American Concrete Pipe Association

An Introduction to ASTM Concrete Pipe & Box Culvert Joint Standards

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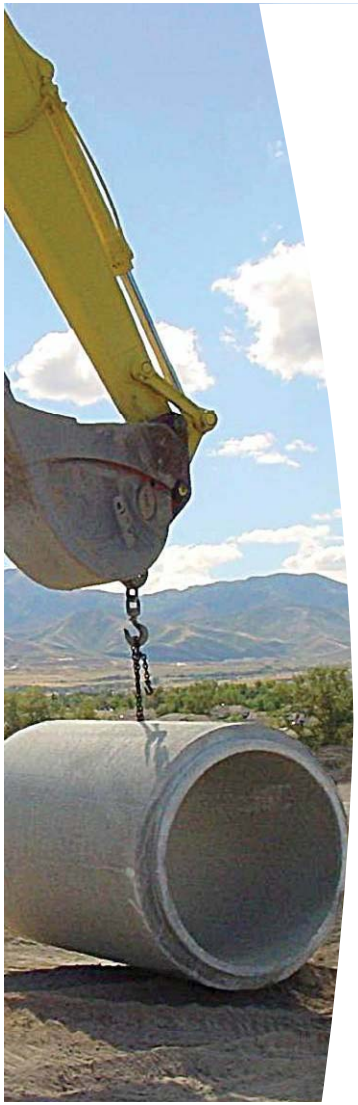


What is ASTM?

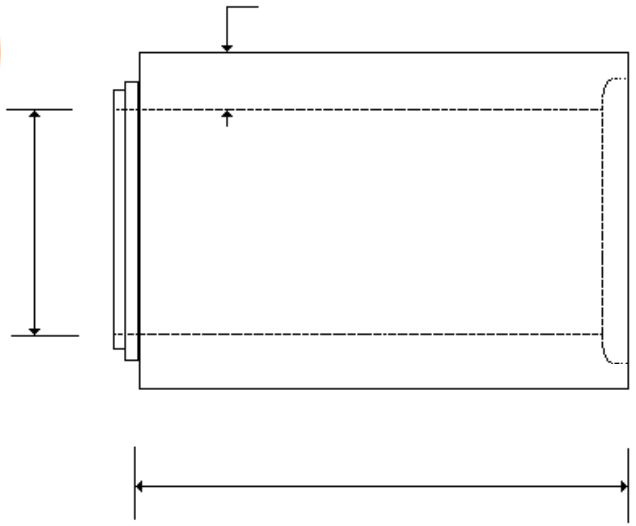
- American Society for Testing and Materials,established in 1898
- **ASTM International**
  - A <u>voluntary consensus based</u> organization which establishes material standards or testing protocols
- American Section of the International Association for Testing Materials. The members grappled with two questions that were widely discussed throughout the engineering community at the turn of the century. First, **<u>how could standards for materials *contribute to industrial progress*</u>**? And second, **<u>how could producers and users of industrial materials *reach a consensus on standards?*</u>** ASTM's early history was in large part a quest to find answers to these pivotal questions

Weakest Link of Conduit

American Concrete Pipe Association

ASTM C76 – Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe

ASTM C76 – Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe



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11.11 *Test Equipment*— Every manufacturer furnishing pipe under this specification shall furnish all facilities and personnel necessary to carry out the tests described in Test Methods C 497.

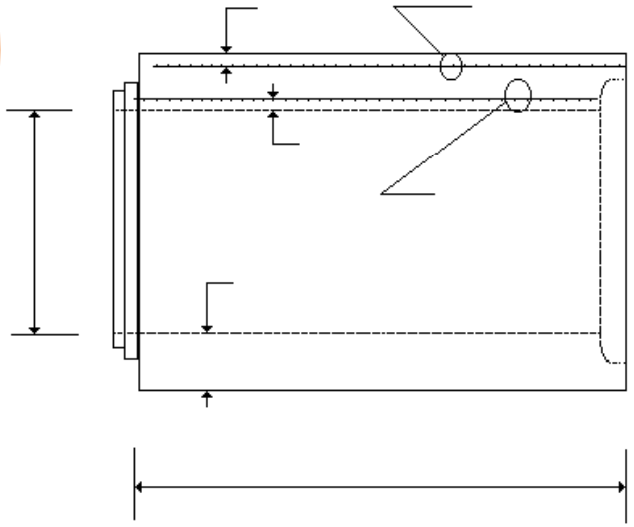
12. Permissible Variations

12.1 *Internal Diameter*—The internal diameter of 12-in. through 24-in. pipe shall not vary by more than 2 % of the design diameter for 12-in. pipe and 1.5 % for 24-in. pipe with intermediate sizes variation being a linear scale between 2 % and 1.5 %. The internal diameter of sizes 27-in. and larger shall not vary by more than 1 % of the design diameter or ±⅜-in., whichever is greater. These diameter requirements are based on the average of four diameter measurements at a distance of 12 in. from the end of the bell or spigot of the pipe. Diameter verification shall be made on the number of pipe selected for test per Section 11.

