Engineering Design File

Transportation of the PM-2A Tanks from the TSF-26 Site to the TAN-607A High Bay

Portage Project No.: 2703.00
Project Title: PM-2A Remediation Phase 1

Portage ENVIRONMENTAL

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ENGINEERING DESIGN FILE

1. Portage Project No.: 2703.00   2. Project/Task: PM-2A Remediation Phase 1

3. Subtask: Tank Excavation, Transport, and Storage

4. Title: Transport of the PM-2A Tanks from the TSF-26 Site to the TAN-607A High Bay

5. Summary:

This engineering design file evaluates the impact of loads imposed during the transportation of the PM-2A tanks to the Test Area North-607A High Bay may have on underground utilities within the transport path. This engineering design file also identifies overhead power and communication lines in the transport path that require rerouting or lifting and fill/grading requirements for the transport path.

6. Distribution: (Portage Environmental, Inc.)

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(Identify minimum reviews and approvals. Additional reviews/approvals may be added.)

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TABLES

1. INTRODUCTION AND PURPOSE

The purpose of this engineering design file (EDF) is to evaluate the impact of loads imposed on underground utilities located beneath the transport path for the PM-2A tanks from the Technical Support Facility (TSF)-26 site to the Test Area North (TAN)-607A High Bay and to determine the need for modification of the transport path.

This EDF also addresses necessary relocation of overhead communication and electrical lines and transport path preparation activities (i.e., fill and grade) necessary for transport of the PM-2A tanks from the TSF-26 site to the TAN-607A High Bay.

2. UNDERGROUND UTILITIES

A variety of underground piping is located beneath the proposed transport path. Table 1 provides a summary of the buried piping between the TSF-26 site and the TAN-607A High Bay. This piping was evaluated to determine whether the load imposed during transport of the PM-2A tanks would detrimentally impact the buried piping.

Table 1. Summary of the buried piping between the TSF-26 site and the TAN-607A High Bay.

Pipe Number	Description/Type[a]	Size	Material of Construction	Depth Below Grade at Crossing	Status
10″ SSD-10001	Sanitary sewer from TSF area to TAN-711	10 in.	Concrete	8.21 ft	In service
Unidentified line (see Drawing 423185, Sheet 3 of 6)	Fire water west of Firehole Road	8 in.	Steel	Approx. 5 ft	Abandoned
10″ SWD-10035	Service waste to TAN injection well	10 in.	Concrete	5 ft	Not in service
Unidentified line (see Drawing 423185, Sheet 3 of 6)	Fire water main west of Firehole Road	4 in.	Steel	Approx. 5 ft	In service
Unidentified line (see Drawing 217515)	Water line east of Firehole Road	4 in. (assumed)	Steel	Approx. 5 ft	In service
Unidentified line (see Drawing 217515)	Water line from TAN-609	4 in. (assumed)	Steel	Approx. 5 ft	Abandoned
Unidentified line (see Drawing 423185, Sheet 3 of 6)	Fire water line from TAN-609	4 in. (assumed)	Steel	Approx. 5 ft	Abandoned
Unidentified line (see Drawing 423185, Sheet 3 of 6)	Fire water main	4 in. (assumed)	Steel	Approx. 5 ft	In service
8″ SSD-10009	Sanitary sewer from TAN-609	8 in.	Concrete	Approx. 7 ft	Abandoned

Table 1. (continued).

Pipe Number	Description/Type[a]	Size	Material of Construction	Depth Below Grade at Crossing	Status
8″ SSD-10002	Sanitary sewer MH#1 to MH#2	8 in.	Concrete	Approx. 10 ft	In service
8″ SWD-10036	Service waste from TAN-607	8 in.	Concrete	Approx. 5 ft	Abandoned
8″ SWD-10038	Service waste from TAN-609	8 in.	Concrete	Approx. 5 ft	Abandoned
Unidentified line (see Drawing 217515)	Water across Snake Avenue	8 in.	Steel	Approx. 5 ft	In service
Unidentified line (see Drawing 217515)	Water west of TAN-607	8 in.	Steel encased in concrete under tracks	Approx. 5 ft	In service
10″ SSD-10001	Sanitary sewer	10 in.	Concrete encased in concrete under tracks	Approx. 9 ft	In service

a. *Buried Waste Line Register for NRTS* (Paige 1972).

Based on a review of the piping, the two concrete sanitary sewer lines were determined to have the highest potential for damage resulting from transport of the PM-2A tanks. The 10-in. line is approximately 8 ft below the ramp from the TSF-26 site. The 8-in. line is approximately 10 ft below Snake Avenue.

2.1 Imposed Load

The weight of the transporter, tank, and saddle supports is estimated to be 237,000 lb. The wheel load is estimated to be 4,032 lb/ft^2 (Duratek Drawing C-067-RP0003-003).

2.2 Breaking Strength of the 10-in. Sewer Pipe

Available records indicate that the sanitary sewer line is 10-in. concrete pipe (R. M. Parsons Drawing 1229-5-ANP/GE-3-607-U106). No additional design data have been identified for the sanitary sewer line. Therefore, it is assumed that line is bedded properly and the crushing strength is equal to 2,000 lb/lf. (*Design Data 25*; see Attachment 1 [ACPA 1974])

2.3 Load Analysis

The vertical external load on the 10-in. sanitary sewer line is calculated with the following assumptions:

- The soil are relatively dry soils conservatively estimated to weigh, W = 120 lb/ft^3
- The height of the soil above the top of the pipe, H, is 8.21 ft.

2.3.1 Live Load

- Impact factor (1.75, most conservative value)
- Percent of wheel load on pipe (from table on Page 40 of Clay Pipe Engineering Manual; see Attachment 1 [NCPI 1968]) = 0.60%
- From table on Page 101 of the Concrete Pipe Design Manual (see Attachment 1 [ACPA 1970]), a 10-in. pipe, the weight of the soil at 120 lb/ ft^3, and a 8-ft depth the maximum worst-case load = 1,193 lb
- The wheel load transmitted to the pipe x impact factor x wheel load
- (0.006 x 1.75) (4,032 lb) $\cong$ 42 lb.

2.3.2 Maximum Actual Load

- 1193 lb + 42 lb = 1,235 lb, which is less than 2,000-lb crushing strength. Therefore, no reinforcing is necessary.

Using appropriate values for the 8-in. line, the maximum load is calculated at 1,248 lb, which is less than the 2,000 lb required to crush the pipe (see Attachment 1).

2.4 Evaluation of Other Piping

The steel water lines and fire water lines have allowable working pressures that are in excess of the crushing strength of the 10-in. or 8-in. sanitary sewer lines. The maximum working pressures for these pipes (assumed to be Schedule 40 wrought steel pipe) are 1,400 psi for the 4-in. pipe and 1,100 psi for the 8-in. line, respectively. Because of the working pressure of these lines, no additional evaluation is necessary.

3. OVERHEAD COMMUNICATION AND ELECTRICAL LINES

The height of the transporter and tank is approximately 21.5 ft. The following list summarizes the overhead line heights and required actions.

- Immediately east of the TSF-26 site, power and communication lines cross the path of the transporter at heights of 33.1 ft and 20.8 ft, respectively. The communication line should be raised or removed.
- Two communication lines run south from power pole #54-8 across the transporter path at heights of 19.7 ft and 18.6 ft. Both of these lines will need to be raised or removed.

