Designation: C361M – 22

Standard Specification for Reinforced Concrete Low-Head Pressure Pipe (Metric)[1]

This standard is issued under the fixed designation C361M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This specification covers reinforced concrete pipe intended to be used for the construction of pressure pipelines with low internal hydrostatic heads generally not exceeding 375 kPa.

1.2 This specification is the SI companion to Specification C361. It is compatible in technical content.

NOTE 1—Field tests on completed portions of the pipeline are not covered by this specification for the manufacture of the pipe but should be included in specifications for pipe laying.

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A27/A27M Specification for Steel Castings, Carbon, for General Application

A36/A36M Specification for Carbon Structural Steel

A82/A82M Specification for Steel Wire, Plain, for Concrete Reinforcement (Withdrawn 2013)[3]

A185/A185M Specification for Steel Welded Wire Reinforcement, Plain, for Concrete (Withdrawn 2013)[3]

A283/A283M Specification for Low and Intermediate Tensile Strength Carbon Steel Plates

A496/A496M Specification for Steel Wire, Deformed, for Concrete Reinforcement (Withdrawn 2013)[3]

A497/A497M Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete (Withdrawn 2013)[3]

A575 Specification for Steel Bars, Carbon, Merchant Quality, M-Grades

A576 Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality

A615/A615M Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

A675/A675M Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties

A1008/A1008M Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Required Hardness, Solution Hardened, and Bake Hardenable

A1011/A1011M Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength

C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field

C33/C33M Specification for Concrete Aggregates

C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens

C150/C150M Specification for Portland Cement

C260/C260M Specification for Air-Entraining Admixtures for Concrete

C309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete

C497M Test Methods for Concrete Pipe, Concrete Box Sections, Manhole Sections, or Tile (Metric)

C595/C595M Specification for Blended Hydraulic Cements

C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

C822 Terminology Relating to Concrete Pipe and Related Products

C1602/C1602M Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete

C1619 Specification for Elastomeric Seals for Joining Concrete Structures

D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))

[1] This specification is under the jurisdiction of ASTM Committee C13 on Concrete Pipe and is the direct responsibility of Subcommittee C13.04 on Low Head Pressure Pipe.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

***A Summary of Changes section appears at the end of this standard**

D4253 Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table

D4254 Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density

2.2 *Other Standard:*

ACI Code 318 Standard Building Code Requirements for Reinforced Concrete[4]

AISI-C1012[5]

3. Terminology

3.1 *Definitions*—For definitions of terms relating to concrete pipe, see Terminology C822.

4. Classification

4.1 Pipe manufactured according to this specification shall be for hydrostatic heads of 75, 150, 225, 300, and 375 kPa measured to the centerline of the pipe. Designs are provided in Table 1 and Table 2 for the above hydrostatic heads combined with external loadings of 1.5, 3.0, 4.5, and 6.0 m (designated *A*, *B*, *C*, and *D* in Table 1 and Table 2) of earth cover over the top of the pipe under specific installation conditions. The specific installation conditions are covered in Appendix X1. Where the hydrostatic head, external loadings, and installation conditions vary from those given in Table 1 and Table 2 and Appendix X1, detailed design calculations shall be made. The design criteria for Table 1 and Table 2 are presented in Appendix X2.

5. Basis of Acceptance

5.1 Acceptability of the pipe in all diameters and classes shall be determined by the results of such material tests as are required in 6.2 through 6.9 by crushing tests on cured concrete cylinders, by hydrostatic pressure tests on units of the pipe, by joint leakage tests, and by inspection during or after manufacture to determine whether the pipe conforms to this specification as to design and freedom from defects.

5.2 *Age for Acceptance*—Pipe shall be considered ready for acceptance when they conform to the requirements, as indicated by the specified tests.

6. Materials

6.1 *Reinforced Concrete*—The reinforced concrete shall consist of portland cement, mineral aggregates, and water, in which steel has been embedded in such a manner that the steel and concrete act together. Fly ash or pozzolan is not prohibited when used as a partial cement replacement; see 9.1.

6.2 *Cementitious Materials:*

6.2.1 *Cement:*

6.2.1.1 *Portland Cement*—Portland cement shall conform to the requirements of Specification C150/C150M.

6.2.1.2 *Blended Hydraulic Cement*—Blended cement shall conform to the requirements of Specification C595/C595M for Type IS portland blast furnace slag cement or Type IP portland pozzolan cement, except that the pozzolan constituent in the Type IP portland pozzolan cement shall not exceed 20 % by weight.

6.2.2 *Fly Ash or Pozzolan*—Fly ash or pozzolan shall conform to the requirements of Specification C618.

6.2.3 *Allowable Cementitious Materials*—The combination of cementitious materials used in the concrete shall be one of the following:

6.2.3.1 Portland cement only,

6.2.3.2 Portland blast furnace slag cement only,

6.2.3.3 Portland pozzolan cement only, or

6.2.3.4 A combination of portland cement and fly ash or pozzolan, wherein the proportion of fly ash or pozzolan is between 5 and 20 % by weight of total cementitious material (portland cement plus fly ash or pozzolan).

6.3 *Aggregates*—Aggregates shall conform to Specification C33/C33M, except that the requirements for grading are waived.