12.2 *Wall Thickness*—The wall thickness shall not vary more than shown in the design or specified wall by more than ±5 % or 3/16 in., whichever is greater. A specified wall thickness more than required in the design is not cause for rejection. Pipe having localized variations in wall thickness exceeding those specified above shall be accepted if the three-edge-bearing strength and minimum steel cover requirements are met.

12.3 *Length of Two Opposite Sides*—Variations in the laying length of two opposite sides of the pipe shall not be more

ASTM C76 – Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe



C 76 – 08a

TABLE 3 Design Requirements for Class III Reinforced Concrete Pipe[A]

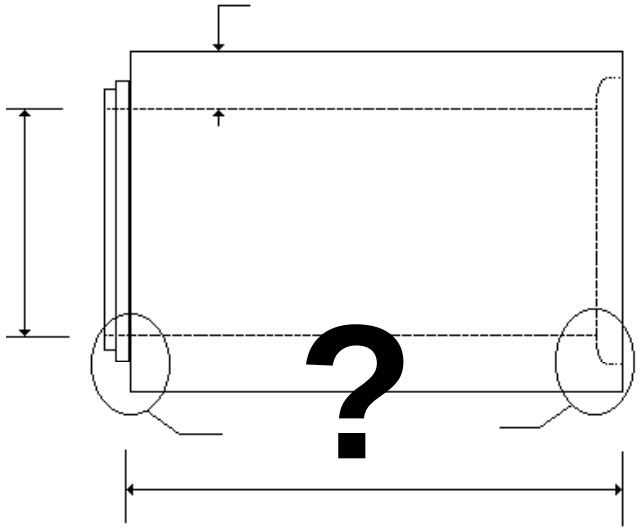
NOTE 1—See Section 5 for basis of acceptance specified by the owner.

The strength test requirements in pounds-force per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds-force per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.

D-load to produce a 0.01-in. crack	1350
D-load to produce the ultimate load	2000

Internal Designated Diameter, in.	Reinforcement, in.²/linear ft of pipe wall											
	Wall A				Wall B				Wall C			
	Concrete Strength, 4000 psi				Concrete Strength, 4000 psi				Concrete Strength, 4000 psi			
	Wall Thicknesses, in.	Circular Reinforcement[B]		Elliptical Reinforcement[C]	Wall Thicknesses, in.	Circular Reinforcement[B]		Elliptical Reinforcement[C]	Wall Thicknesses, in.	Circular Reinforcement[B]		Elliptical Reinforcement[C]
		Inner Cage	Outer Cage			Inner Cage	Outer Cage			Inner Cage	Outer Cage	
12	1¾	0.07[D]	...	...	2	0.07[D]	...	...	2¾	0.07[D]	...	...
15	1⅞	0.07[D]	...	...	2¼	0.07[D]	...	...	3	0.07[D]	...	...
18	2	0.07[D]	...	0.07[D]	2½	0.07[D]	...	0.07[D]	3¼	0.07[D]	...	0.07[D]
21	2¼	0.14	...	0.11	2¾	0.07[D]	...	0.07[D]	3½	0.07[D]	...	0.07[D]
24	2½	0.17	...	0.14	3	0.07[D]	...	0.07[D]	3¾	0.07	...	0.07[D]
27	2⅝	0.18	...	0.16	3¼	0.16	...	0.14	4	0.08	...	0.07[D]
30	2¾	0.19	...	0.18	3½	0.18	...	0.15	4¼	0.10	...	0.08
33	2⅞	0.21	...	0.20	3¾	0.20	...	0.17	4½	0.12	...	0.10
36	3	0.21	0.13	0.23	4[E]	0.17	0.10	0.19	4¾[E]	0.08	0.07	0.09
42	3½	0.25	0.15	0.28	4½	0.21	0.13	0.23	5¼	0.12	0.07	0.13
48	4	0.32	0.19	0.35	5	0.24	0.14	0.27	5¾	0.16	0.10	0.18

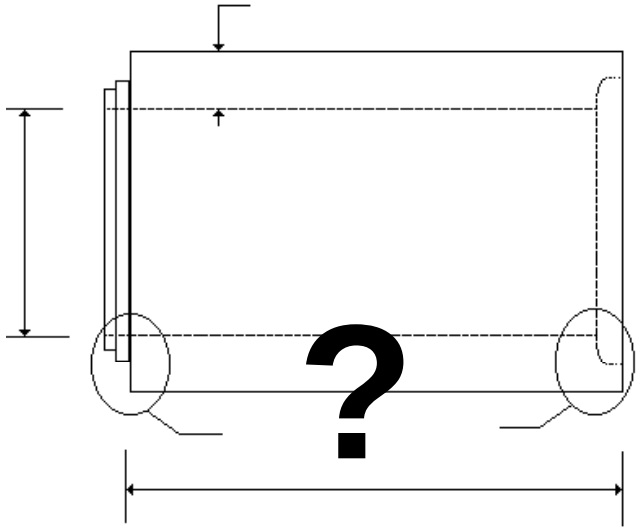
ASTM C76 – Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe



9. Joints

9.1 The joints shall be of such design and the ends of the concrete pipe sections so formed that the pipe can be laid together to make a continuous line of pipe compatible with the permissible variations given in Section 12.