- A set of power and communication lines run parallel to Snake Avenue. The transport path crosses beneath these lines between power pole #54-8 and #54-7. The power lines are at a height of 40.5 ft and communication lines are located at 20.5 ft, 21.1 ft, 21.7 ft, and 24.5 ft. The three communication lines should be raised or removed.

4. TRANSPORT PATH FILL AND GRADE REQUIREMENTS

Based on site visits conducted by Portage Environmental, Inc., and its sub-tier contractors, only one area of the proposed transport path requires additional fill and grading to support transport of the PM-2A tanks beyond that already specified as part of tank excavation and site preparation activities associated with the TSF-26 site. The area directly west of the TAN-607A High Bay entrance and the access road requires fill and grading to support the turn radius of the transporter to allow the load to be backed into the TAN-607A High Bay.

An area 20 ft in width and 90 ft in length from the edge of the existing asphalt top will need to be filled, graded, and compacted along the railroad tracks. Fill materials shall be placed in loose lifts not exceeding 6 in. in thickness, uniformly moisture-conditioned, and compacted to a minimum of 90% of maximum dry density per ASTM D-698, within 2% of optimum moisture content. The top of the finished grade (ground surface) will be flat and level with the tops of the rails.

5. CONCLUSIONS AND RECOMMENDATIONS

Based on review of the buried piping beneath the transport path, no additional site preparation actions are necessary for the transport of the tanks.

Six overhead communication lines need to be removed or raised to provide adequate entrance during transport of the tanks.

Grade and fill activities are required west of the TAN-607A High Bay.

6. REFERENCES

ACPA, 1970, *Concrete Pipe Design Manual*, American Concrete Pipe Association, 1970.

ACPA, 1974, "Three-Edge Bearing Strengths Nonreinforced Concrete Pipe and Clay Pipe," *Design Data 25*, American Concrete Pipe Association, July 1974.

NCPI, 1968, *Clay Pipe Engineering Manual*, National Clay Pipe Institute, 1968.

Paige, B. E., 1972, *Buried Waste Line Register for NRTS, Part II TAN*, Allied Chemical Corporation, ACI-108, January 1972.

7. DRAWINGS

C-067-RP0003-003, Duratek Drawing, *INEEL PM-2A Tank Site Transportation and Hardware*, Revision 2, May 12, 2004.

1229-5 ANP/GE-3-607-U106, The Ralph M. Parsons Company Drawing, *ANP Assembly & Maintenance Area Expansion of Assembly & Maintenance Bldg. 607 Civil Water-Engine Fuel-Steam-Sanitary Sewer Plans and Profiles*, Revision B, August 3, 1956.

1230 TAN/TSF 305-1, *TAN Area Waste Line Identification*, November 16, 1971.

217515, *Water Line A&M Area*, April 1, 1957.

423185, Revision 9, Sheet 3 of 6.

Attachment I

Design Calculations and Reference Tables

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design data 25

american concrete pipe association

THREE-EDGE BEARING STRENGTHS NONREINFORCED CONCRETE PIPE AND CLAY PIPE

Pipe strength classifications established by manufacturing and material standards for nonreinforced concrete pipe and clay pipe are based on three-edge bearing test strengths expressed in pounds per linear foot. These test strengths are directly related to the load carrying capacity of the buried pipe. Although the methods of presenting the strength classes of these two pipe materials are similar, nonreinforced concrete pipe strength classes provide the designer with additional latitude in selecting pipe strengths to satisfy a broader range of performance requirements.

STRENGTH COMPARISONS

The American Society for Testing and Materials (ASTM) Specification C14, Concrete Sewer, Storm Drain and Culvert Pipe, covers the three strength classes of nonreinforced concrete pipe. ASTM Specification C700, Extra Strength and Standard Strength Clay Pipe and Perforated Clay Pipe, covers two strength classifications of clay pipe. Table I presents a comparison of the specified minimum three-edge bearing strengths of the three classes of nonreinforced concrete pipe versus the standard strength class and extra strength class of clay pipe through 24 inch diameter. Class 1 minimum three-edge bearing strengths for nonreinforced concrete pipe exceed or meet the minimum three-edge bearing strengths of standard strength clay pipe in each size. Class 3 minimum three-edge bearing strengths for nonreinforced concrete pipe exceed or meet the minimum three-edge bearing strengths of extra strength clay pipe in each size. Class 2 nonreinforced concrete pipe provides the designer with intermediate strengths and the option to select a strength meeting load requirements more realistically and economically. Figure 1 presents these comparisons in graphic form and enables the designer to readily determine the inherent structural advantages of nonreinforced concrete pipe.

TESTING PROCEDURE

The complete procedure of testing concrete pipe and clay pipe are contained in ASTM Standard C497, Methods of Testing Concrete Pipe and Tile, and ASTM Standard C301, Methods of Testing Clay Pipe. The external load crushing strength test with the load applied by three-edge bearing is the accepted test method for both clay and concrete pipe. The test procedures are similar, except when wooden bearing strips are used for clay pipe plaster of paris must be cast on the contact edges since the barrel of the pipe is often irregular. This same procedure may be employed in the testing of concrete pipe if it is mutually agreed upon by the manufacturer and purchaser prior to testing.

SELECTION OF PIPE STRENGTH

The required three-edge bearing strengths for concrete pipe and clay pipe are computed by the equation:

$$\text{T.E.B.} = \frac{W_L + W_E}{L_f} \times \text{F.S.} \quad (1)$$

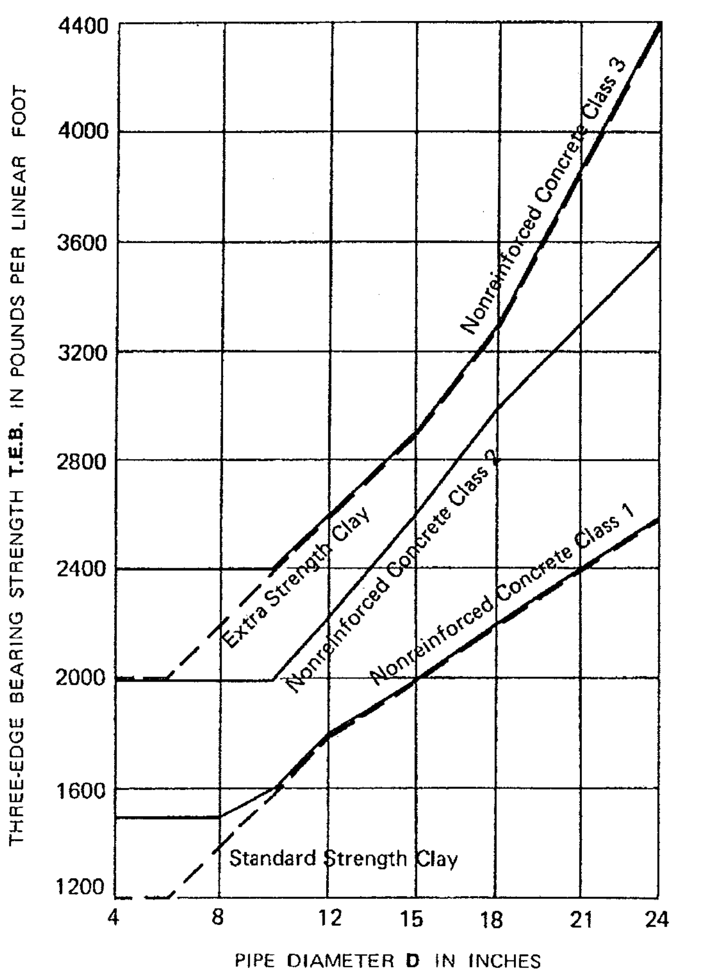
where:

