420	458	352	880	744	573	1,433
6	297	228	570	634	488	1,220	1,041	801	2,003
8	371	286	715	814	626	1,565	1,344	1,034	2,585
10	450	346	865	1,012	778	1,945	1,688	1,299	3,248
12	507	390	975	1,174	903	2,258	1,975	1,519	3,798
14	559	400	1,000	1,336	954	2,385	2,267	1,619	4,048
16	604	431	1,078	1,484	1,060	2,650	2,398	1,712	4,280
18	643	459	1,148	1,644	1,175	2,938	2,528	1,805	4,513
20	670	479	1,198	1,779	1,270	3,175	2,712	1,937	4,843
24	734	489	1,223	2,022	1,348	3,370	3,014	2,009	5,023
30	887	592	1,480	2,328	1,552	3,880	3,451	2,300	5,750
36	976	651	1,628	2,552	1,701	4,253	3,990	2,660	6,650

	12 ft of Cover			16 ft of Cover			20 ft of Cover		
4	1,127	867	2,168	1,510	1,161	2,903	1,893	1,456	3,640
6	1,584	1,219	3,048	2,124	1,634	4,085	2,550	1,961	4,903
8	2,051	1,578	3,945	2,602	2,002	5,005	2,816	2,166	5,415
10	2,451	1,885	4,713	2,835	2,181	5,453	3,076	2,366	5,915
12	2,678	2,060	5,150	3,078	2,368	5,920	3,402	2,617	6,543
14	2,886	2,061	5,153	3,367	2,405	6,013	3,727	2,662	6,655
16	3,130	2,235	5,588	3,663	2,616	6,540	4,063	2,902	7,255
18	3,337	2,383	5,958	3,969	2,835	7,088	4,336	3,097	7,743
20	3,551	2,536	6,340	4,277	3,055	7,638	4,680	3,343	8,358
24	4,032	2,688	6,720	4,800	3,200	8,000	5,376	3,584	8,960
30	4,666	3,110	7,775	5,589	3,726	9,315	6,318	4,212	10,530
36	5,400	3,600	9,000	6,450	4,300	10,750	7,500	5,000	12,500

TABLE A1—*Determination of Design External Load (w) Applied in 3-Edge Bearing (contd.)*

	1	2	3	1	2	3	1	2	3
Pipe Size in.	Ex-ternal Load lb	Equivalent Three-Edge Bearing Load Col. 1 (Load Factor)	w External Load Applied in Three-Edge Bearing (Col. 2 $\times$ 2.5 Factor of Safety)	Ex-ternal Load lb	Equivalent Three-Edge Bearing Load Col. 1 (Load Factor)	w External Load Applied in Three-Edge Bearing (Col. 2 $\times$ 2.5 Factor of Safety)	Ex-ternal Load lb	Equivalent Three-Edge Bearing Load Col. 1 (Load Factor)	w External Load Applied in Three-Edge Bearing (Col. 2 $\times$ 2.5 Factor of Safety)
Class D Bedding Condition									
	2.5 ft of Cover			5 ft of Cover			8 ft of Cover		
4	219	199	498	458	416	1,040	744	677	1,693
6	297	270	675	634	577	1,443	1,041	946	2,365
8	371	338	845	814	740	1,850	1,344	1,221	3,053
10	450	409	1,023	1,012	920	2,300	1,688	1,535	3,838
12	507	461	1,153	1,174	1,068	2,670	1,975	1,795	4,488
14	559	509	1,273	1,336	1,214	3,035	2,267	2,061	5,153
16	604	549	1,373	1,484	1,349	3,373	2,398	2,180	5,450
18	643	584	1,460	1,644	1,495	3,738	2,528	2,298	5,745
20	670	610	1,525	1,779	1,617	4,043	2,712	2,465	6,163
24	734	667	1,668	2,022	1,838	4,595	3,014	2,740	6,850
30	887	807	2,018	2,328	2,116	5,290	3,451	3,137	7,843
36	976	887	2,218	2,552	2,320	5,800	3,990	3,627	9,068
	12 ft of Cover			16 ft of Cover			20 ft of Cover		
4	1,127	1,025	2,563	1,510	1,373	3,433	1,893	1,721	4,303
6	1,584	1,440	3,600	2,124	1,931	4,828	2,550	2,318	5,795
8	2,051	1,864	4,660	2,602	2,366	5,915	2,816	2,560	6,400
10	2,451	2,228	5,570	2,835	2,578	6,445	3,076	2,796	6,990
12	2,678	2,434	6,085	3,078	2,798	6,995	3,402	3,093	7,733
14	2,886	2,623	6,558	3,367	3,061	7,653	3,727	3,388	8,470
16	3,130	2,845	7,113	3,663	3,330	8,325	4,063	3,693	9,233
18	3,337	3,033	7,583	3,969	3,608	9,020	4,336	3,942	9,855
20	3,551	3,228	8,070	4,277	3,888	9,720	4,680	4,255	10,638
24	4,032	3,665	9,163	4,800	4,364	10,910	5,376	4,887	12,218
30	4,666	4,241	10,603	5,589	5,081	12,703	6,318	5,744	14,360
36	5,400	4,909	12,273	6,450	5,864	14,660	7,500	6,818	17,045