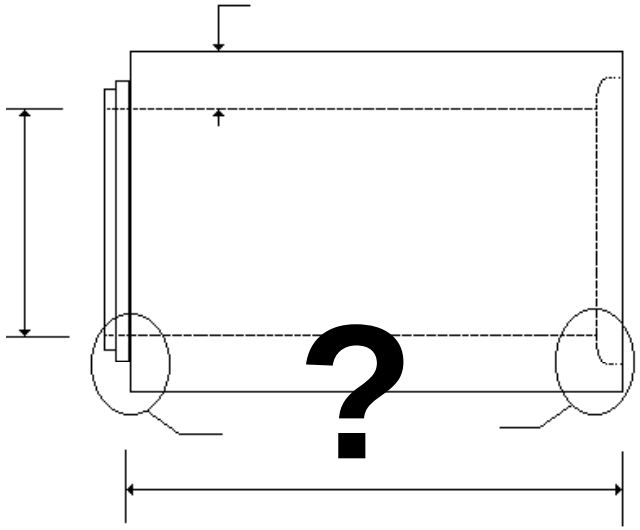
ASTM C76 – Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe



8.1.6 Where the wall reinforcement does not extend into the joint, the maximum longitudinal distance to the last circumferential from the inside shoulder of the bell or the shoulder of the spigot shall be 3 in. except that if this distance exceeds one-half the wall thickness, the pipe wall shall contain at least a total reinforcement area of the minimum specified area per linear foot times the laying length of the pipe section. The minimum cover on the last circumferential near the spigot shoulder shall be 1.2 in.

8.1.6.1 Where reinforcement is in the bell or spigot the minimum end cover on the last circumferential shall be ½ in. in the bell or ¼ in. in the spigot.

ASTM C76 – Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe



8.3 ***Joint Reinforcement*—The** length of the joint as used herein means the inside length of the bell or the outside length of the spigot from the shoulder to the end of the pipe section. The end distances or cover on the end circumferential shall apply to any point on the circumference of the pipe or joint. When convoluted reinforcement is used, these distances and reinforcement areas shall be taken from the points on the convolutions closest to the end of the pipe section. Unless otherwise permitted by the owner, the following requirements for joint reinforcement shall apply.

8.3.1 ***Joint Reinforcement for Non-Rubber Gasket Joints***:

8.3.1.1 For pipe 36 in. and larger in diameter, either the bell or spigot shall contain circumferential reinforcement. This reinforcement shall be an extension of a wall cage, or may be a separate cage of at least the area per foot of that specified for the outer cage or one-half of that specified for single cage wall reinforcement, whichever is less.

8.3.1.2 Where bells or spigots require reinforcement, the maximum end cover on the last circumferential shall be one-half the length of the joint or 3 in., whichever is less.

8.3.2 ***Joint Reinforcement for Rubber Gasket Joints*:**

8.3.2.1 For pipe 12 in. and larger in diameter, the bell ends shall contain circumferential reinforcement. This reinforcement shall be an extension of the outer cage or a single wall cage, whichever is less, or may be a separate cage of at least the same area per foot with longitudinals as required in 8.2. If a separate cage is used, the cage shall extend into the pipe with the last circumferential wire at least one in. past the inside shoulder where the pipe barrel meets the bell of the joint.

8.3.2.2 Where bells require reinforcement, the maximum end cover on the last circumferential shall be 1 1/2 in.

The “Good ol’ Days”

Making the pipe Today

If we're not backcharged

It's a good joint!

SOME HISTORICAL PERSPECTIVE

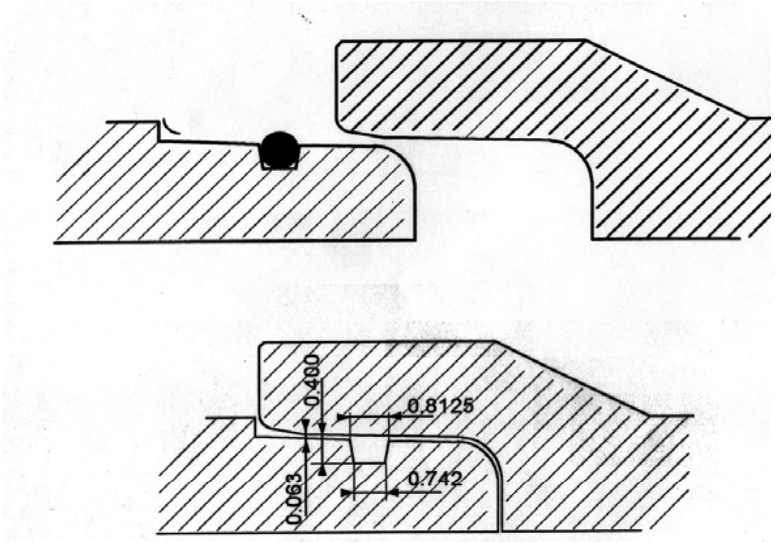
- Most early sewer and culvert installations used plain, mortar, or mastic joint sealant.
- Gasketed pipe joints were primarily used for pressure applications
  - England mid 1800's
  - 1st US concrete pressure line 1914
- US profile gaskets use early 1930's
  - "Flexlock" by B.F. Goodrich-T.D .Nathan
  - Hamilton-Kent; Tylox 1944

