Plumbing Board
c/o Department of Labor and Industry
443 Lafayette Road North
St. Paul, MN 55155-4344
www.dli.mn.gov

PRINT IN INK or TYPE

Plumbing Board
Request for Action

NAME OF SUBMITTER	PURPOSE OF REQUEST (check all that apply): ☒ New Code
Aaron Ganson	☒ Code Amendment ☐ Repeal of an existing Rule

The Minnesota Plumbing Code (MN Rules, Chapter 4714) is available at www.dli.mn.gov/CCLD/PlumbingCode.asp

Specify the purpose of the proposal: If recommendation for code change for appurtenance or method (check all that apply)

☐ Appurtenance (e.g., water conditioning equipment) ☐ Test Method

☒ Other (describe) Material approval for Table 701.1

Does your submission contain a Trade Secret? ☐ Yes ☒ No

If Yes, mark **"TRADE SECRET"** prominently on each page of your submission that you believe contains trade secret information. Minnesota Statutes, section 13.37, subdivision 1(b), defines "trade secret" as follows:

> "Trade secret information" means government data, including a formula, pattern, compilation, program, device, method, technique or process (1) that was supplied by the affected individual or organization, (2) that is the subject of efforts by the individual or organization that are reasonable under the circumstances to maintain its secrecy, and (3) that derives independent economic value, actual or potential, from not being generally known to, and not being readily ascertainable by proper means by, other persons who can obtain economic value from its disclosure or use.

Note that, although "trade secret" information is generally not public, the Board and its committees may disclose "trade secret" information at a public meeting of the Board or committee if reasonably necessary for the Board or committee to conduct the business or agenda item before it (such as your request.) The record of the meeting will be public.

Describe the proposed change. The Minnesota Plumbing Code (Minnesota Rules Chapter 4714) is available via the World Wide Web at http://www.revisor.leg.state.mn.us/arule/4714/

NOTE:

- Please review the Minnesota Plumbing Code and include all parts of the Code that require revision to accomplish your purpose.
- The proposed change, including suggested rule language, should be *specific*. If modifying existing rule language, underline new words and ~~strike through deleted words~~. Please list all areas of the Minnesota Plumbing Code that would be affected.

The proposed change would add Polypropylene Pipe per ASTM F2736 and ASTM F2764 as Building Sewer to Table 701.1 and added to Table 1401.1 Referenced Standards appropriately. Additionally, a new section 705.XX for Polypropylene Pipe and Joints would need to be provided as well. Specific language and table adjustments are submitted in the attached documentation. The requested change would mirror the 2018 ICC-IPC addition directly.

Office Use Only

RFA File No.	Date Received by DLI	Dated Received by Committee	Date of Forwarded to Board
PB0107			
Title of RFA	By:		

Committee Recommendation to the Board: ☐ Accept ☐ Reject ☐ Abstain

Board approved as submitted: ☐ Yes ☐ No Board approved as modified: ☐ Yes ☐ No

Need and Reasons For the Change. Thoroughly explain the need and why you believe it is reasonable to make this change. During a rulemaking process, the need and reasonableness of all proposed rule changes must be justified; therefore, a detailed explanation is necessary to ensure the Board thoroughly considers all aspects of the proposal.
The Board should thoroughly consider the proposed code change because there is currently an ASTM Standard Specification for this pipe material for use in Sanitary Applications. Further, the Canadian Standards Association (CSA) has also identified this pipe material as an acceptable product. Polyproylene pipe has been used in gravity flow sanitary sewer applications in Europe for over 30 years and is now being manufactured in the United States. Currently, polyproyplene is a widely used material for sanitary sewer across the United States and it will provide a high performing, clean, safe, cost-effective material to be utilized on developments all across the state. The change would not require any significant adjustments to the Minnesota State Plumbing Code in how it's written, structured, reviewed or enforced. It would simply allow another qualified building sewer material to be utilized in Minnesota. Additionally, the material would be used exclusively as building sewer and private sewer underground, outside of the building. The material would also highly reduce joint issues and leakage, by exceeding the field joint performance of many materials currently allowed as site and building sewers, as it can utilize a pressure testable, dual-gasketed connection that is required to be tested for 1000-hrs.