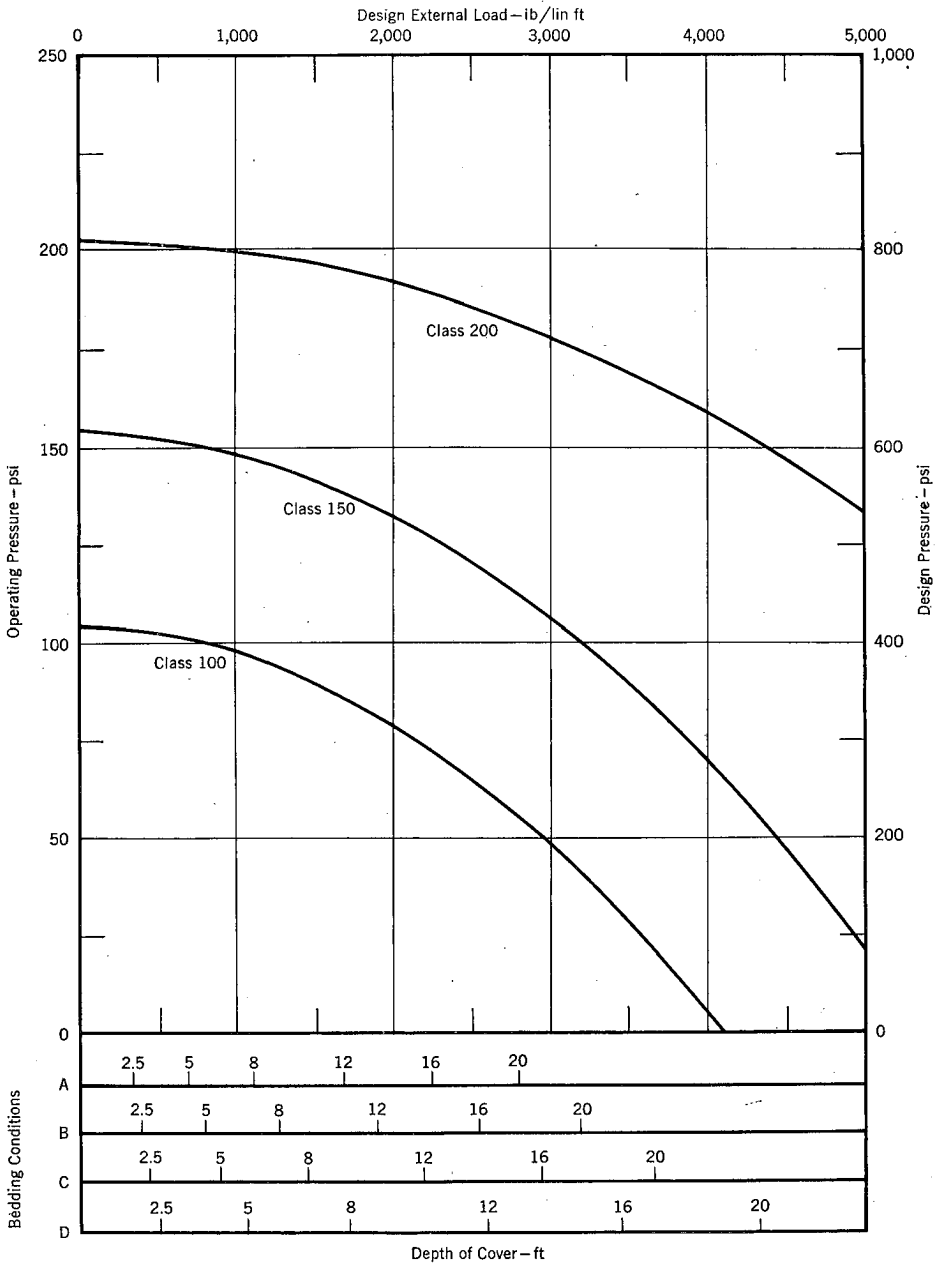
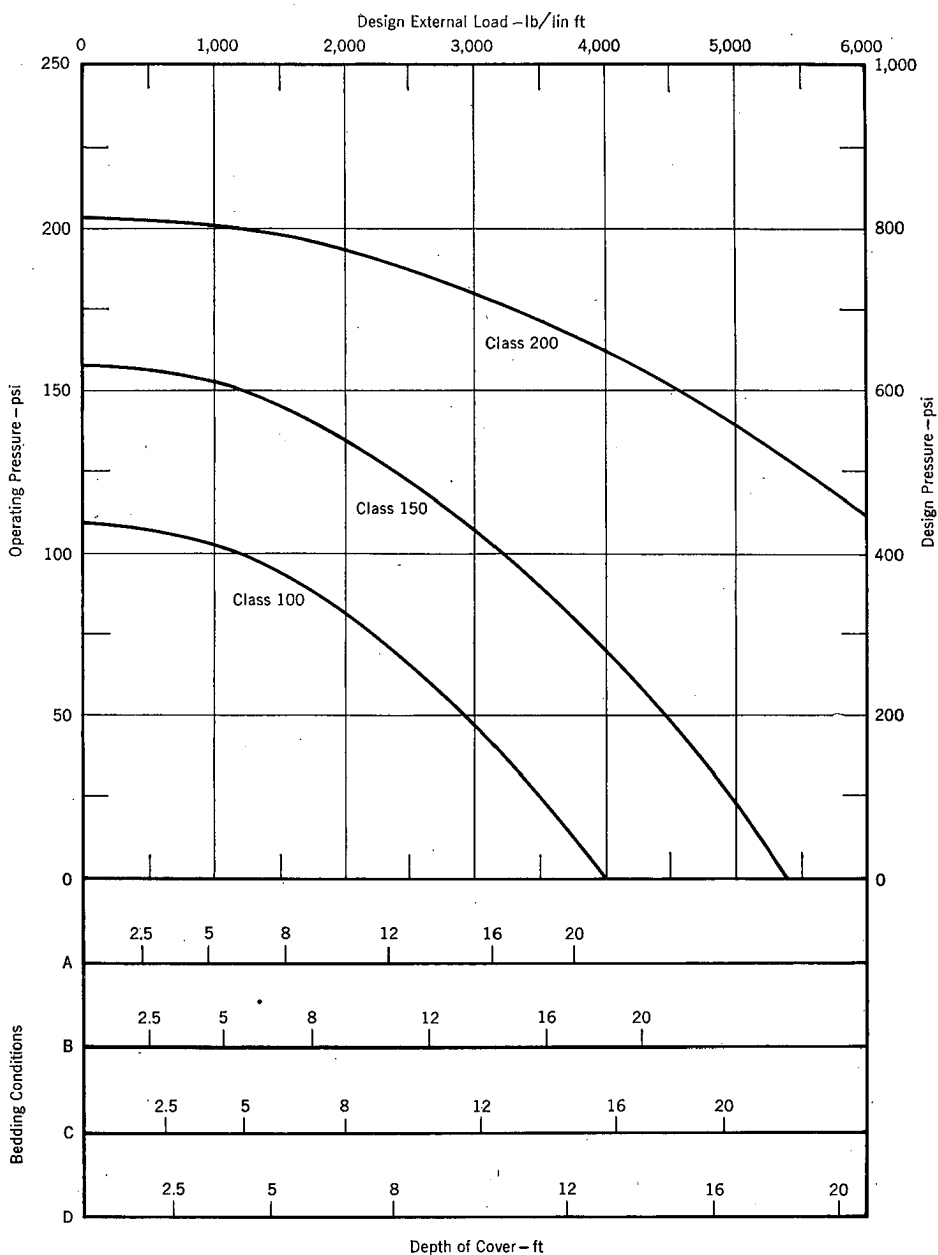