- T.E.B. = three-edge bearing strength, pounds per linear foot
- W_L = live load, pounds per linear foot
- W_E = earth load, pounds per linear foot
- L_f = load factor
- F.S. = factor of safety

TABLE I: Three-Edge Bearing Strengths — Nonreinforced Concrete, Classes 1, 2, and 3, Clay, Standard Strength and Extra Strength

Diameter	Nonreinforced Concrete			Clay		Diameter
	Class 1	Class 2	Class 3	Standard Strength	Extra Strength	
4	1500	2000	2400	1200	2000	4
6	1500	2000	2400	1200	2000	6
8	1500	2000	2400	1400	2200	8
10	1600	2000	2400	1600	2400	10
12	1800	2250	2600	1800	2600	12
15	2000	2600	2900	2000	2900	15
18	2200	3000	3300	2200	3300	18
21	2400	3300	3850	2400	3850	21
24	2600	3600	4400	2600	4400	24

FIGURE 1: Strength Comparison
Nonreinforced Concrete Pipe and Clay Pipe



EXAMPLE 1

Given: A 24-inch diameter sanitary sewer line is to be installed on a Class B bedding with a load factor (L_f) of 1.9, in a trench 17 feet deep, with a factor of safety of 1.5. Live load is negligible. Earth load is 4372 pounds per linear foot.

Find: The required strength class of nonreinforced concrete pipe and clay pipe to carry the field loads.

Solution: Determine the required three-edge bearing test strength from equation (1)..

$$T.E.B. = \left(\frac{W_L}{1.5^*} + \frac{W_E}{L_f}\right) F.S.$$
$$= \frac{4372}{1.9} \times 1.5$$
$$= 3452 \text{ pounds per linear foot}$$

Using Table I, locate 24-inch diameter in appropriate column. Proceeding to the right determine most economical class of nonreinforced concrete pipe that exceeds the 3452 T.E.B. strength required. Follow same procedure to determine required class of clay pipe.

Answer: A Class 2 nonreinforced concrete pipe or an extra strength clay pipe is required.

The required strength class could also have been obtained from Figure 1.

EXAMPLE 2

Given: A 12-inch sanitary sewer line is to be installed in a 2½-foot wide trench with 13 feet of cover over the top of the pipe. The pipe will be backfilled with ordinary clay weighing 120 pounds per cubic foot. A Class C bedding is specified and a factor of safety of 1.5 will be used. Live load is negligible and earth load is 2137 pounds per linear foot.

Find: The required strength class of nonreinforced concrete pipe and clay pipe to carry the field loads.

Solution: Determine the required three-edge bearing test strength from equation (1).

$$T.E.B. = \left(\frac{W_L}{1.5^*} + \frac{W_E}{L_f}\right) F.S.$$
$$= \frac{2137}{1.5} \times 1.5$$
$$= 2137 \text{ pounds per linear foot}$$

Enter Figure 1 at D = 12 inches on the horizontal scale and project a vertical line to the nonreinforced concrete pipe class and clay pipe class which has a three-edge bearing strength greater than 2137 as indicated on the vertical scale.

Answer: A Class 2 nonreinforced concrete pipe or an extra strength clay pipe is required.

The required strength class could also have been obtained from Table I.

* maximum live load factor of 1.5 is recommended

PERCENTAGE OF WHEEL LOADS
TRANSMITTED TO UNDERGROUND PIPES*

Tabulated figures show percentage of wheel load applied to one lineal foot of pipe.

Depth of Backfill Over Top of Pipe in feet	Pipe Size Inches	6″	8″	10″	12″	15″	18″	21″	24″	27″	30″	33″	36″	39″	42″
	Outside Diam. of Pipe in Feet (Approx.)	.64	.81	1.0	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.3	3.5	3.9	4.2
1		12.8	15.0	17.3	20.0	22.6	24.8	26.4	27.2	28.0	28.6	29.0	29.4	29.8	29.9
2		5.7	7.0	8.3	9.6	11.5	13.2	15.0	15.6	16.8	17.8	18.7	19.5	20.0	20.5
3		2.9	3.6	4.3	5.2	6.4	7.5	8.6	9.3	10.2	11.1	11.8	12.5	12.9	13.5
4		1.7	2.1	2.5	3.1	3.9	4.6	5.3	5.8	6.5	7.2	7.9	8.5	8.8	9.2
5		1.2	1.4	1.7	2.1	2.6	3.1	3.6	3.9	4.4	4.9	5.3	5.8	6.1	6.4
6		0.8	1.0	1.1	1.4	1.8	2.1	2.5	2.8	3.1	3.5	3.8	4.2	4.3	4.4
7		0.5	0.7	0.8	1.0	1.3	1.6	1.9	2.1	2.3	2.6	2.9	3.2	3.3	3.5
8		0.4	0.5	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.3	2.5	2.6

*These figures make no allowance for impact. For moving loads (particularly construction equipment, etc.) on unsurfaced areas the percentage figures above should be multiplied by an impact factor of 1.5 Highway, 1.75 Railway, 1.00 Airfield Runways, 1.50 Airfield Taxiways.

Unless other data are available, it is safe to estimate that truck wheel loads are the greatest live loads to be supported. H-20 wheel loadings are standard for highway and bridge design and are equally applicable for estimating live loads on sewers.

H-20 refers to loadings resulting from the passage of trucks having a gross weight of 20 tons, 80% of which is on the rear axle, with axle spacing of 14′0″ center to center, and a wheel gauge of 6′0″, each rear wheel carrying one half this load or 16,000 pounds each without impact.

Superimposed Loads

Sewers located in yards of industrial plants or under earth fills may have to withstand superimposed loads in addition to trench backfill loads.

Where superimposed loads are encountered they are added to the predetermined backfill load. To compute the superimposed load on a pipe the following Marston formula is used.

$$W_{us} = C_{us} B_d U_s$$

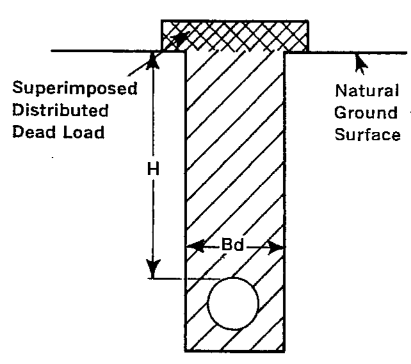
W_{us} = The average total vertical load on a section of a conduit due to U_s, pounds per linear foot.

C_{us} = A coefficient for superimposed loads on ditch conduits, abstract number. (See table on p. 41.)

B_d = Horizontal breadth of ditch at top of conduit, feet.

U_s = uniformly distributed, superimposed load, pounds per square foot.