6.4 *Admixtures*—Admixtures, except for air-entraining agents, shall not be added to the concrete unless permitted by the owner. At the option of the manufacturer, or if specified by the owner, the concrete in precast concrete pipe placed by the cast-and-vibrated method shall contain an air-entraining agent conforming to Specification C260/C260M. The amount of air-entraining agent used shall be such as will affect the entrainment of not more than 3 % air by volume of concrete as discharged from the mixer.

6.5 *Steel Reinforcement*—Reinforcement shall consist of wire conforming to Specification A82/A82M, Specification A496/A496M, or of wire reinforcement conforming to Specification A185/A185M or Specification A497/A497M, or of bars of Grade 300 steel conforming to Specification A615/A615M.

6.6 *Steel for Joint Rings:*

6.6.1 Steel strips for bell rings less than 6 mm thick shall conform to Grade SS30 of Specification A1011/A1011M or Grade Designation 1012 of Specification A575. Steel that meets the requirements of AISI-C1012 for chemical components will be acceptable provided it conforms to Grade SS30 of Specification A1011/A1011M in other respects.

6.6.2 Steel plate for bell rings 6 mm or more in thickness and special shapes for spigot joint rings shall conform to Specification A36/A36M, or to Grade A of Specification A283/A283M, or to Grade Designation 1012 of Specification A576, or to Grade 50 of Specification A675/A675M. Steel that meets the requirements of AISI-C1012 for chemical components will be acceptable provided it conforms to Specification A36/A36M or to Specification A283/A283M in other respects.

6.7 *Steel Castings for Fittings*—Steel castings for fittings shall conform to Grade 70-36, Normalized, of Specification A27/A27M.

6.8 *Steel Plates and Sheets for Specials and Fittings*—Steel plates for specials and fittings shall conform to Specification A36/A36M or to Grade B or C of Specification A283/A283M or Grade SS30 or SS33 of Specification A1011/A1011M or Grade SS30 of Specification A1008/A1008M.

[4] Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, http://www.concrete.org.

[5] Available from the American Iron and Steel Institute (AISI), 1140 Connecticut Ave. NW, Suite 705, Washington D.C. 20036, http://www.steel.org.

TABLE 1 Design Requirements for Reinforced Concrete Low-Head Pressure Pipe [300 to 3650 mm Diameter], Concrete Design Strength 34.5 MPa (except as noted) Steel Reinforced Yield Strength 276 MPa

NOTE 1—See Appendix for specific installation conditions and design criteria conditions required in conjunction with the use of Table 1.

NOTE 2—Designations A, B, C, and D, for class of pipe, denote 1.5, 3.0, 4.5, and 6.0 m of earth cover over top of pipe. Figures 75, Figures 150, Figures 225, etc. for class of pipe, denote hydrostatic pressure heads in kilopascals measured to centerline of pipe.

NOTE 3—An "s" in place of a steel area indicates the pipe class is a special design requiring stirrup reinforcement. Stirrups may be eliminated by changing wall thickness, main reinforcement, concrete strength, or a combination thereof.

NOTE 4—The boldfaced value denotes 41.4 MPa concrete strength required.

Circumferential reinforcement, mm²/linear m of pipe[A, B]																								
Internal Designated Dia, mm	300		375		450				525				600				675							
Type of Reinforcement	Circular		Circular		Circular		Elliptical		Circular		Elliptical		Circular		Elliptical		Circular						Elliptical	
Wall Thickness, mm	50	75	50	75	57	75	57	75	60	75	60	75	63	75	63	75	66	79	82		107		66	82
Layers of Reinforcement	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Inner	Outer	Inner	Outer	Single	Single
Class																								
A-75	140	120	200	170	250	220	250	250	320	280	320	290	390	350	390	350	460	410	290	200	230	160	460	370
B-75	210	170	310	240	390	320	390	320	500	420	500	420	610	540	610	540	740	650	440	280	340	210	740	440
C-75	280	220	420	310	540	430	540	430	690	570	690	570	870	730	870	730	1060	890	590	350	450	250	1060	590
D-75	360	270	540	390	700	540	700	540	910	730	910	730	1150	950	1150	950	1430	1170	750	440	560	300	1430	750
A-150	220	220	280	270	350	320	520	520	430	390	610	610	510	480	690	690	600	550	390	300	330	250	780	780
B-150	270	230	380	320	480	420	520	520	600	530	610	610	740	660	740	690	880	780	540	370	430	300	880	780
C-150	340	280	500	390	630	520	630	520	800	680	800	680	990	860	990	860	1190	1030	690	450	540	340	1190	780
D-150	420	330	620	470	790	640	790	640	1020	840	1020	840	1280	1070	1280	1070	1570	1310	850	530	650	390	1570	850
A-225	340	340	430	430	520	520	...	...	600	600	...	...	690	690	...	...	770	770	490	400	430	350	...	...
B-225	340	340	460	430	580	520	...	...	710	640	...	...	860	780	...	...	1020	920	640	470	520	390	...	...
C-225	400	340	570	470	720	620	...	...	910	790	...	...	1110	980	...	...	1330	1170	790	550	630	440	...	...
D-225	480	390	700	550	880	730	...	...	1130	950	...	...	1400	1200	...	...	1710	1440	940	630	730	480	...	...
A-300	490	490	610	610	730	730	...	...	860	860	...	...	980	980	...	...	1100	1100	590	500	590	510	...	...
B-300	490	490	610	610	730	730	...	...	860	860	...	...	980	980	...	...	1160	1100	740	570	620	480	...	...
C-300	490	490	650	610	820	730	...	...	1020	900	...	...	1240	1110	...	...	1470	1310	880	650	720	530	...	...
D-300	540	490	770	620	980	820	...	...	1240	1050	...	...	1530	1320	...	...	1850	1580	1040	730	820	570	...	...
A-375	650	650	820	820	980	980	...	...	1140	1140	...	...	1310	1310	...	...	1470	1470	790	680	780	690	...	...
B-375	650	650	820	820	980	980	...	...	1140	1140	...	...	1310	1310	...	...	1470	1470	830	670	810	660	...	...
C-375	650	650	820	820	980	980	...	...	1140	1140	...	...	1360	1310	...	...	1610	1470	980	750	830	640	...	...
D-375	650	650	850	820	1070	980	...	...	1350	1160	...	...	1650	1450	...	...	1990	1720	1140	830	910	670	...	...

