Designation: C361M – 08

StandardSpecification 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 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.

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

A185/A185M Specification for Steel Welded Wire Reinforcement, Plain, for Concrete

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

A496/A496M Specification for Steel Wire, Deformed, for Concrete Reinforcement

A497/A497M Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete

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, 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 Specification for Concrete Aggregates

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

C150 Specification for Portland Cement

C260 Specification for Air-Entraining Admixtures for Concrete

C309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete

C497M Test Methods for Concrete Pipe, Manhole Sections, or Tile [Metric]

C595 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

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))

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

AISI-C1012[4]

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 for the above hydrostatic heads combined with external loadings of 1.5, 3.0, 4.5, and 6.0 (designated *A*, *B*, *C*, and *D* in Table 1) 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 Appendix X1, detailed design calculations shall be made. The design criteria for Table 1 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.

6.2.1.2 *Blended Hydraulic Cement*—Blended cement shall conform to the requirements of Specification C595 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, 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. 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.

6.9 *Rubber Gaskets:*

6.9.1 *Composition and Properties* —All rubber gaskets shall comply with Specification C1619 in terms of material and manufacture. The gaskets shall be of a solid circular cross section and shall be extruded or molded to the specified size within a diametrical tolerance of ±0.4 mm or ±1.5 % of the diameter, whichever is larger.

6.9.1.1 *Standard Gasket Requirements* —All rubber gaskets shall meet the dimensions, tolerances, and physical requirements of Specification C1619, Class A.

[4] 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[A] [300 to 2700 mm Diameter], Concrete Design Strength 31 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.

	Circumferential reinforcement, mm^2/linear m of pipe[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	160	250	220	250	250	310	270	290	290	370	330	330	330	430	390	290	190	220	150	370	370
B-75	200	150	300	220	370	300	370	250	480	400	440	310	590	510	520	400	720	610	440	250	320	170	600	440
C-75	260	190	400	290	510	400	500	310	670	540	610	420	840	700	730	530	1030	840	590	310	420	190	840	590
D-75	330	230	520	350	660	500	650	390	880	690	800	520	1130	910	960	680	...	1110	740	370	510	220	1120	740
A-150	220	220	290	270	360	330	520	520	440	400	610	610	520	480	700	700	600	560	410	320	340	260	780	780
B-150	270	230	390	320	480	420	520	520	610	530	610	610	740	660	700	700	890	780	560	370	430	280	780	780
C-150	330	260	500	380	620	510	610	520	800	670	730	610	990	850	860	700	1200	1010	710	430	530	300	980	780
D-150	400	300	610	440	770	610	750	520	1010	820	920	620	1280	1060	1090	790	...	1280	860	490	620	330	1260	860
A-225	350	350	440	440	520	520	...	...	610	610	...	...	690	690	...	...	780	780	540	440	450	370	...	...
B-225	350	350	480	440	600	530	...	...	740	660	...	...	890	810	...	...	1050	950	690	500	550	390	...	...
C-225	410	350	590	470	730	620	...	...	930	800	...	...	1140	1000	...	...	1360	1180	830	550	640	410	...	...
D-225	480	380	710	540	880	720	...	...	1140	950	...	...	1430	1210	...	...	...	1440	980	610	730	440	...	...
A-300	490	490	620	620	740	740	...	...	860	860	...	...	980	980	...	...	1100	1100	660	570	600	500	...	...
B-300	490	490	620	620	740	740	...	...	870	860	...	...	1040	980	...	...	1220	1120	810	620	660	510	...	...
C-300	490	490	680	620	840	740	...	...	1060	930	...	...	1280	1150	...	...	1530	1350	950	680	750	530	...	...
D-300	550	490	800	630	1000	840	...	...	1270	1080	...	...	1580	1360	...	...	...	1610	1100	740	840	550	...	...
A-375	660	660	830	830	990	990	...	...	1150	1150	...	...	1310	1310	...	...	1480	1480	800	680	800	680	...	...
B-375	660	660	830	830	990	990	...	...	1150	1150	...	...	1310	1310	...	...	1480	1480	940	750	820	660	...	...
C-375	660	660	830	830	990	990	...	...	1190	1150	...	...	1430	1310	...	...	1700	1510	1080	800	860	640	...	...
D-375	660	660	890	830	1110	990	...	...	1400	1210	...	...	1730	1500	...	...	...	1780	1230	860	950	660	...	...