If your product/method standard(s) is not currently listed in both national codes, your Request For Action will not be considered by the Board or its committees, however, you are welcome to present at any Board meeting during the Open Forum section of the Agenda.

The proposal must be accompanied by copies of any published standards, the results of testing, and copies of any product listings, as documentation of the health, sanitation and safety performance of any materials, methods, fixtures, and/or appurtenances. If none are available, please explain:
International Code Council - International Plumbing Code 2018 Table 702.3 Building Sewer
ASTM International Standard Specifications: F2736 & F2764
Candian Standards Association: B182.13
United Facilities Guide Specifications 33 00 00 Sanitary Sewerage

Please attach electronic scanned copies of any literature, standards and product approvals or listings. Printed or copyrighted materials, ***along with written permission from the publisher to distribute the materials at meetings***, should be sent to the Plumbing Board, c/o Department of Labor and Industry, 443 Lafayette Road No., St. Paul, MN 55155-4344.

Primary reason for change: (check only one)

- ☐ Protect public, health, safety, welfare, or security
- ☒ Lower construction costs
- ☐ Encourage new methods and materials
- ☐ Change made at national level
- ☐ Other (describe)
- ☐ Mandated by legislature
- ☐ Provide uniform application
- ☐ Clarify provisions
- ☐ Situation unique to Minnesota

Anticipated benefits: (check all that apply)

- ☐ Save lives/reduce injuries
- ☐ Improve uniform application
- ☐ Improve health of indoor environment
- ☒ Provide more construction alternatives
- ☒ Reduce regulation
- ☐ Other (describe)
- ☒ Provide more affordable construction
- ☐ Provide building property
- ☐ Drinking water quality protection
- ☐ Decrease cost of enforcement

Economic impact: (explain all answers marked "yes")

1. Does the proposed change increase or decrease the cost of enforcement? ☐ Yes ☒ No If yes, explain

2. Does the proposed change increase or decrease the cost of compliance? ☐ Yes ☒ No If yes, explain
Include the estimated cost increase or decrease, and who will bear the cost increase or experience the cost decrease:

3. Are there less costly or intrusive methods to achieve the proposed change? ☐ Yes ☒ No If yes, explain

4. Were alternative methods considered? ☒ Yes ☐ No If no, why not? If yes, explain what alternative methods were considered and why they were rejected.
Strict adherence to the materials currently listed in Table 701.1 for private building sewer is common practice. Request per 301.2 have been denied in certain regions of the state consistently for this and other materials.

5. If there is a fiscal impact, try to explain any benefit that will offset the cost of the change. If there is no impact, mark "N/A." The fiscal impact will be positive and more cost efficient for projects in the State especially where larger diameter piping is utilized >15". This will save state institutional developments and more significant money while still maintaining performance required for sanitary drainage.

6. Provide a description of the classes of persons affected by a proposed change, who will bear the cost, and who will benefit. State and regional inspectors and plan reviewers will be affected in that they will have to know the updated Table and listings. Developers and institutions will benefit by having multiple high performing material options to bid and utilize on projects. In addition, developers and institutions will be able to minimize construction delays due to availability of materials with more qualified options to select. Polypropylene manufacturers will benefit as they will be able to supply materials meeting these specifications.

7. Does the proposed rule affect farming operations? (Agricultural buildings are exempt from the Minnesota Building Code under Minnesota Statutes, Section 326B.121.) ☐ Yes ☒ No If yes, explain

Are there any existing Federal Standards? ☒ Yes ☐ No If yes, list:
United Facilities Guide Specifications 33 30 00 Sanitary Sewerage

Are there any differences between the proposed change and existing federal regulations? ☒ Yes ☐ No
☐ Not applicable ☐ Unknown If yes, describe each difference & explain why each difference is needed & reasonable.
Federal regulations have adopted more recent versions of the same ASTM standards. We are submitting the previous versions to be consistent with what is currently published in the ICC-IPC 2018. More current versions of the ASTM Standards can be furnished upon request.