TABLE 1 *Continued*

Circumferential reinforcement, mm²/linear m of pipe[A, B]																				
Internal Designated Dia, mm	750										825									
Type of Reinforcement	Circular								Elliptical		Circular								Elliptical	
Wall Thickness, mm	69	79	82		88		119		69	88	72	79	82		94		119		72	94
Layers of Reinforcement	Single	Single	Inner	Outer	Inner	Outer	Inner	Outer	Single	Single	Single	Single	Inner	Outer	Inner	Outer	Inner	Outer	Single	Single
Class																				
A-75	530	490	340	230	320	220	250	170	530	410	610	570	400	270	350	240	290	200	610	450
B-75	880	790	530	340	490	310	370	220	880	490	1020	950	630	400	540	340	440	270	1020	540
C-75	1260	1110	720	440	660	400	490	280	1260	660	1490	1360	870	530	730	440	580	330	1490	730
D-75	1750	1470	920	550	840	490	600	330	1750	840	**1940**	1850	1120	670	930	540	720	400	**1940**	930
A-150	680	640	450	350	430	330	350	270	870	870	780	740	520	400	470	360	400	310	950	950
B-150	1030	940	640	450	600	420	470	320	1030	870	1190	1120	750	520	660	460	550	380	1190	950
C-150	1420	1260	830	550	770	500	580	370	1420	870	1660	1530	980	650	840	550	680	440	1660	950
D-150	1900	1630	1030	650	940	600	700	430	1900	940	**2110**	2020	1230	780	1040	660	820	510	**2110**	1040
A-225	860	860	560	460	530	440	470	390	...	...	950	950	640	520	580	470	520	430	...	...
B-225	1180	1100	750	560	700	520	570	420	...	...	1360	1290	870	640	770	570	650	480	...	...
C-225	1570	1410	940	660	870	610	680	470	...	...	1830	1700	1100	770	950	670	790	550	...	...
D-225	2060	1780	1130	760	1040	700	800	520	...	...	**2280**	2190	1340	900	1150	770	930	610	...	...
A-300	1220	1220	670	570	660	560	660	560	...	...	1340	1340	760	640	730	620	730	620	...	...
B-300	1340	1250	860	670	810	630	690	540	...	...	1530	1460	990	760	890	690	760	590	...	...
C-300	1730	1570	1040	760	980	720	780	570	...	...	2000	1870	1220	890	1070	780	900	660	...	...
D-300	2210	1930	1240	870	1150	810	890	620	...	...	**2450**	2360	1460	1020	1260	880	1030	720	...	...
A-375	1630	1630	870	760	870	760	870	760	...	...	1800	1800	960	830	960	840	960	840	...	...
B-375	1630	1630	970	780	920	740	900	730	...	...	1800	1800	1110	890	1000	800	990	800	...	...
C-375	1880	1720	1150	870	1080	820	930	710	...	...	2170	2040	1330	1010	1180	900	1020	780	...	...
D-375	2360	2090	1340	980	1250	910	990	720	...	...	**2620**	2530	1570	1140	1370	990	1140	830	...	...