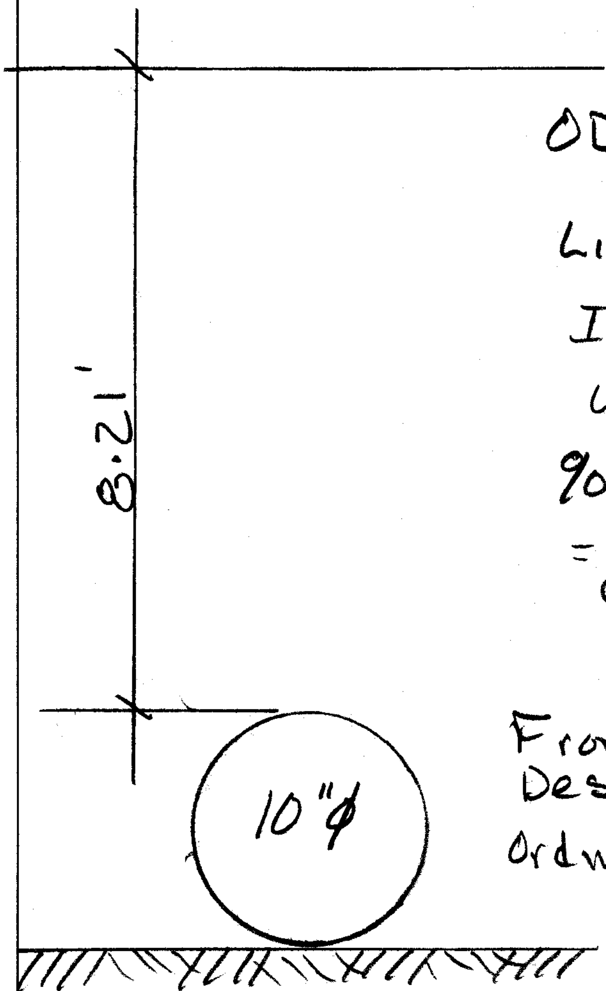
H = Vertical height from top of conduit to upper surface of fill, feet.



C B Poteluuas
9 June 2004

Load analysis on 10" Sanitary Sewer

Wheel Load = 4032 #/ft²
Assume Soil Dry Clay 120 #/ft³



OD = 1'-0"   D = 8.21'

Live Load:

Impact factor Range 1.0 to 1.75
Use 1.75 (most conservative)

% of wheel load to reach pipe
= 0.6% from Table page 40
Clay Pipe Engrg Manual

From Table 14 Conc Pipe Design Manual
Ordinary Clay @ 8' depth
Maximum Value = 1193 #/lf

Max Actual Load = (0.006 × 1.75)(4032)# + 1193 #/lf
= 1235 #/lf.

Bearing strength of 10" Conc Pipe from ACPI Design Data 25 = 2000 #

1235 #/lf < 2000 #/lf

13-782 500 SHEETS, FILLER 5 SQUARE
42-381 50 SHEETS EYE-EASE® 5 SQUARE
42-382 100 SHEETS EYE-EASE® 5 SQUARE
42-389 200 SHEETS EYE-EASE® 5 SQUARE
National® Brand
Made in U.S.A.

Load analysis on 8" Sanitary Sewer
OD = 0.8125'   D = 9.1875'
Wheel load = 4032 #/ft²
Assume Soil Dry Clay 120#/ft³

Live Load:
Impact factor Range 1.0 to 1.75 Use <u>1.75</u>
reasons stated previously. (most conservative)
% of wheel load to Reach pipe = 0.5%
from Table page <u>40</u> Clay Pipe Engrg Manual.

From Table 13 Concrete Pipe Design Manual
Max value for 10' depth = 1213 #/lf
Max Actual Load = Impact Load + Backfill Load
$= (0.005 \times 1.75)(4032)\frac{\#}{ft^2} + 1213\ \#/lf$
$= 1248.28\ \#/lf$

Bearing Strength of 8" Conc Pipe from
ACPI Design Data 25 = 2000 #

$1248\ \#/lf < 2000\ \#/lf$

13-782 500 SHEETS, FILLER 5 SQUARE
42-381 50 SHEETS EYE-EASE® 5 SQUARE
42-382 100 SHEETS EYE-EASE® 5 SQUARE
42-389 200 SHEETS EYE-EASE® 5 SQUARE
Made in U.S.A.
National® Brand

TABLE 13

8" BACKFILL LOADS ON CIRCULAR PIPE IN TRENCH INSTALLATION 8"

*100 POUNDS PER CUBIC FOOT BACKFILL MATERIAL — LOADS IN POUNDS PER LINEAR FOOT

A SAND AND GRAVEL Kμ'—0.165

HEIGHT OF BACKFILL H ABOVE TOP OF PIPE, FEET	TRENCH WIDTH AT TOP OF PIPE 1'-6"	1'-9"	2'-0"	2'-3"	2'-6"	2'-9"	3'-0"	3'-3"	3'-6"	4'-0"	▲TRANSITION WIDTH
5	454	566	**603**								1'-10"
6	499	628	**724**								1'-11"
7	535	680	**847**								2'- 0"
8	564	722	888	**969**							2'- 1"
9	587	758	937	**1088**							2'- 2"
10	606	787	979	**1213**							2'- 3"
11	621	811	1014	1228	**1332**						2'- 4"
12	633	831	1044	1270	**1458**						2'- 5"
13	642	848	1070	1306	**1575**						2'- 6"
14	650	861	1091	1337	1595	**1698**					2'- 7"
15	656	873	1010	1364	1632	**1818**					2'- 8"
16	661	882	1125	1387	1664	**1942**					2'- 9"
17	665	890	1138	1407	1693	1993	**2065**				2'-10"
18	668	896	1149	1424	1717	2027	**2182**				2'-10"
19	671	902	1159	1439	1739	2057	**2308**				2'-11"
20	673	906	1167	1452	1758	2083	**2429**				3'- 0"
21	675	910	1174	1463	1775	2107	2456	**2553**			3'- 1"
22	676	913	1179	1473	1790	2128	2484	**2673**			3'- 2"
23	677	915	1184	1481	1802	2146	2510	**2788**			3'- 2"
24	678	917	1189	1488	1814	2163	2532	**2910**			3'- 3"
25	679	919	1192	1494	1824	2177	2552	2947	**3041**		3'- 4"
26	679	921	1195	1500	1832	2190	2571	2972	**3154**		3'- 4"
27	680	922	1198	1504	1840	2201	2587	2994	**3278**		3'- 5"
28	680	923	1200	1508	1846	2212	2601	3014	**3398**		3'- 6"
29	680	924	1201	1512	1852	2221	2614	3032	**3514**		3'- 6"
30	680	924	1203	1515	1857	2229	2626	3048	3492	**3646**	3'- 7"
31	681	925	1204	1517	1862	2236	2637	3063	3512	**3776**	3'- 8"
32	681	925	1205	1520	1866	2242	2646	3076	3530	**3880**	3'- 8"
33	681	926	1206	1521	1869	2247	2654	3088	3546	**4004**	3'- 9"
34	681	926	1207	1523	1872	2252	2662	3099	3561	**4124**	3'- 9"
35	681	926	1208	1525	1875	2257	2669	3109	3575	**4241**	3'-10"
36	681	926	1208	1526	1877	2261	2675	3118	3587	**4384**	3'-11"
37	681	927	1209	1527	1879	2264	2680	3126	3598	**4495**	3'-11"
38	681	927	1209	1528	1881	2267	2685	3133	3608	**4603**	4'- 0"
39	681	927	1210	1529	1882	2270	2689	3139	3618	**4740**	4'- 0"
40	681	927	1210	1529	1884	2272	2693	3142	3626	**4877**	4'- 1"