TABLE 1 *Continued*

Circumferential reinforcement, mm^2/linear m of pipe[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	510	470	340	230	320	210	240	160	420	410	580	540	400	270	340	230	280	190	460	450
B-75	860	760	530	310	490	280	350	180	690	490	1010	920	640	380	540	310	420	220	780	540
C-75	1250	1060	720	390	650	350	450	210	970	650	...	1320	870	490	720	380	540	260	1100	720
D-75	...	1430	930	480	830	420	560	240	1300	830	...	...	1140	610	910	470	670	300	1540	910
A-150	690	650	480	370	450	350	360	280	870	870	780	750	550	420	490	380	410	320	960	960
B-150	1050	950	670	450	620	410	470	300	870	870	1210	1120	790	530	680	450	550	360	960	960
C-150	1440	1250	860	530	780	480	570	330	1120	870	...	1520	1020	630	860	520	670	390	1250	960
D-150	...	1620	1060	620	960	550	670	360	1450	960	...	...	1280	750	1050	600	790	430	1690	1050
A-225	880	870	620	510	590	480	490	390	...	...	990	950	700	580	630	520	550	440	...	...
B-225	1230	1130	810	590	750	550	590	430	...	...	1420	1330	940	680	820	590	680	490	...	...
C-225	1630	1440	990	670	910	610	690	450	...	...	...	1730	1170	780	990	670	800	520	...	...
D-225	...	1810	1190	750	1090	680	790	470	...	...	...	...	1420	900	1180	740	920	560	...	...
A-300	1230	1230	760	650	720	620	670	560	...	...	1350	1350	860	730	780	650	740	610	...	...
B-300	1420	1320	950	730	890	680	710	550	...	...	1620	1530	1090	830	960	740	810	620	...	...
C-300	1810	1620	1130	800	1050	740	810	570	...	...	...	1930	1310	930	1130	810	930	650	...	...
D-300	...	1990	1320	890	1210	810	910	590	...	...	...	...	1600	1040	1320	880	1050	690	...	...
A-375	1640	1640	900	770	900	740	880	760	...	...	1810	1810	1010	880	980	830	980	830	...	...
B-375	1640	1640	1090	870	1020	820	910	730	...	...	1830	1810	1240	990	1110	880	1000	810	...	...
C-375	2000	1810	1260	940	1180	880	940	700	...	...	...	2140	1460	1080	1280	950	1060	790	...	...
D-375	...	2180	1460	1020	1340	940	1030	710	...	...	...	...	1740	1190	1460	1020	1180	820		...

TABLE 1 *Continued*

Circumferential reinforcement, mm²/linear m of pipe[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	630	460	310	370	250	310	210	490	490	480	330	400	270	340	220	530	530	510	350	430	290	370	250	580	580	
B-75	1100	750	450	580	340	460	250	800	580	800	480	630	360	500	280	800	630	840	510	670	390	540	300	840	670	
C-75	...	1050	590	780	420	600	300	1110	780	1100	630	840	450	660	330	1100	840	1170	660	910	500	720	370	1170	910	
D-75	...	1370	750	990	510	740	350	1480	990	1440	790	1060	550	810	390	1440	1060	1550	840	1150	600	900	430	1550	1150	
A-150	860	620	480	520	410	450	350	1040	1040	660	500	560	430	490	380	1130	1130	690	530	600	460	530	410	1220	1220	
B-150	1330	920	620	730	490	600	390	1040	1040	970	650	790	520	650	430	1130	1130	1010	690	840	560	700	460	1220	1220	
C-150	...	1200	750	930	570	740	440	1270	1040	1260	790	990	610	800	480	1260	1130	1330	840	1070	660	880	530	1330	1220	
D-150	...	1560	900	1140	660	880	480	1680	1140	1630	950	1210	710	960	530	1630	1210	1710	1010	1310	770	1050	590	1710	1310	
A-225	1080	790	650	680	560	590	480	...	...	830	680	720	600	640	520	...	...	880	720	770	640	690	560	...	...	
B-225	1550	1080	780	880	640	740	540	...	...	1140	820	940	680	800	580	...	...	1190	860	1000	730	860	630	...	...	
C-225	...	1360	910	1080	720	880	580	...	...	1430	960	1150	770	950	630	...	...	1500	1010	1230	830	1040	680	...	...	
D-225	...	1720	1060	1280	810	1020	620	...	...	1790	1110	1360	860	1100	680	...	...	1880	1180	1470	930	1200	740	...	...	
A-300	1470	960	820	830	690	800	670	...	...	1010	860	890	730	870	720	...	...	1060	900	940	780	940	780	...	...	
B-300	1770	1240	950	1040	790	890	680	...	...	1310	1000	1100	840	950	730	...	...	1370	1050	1170	900	1020	790	...	...	
C-300	...	1550	1070	1220	870	1020	720	...	...	1620	1130	1300	930	1100	780	...	...	1710	1190	1400	990	1190	840	...	...	
D-300	...	1870	1220	1420	950	1150	760	...	...	1950	1280	1540	1020	1250	830	...	...	2090	1350	1650	1090	1360	900	...	...	
A-375	1970	1130	990	1070	900	1060	910	...	...	1180	1010	1160	970	1150	980	...	...	1250	1050	1240	1060	1240	1060	...	...	
B-375	1990	1410	1110	1190	950	1100	870	...	...	1480	1170	1260	1010	1180	950	...	...	1570	1230	1340	1070	1280	1020	...	...	
C-375	...	1710	1240	1370	1020	1160	860	...	...	1790	1300	1460	1090	1250	930	...	...	1880	1370	1580	1160	1350	1000	...	...	
D-375	...	2080	1380	1590	1100	1290	900	...	...	2160	1440	1690	1170	1400	980	...	...	2260	1550	1810	1260	1520	1060	...	...	