TABLE 1 *Continued*

Circumferential reinforcement, mm^2/linear m of pipe[A, B]																									
Internal Designated Dia, mm	900									975[C]								1050							
Type of Reinforcement	Circular							Elliptical		Circular						Elliptical		Circular						Elliptical	
Wall Thickness, mm	79	82		100		125		79	100	88		107		132		88	107	94		113		138		94	113
Layers of Reinforcement	Single	Inner	Outer	Inner	Outer	Inner	Outer	Single	Single	Inner	Outer	Inner	Outer	Inner	Outer	Single	Single	Inner	Outer	Inner	Outer	Inner	Outer	Single	Single
Class																									
A-75	670	460	320	380	260	330	220	670	490	490	340	420	290	360	240	530	530	520	360	450	310	390	270	570	570
B-75	1130	740	480	600	380	490	300	1130	600	790	510	650	410	540	330	790	650	850	540	710	450	590	370	850	710
C-75	1650	1030	640	800	480	640	370	1650	800	1090	680	870	530	710	420	1090	870	1160	720	940	570	780	460	1160	940
D-75	**2150**	1330	800	1010	600	800	450	**2150**	1010	1410	860	1100	650	880	500	1410	1100	1500	910	1190	710	970	550	1500	1190
A-150	850	590	450	510	390	440	340	1040	1040	630	480	550	420	480	370	1130	1130	670	510	590	450	530	400	1210	1210
B-150	1320	870	610	720	500	610	420	1320	1040	930	650	780	540	660	460	1130	1130	990	690	840	580	730	500	1210	1210
C-150	1840	1150	760	920	610	760	490	1840	1040	1220	810	1000	660	830	540	1220	1130	1300	860	1080	710	910	590	1300	1210
D-150	**2330**	1450	930	1130	720	910	570	**2330**	1130	1540	990	1230	780	1000	620	1540	1230	1630	1050	1330	840	1100	680	1630	1330
A-225	1040	720	580	630	510	570	460	...	...	770	620	680	550	620	500	...	...	810	650	730	590	670	540	...	...
B-225	1500	1000	740	840	620	720	530	...	...	1070	780	910	670	790	580	...	...	1130	830	980	720	860	630	...	...
C-225	2030	1280	890	1040	730	870	610	...	...	1360	950	1130	790	950	660	...	...	1440	1000	1210	850	1040	720	...	...
D-225	**2520**	1580	1060	1250	840	1030	680	...	...	1670	1120	1350	910	1130	750	...	...	1760	1180	1460	980	1230	820	...	...
A-300	1470	860	720	800	670	790	670	...	...	910	760	860	730	860	730	...	...	960	800	930	780	930	780	...	...
B-300	1690	1130	870	960	740	840	650	...	...	1200	920	1040	800	910	710	...	...	1270	980	1120	860	990	770	...	...
C-300	2210	1400	1020	1160	850	990	720	...	...	1490	1080	1250	920	1080	790	...	...	1580	1150	1350	980	1170	850	...	...
D-300	**2700**	1700	1180	1370	960	1140	800	...	...	1800	1250	1480	1040	1250	870	...	...	1900	1320	1590	1110	1360	950	...	...
A-375	1960	1050	910	1050	910	1050	910	...	...	1140	980	1140	980	1140	990	...	...	1230	1060	1230	1060	1230	1060	...	...
B-375	1960	1260	1000	1090	870	1090	870	...	...	1340	1060	1180	940	1180	950	...	...	1420	1120	1270	1010	1270	1020	...	...
C-375	2400	1530	1150	1280	970	1110	850	...	...	1620	1220	1380	1050	1210	920	...	...	1720	1290	1480	1120	1300	990	...	...
D-375	**2890**	1820	1310	1480	1080	1250	910	...	...	1920	1390	1600	1160	1370	990	...	...	2030	1460	1720	1250	1490	1080	...	...

TABLE 1 *Continued*

Circumferential reinforcement, mm²/linear m of pipe[A, B]																								
Internal Designated Dia, mm	1125[C]								1200								1275[C]							
Type of Reinforcement	Circular						Elliptical		Circular						Elliptical		Circular						Elliptical	
Wall Thickness, mm	97		119		144		97	119	104		125		144		104	125	107		132		150		107	132
Layers of Reinforcement	Inner	Outer	Inner	Outer	Inner	Outer	Single	Single	Inner	Outer	Inner	Outer	Inner	Outer	Single	Single	Inner	Outer	Inner	Outer	Inner	Outer	Single	Single
Class																								
A-75	570	390	480	330	430	290	610	610	620	420	530	360	480	330	650	650	670	460	570	390	520	350	700	700
B-75	930	600	760	480	650	400	930	760	1010	650	830	530	740	460	1010	830	1100	710	890	560	790	490	1100	890
C-75	1280	790	1020	620	850	500	1280	1020	1380	860	1110	680	970	580	1380	1110	1510	940	1190	720	1040	630	1510	1190
D-75	1650	1000	1290	770	1060	610	1650	1290	1790	1080	1410	840	1210	710	1790	1410	1950	1190	1500	890	1300	760	1950	1500
A-150	720	550	630	480	570	430	1300	1300	780	590	690	520	640	480	1380	1380	840	640	730	550	680	510	1470	1470
B-150	1080	750	910	630	790	540	1300	1300	1170	810	990	680	890	610	1380	1380	1270	880	1050	720	950	650	1470	1470
C-150	1420	940	1160	760	990	640	1420	1300	1540	1020	1260	830	1120	730	1540	1380	1670	1100	1350	890	1200	780	1670	1470
D-150	1790	1150	1420	910	1190	750	1790	1420	1930	1240	1550	990	1360	850	1930	1550	2100	1350	1650	1050	1460	920	2100	1650
A-225	880	710	780	630	710	580	...	...	950	760	850	680	790	640	...	...	1020	810	900	720	840	680	...	...
B-225	1230	900	1050	770	930	680	...	...	1330	970	1140	840	1040	760	...	...	1430	1050	1210	890	1110	810	...	...
C-225	1570	1090	1300	910	1130	780	...	...	1690	1180	1410	990	1270	880	...	...	1830	1270	1510	1050	1360	940	...	...
D-225	1930	1300	1560	1050	1330	880	...	...	2080	1390	1700	1140	1500	1000	...	...	2260	1510	1810	1210	1610	1070	...	...
A-300	1040	860	1000	840	1000	840	...	...	1110	930	1070	890	1060	890	...	...	1190	990	1130	940	1130	950	...	...
B-300	1380	1060	1200	920	1070	830	...	...	1490	1140	1300	1000	1190	920	...	...	1600	1220	1380	1050	1270	970	...	...
C-300	1720	1240	1440	1050	1270	920	...	...	1850	1340	1570	1140	1420	1030	...	...	1990	1440	1670	1210	1520	1100	...	...
D-300	2070	1440	1700	1190	1470	1020	...	...	2230	1550	1850	1290	1650	1150	...	...	2410	1670	1960	1370	1760	1230	...	...
A-375	1320	1130	1320	1130	1310	1140	...	...	1410	1200	1410	1210	1400	1210	...	...	1500	1280	1500	1280	1490	1280	...	...
B-375	1540	1210	1360	1090	1360	1090	...	...	1650	1300	1460	1160	1450	1160	...	...	1780	1400	1550	1230	1550	1230	...	...
C-375	1860	1400	1590	1200	1410	1060	...	...	2010	1500	1720	1300	1570	1180	...	...	2160	1610	1830	1370	1670	1260	...	...
D-375	2220	1590	1840	1330	1600	1160	...	...	2380	1710	2000	1450	1800	1300	...	...	2570	1840	2120	1530	1920	1390	...	...