ASTM Gasketed Joint Standards Development

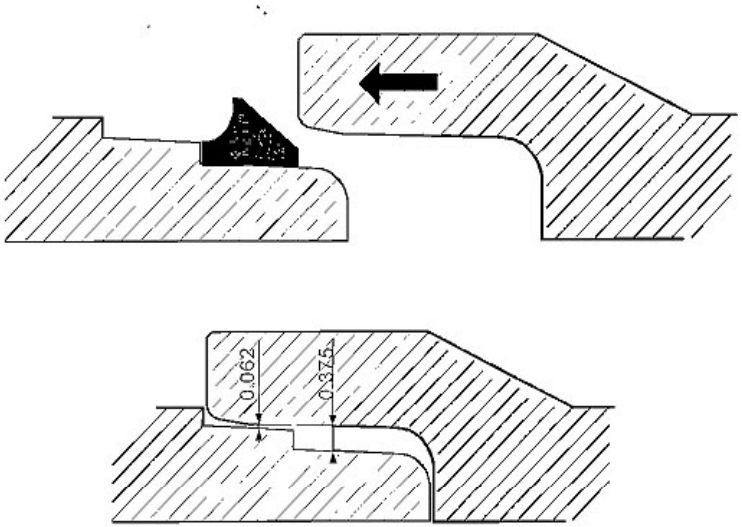
C361-1955 Reinforced Concrete Low-Head Pressure Pipe

C443-1959 Joints for *Circular* Concrete Sewer and Culvert Pipe, Using Rubber Gaskets

O-ring Detail



Profile Detail

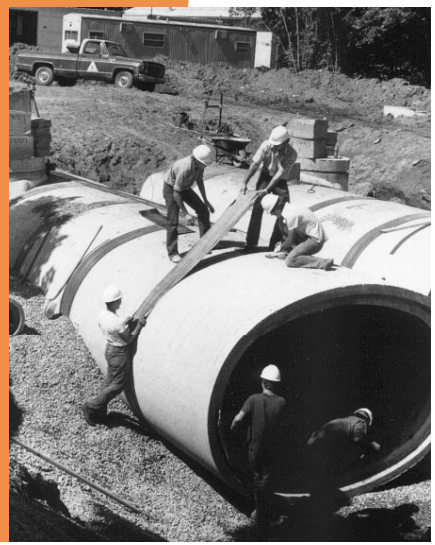


ASTM Alternate Joint Standards Development

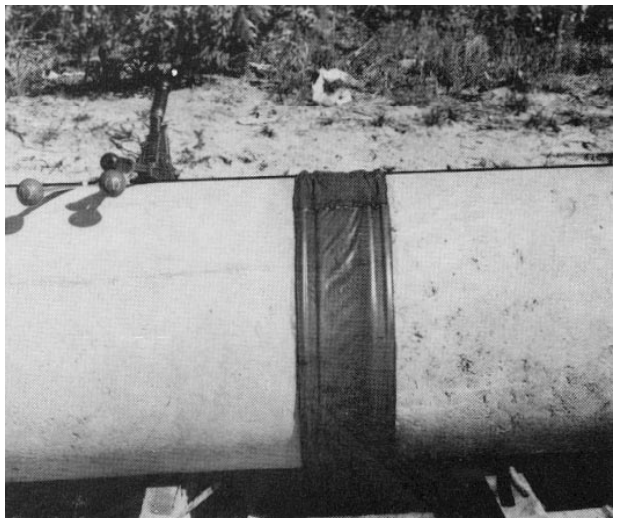
C877-1977 External Sealing Bands for Noncircular Concrete Sewer, Storm Drain, and Culvert Pipe

C990-1991 Joints for Concrete Pipe, Manholes, and Precast Box Sections Using *Preformed* Flexible Joint Sealants