Fig. A3. Selection Curves for 4-in. Asbestos-Cement Pipe

**Fig. A4. Selection Curves for 6-in. Asbestos-Cement Pipe**

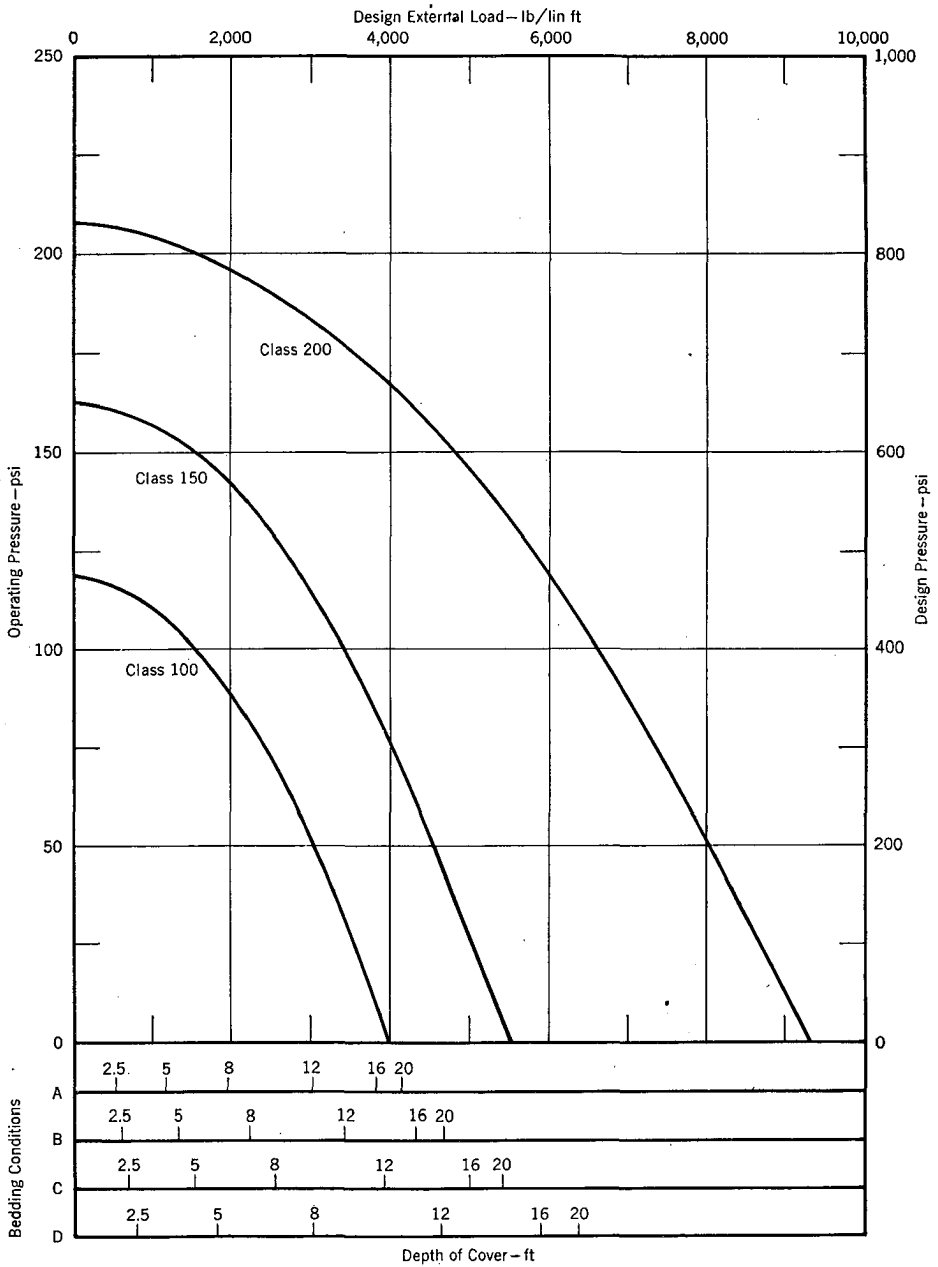


Fig. A5. Selection Curves for 8-in. Asbestos-Cement Pipe

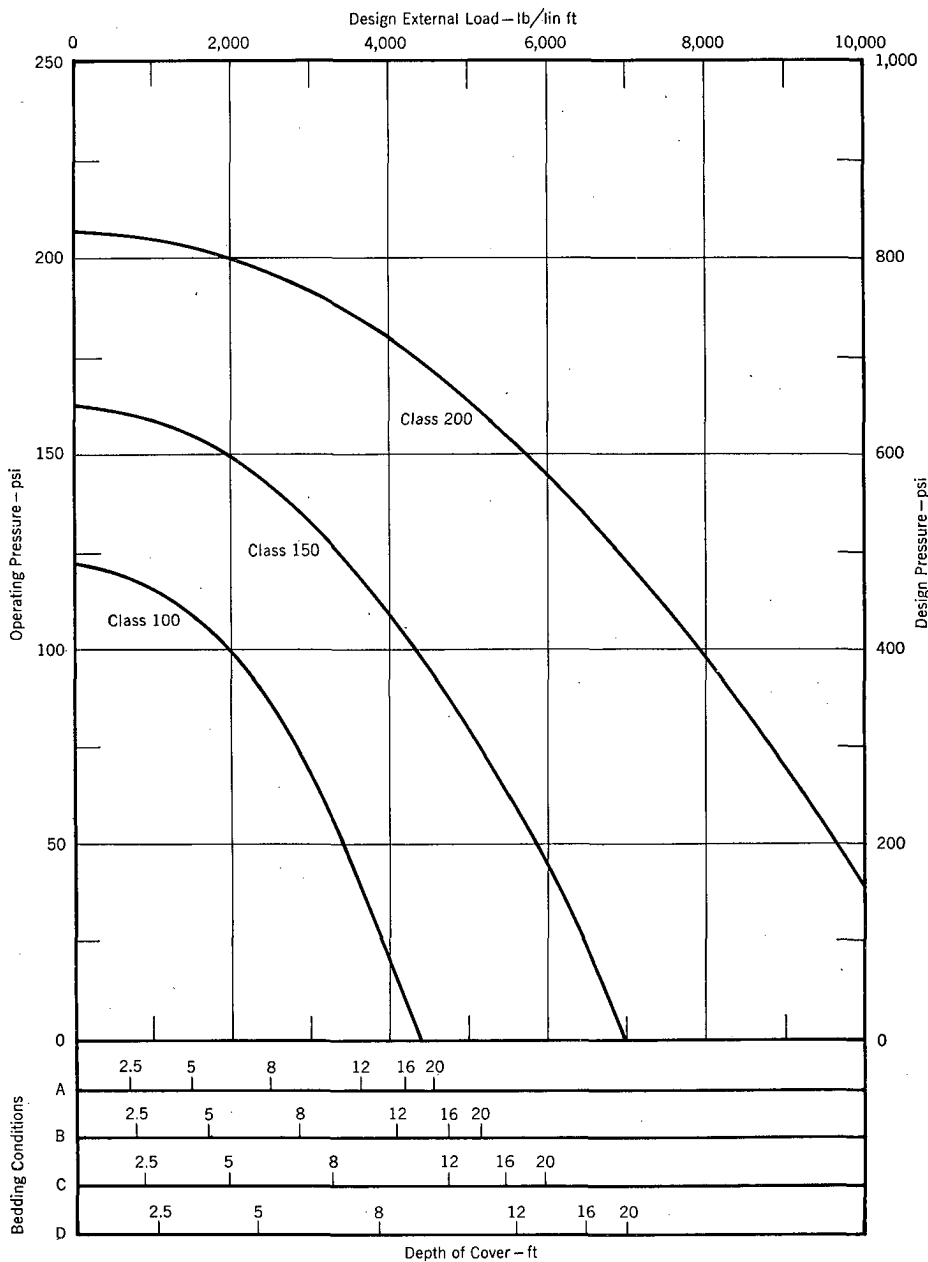


Fig. A6. Selection Curves for 10-in. Asbestos-Cement Pipe