TABLE 1 *Continued*

Internal Designated Dia, mm	1350								1425^{C}								1500							
Type of Reinforcement	Circular						Elliptical		Circular						Elliptical		Circular						Elliptical	
Wall Thickness, mm	113		138		157		113	138	119		144		163		119	144	125		150		169		125	150
Layers of Reinforcement	Inner	Outer	Inner	Outer	Inner	Outer	Single	Single	Inner	Outer	Inner	Outer	Inner	Outer	Single	Single	Inner	Outer	Inner	Outer	Inner	Outer	Single	Single
	Circumferential reinforcement, mm^2/linear m of pipe$^{A, B}$																							
Class																								
A-75	710	480	610	410	560	380	740	740	740	510	640	440	600	400	780	780	780	530	690	460	640	430	820	820
B-75	1140	730	940	590	840	520	1140	940	1190	760	990	630	890	560	1190	990	1240	790	1040	660	940	590	1240	1040
C-75	1580	980	1270	770	1120	670	1580	1270	1650	1030	1340	820	1200	720	1650	1340	1730	1070	1420	870	1270	770	1730	1420
D-75	2030	1240	1590	950	1400	820	2030	1590	2120	1290	1690	1010	1490	880	2120	1690	2210	1350	1790	1070	1590	930	2210	1790
A-150	890	670	780	590	730	550	1560	1560	930	700	830	620	770	580	1640	1640	980	730	870	660	820	620	1730	1730
B-150	1320	910	1110	760	1010	690	1560	1560	1370	950	1170	810	1070	730	1640	1640	1430	990	1230	850	1130	770	1730	1730
C-150	1740	1150	1430	940	1280	840	1740	1560	1820	1210	1520	1000	1370	890	1820	1640	1910	1260	1600	1050	1450	950	1910	1730
D-150	2190	1410	1760	1120	1560	980	2190	1760	2290	1470	1860	1180	1660	1050	2290	1860	2380	1530	1960	1250	1760	1110	2380	1960
A-225	1070	850	950	760	900	720	...	...	1120	890	1010	800	950	760	...	...	1170	930	1060	850	1010	800	...	...
B-225	1490	1090	1280	940	1170	860	...	...	1550	1140	1340	990	1240	910	...	...	1620	1180	1410	1030	1310	960	...	...
C-225	1910	1330	1600	1110	1450	1000	...	...	2000	1390	1690	1170	1540	1070	...	...	2090	1450	1780	1240	1630	1130	...	...
D-225	2350	1580	1920	1280	1720	1150	...	...	2460	1640	2030	1360	1830	1220	...	...	2560	1710	2140	1430	1940	1290	...	...
A-300	1250	1030	1200	1000	1200	1000	...	...	1310	1080	1270	1050	1270	1050	...	...	1370	1130	1340	1110	1340	1110	...	...
B-300	1670	1270	1450	1110	1340	1030	...	...	1740	1320	1520	1170	1420	1090	...	...	1810	1380	1600	1220	1490	1150	...	...
C-300	2080	1500	1760	1280	1610	1170	...	...	2180	1570	1860	1350	1710	1240	...	...	2270	1640	1970	1420	1810	1310	...	...
D-300	2520	1750	2080	1450	1880	1310	...	...	2620	1820	2200	1530	2000	1390	...	...	2740	1900	2320	1610	2110	1470	...	...
A-375	1590	1350	1580	1360	1580	1360	...	...	1680	1420	1670	1430	1670	1430	...	...	1770	1500	1760	1500	1760	1500	...	...
B-375	1850	1450	1640	1300	1640	1300	...	...	1920	1510	1730	1370	1730	1370	...	...	2000	1570	1820	1440	1820	1450	...	...
C-375	2260	1680	1930	1450	1780	1340	...	...	2360	1760	2040	1530	1890	1420	...	...	2460	1830	2150	1610	2000	1500	...	...
D-375	2680	1920	2250	1620	2040	1480	...	...	2800	2000	2370	1710	2170	1560	...	...	2910	2080	2500	1800	2290	1650	...	...