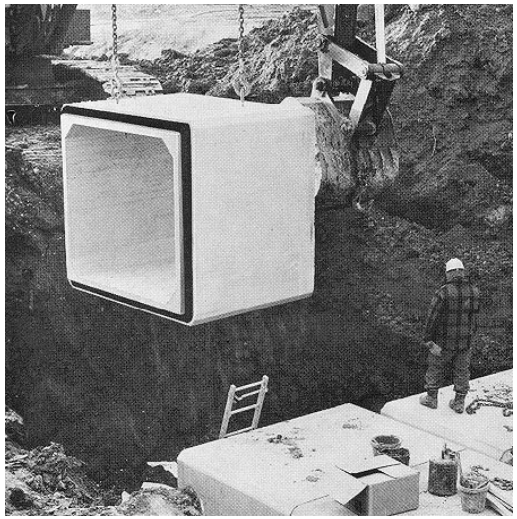
C877 Type 1



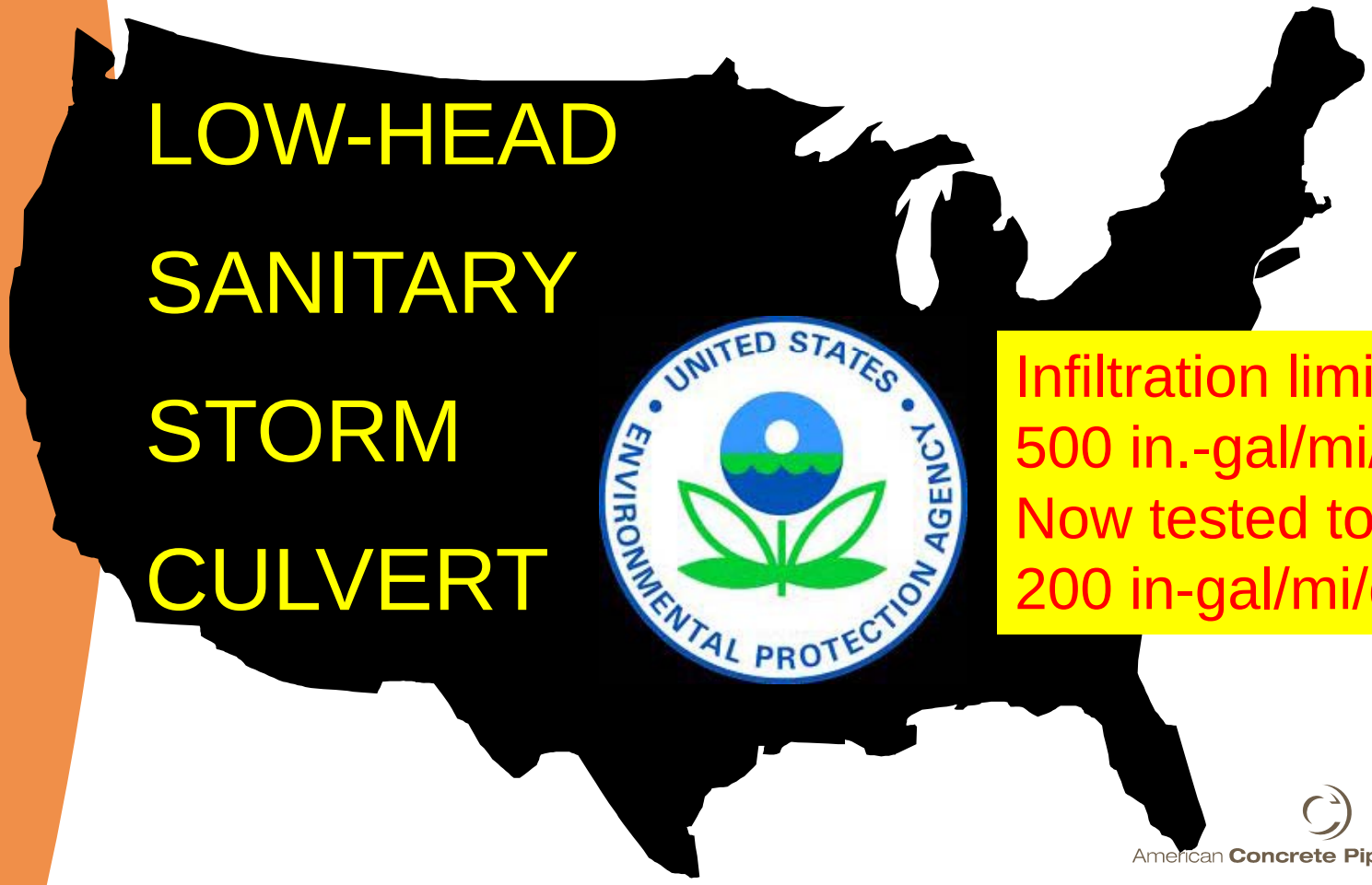
C877 Type 2



C990



CONCRETE PIPE JOINT STANDARDS USE IN MUNICIPAL PIPE APPLICATIONS



Infiltration limits:
500 in.-gal/mi/day
Now tested to:
200 in-gal/mi/day!