Minnesota Statutes, section 14.127, requires the Board to determine if the cost of complying with proposed rule changes in the first year after the changes take effect will exceed $25,000 for any small business or small city. A small business is defined as a business (either for profit or nonprofit) with less than 50 full-time employees and a small city is defined as a city with less than ten full-time employees.

During the first year after the proposed changes go into effect, will it cost more than $25,000 for any small business or

small city of comply with the change? ☐ Yes ☒ No If yes, identify by name the small business(es or small city(ies).

Will this proposed plumbing code amendment require any local government to adopt or amend an ordinance or other regulation in order to comply with the proposed plumbing code amendment? ☐ Yes ☒ No, If yes, identify by name the government(s) and ordinances(s) that will need to be amended in order to comply with the proposed plumbing code amendment.

Additional supporting documentation may also be attached to this form. Are there any additional comments you feel the Committee/Board may need to consider? If so, please state them here:

The supporting documentation is attached alongside this RFA. We have obtained permission to mail two copyrighted photocopies of the ASTM standards which will be mailed directly to the Board. We would be very grateful for the opportunity to present and discuss this topic in front of the Plumbing Board.

ICC-IPC Links
https://codes.iccsafe.org/content/IPC2018/chapter-7-sanitary-drainage
https://codes.iccsafe.org/content/IPC2018/chapter-15-referenced-standards

Information regarding submitting this form:

- Submissions are received and heard by the Committee on an "as received" basis. **Any missing documentation will delay the process, and your proposal will be listed as the date it was received "Complete."**
- **Submit any supporting documentation to be considered,** such as manufacturer's literature, approvals by other states, and engineering data electronically to DLI.CCLDBOARDS@state.mn.us. Once your Request For Action form has been received, it will be assigned a file number. Please reference this file number on any correspondence and supplemental submissions.
- **For copyrighted materials that must be purchased from publishers, such as published standards, product approvals or testing data, listings by agencies (IAPMO, ASSE, ASTM, etc.,) you may send just 2 copies, *along with written permission from the publisher to distribute the materials at meetings*, via U.S. Mail to: Plumbing Board, c/o Department of Labor and Industry, 443 Lafayette Road No., St. Paul, MN 55155-4344.**
- **For materials that must be submitted by U.S. Mail, please include a copy of your "Request For Action" form originally submitted and reference your assigned RFA file number.**

Information for presentation to the Committee and/or Board:

- Limit presentations to 5 minutes or less.
- Be prepared to answer questions regarding the proposal and any documentation.

Information regarding Committee and/or Board function:

- The Plumbing Board or designated Committee.

I understand that any action is a recommendation to the Plumbing Board and is not to be considered final action.

NAME AND E-MAIL ADDRESS	FIRM NAME
Aaron Ganson aaron.ganson@ads-pipe.com	Advanced Drainage Systems, Inc.

NAME, PHONE NUMBER AND E-MAIL ADDRESS OF PRESENTER TO THE COMMITTEE (if different):

Bryan Miko, (630)945-7189, bryan.miko@ads-pipe.com

ADDRESS	CITY	STATE	ZIP CODE
6424 Vernon Avenue South	Edina	MN	55436

PHONE	SIGNATURE (original or electronic)	DATE
(612)271-7026	K. Aaron Ganson	12/17/2018

For Assistance or questions on completing this form, contact Cathy Tran, Department of Labor and Industry at 651-284-5898.

For Office/Committee Use Only Proposal received completed? ☐ Yes ☐ No			
Date Proposer notified of gaps:	Mode of notification (e.g., e-mail)	Date returned to Proposer:	Date materials re-received:

Proposed Changes
4714.0701 MATERIALS.