TABLE 1 *Continued*

Internal Designated Dia, mm	1575[C]								1650								1725[C]							
Type of Reinforcement	Circular						Elliptical		Circular						Elliptical		Circular						Elliptical	
Wall Thickness, mm	132		157		175		132	157	138		163		182		138	163	144		169		188		144	169
Layers of Reinforcement	Inner	Outer	Inner	Outer	Inner	Outer	Single	Single	Inner	Outer	Inner	Outer	Inner	Outer	Single	Single	Inner	Outer	Inner	Outer	Inner	Outer	Single	Single
Class	Circumferential reinforcement, mm^2/linear m of pipe[A, B]																							
A-75	840	570	740	500	690	460	860	860	880	600	780	530	730	490	900	900	920	620	820	550	770	520	940	940
B-75	1310	840	1110	700	1010	630	1310	1110	1360	870	1160	740	1060	670	1360	1160	1410	910	1220	770	1120	700	1410	1220
C-75	1840	1140	1520	930	1370	820	1840	1520	1910	1190	1610	980	1450	870	1910	1610	1990	1240	1690	1030	1530	920	1990	1690
D-75	2350	1430	1920	1150	1700	1000	2350	1920	2450	1490	2020	1210	1800	1060	2450	2020	2540	1550	2120	1270	1900	1120	2540	2120
A-150	1040	780	940	700	880	660	1820	1820	1090	810	990	730	930	690	1900	1900	1140	850	1040	770	980	730	1990	1990
B-150	1510	1040	1300	900	1200	830	1820	1820	1560	1080	1370	940	1260	870	1900	1900	1620	1120	1430	990	1330	910	1990	1990
C-150	2030	1340	1710	1120	1560	1020	2030	1820	2110	1390	1800	1180	1650	1070	2110	1900	2200	1450	1890	1240	1730	1130	2200	1990
D-150	2530	1620	2100	1340	1890	1190	2530	2100	2630	1690	2210	1400	1990	1260	2630	2210	2740	1750	2310	1470	2100	1330	2740	2310
A-225	1250	990	1140	900	1080	860	...	...	1300	1030	1190	940	1140	900	...	...	1360	1070	1250	990	1200	940	...	...
B-225	1710	1250	1500	1100	1390	1020	...	...	1770	1290	1570	1150	1460	1070	...	...	1840	1340	1640	1200	1540	1120	...	...
C-225	2220	1540	1900	1320	1750	1210	...	...	2310	1600	2000	1380	1840	1270	...	...	2400	1660	2100	1450	1940	1340	...	...
D-225	2720	1820	2280	1530	2070	1380	...	...	2820	1890	2400	1600	2190	1460	...	...	2930	1960	2510	1680	2300	1530	...	...
A-300	1460	1200	1410	1160	1400	1160	...	...	1520	1250	1470	1210	1470	1210	...	...	1580	1300	1540	1270	1540	1270	...	...
B-300	1910	1450	1700	1300	1590	1220	...	...	1980	1510	1770	1360	1670	1280	...	...	2050	1560	1850	1420	1750	1340	...	...
C-300	2410	1740	2100	1520	1940	1400	...	...	2510	1810	2200	1590	2040	1470	...	...	2610	1880	2300	1660	2140	1550	...	...
D-300	2900	2010	2470	1720	2260	1570	...	...	3010	2090	2590	1800	2380	1650	...	...	3130	2170	2710	1890	2500	1740	...	...
A-375	1860	1570	1860	1580	1850	1580	...	...	1950	1640	1950	1650	1940	1650	...	...	2040	1720	2040	1720	2030	1720	...	...
B-375	2110	1660	1920	1510	1910	1520	...	...	2190	1720	2010	1590	2000	1590	...	...	2270	1780	2100	1660	2100	1660	...	...
C-375	2610	1940	2290	1710	2130	1600	...	...	2710	2010	2400	1790	2240	1680	...	...	2820	2090	2510	1870	2350	1760	...	...
D-375	3090	2210	2660	1910	2450	1760	...	...	3210	2290	2790	2000	2570	1850	...	...	3330	2380	2920	2090	2700	1940	...	...