B SATURATED TOP SOIL Kμ'—0.150

HEIGHT OF BACKFILL H ABOVE TOP OF PIPE, FEET	TRENCH WIDTH AT TOP OF PIPE 1'-6"	1'-9"	2'-0"	2'-3"	2'-6"	2'-9"	3'-0"	3'-3"	3'-6"	4'-0"	▲TRANSITION WIDTH
5	474	**603**									1'- 9"
6	524	655	**724**								1'-11"
7	565	713	**847**								2'- 0"
8	598	761	931	**969**							2'- 1"
9	626	802	987	**1088**							2'- 2"
10	648	836	1035	**1213**							2'- 3"
11	666	865	1077	**1332**							2'- 3"
12	681	890	1112	1346	**1458**						2'- 4"
13	694	910	1143	1389	**1575**						2'- 5"
14	704	928	1170	1426	**1698**						2'- 6"
15	712	942	1192	1459	1738	**1818**					2'- 7"
16	719	955	1212	1487	1777	**1942**					2'- 8"
17	724	965	1229	1512	1812	**2065**					2'- 8"
18	729	974	1243	1534	1843	**2182**					2'- 9"
19	733	981	1256	1553	1870	2203	**2308**				2'-10"
20	736	987	1266	1570	1894	2236	**2429**				2'-11"
21	738	992	1276	1584	1915	2265	**2553**				2'-11"
22	740	997	1284	1597	1934	2292	**2673**				3'- 0"
23	742	1001	1291	1608	1951	2315	2699	**2788**			3'- 1"
24	743	1004	1296	1618	1966	2336	2727	**2910**			3'- 1"
25	744	1006	1301	1627	1979	2355	2753	**3041**			3'- 2"
26	745	1008	1306	1634	1991	2373	2777	**3154**			3' 3"
27	746	1010	1310	1641	2001	2388	2798	**3278**			3'- 3"
28	747	1012	1313	1647	2010	2401	2817	3255	**3398**		3'- 4"
29	747	1013	1316	1652	2019	2414	2834	3278	**3514**		3'- 5"
30	748	1014	1318	1656	2026	2425	2850	3300	**3646**		3'- 5"
31	748	1015	1320	1660	2032	2435	2864	3319	**3776**		3'- 6"
32	748	1016	1322	1663	2038	2444	2877	3337	**3880**		3'- 6"
33	748	1017	1323	1666	2043	2451	2889	3353	3842	**4004**	3'- 7"
34	749	1017	1325	1669	2048	2459	2899	3368	3861	**4124**	3'- 8"
35	749	1018	1326	1671	2052	2465	2909	3381	3880	**4241**	3'- 8"
36	749	1018	1327	1673	2055	2471	2918	3393	3896	**4384**	3'- 9"
37	749	1019	1328	1675	2058	2476	2925	3405	3912	**4495**	3'- 9"
38	749	1019	1328	1676	2061	2480	2932	3415	3926	**4603**	3'-10"
39	749	1019	1329	1678	2064	2485	2939	3424	3939	**4740**	3'-10"
40	749	1019	1330	1679	2066	2488	2945	3433	3950	**4877**	3'-11"

C ORDINARY CLAY Kμ'—0.130

maximum value

HEIGHT OF BACKFILL H ABOVE TOP OF PIPE, FEET	TRENCH WIDTH AT TOP OF PIPE 1'-6"	1'-9"	2'-0"	2'-3"	2'-6"	2'-9"	3'-0"	3'-3"	3'-6"	4'-0"	▲TRANSITION WIDTH
5	501	**603**									1'- 9"
6	559	694	**724**								1'-10"
7	608	761	**847**								1'-11"
8	649	819	**969**								2'- 0"
9	683	868	**1088**								2'- 0"
10	712	911	1119	**1213**							2'- 1"
11	736	948	1170	**1332**							2'- 2"
12	757	979	1215	**1458**							2'- 3"
13	774	1007	1254	1513	**1575**						2'- 4"
14	788	1030	1289	1560	**1698**						2'- 4"
15	801	1051	1319	1603	**1818**						2'- 5"
16	811	1068	1346	1640	**1942**						2'- 6"
17	819	1083	1369	1674	1993	**2065**					2'- 7"
18	827	1096	1390	1703	2034	**2182**					2'- 7"
19	833	1107	1408	1730	2070	**2308**					2'- 8"
20	838	1117	1424	1754	2103	**2429**					2'- 9"
21	842	1125	1438	1775	2133	**2553**					2'- 9"
22	846	1133	1450	1793	2159	2545	**2673**				2'-10"
23	849	1139	1461	1810	2184	2578	**2788**				2'-11"
24	851	1144	1470	1825	2205	2607	**2910**				2'-11"
25	854	1149	1478	1838	2225	2635	**3041**				3'- 0"
26	855	1153	1486	1850	2242	2659	**3154**				3'- 0"
27	857	1156	1492	1861	2258	2682	3128	**3278**			3'- 1"
28	858	1159	1498	1870	2273	2702	3155	**3398**			3'- 2"
29	859	1162	1502	1878	2286	2721	3181	**3514**			3'- 2"
30	860	1164	1507	1886	2297	2738	3204	**3646**			3'- 3"
31	861	1166	1511	1892	2308	2753	3225	**3776**			3'-.3"
32	862	1167	1514	1898	2317	2767	3245	3748	**3880**		3'- 4"
33	862	1169	1517	1904	2326	2780	3263	3772	**4004**		3'- 4"
34	862	1170	1519	1908	2333	2791	3279	3794	**4124**		3'- 5"
35	863	1171	1522	1913	2340	2802	3294	3815	**4241**		3'- 5"
36	863	1172	1524	1916	2346	2811	3308	3834	**4384**		3'- 6"
37	863	1173	1525	1920	2352	2820	3321	3851	**4495**		3'- 6"
38	864	1173	1527	1922	2357	2828	3333	3868	4431	**4603**	3'- 7"
39	864	1174	1528	1925	2362	2835	3343	3883	4451	**4740**	3'- 7"
40	864	1174	1529	1927	2366	2842	3353	3896	4470	**4877**	3'- 8"

D SATURATED CLAY Kμ'—0.110

HEIGHT OF BACKFILL H ABOVE TOP OF PIPE, FEET	TRENCH WIDTH AT TOP OF PIPE 1'-6"	1'-9"	2'-0"	2'-3"	2'-6"	2'-9"	3'-0"	3'-3"	3'-6"	4'-0"	▲TRANSITION WIDTH
5	531	**603**									1'- 8"
6	598	**724**									1'- 9"
7	656	814	**847**								1'-10"
8	706	882	**969**								1'-10"
9	749	943	**1088**								1'-11"
10	786	996	**1213**								2'- 0"
11	818	1042	1276	**1332**							2'- 1"
12	846	1084	1332	**1458**							2'- 1"
13	870	1120	1383	**1575**							2'- 2"
14	891	1152	1428	**1698**							2'- 3"
15	909	1180	1469	**1818**							2'- 3"
16	924	1205	1505	1819	**1942**						2'- 4"
17	938	1227	1537	1864	**2065**						2'- 5"
18	949	1247	1567	1905	**2182**						2'- 5"
19	959	1264	1593	1942	**2308**						2'- 6"
20	968	1279	1616	1975	2352	**2429**					2'- 7"
21	975	1292	1637	2005	2393	**2553**					2'- 7"
22	982	1304	1656	2033	2431	**2673**					2'- 8"
23	987	1314	1673	2058	2465	**2788**					2'- 8"
24	992	1323	1688	2080	2497	**2910**					2'- 9"
25	996	1331	1701	2101	2526	**3041**					2'- 9"
26	1000	1339	1714	2120	2552	3008	**3154**				2'-10"
27	1003	1345	1724	2136	2576	3041	**3278**				2'-10"
28	1005	1350	1734	2152	2599	3071	**3398**				2'-11"
29	1008	1355	1743	2166	2619	3099	**3514**				3'- 0"
30	1010	1360	1751	2178	2638	3125	**3646**				3'- 0"
31	1011	1363	1758	2190	2655	3149	3669	**3776**			3'- 1"
32	1013	1367	1764	2200	2670	3171	3699	**3880**			3'- 1"
33	1014	1370	1769	2209	2685	3192	3727	**4004**			3'- 2"
34	1015	1372	1774	2218	2698	3211	3752	**4124**			3'- 2"
35	1016	1374	1779	2226	2710	3228	3776	**4241**			3'- 2"
36	1017	1376	1783	2233	2721	3244	3798	**4384**			3'- 3"
37	1018	1378	1787	2239	2731	3259	3819	**4495**			3'- 3"
38	1018	1380	1790	2245	2740	3273	3838	4434	**4603**		3'- 4"
39	1019	1381	1793	2250	2749	3285	3856	4458	**4740**		3'- 4"
40	1019	1382	1795	2255	2756	3297	3873	4480	**4877**		3'- 5"