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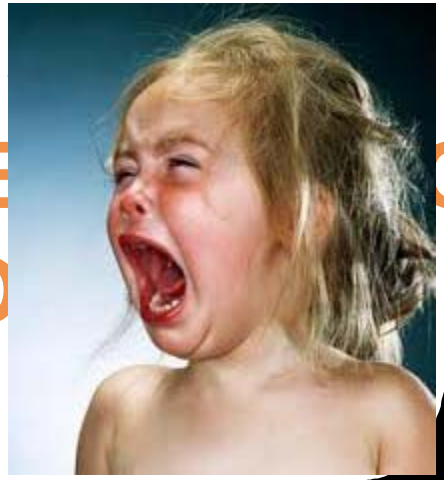

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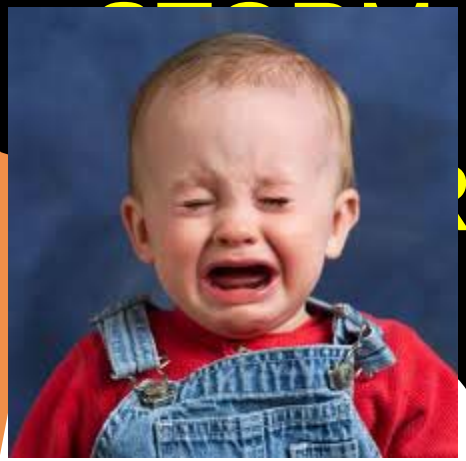

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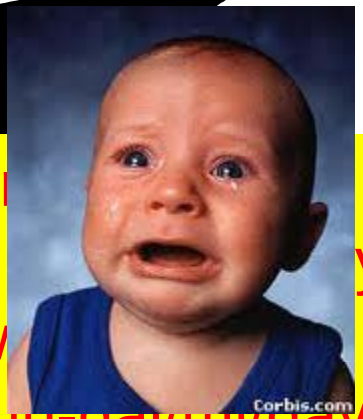


CONCRETE PIPE JOINT STANDARDS USE IN TRANSPORTATION PIPE APPLICATIONS

AASHTO PP63-09 - *Standard Recommended Practice for Pipe Joint Selection for Highway Culvert and Storm Drains*

Joint Type	Joint Systems	Joint System Standard AASHTO	Joint System Standard ASTM	Plant Proof of Design	Plant Test Criteria
Soil Tight	Mastic filler	AASHTO M198	ASTM C990	Material Certification	Dimensional checks
	External Geotextile wrap	AASHTO M288	-		
	External Sealing Bands	-	ASTM C877		
	Rubber Gasket	AASHTO M315	ASTM C443		
Silt Tight	Mastic filler	AASHTO M198	ASTM C990	Material Certification & 3 psi joint test	Dimensional Checks & Joint Test AASHTO M315 (3 psi test in deflected position in lieu of 10 psi)
	External Sealing Bands	-	ASTM C877		
	Rubber Gasket	AASHTO M315	ASTM C443		
Water Resistant	Rubber Gasket	AASHTO M315	ASTM C443	Material Certification & 13 psi joint test	Dimensional Checks & Joint Test AASHTO M315 (13 psi test in straight alignment, and 10.8 psi in deflected position)

Soil Tight — Conduit joint which will not allow the transmission of backfill or native soil through the joint with design flow conditions
Application: Culverts and storm sewers above water table, open channel flow

Silt Tight — Conduit joint which will not allow the transmission of course or fine grain backfill or native soil through the joint with design flow conditions in the presence of external ground water or low internal head conditions.
Application: Culverts and storm sewers presence of water table at or near top of pipe and fine grain insitu soil,

Water Resistant — Conduit joint which will not allow the transmission of water in excess of a defined measurable rate through the joint with design flow conditions with or without the presence of external ground water or low internal head conditions. Must also meet/exceed "Soil and Silt Tight Joints
Application: Storm sewers with presence of water table over top of pipe and fine grain insitu soil, possible low head flow conditions

A Complete Pipe Standard

Pipe Barrel Standard (round, elliptical, arch, box)

+ Pipe Joint Standard (gasket, mastic, exterior wrap)

Total Concrete Pipe Product

ASTM Concrete Pipe Joint Standards 2010

- **ASTM C 361 08**
  - Standard Specification for Reinforced Concrete Low-Head Pressure Pipe
- **ASTM C 443 05**
  - Standard Specification for Joints for Concrete Pipe and Manholes Using Rubber Gaskets
- **ASTM C 1628 06**
  - Standard Specification for Joints for Concrete Gravity Flow Sewer Pipe Using Rubber Gaskets
- **ASTM C 1677 09**
  - Standard Specification for Joints for Concrete Box, Using Rubber Gaskets
- **ASTM C 1619 05**
  - Standard Specification for Elastomeric Seals for Joining Concrete Structures
- **ASTM C 505 05a**
  - Standard Specification for Irrigation Pipe with Rubber Gasket Joints

ASTM Concrete Pipe Joint Standards 2010

- **ASTM C 877 08**
  - Standard Specification for External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections
- **ASTM C 990 09**
  - Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
- **ASTM C 1103 03**
  - Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
- **ASTM C 497 05**
  - Standard Test methods for Concrete Pipe, Manhole Sections, or Tile