TABLE 1 *Continued*

Circumferential reinforcement, mm²/linear m of pipe[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	470	320	410	270	620	620	600	410	500	340	450	300	660	660	650	440	530	360	480	320	700	700
B-75	940	570	730	430	600	340	940	730	960	590	770	460	670	380	960	770	1030	630	810	480	710	410	1030	810
C-75	1330	760	1000	550	800	410	1330	1000	1370	790	1070	590	910	480	1370	1070	1490	860	1130	620	970	520	1490	1130
D-75	1790	970	1270	670	990	490	1790	1270	1820	990	1350	720	1130	570	1820	1350	2020	1090	1430	760	1210	620	...	1430
A-150	770	590	660	500	580	450	1300	1300	800	620	700	540	640	490	1390	1390	860	660	730	560	680	520	1470	1470
B-150	1130	770	910	610	770	510	1300	1300	1160	790	960	650	850	570	1390	1390	1240	840	1000	680	900	600	1470	1470
C-150	1540	950	1170	730	970	580	1540	1300	1580	980	1250	770	1080	660	1580	1390	1710	1070	1320	820	1160	710	1710	1470
D-150	1960	1150	1440	840	1160	650	1960	1440	2040	1180	1550	900	1300	750	2040	1550	2210	1290	1630	950	1400	800	...	1630
A-225	970	790	840	690	750	610	...	...	1010	820	890	730	820	670	...	...	1070	880	940	770	870	710	...	...
B-225	1320	960	1090	790	940	680	...	...	1360	990	1150	840	1030	750	...	...	1450	1050	1200	880	1090	800	...	...
C-225	1730	1140	1350	900	1140	750	...	...	1780	1180	1430	960	1260	840	...	...	1910	1270	1510	1010	1350	900	...	...
D-225	2180	1330	1630	1020	1330	820	...	...	2220	1370	1730	1080	1480	920	...	...	2400	1480	1810	1140	1590	990	...	...
A-300	1170	990	1030	850	1000	840	...	...	1210	1030	1090	890	1070	890	...	...	1290	1090	1150	930	1140	940	...	...
B-300	1540	1160	1270	980	1110	860	...	...	1580	1190	1340	1030	1210	940	...	...	1680	1270	1400	1080	1290	990	...	...
C-300	1920	1330	1550	1080	1310	920	...	...	1970	1370	1640	1150	1440	1020	...	...	2150	1480	1720	1210	1550	1090	...	...
D-300	2360	1550	1800	1190	1490	990	...	...	2410	1590	1910	1270	1670	1100	...	...	2640	1710	2030	1330	1780	1180	...	...
A-375	1370	1170	1330	1130	1330	1130	...	...	1430	1190	1420	1200	1420	1200	...	...	1510	1270	1510	1270	1500	1280	...	...
B-375	1740	1350	1450	1160	1370	1090	...	...	1780	1400	1550	1220	1460	1160	...	...	1890	1480	1620	1280	1540	1240	...	...
C-375	2150	1550	1730	1270	1480	1100	...	...	2200	1600	1830	1340	1640	1210	...	...	2360	1710	1920	1410	1740	1280	...	...
D-375	2600	1740	1980	1370	1680	1160	...	...	2650	1780	2120	1450	1850	1280	...	...	2840	1910	2220	1540	1970	1370	...	...