** For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.*

*▲Transition loads **(bold type)** and widths based on Kμ—0.19, $r_{sd}p$—0.5 in the embankment equation*

Interpolate for intermediate heights of backfill and/or trench widths

TABLE 14

10" BACKFILL LOADS ON CIRCULAR PIPE IN TRENCH INSTALLATION 10"

*100 POUNDS PER CUBIC FOOT BACKFILL MATERIAL — LOADS IN POUNDS PER LINEAR FOOT

A — SAND AND GRAVEL Kμ'—0.165

HEIGHT OF BACKFILL H ABOVE TOP OF PIPE, FEET	1'-9"	2'-0"	2'-3"	2'-6"	2'-9"	3'-0"	3'-3"	3'-6"	4'-0"	4'-6"	▲TRANSITION WIDTH
5	566	680	**743**								2'-2"
6	628	761	**893**								2'-3"
7	680	830	984	**1043**							2'-4"
8	722	888	1059	**1193**							2'-5"
9	758	937	1124	**1344**							2'-6"
10	787	979	1180	1388	**1495**						2'-8"
11	811	1014	1228	1450	**1645**						2'-8"
12	831	1044	1270	1505	1748	**1795**					2'-10"
13	848	1070	1306	1553	1810	**1946**					2'-11"
14	861	1091	1337	1595	1864	**2094**					3'-0"
15	873	1110	1364	1632	1912	**2241**					3'-0"
16	882	1125	1387	1664	1955	2258	**2395**				3'-1"
17	890	1138	1407	1693	1993	2306	**2547**				3'-2"
18	896	1149	1424	1717	2027	2350	**2698**				3'-3"
19	902	1159	1439	1739	2057	2389	2735	**2842**			3'-4"
20	906	1167	1452	1758	2083	2425	2780	**2994**			3'-5"
21	910	1174	1463	1775	2107	2456	2821	**3150**			3'-6"
22	913	1179	1473	1790	2128	2484	2857	**3301**			3'-6"
23	915	1184	1481	1802	2146	2510	2891	3287	**3445**		3'-7"
24	917	1189	1488	1814	2163	2532	2920	3325	**3595**		3'-8"
25	919	1192	1494	1824	2177	2552	2947	3360	**3739**		3'-9"
26	921	1195	1500	1832	2190	2571	2972	3392	**3892**		3'-9"
27	922	1198	1504	1840	2201	2587	2994	3421	**4041**		3'-10"
28	923	1200	1508	1846	2212	2601	3014	3447	**4201**		3'-11"
29	924	1201	1512	1852	2221	2614	3032	3471	**4340**		4'-0"
30	924	1203	1515	1857	2229	2626	3048	3492	**4493**		4'-0"
31	925	1204	1517	1862	2236	2637	3063	3512	4472	**4642**	4'-1"
32	925	1205	1520	1866	2242	2646	3076	3530	4502	**4786**	4'-2"
33	926	1206	1521	1869	2247	2654	3088	3546	4529	**4950**	4'-2"
34	926	1207	1523	1872	2252	2662	3099	3561	4555	**5085**	4'-3"
35	926	1208	1525	1875	2257	2669	3109	3575	4578	**5243**	4'-4"
36	926	1208	1526	1877	2261	2675	3118	3587	4599	**5397**	4'-4"
37	927	1209	1527	1879	2264	2680	3126	3598	4619	**5549**	4'-5"
38	927	1209	1528	1881	2267	2685	3133	3608	4637	**5697**	4'-6"
39	927	1210	1529	1882	2270	2689	3139	3618	4654	**5842**	4'-6"
40	927	1210	1529	1884	2272	2693	3145	3626	4669	**5983**	4'-7"

B — SATURATED TOP SOIL Kμ'—0.150

HEIGHT OF BACKFILL H ABOVE TOP OF PIPE, FEET	1'-9"	2'-0"	2'-3"	2'-6"	2'-9"	3'-0"	3'-3"	3'-6"	4'-0"	4'-6"	▲TRANSITION WIDTH
5	587	703	**743**								2'-1"
6	655	791	**893**								2'-2"
7	713	866	**1043**								2'-3"
8	761	931	1106	**1193**							2'-4"
9	802	987	1179	**1344**							2'-5"
10	836	1035	1242	1455	**1495**						2'-7"
11	865	1077	1298	1526	**1645**						2'-8"
12	890	1112	1346	1589	**1795**						2'-9"
13	910	1143	1389	1645	**1946**						2'-9"
14	928	1170	1426	1695	1973	**2094**					2'-10"
15	942	1192	1459	1738	2030	**2241**					2'-11"
16	955	1212	1487	1777	2080	**2395**					3'-0"
17	965	1229	1512	1812	2126	2451	**2547**				3'-1"
18	974	1243	1534	1843	2167	2504	**2698**				3'-2"
19	981	1256	1553	1870	2203	2551	**2842**				3'-2"
20	987	1266	1570	1894	2236	2593	**2994**				3'-3"
21	992	1276	1584	1915	2265	2632	3014	**3150**			3'-4"
22	997	1284	1597	1934	2292	2667	3058	**3301**			3'-5"
23	1001	1291	1608	1951	2315	2699	3099	**3445**			3'-5"
24	1004	1296	1618	1966	2336	2727	3136	**3595**			3'-6"
25	1006	1301	1627	1979	2355	2753	3170	3604	**3739**		3'-7"
26	1008	1306	1634	1991	2373	2777	3201	3643	**3892**		3'-8"
27	1010	1310	1641	2001	2388	2798	3229	3679	**4041**		3'-8"
28	1012	1313	1647	2010	2401	2817	3255	3712	**4201**		3'-9"
29	1013	1316	1652	2019	2414	2834	3278	3743	**4340**		3'-10"
30	1014	1318	1656	2026	2425	2850	3300	3771	**4493**		3'-10"
31	1015	1320	1660	2032	2435	2864	3319	3796	**4642**		3'-11"
32	1016	1322	1663	2038	2444	2877	3337	3820	**4786**		4'-0"
33	1017	1323	1666	2043	2451	2889	3353	3842	**4950**		4'-0"
34	1017	1325	1669	2048	2459	2899	3368	3861	4916	**5085**	4'-1"
35	1018	1326	1671	2052	2465	2909	3381	3880	4946	**5243**	4'-2"
36	1018	1327	1673	2055	2471	2918	3393	3896	4974	**5397**	4'-2"
37	1019	1328	1675	2058	2476	2925	3405	3912	5000	**5549**	4'-3"
38	1019	1328	1676	2061	2480	2932	3415	3926	5024	**5697**	4'-3"
39	1019	1329	1678	2064	2485	2939	3424	3939	5047	**5842**	4'-4"
40	1019	1330	1679	2066	2488	2945	3433	3950	5067	**5983**	4'-5"