ASTM Concrete Pipe Rubber Gasketed Joint Standards 2010

- **ASTM C 361 08**
  - Standard Specification for Reinforced Concrete Low-Head Pressure Pipe
- **ASTM C 443 05**
  - Standard Specification for Joints for Concrete Pipe and Manholes Using Rubber Gaskets
- **ASTM C 1628 06**
  - Standard Specification for Joints for Concrete Gravity Flow Sewer Pipe Using Rubber Gaskets
- **ASTM C 1677 09**
  - Standard Specification for Joints for Concrete Box, Using Rubber Gaskets
- **ASTM C 1619 05**
  - Standard Specification for Elastomeric Seals for Joining Concrete Structures
- **ASTM C 505 05a**
  - Standard Specification for Irrigation Pipe with Rubber Gasket Joints

ASTM C 361

Standard Specification for Reinforced Concrete Low-Head Pressure Pipe (1955)

C361 Key Points

- **Complete pipe standard**, 6 Sack Mix (564 Lbs)
- Steel End Ring and Concrete Joints
- Gasket Deformation Limits (50%/15%) - Deformation Calculations w/Full Tolerances Applied
- Hydrostatic Test to 120% of Design Pressure for 20 minutes (design 25’ -125’) Off-Center (Concrete to Concrete Contact or 150 lbs/inch) Hydrostatic Test Required
- Alternate Designs & Gaskets Allowed (Par. 8.5)
- 100% of Gsk. To Be Contained In Groove

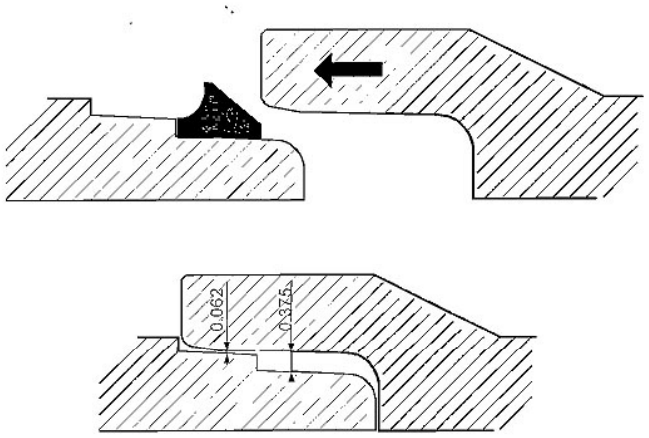
C361 Key Points

ASTM C 443

Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets (1959)