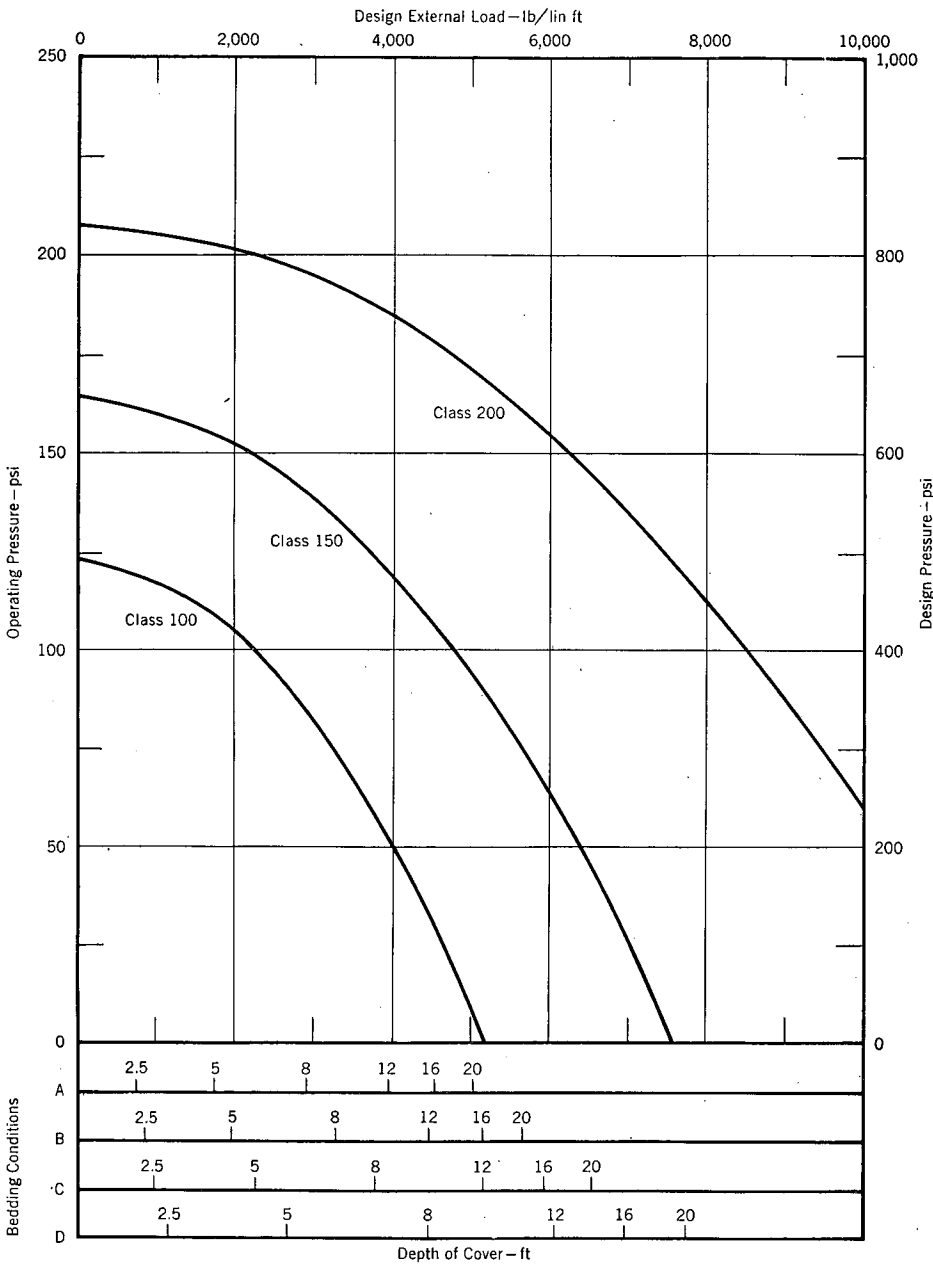


Fig. A7. Selection Curves for 12-in. Asbestos-Cement Pipe

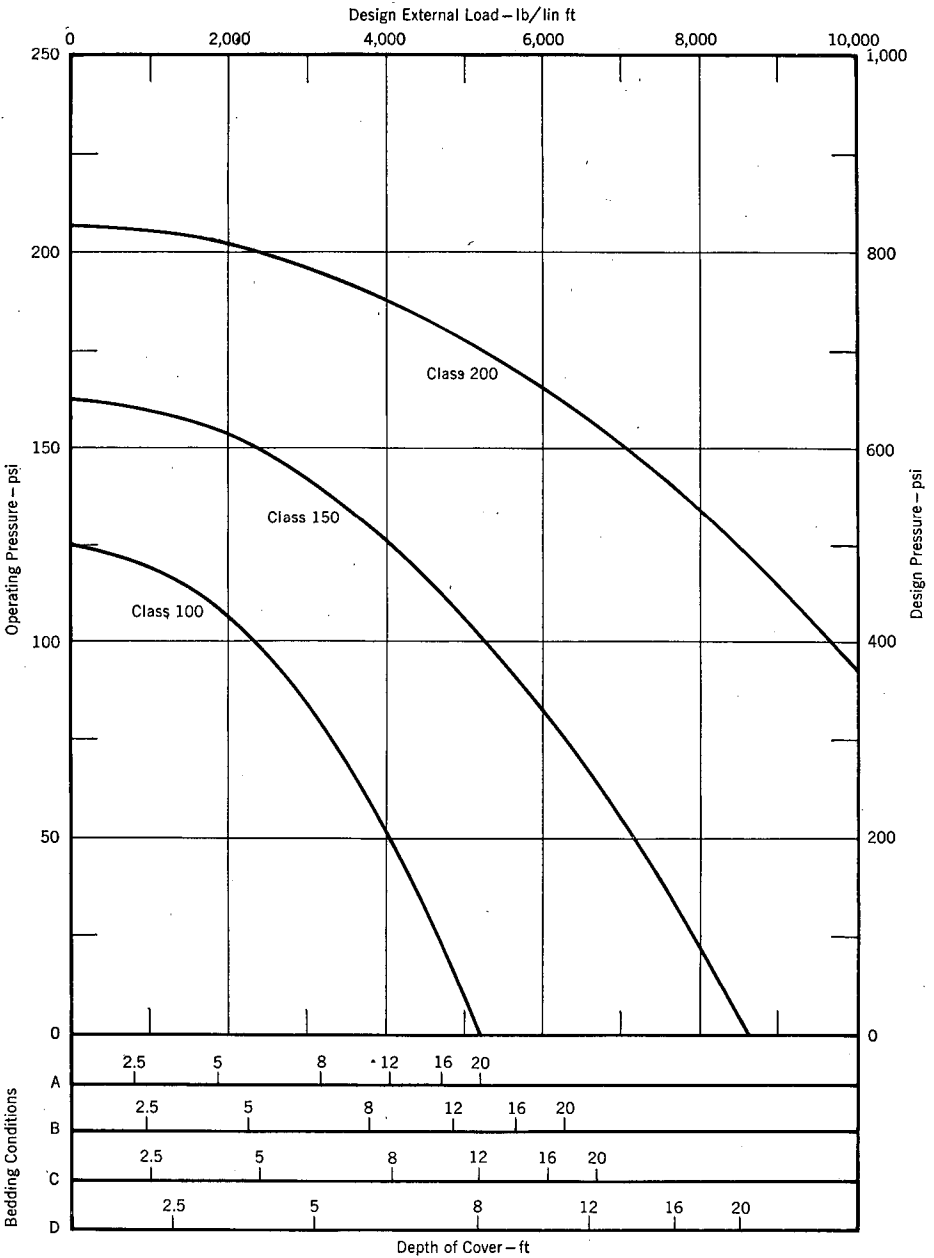


Fig. A8. Selection Curves for 14-in. Asbestos-Cement Pipe

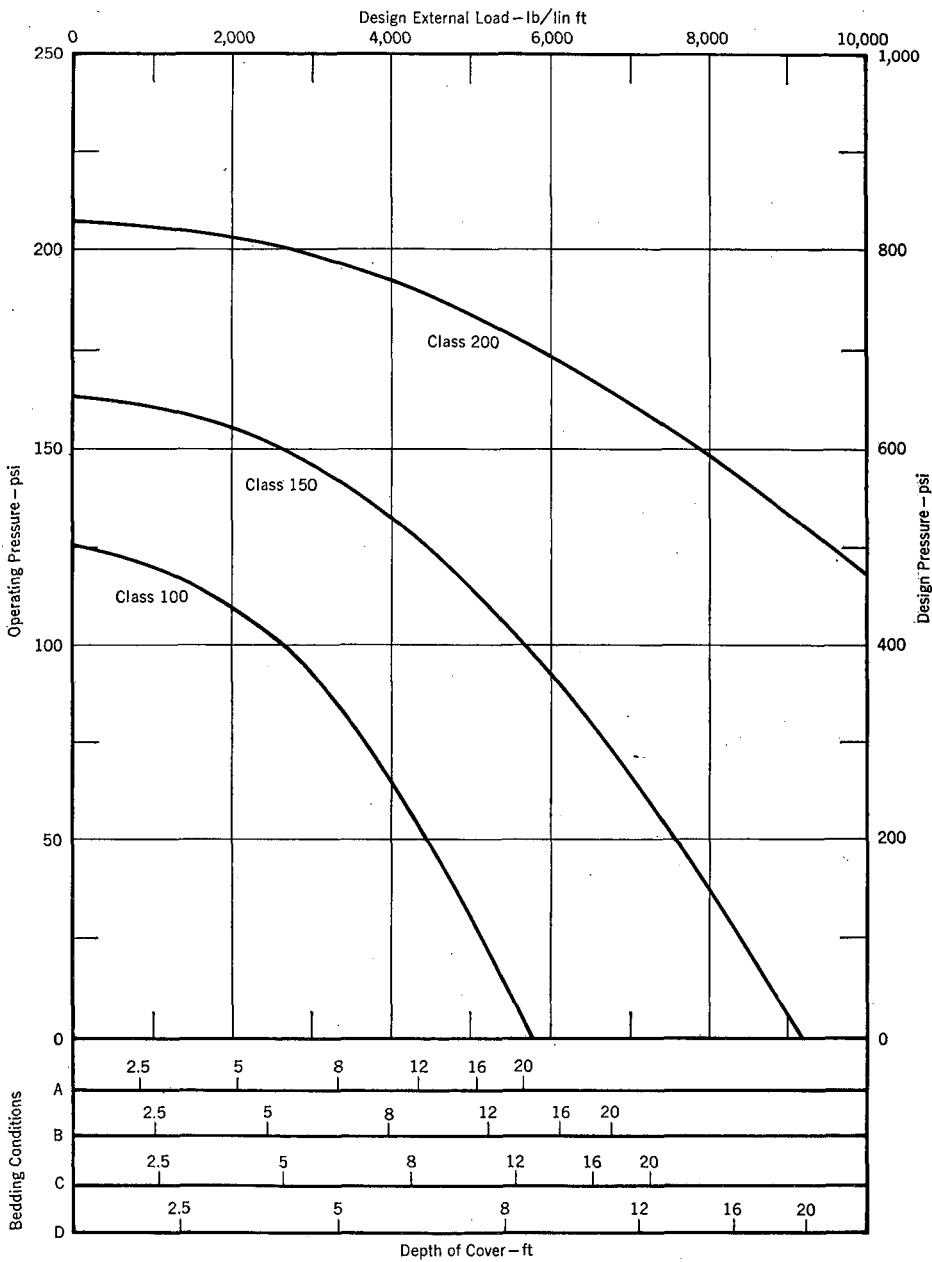


Fig. A9. Selection Curves for 16-in. Asbestos-Cement Pipe