C — ORDINARY CLAY Kμ'—0.130

Maximum value

HEIGHT OF BACKFILL H ABOVE TOP OF PIPE, FEET	1'-9"	2'-0"	2'-3"	2'-6"	2'-9"	3'-0"	3'-3"	3'-6"	4'-0"	4'-6"	▲TRANSITION WIDTH
5	617	**743**									2'-0"
6	694	833	**893**								2'-1"
7	761	919	**1043**								2'-2"
8	819	994	**1193**								2'-3"
9	868	1060	1258	**1344**							2'-4"
10	911	1119	1334	**1495**							2'-5"
11	948	1170	1400	**1645**							2'-6"
12	979	1215	1460	1713	**1795**						2'-7"
13	1007	1254	1513	1781	**1946**						2'-8"
14	1030	1289	1560	1843	**2094**						2'-8"
15	1051	1319	1603	1898	**2241**						2'-9"
16	1068	1346	1640	1948	2267	**2395**					2'-10"
17	1083	1369	1674	1993	2325	**2547**					2'-11"
18	1096	1390	1703	2034	2378	**2698**					3'-0"
19	1107	1408	1730	2070	2426	**2842**					3'-0"
20	1117	1424	1754	2103	2469	2849	**2994**				3'-1"
21	1125	1438	1775	2133	2509	2900	**3150**				3'-2"
22	1133	1450	1793	2159	2545	2947	**3301**				3'-2"
23	1139	1461	1810	2184	2578	2989	**3445**				3'-3"
24	1144	1470	1825	2205	2607	3029	3466	**3595**			3'-4"
25	1149	1478	1838	2225	2635	3064	3512	**3739**			3'-5"
26	1153	1486	1850	2242	2659	3097	3554	**3892**			3'-5"
27	1156	1492	1861	2258	2682	3128	3593	**4041**			3'-6"
28	1159	1498	1870	2273	2702	3155	3630	**4201**			3'-6"
29	1162	1502	1878	2286	2721	3181	3663	4165	**4340**		3'-7"
30	1164	1507	1886	2297	2738	3204	3693	4204	**4493**		3'-8"
31	1166	1511	1892	2308	2753	3225	3722	4240	**4642**		3'-8"
32	1167	1514	1898	2317	2767	3245	3748	4274	**4786**		3'-9"
33	1169	1517	1904	2326	2780	3263	3772	4305	**4950**		3'-9"
34	1170	1519	1908	2333	2791	3279	3794	4334	**5085**		3'-10"
35	1171	1522	1913	2340	2802	3294	3815	4361	**5243**		3'-11"
36	1172	1524	1916	2346	2811	3308	3834	4386	**5397**		3'-11"
37	1173	1525	1920	2352	2820	3321	3851	4409	**5549**		4'-0"
38	1173	1527	1922	2357	2828	3333	3868	4431	**5697**		4'-0"
39	1174	1528	1925	2362	2835	3343	3883	4451	5666	**5842**	4'-1"
40	1174	1529	1927	2366	2842	3353	3896	4470	5696	**5983**	4'-1"

D — SATURATED CLAY Kμ'—0.110

HEIGHT OF BACKFILL H ABOVE TOP OF PIPE, FEET	1'-9"	2'-0"	2'-3"	2'-6"	2'-9"	3'-0"	3'-3"	3'-6"	4'-0"	4'-6"	▲TRANSITION WIDTH
5	649	**743**									1'-11"
6	737	**893**									2'-0"
7	814	976	**1043**								2'-1"
8	882	1064	**1193**								2'-2"
9	943	1142	**1344**								2'-3"
10	996	1212	1435	**1495**							2'-4"
11	1042	1276	1516	**1645**							2'-5"
12	1084	1332	1589	**1795**							2'-5"
13	1120	1383	1655	**1946**							2'-6"
14	1152	1428	1715	2012	**2094**						2'-7"
15	1180	1469	1770	2082	**2241**						2'-8"
16	1205	1505	1819	2145	**2395**						2'-8"
17	1227	1537	1864	2204	**2547**						2'-9"
18	1247	1567	1905	2258	2623	**2698**					2'-10"
19	1264	1593	1942	2307	2685	**2842**					2'-10"
20	1279	1616	1975	2352	2743	**2994**					2'-11"
21	1292	1637	2005	2393	2796	**3150**					3'-0"
22	1304	1656	2033	2431	2846	**3301**					3'-0"
23	1314	1673	2058	2465	2891	3333	**3445**				3'-1"
24	1323	1688	2080	2497	2933	3387	**3595**				3'-1"
25	1331	1701	2101	2526	2972	3436	**3739**				3'-2"
26	1339	1714	2120	2552	3008	3483	**3892**				3'-2"
27	1345	1724	2136	2576	3041	3526	**4041**				3'-3"
28	1350	1734	2152	2599	3071	3566	4079	**4201**			3'-4"
29	1355	1743	2166	2619	3099	3603	4126	**4340**			3'-4"
30	1360	1751	2178	2638	3125	3637	4171	**4493**			3'-5"
31	1363	1758	2190	2655	3149	3669	4212	**4642**			3'-5"
32	1367	1764	2200	2670	3171	3699	4250	**4786**			3'-6"
33	1370	1769	2209	2685	3192	3727	4286	**4950**			3'-6"
34	1372	1774	2218	2698	3211	3752	4320	4911	**5085**		3'-7"
35	1374	1779	2226	2710	3228	3776	4351	4951	**5243**		3'-7"
36	1376	1783	2233	2721	3244	3798	4381	4988	**5397**		3'-8"
37	1378	1787	2239	2731	3259	3819	4408	5024	**5549**		3'-8"
38	1380	1790	2245	2740	3273	3838	4434	5057	**5697**		3'-9"
39	1381	1793	2250	2749	3285	3856	4458	5088	**5842**		3'-9"
40	1382	1795	2255	2756	3297	3873	4480	5117	**5983**		3'-10"

** For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase 20%; etc.*

*▲Transition loads **(bold type)** and widths based on Kμ—0.19, $r_{sd}p$—0.5 in the embankment equation*