TABLE 1 *Continued*

Circumferential reinforcement, mm²/linear m of pipe[A, B]																				
Internal Designated Dia, mm	1800								1950						2100					
Type of Reinforcement	Circular						Elliptical		Circular						Circular					
Wall Thickness, mm	150		175		194		150	175	163		188		207		175		200		219	
Layers of Reinforcement	Inner	Outer	Inner	Outer	Inner	Outer	Single	Single	Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer
Class																				
A-75	1020	690	910	610	850	570	1020	980	1110	750	1000	670	940	630	1210	810	1100	730	1040	690
B-75	1550	1000	1340	850	1230	770	1550	1340	1660	1060	1460	920	1340	840	1780	1140	1580	1000	1460	920
C-75	2210	1370	1860	1140	1690	1020	2210	1860	2370	1470	2020	1240	1840	1110	2500	1550	2170	1330	1990	1200
D-75	2830	1720	2340	1400	2100	1240	2830	2340	3020	1840	2550	1530	2300	1360	**3150**	**1920**	2760	1660	2520	1490
A-150	1260	930	1140	850	1080	800	2080	2080	1370	1010	1250	920	1190	870	1480	1080	1360	1000	1300	950
B-150	1790	1230	1570	1080	1450	1000	2080	2080	1910	1320	1700	1170	1580	1090	2040	1400	1830	1260	1720	1180
C-150	2430	1600	2080	1360	1900	1240	2430	2080	2600	1710	2260	1480	2070	1350	2750	1810	2420	1580	2230	1460
D-150	3040	1940	2550	1620	2310	1460	3040	2550	3250	2070	2770	1760	2530	1600	**3400**	**2180**	3000	1910	2760	1740
A-225	1500	1180	1370	1080	1310	1030	...	...	1620	1270	1500	1170	1430	1120	1750	1360	1630	1270	1560	1210
B-225	2020	1470	1790	1310	1680	1220	...	...	2160	1570	1940	1410	1820	1330	2300	1670	2090	1520	1980	1440
C-225	2660	1830	2310	1590	2120	1460	...	...	2840	1960	2490	1720	2310	1590	3000	2070	2670	1840	2480	1710
D-225	3250	2160	2770	1840	2520	1680	...	...	3470	2310	3000	2000	2760	1830	**3650**	**2440**	3240	2160	3000	1990
A-300	1740	1420	1610	1320	1610	1320	...	...	1880	1530	1750	1430	1750	1430	2020	1630	1890	1530	1890	1530
B-300	2260	1710	2020	1540	1900	1450	...	...	2410	1820	2190	1660	2070	1570	2560	1940	2350	1790	2230	1700
C-300	2880	2070	2530	1820	2350	1690	...	...	3080	2200	2730	1960	2540	1830	3250	2330	2920	2100	2740	1970
D-300	3470	2390	2980	2070	2740	1900	...	...	3700	2550	3230	2240	2990	2070	**3890**	**2690**	3490	2410	3240	2240
A-375	2130	1790	2130	1790	2130	1790	...	...	2310	1930	2310	1940	2310	1940	2500	2080	2490	2080	2490	2080
B-375	2490	1950	2260	1780	2190	1730	...	...	2660	2080	2430	1910	2370	1870	2830	2210	2610	2050	2560	2010
C-375	3110	2300	2750	2050	2570	1910	...	...	3320	2450	2970	2210	2780	2070	3510	2590	3170	2360	2990	2230
D-375	3690	2620	3200	2290	2960	2120	...	...	3930	2790	3470	2480	3220	2310	**4150**	**2960**	3730	2660	3490	2490

TABLE 1 *Continued*

Internal Designated Dia, mm	2250				2400				2550				2700				3050		3350		3650	
Type of Reinforcement	Circular				Circular				Circular				Circular				Circular		Circular		Circular	
Wall Thickness, mm	188		200		200		213		213		225		225		238		254		279		305	
Layers of Reinforcement	Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer	Inner	Outer
Class	Circumferential reinforcement, mm²/linear m of pipe[A, B]																					
A-75	1310	880	1250	830	1410	940	1360	900	1520	1010	1470	970	1640	1080	1580	1040	1880	1240	2140	1400	2420	1570
B-75	1900	1210	1790	1140	2020	1290	1920	1220	2160	1370	2050	1300	2290	1460	2190	1390	2580	1640	2890	1830	3210	2030
C-75	2640	1630	2460	1520	2780	1720	2610	1610	2930	1820	2770	1710	3090	1910	2930	1810	3420	2120	3770	2330	4140	2560
D-75	**3360**	**2050**	3190	1930	**3580**	**2180**	3410	2060	**3790**	**2310**	**3570**	**2160**	**3980**	**2420**	**3750**	**2280**	S	S	S	S	S	S
A-150	1590	1160	1530	1120	1710	1240	1650	1200	1830	1330	1780	1290	1960	1420	1910	1370	2240	1600	2520	1790	2830	1990
B-150	2170	1490	2060	1420	2310	1590	2210	1510	2460	1680	2360	1610	2610	1780	2510	1710	2920	1990	3260	2210	3610	2440
C-150	2900	1910	2720	1790	3060	2010	2890	1900	3220	2120	3060	2010	3390	2230	3230	2120	3750	2460	4130	2710	4530	2960
D-150	**3620**	**2320**	3440	2190	**3850**	**2460**	3670	2340	**4080**	**2610**	**3860**	**2460**	**4270**	**2740**	**4050**	**2590**	S	S	S	S	S	S
A-225	1880	1450	1810	1400	2010	1550	1950	1500	2150	1650	2090	1600	2290	1750	2230	1710	2600	1960	2910	2190	3250	2420
B-225	2450	1780	2340	1700	2600	1880	2500	1810	2760	2000	2660	1920	2930	2110	2830	2040	3270	2350	3640	2600	4020	2860
C-225	3160	2180	2990	2060	3340	2300	3170	2190	3520	2420	3350	2310	3700	2550	3540	2440	4090	2810	4500	3080	4920	3370
D-225	**3880**	**2590**	3690	2450	**4120**	**2750**	3940	2620	**4370**	**2910**	**4140**	**2760**	**4570**	**3050**	**4350**	**2900**	S	S	S	S	S	S
A-300	2160	1740	2100	1690	2310	1850	2250	1800	2470	1970	2400	1920	2630	2090	2560	2040	2960	2330	3310	2590	3670	2850
B-300	2730	2060	2620	1980	2900	2180	2790	2110	3070	2310	2970	2230	3250	2440	3150	2370	3630	2710	4020	2990	4430	3280
C-300	3430	2460	3260	2340	3620	2590	3450	2480	3810	2730	3650	2620	4010	2870	3850	2760	4430	3160	4860	3470	5320	3780
D-300	**4140**	**2860**	3950	2720	**4400**	**3030**	4210	2900	**4660**	**3210**	**4430**	**3060**	**4880**	**3360**	**4660**	**3210**	S	S	S	S	S	S
A-375	2680	2220	2680	2220	2860	2360	2860	2370	3050	2510	3050	2510	3230	2650	3230	2650	3600	2930	3980	3210	4350	3490
B-375	3010	2350	2900	2260	3190	2490	3080	2410	3380	2630	3280	2550	3580	2770	3470	2700	3980	3070	4410	3380	4850	3700
C-375	3700	2740	3530	2620	3900	2890	3740	2770	4110	3040	3950	2920	4330	3190	4170	3080	4770	3520	5240	3850	5720	4200
D-375	**4410**	**3140**	4210	2990	**4670**	**3320**	4810	3180	**4950**	**3510**	**4730**	**3360**	**5190**	**3680**	**4970**	**3530**	S	S	S	S	S	S