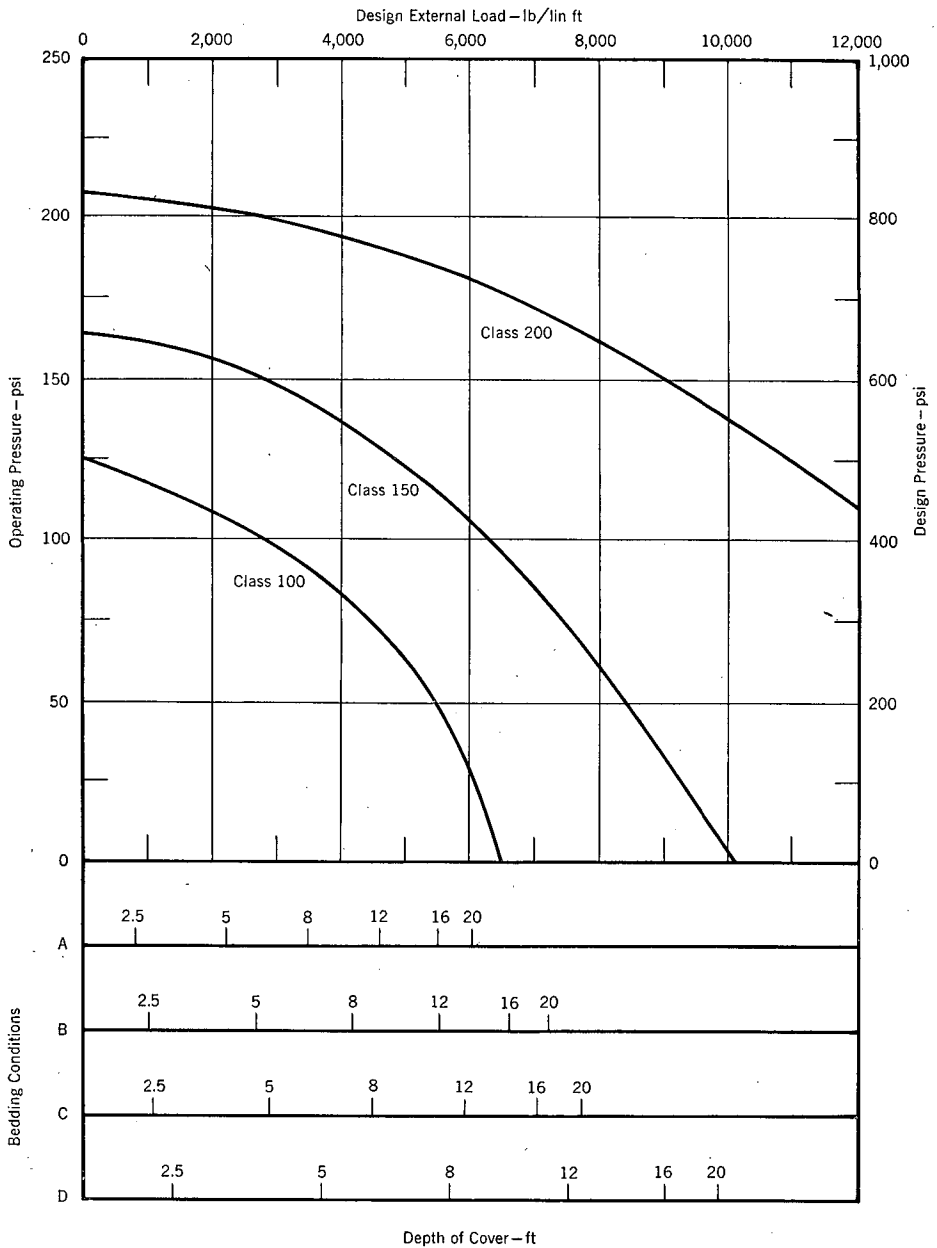


Fig. A10. Selection Curves for 18-in. Asbestos-Cement Pipe

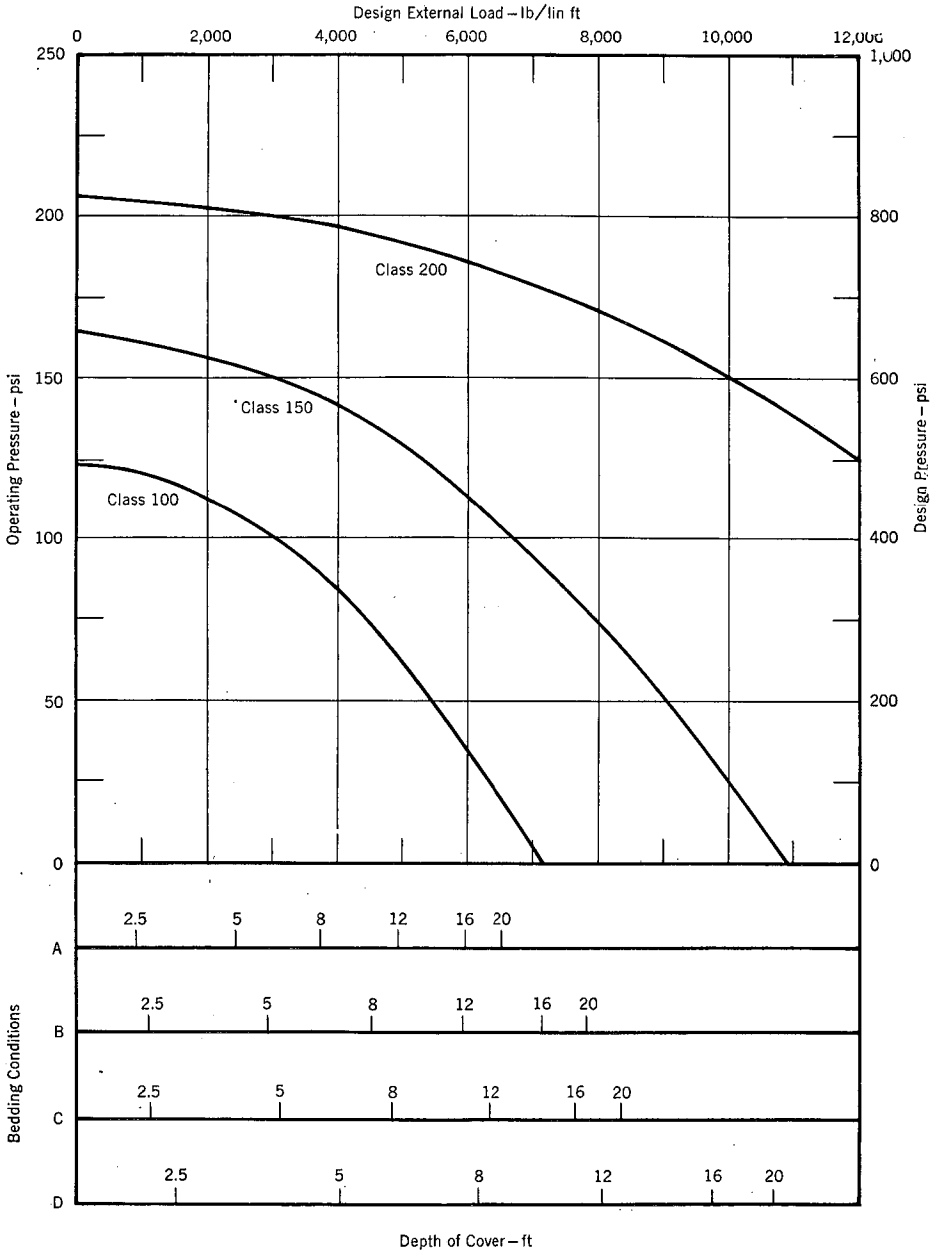


Fig. A11. Selection Curves for 20-in. Asbestos-Cement Pipe

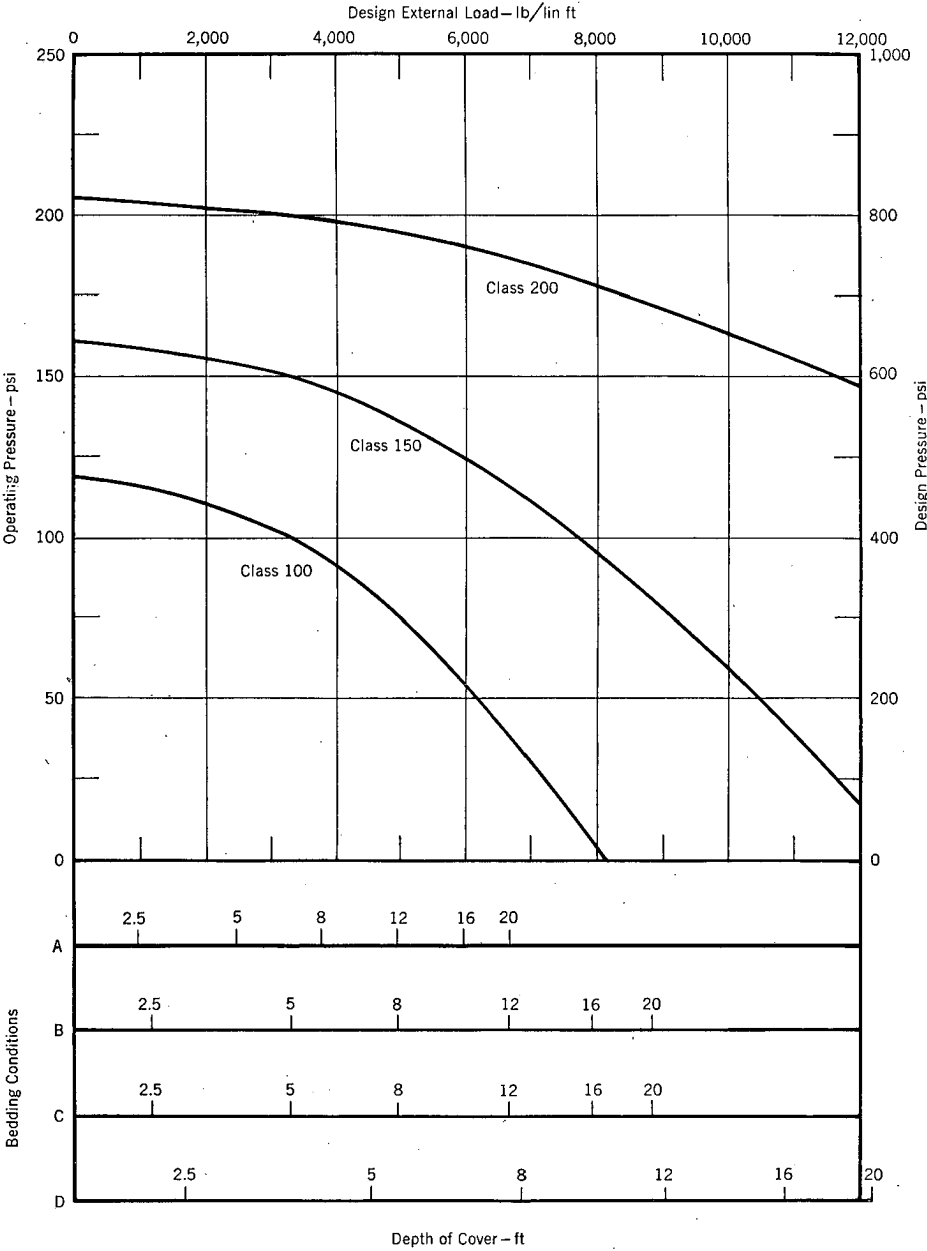