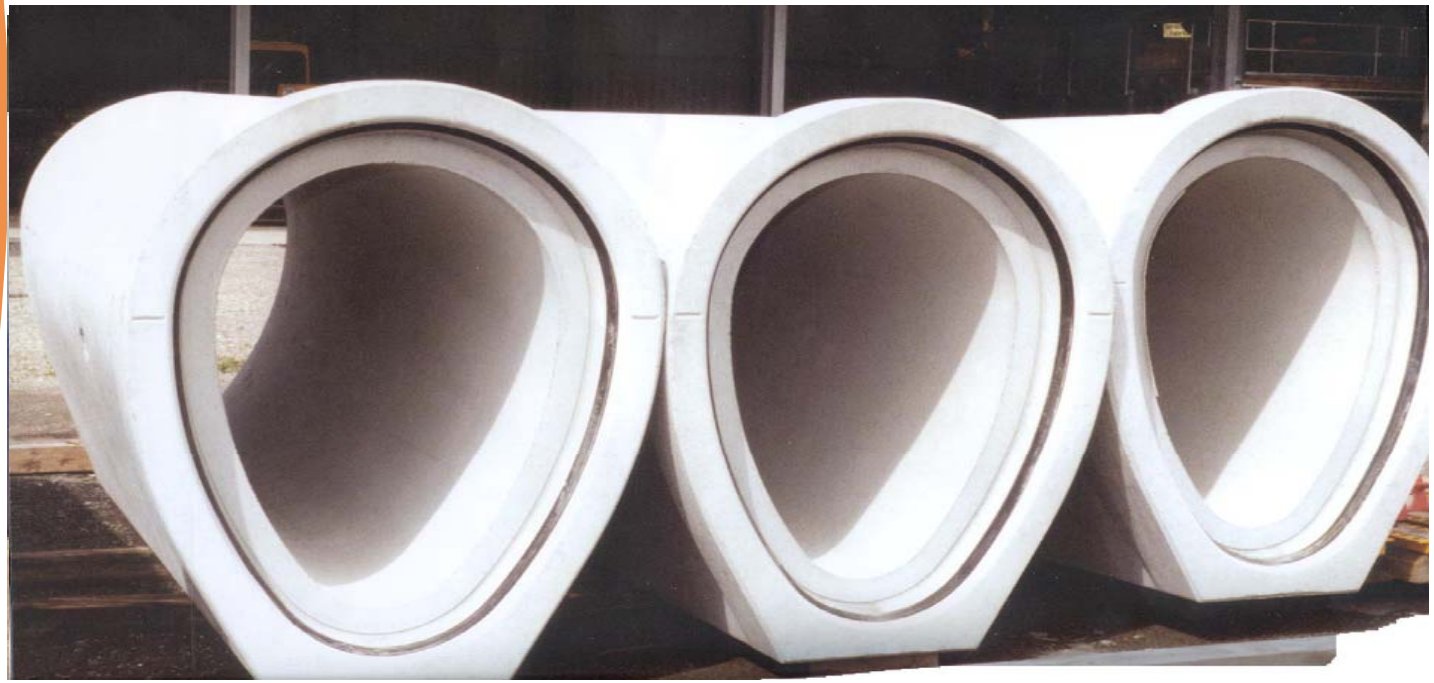
Gasketed Joint Material Standards

- ASTM C443 Standard Specification for Joints for ~~Circular~~ Concrete Pipe and Manholes, Using Rubber Gaskets



Gasketed Joint Material Standards

- ASTM C443 Standard Specification for Joints for ~~Circular~~ Concrete Pipe and Manholes, Using Rubber Gaskets



C443 Key Points

- Gasket Deformation Limits (25%) Centered Position
- Bell taper 3.5°, up to 5° if proven by testing
- Reduced Gasket Tensile Properties from C361
- Alternate Designs Allowed (Par. 7.2)
- When **Required by Owner**, Hydrostatic Test to 13 psi Straight & 10 psi Deflected ½ “ all in the Centered Position

ASTM C 1628

Standard Specification for Joints for Concrete Gravity Flow Sewer Pipe, Using Rubber Gaskets (2007)

Designation: C 1628
Standard Specification for Joints for Concrete Gravity Flow Sewer Pipe, Using Rubber Gaskets1

1. Scope

1.1 This specification covers flexible leak resistant joints for concrete gravity flow sewer pipe using rubber gaskets for sealing the joints, **where measurable or defined infiltration or exfiltration is a factor of the design**. The specification covers the design of joints and the requirements for rubber gaskets to be used therewith, for pipe conforming in all other respects to Specifications C14, C76, C655, C985, and C1417, provided that, if there is conflict in permissible variations in dimension, the requirements of this specification shall govern for joints.

C1628 Key Points

C1628 Key Points

- Rubber gasketed-include rational design parameters for o-ring & profile & alternate concepts
- include plant **proof of design** C443 hydrostatic test criteria, “deflected and off-centered” (concrete to concrete contact or 150 lbs/inch)
- include plant **proof of design** joint shear test criteria (4000#/ft. dia.)
- include design and testing submittal examples to insure uniformity
- include manufacturing QC/QA criteria to insure the joint submitted is the joint shipped

ASTM C 1677

Standard Specification for Joints for Concrete Box, Using Rubber Gaskets (2009)

Gasketed box section joints are a reality in many areas

C1677 Key Points

- Gasket deformation limits (25%) centered position <u>including manufacturing tolerances</u> in calculations, not less that 15% in off-centered position

ASTM C 1619

Standard Specification for Elastomeric Seals for Joining Concrete Structure (2005)

C1619 Key Points

- All ASTM C13 joint standards using gaskets to refer to this standard for gasket properties
- Gasket properties are defined in five classifications A-E
- Gasket markings to meet this standard

TABLE 1 Physical Property Requirements for Elastomeric Seals

	Class A	Class B	Class C	Class D	Class E
Tensile, min, psi (MPa)	2300 (15.9)	1500 (10.3)	1200 (8-3)	1200 (8.3)	1800 (12.4)
Elongation at break, min, %	425	350	350	350	425
Specified Hardness, Shore A	40-60	40-60	40-60	40-60	40-60
Oven-Age Tensile reduction, max % of original	15	20	15	20	15
Oven-Age Elongation reduction, max % of original	20	40	20	40	20
Oven-Age hardness increase, max	—	15	—	15	—
Compression Set, max %	20	20	25	25	20
Water Absorption, max % weight increase	5	15	10	15	5
Ozone Resistance level, 50 pphm	No cracks	No cracks	No cracks	No cracks	No cracks
Liquid Immersion IRM 903 Oil. Max % volume change	—	80	—	80	—
Splice Strength Classification	Class 3	Class 2	Class 3	Class 2	Class 3

SUGGESTED FUTURE ASTM JOINT STANDARDS GRID

DESCRIPTION	TYPICAL USE	ASTM
Low-Head	Levees, dams, surcharged sewers, water irrigation	C 361
Measurable infiltration & exfiltration	Gravity flow sanitary sewers, hazard waste sewers, etc,	C 1628
Water resistant, no visible leakage	Storm sewer, culverts under high use roads	C 443 C 877* C 990*
Soil resistant	Culverts, storm sewers above w.t.	C 877 C 990

INNOVATION:
Independent Concrete Pipe Companies first self unloading truck