[A] Steel areas may be interpolated between those shown for variations in wall thickness. See 7.2 for provisions for special designs.
[B] The prescribed amounts of reinforcement do not provide any allowance for pressure surges (water hammer) in pipelines.
[C] Available in some areas.

TABLE 2 Design Requirements for Reinforced Concrete Low-Head Pressure Pipe [300 to 3650 mm Diameter], Concrete Design Strength 34.5 MPa (except as noted) Steel Reinforcement Yield Strength 414 Mpa

NOTE 1—See Appendix for specific installation conditions and design criteria conditions required in conjunction with the use of Table 2.

NOTE 2—Designations A, B, C, and D, for class of pipe, denote 1.5, 3.0, 4.5, and 6.0 m of earth cover over top of pipe. Figures 75, Figures 150, Figures 225, etc. for class of pipe, denote hydrostatic pressure heads in kilopascals measured to centerline of pipe.

NOTE 3—An "s" in place of a steel area indicates the pipe class is a special design requiring stirrup reinforcement. Stirrups may be eliminated by changing wall thickness, main reinforcement, concrete strength, or a combination thereof.

NOTE 4—The boldfaced value denotes 41.4 MPa concrete strength required.

	Circumferential reinforcement, mm²/linear m of pipe[A, B]																							
Internal Designated Dia, mm	300		375		450				525				600				675							
Type of Reinforcement	Circular		Circular		Circular		Elliptical		Circular		Elliptical		Circular		Elliptical		Circular						Elliptical	
Wall Thickness, mm	50	75	50	75	57	75	57	75	60	75	60	75	63	75	63	75	66	79	82		107		66	82
Layers of Reinforcement	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single	Inner	Outer	Inner	Outer	Single	Single
Class																								
A-75	100	100	130	130	170	150	250	250	210	190	290	290	260	230	330	330	300	280	190	130	160	110	370	370
B-75	140	110	200	160	260	220	260	250	330	280	330	290	410	360	410	360	490	430	290	180	230	140	490	370
C-75	190	140	280	210	360	290	360	290	460	380	460	380	580	490	580	490	700	590	400	240	300	170	700	400
D-75	240	180	360	260	470	360	470	360	610	490	610	490	770	630	770	630	950	780	500	290	370	200	950	500
A-150	220	220	270	270	320	320	520	520	380	380	610	610	430	430	690	690	490	490	280	210	280	210	780	780
B-150	220	220	270	270	320	320	520	520	400	380	610	610	490	440	690	690	590	520	360	250	290	200	780	780
C-150	230	220	330	270	420	350	520	520	530	450	610	610	660	570	690	690	800	690	460	300	360	230	800	780
D-150	280	220	410	310	530	420	530	520	680	560	680	610	850	720	850	720	1050	870	570	360	430	260	1050	780
A-225	340	340	430	430	520	520	...	...	600	600	...	...	690	690	...	...	770	770	430	350	430	350	...	...
B-225	340	340	430	430	520	520	...	...	600	600	...	...	690	690	...	...	770	770	440	330	440	330	...	...
C-225	340	340	430	430	520	520	...	...	610	600	...	...	740	690	...	...	890	780	520	370	460	320	...	...
D-225	340	340	470	430	590	520	...	...	750	630	...	...	930	800	...	...	1140	960	630	420	490	320	...	...
A-300	490	490	610	610	730	730	...	...	860	860	...	...	980	980	...	...	1100	1100	590	500	590	510	...	...
B-300	490	490	610	610	730	730	...	...	860	860	...	...	980	980	...	...	1100	1100	620	480	620	480	...	...
C-300	490	490	610	610	730	730	...	...	860	860	...	...	980	980	...	...	1100	1100	630	470	630	470	...	...
D-300	490	490	610	610	730	730	...	...	860	860	...	...	1020	980	...	...	1230	1100	690	490	650	450	...	...
A-375	650	650	820	820	980	980	...	...	1140	1140	...	...	1310	1310	...	...	1470	1470	790	680	780	690	...	...
B-375	650	650	820	820	980	980	...	...	1140	1140	...	...	1310	1310	...	...	1470	1470	810	660	810	660	...	...
C-375	650	650	820	820	980	980	...	...	1140	1140	...	...	1310	1310	...	...	1470	1470	830	640	830	640	...	...
D-375	650	650	820	820	980	980	...	...	1140	1140	...	...	1310	1310	...	...	1470	1470	850	620	850	620	...	...