Fig. A12. Selection Curves for 24-in. Asbestos-Cement Pipe

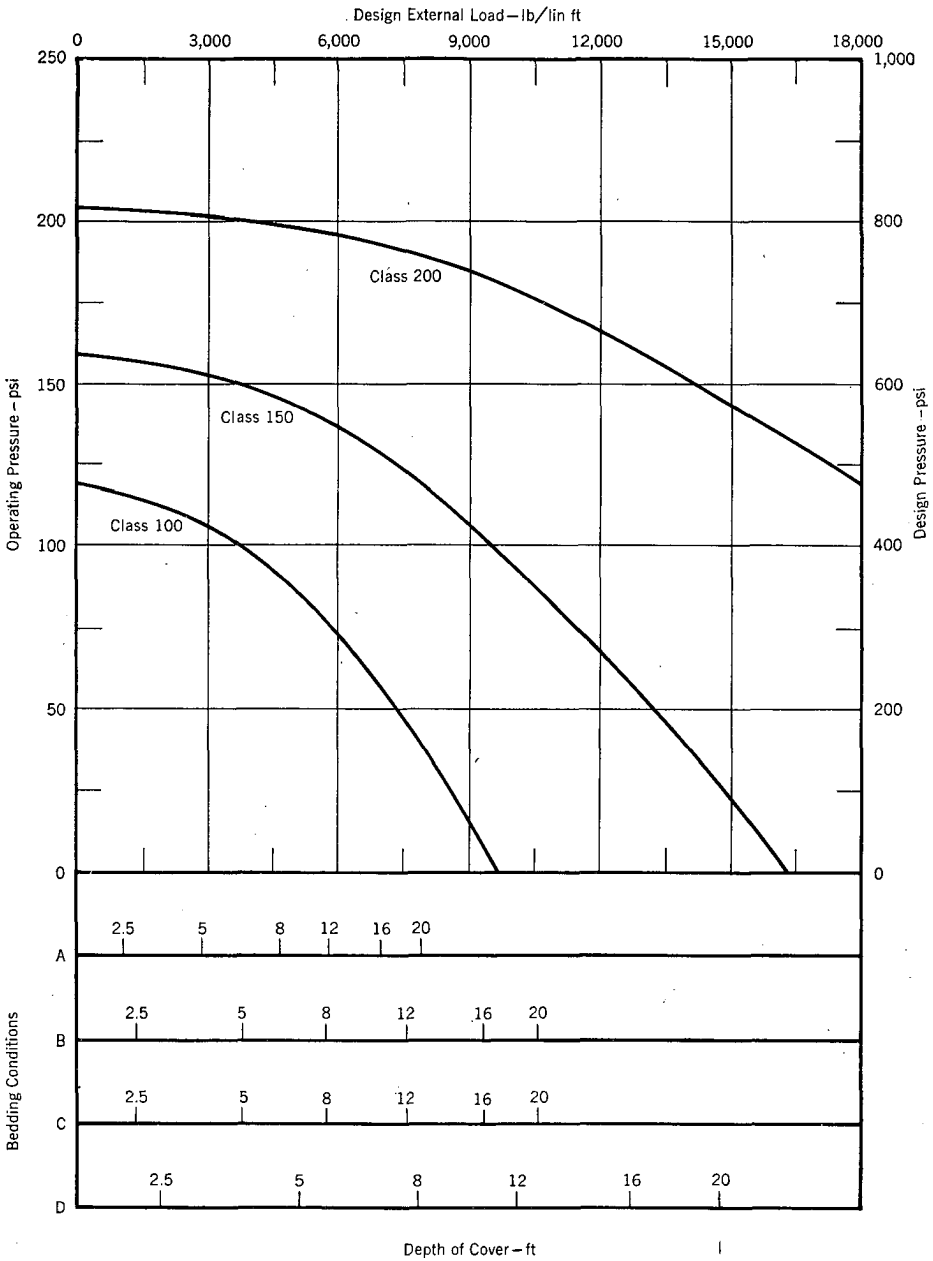


Fig. A13. Selection Curves for 30-in. Asbestos-Cement Pipe

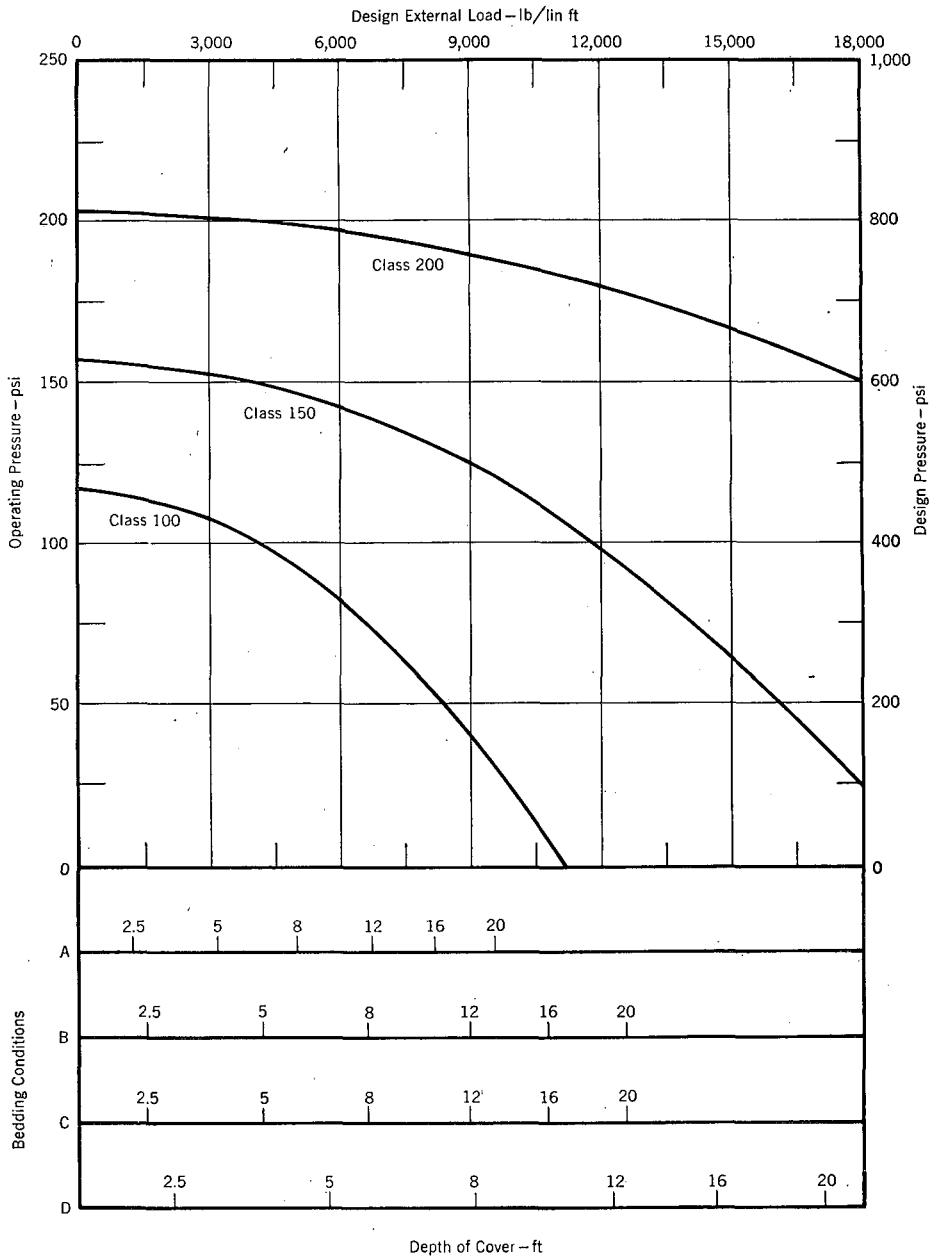


Fig. A14. Selection Curves for 36-in. Asbestos-Cement Pipe

TABLE A2

Design Internal Pressure and Design External Load Intercepts for Use With Selection Curves

Pipe Size in.	Class 100		Class 150		Class 200	
	<i>P</i> psi	<i>W</i> lb/lin ft	<i>P</i> psi	<i>W</i> lb/lin ft	<i>P</i> psi	<i>W</i> lb/lin ft
4	417	4,100	616	5,400	809	8,700
6	441	4,000	632	5,400	815	9,000
8	472	4,000	653	5,500	824	9,300
10	490	4,400	650	7,000	826	11,000
12	490	5,200	658	7,600	830	11,800
14	500	5,200	650	8,600	826	13,500
16	500	5,800	654	9,200	825	15,400
18	495	6,500	655	10,100	826	17,400
20	493	7,100	656	10,900	824	19,400
24	479	8,100	645	12,700	820	22,600
30	468	9,700	638	15,900	816	28,400
36	465	11,200	630	19,600	813	33,800