Interpolate for intermediate heights of backfill and/or trench widths

Welded and Seamless Wrought Steel Pipe

Size	Schedule no	Diameter		Thickness	Circumference		Transverse area		Length of pipe per sq ft of surface area		Weight per ft of length	Allowable working pressure at 100°F*	Water hammer factor
		External	Internal		External	Internal	External	Internal	External surface	Internal surface			
		inches	inches	inches	inches	inches	sq in	sq in	feet	feet	lbs	lb/sq in	
3	40 -S	3.500	3.068	0.216	10.996	9.638	9.621	7.393	1.091	1.245	7.58	1600	2.60
	80 -X		2.900	0.300	10.996	9.111	9.621	6.605	1.091	1.32	10.25	2600	2.92
	160		2.624	0.438	10.996	8.244	9.621	5.408	1.091	1.46	14.32	4100	3.56
	XX		2.300	0.600	10.996	7.226	9.621	4.155	1.091	1.66	18.58	6100	4.64
3½	40 -S	4.000	3.548	0.226	12.566	11.146	12.566	9.886	0.954	1.076	9.11	1500	1.94
	80 -X		3.364	0.318	12.566	10.57	12.566	8.888	0.954	1.14	12.50	2400	2.17
	XX		2.728	0.636	12.566	8.57	12.566	5.845	0.954	1.40		5600	3.29
4	40 -S	4.500	4.026	0.237	14.137	12.648	15.904	12.703	0.848	0.948	10.79	1400	1.51
	80 -X		3.826	0.337	14.137	12.020	15.904	11.497	0.848	0.998	14.98	2300	1.67
	120		3.624	0.438	14.137	11.39	15.904	10.315	0.848	1.05	19.00	3350	1.87
	160		3.438	0.531	14.137	10.80	15.904	9.282	0.848	1.11	22.51	4000	2.08
	XX		3.152	0.674	14.137	9.90	15.904	7.803	0.848	1.21	27.54	5300	2.47
5	40 -S	5.563	5.047	0.258	17.477	15.856	24.306	20.006	0.686	0.756	14.62	1300	0.960
	80 -X		4.813	0.375	17.477	15.120	24.306	18.19	0.686	0.793	20.78	2090	1.06
	120		4.563	0.500	17.477	14.34	24.306	16.35	0.686	0.837	27.04	2950	1.18
	160		4.313	0.625	17.477	13.55	24.306	14.61	0.686	0.897	32.96	3850	1.32
	XX		4.063	0.750	17.477	12.76	24.306	12.97	0.686	0.940	38.55	4780	1.49
6	40 -S	6.625	6.065	0.280	20.813	19.054	34.472	28.891	0.756	0.629	18.97	1210	0.666
	80 -X		5.761	0.432	20.813	18.099	34.472	26.07	0.756	0.663	28.57	2070	0.738
	120		5.501	0.562	20.813	17.29	34.472	23.77	0.756	0.695	36.39	2850	0.810
	160		5.187	0.719	20.813	16.30	34.472	21.13	0.756	0.736	45.35	3760	0.912
	XX		4.897	0.864	20.813	15.38	34.472	18.83	0.756	0.780	53.16	4660	1.02
8	20	8.625	8.125	0.250	27.096	25.53	58.43	51.87	0.443	0.470	22.36	795	0.371
	30		8.071	0.277	27.096	25.39	58.43	51.30	0.443	0.473	24.70	910	0.375
	40 S		7.981	0.322	27.096	25.07	58.43	50.03	0.443	0.478	28.55	1100	0.385
	60		7.813	0.406	27.096	24.54	58.43	47.94	0.443	0.489	35.64	1460	0.402
	80 X		7.625	0.500	27.096	23.955	58.43	45.66	0.443	0.500	43.39	1870	0.422
	100		7.437	0.594	27.096	23.36	58.43	43.44	0.443	0.514	50.95	2280	0.443
	120		7.187	0.719	27.096	22.58	58.43	40.56	0.443	0.532	60.71	2840	0.475
	140		7.001	0.812	27.096	21.99	58.43	38.50	0.443	0.546	67.76	3260	0.500
	XX		6.875	0.875	27.096	21.60	58.43	37.12	0.443	0.556	72.42	3560	0.519
	160		6.813	0.906	27.096	21.40	58.43	36.44	0.443	0.561	74.69	3700	0.529

Selected from ANSI B 36.10—1975. See notes, page 7-19.

Welded and Seamless Wrought Steel Pipe (Continued)

Welded and Seamless Wrought Steel Pipe

Size	Schedule no	Diameter		Thickness	Circumference		Transverse area		Length of pipe per sq ft of surface area		Weight per ft of length	Allowable working pressure at 100°F*	Water hammer factor
		External	Internal		External	Internal	External	Internal	External surface	Internal surface			
		inches	inches	inches	inches	inches	sq in	sq in	feet	feet	lbs	lb/sq in	
10	20	10.750	10.250	0.250	33.77	32.20	90.76	82.52	0.355	0.373	28.04	636	.233
	30		10.136	0.307	33.77	31.84	90.76	80.69	0.355	0.377	34.24	827	.239
	40 S		10.020	0.365	33.77	31.48	90.76	78.85	0.355	0.381	40.48	1030	.244
	60 X		9.750	0.500	33.77	30.63	90.76	74.66	0.355	0.392	54.74	1490	.258
	80		9.562	0.594	33.77	30.04	90.76	71.81	0.355	0.399	64.43	1800	.268
	100		9.312	0.719	33.77	29.25	90.76	68.10	0.355	0.410	77.03	2250	.283
	120		9.062	0.844	33.77	28.48	90.76	64.50	0.355	0.421	89.29	2700	.299
	140 XX		8.750	1.000	33.77	27.49	90.76	60.13	0.355	0.437	104.13	3310	.320
	160		8.500	1.125	33.77	26.70	90.76	56.75	0.355	0.449	115.64	3740	.340
12	20	12.750	12.250	0.250	40.06	38.48	127.68	117.86	0.299	0.312	33.38	535	.163
	30		12.090	0.330	40.06	37.98	127.68	114.80	0.299	0.316	43.77	760	.168
	S		12.000	0.375	40.06	37.70	127.68	113.10	0.299	0.318	49.56	890	.170
	40		11.938	0.406	40.06	37.50	127.68	111.93	0.299	0.320	53.52	1000	.172
	X		11.750	0.500	40.06	36.91	127.68	108.43	0.299	0.325	65.42	1250	.178
	60		11.626	0.562	40.06	36.52	127.68	106.16	0.299	0.329	73.15	1425	.181
	80		11.374	0.688	40.06	35.73	127.68	101.61	0.299	0.336	88.63	1800	.190
	100		11.062	0.844	40.06	34.75	127.68	96.11	0.299	0.345	107.32	2255	.200
	120 XX		10.750	1.000	40.06	33.77	127.68	90.76	0.299	0.355	125.49	2700	.212
	140		10.500	1.125	40.06	32.99	127.68	86.59	0.299	0.364	139.67	3115	.222
	160		10.126	1.312	40.06	31.81	127.68	80.53	0.299	0.377	160.27	3700	.239
14	10	14.000	13.500	0.250	43.98	42.41	153.94	143.14	0.272	0.283	36.71	485	.134
	20		13.376	0.312	43.98	42.02	153.94	140.52	0.272	0.286	45.61	645	.137
	30 S		13.250	0.375	43.98	41.63	153.94	137.89	0.272	0.288	54.57	810	.138
	40		13.124	0.438	43.98	41.23	153.94	135.28	0.272	0.291	63.44	970	.142
	X		13.000	0.500	43.98	40.84	153.94	132.73	0.272	0.294	72.09	1140	.145
	60		12.812	0.594	43.98	40.25	153.94	128.92	0.272	0.298	85.05	1380	.149
	80		12.500	0.750	43.98	39.26	153.94	122.72	0.272	0.306	106.13	1795	.157
	100		12.124	0.938	43.98	38.09	153.94	115.45	0.272	0.315	130.85	2300	.167
	120		11.876	1.062	43.98	37.31	153.94	110.77	0.272	0.322	150.79	2645	.174
	140		11.500	1.250	43.98	36.13	153.94	103.87	0.272	0.332	170.21	3170	.185
	160		11.188	1.406	43.98	35.15	153.94	93.31	0.272	0.341	189.11	3615	.206

Selected from ANSI B 36.10—1975. See notes, page 7-19.

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