UPC Table 701.1 is amended with the following material added:

TABLE 701.1
MATERIALS FOR DRAIN, WASTE, VENT PIPE AND FITTINGS

MATERIAL	UNDERGROUND DRAIN, WASTE, VENT PIPE AND FITTINGS	ABOVEGROUND DRAIN, WASTE, VENT PIPE AND FITTINGS	BUILDING SEWER PIPE AND FITTINGS	REFERENCED STANDARD(S) PIPE	REFERENCED STANDARD(S) FITTINGS
Polypropylene (PP)	=	=	X	ASTM F2736, ASTM F2764	ASTM F2736, ASTM F2764

TABLE 1401.1
REFERENCED STANDARDS

STANDARD NUMBER	STANDARD TITLE	APPLICATION	REFERENED SECTIONS
ASTM F 2736-13e1	6 to 30 in. (152 To 762 mm) Polypropylene (PP) Corrugated Single Wall Pipe and Double Wall Pipe	Piping, Plastic	Table 701.1
ASTM F2764/F2764M-11ae2	30 to 60 in. (750 to 1500 mm) Polypropylene (PP) Triple Wall Pipe and Fittings for Non-pressure Sanitary Sewer Applications	Piping, Plastic	Table 701.1

4714.0705 JOINTS AND CONNECTIONS.

UPC subsection 705.XX added and amended as follows:

705.XX Polypropylene Pipe and Joints. Joining methods for polypropylene pipe and fittings shall be installed in accordance with the manufacturer's installation instructions and shall comply with Section 705.XX.1 through 705.XX.2.

705.XX.1 Mechanical Joints. Mechanical joints shall be designed to provide a permanent seal and shall be of the mechanical or push-on joint type. The push-on joint shall include an elastomeric gasket in accordance with ASTM D3212 and shall provide a compressive force against the spigot and socket after assembly to provide a permanent seal.

SaniTite® HP
HIGH PERFORMANCE

SaniTite® HP Sanitary Sewer Pipe 12"–60"

THE MOST ADVANCED NAME IN WATER MANAGEMENT SOLUTIONS™

ADS SANITARY

SANITITE® HP PIPE 12"–60" FOR SANITARY SEWER

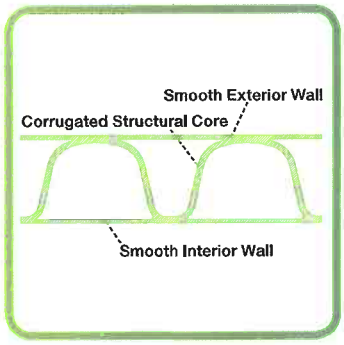
Meets ASTM F2736 and F2764
SaniTite HP (High Performance) couples advanced polypropylene resin technology with a proven dual wall (12"-30") and exclusive triple wall (30"-60") profile design for superior performance and durability. SaniTite HP meets and exceeds typical standards for pipe stiffness and joint integrity. When specifying pipe per ASTM F2736 and/or ASTM F2764 on a gravity flow sanitary sewer project, you are specifying the most stringent performance requirements in the industry.

Advanced Construction

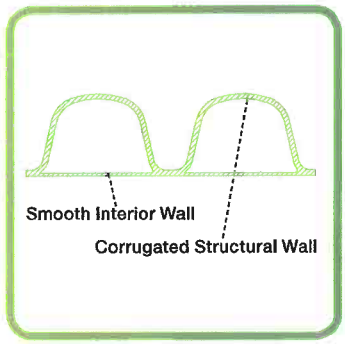
- Standard 12"-60" (300 mm-1500mm) diameters
- Varied lengths available 13' (4.0 m), 16.3' (4.9m) and 20' (6.1m)
- Redundant double gasketed joints
- Inert material
- 1,000 hour 10.8 psi (74.5 kPa) joint test for 30"-60" (750 mm - 1500 mm) pipe per ASTM F2736
- Industry standards for manhole connections, testing and installation

Superior Polypropylene Material
Made from an engineered impact modified co-polymer compound, the superior strength and material properties of polypropylene (PP) offer robust pipe stiffness, excellent handling characteristics, and long service life when compared to traditional sanitary sewer products. It is chemically resistant to hydrogen sulfide gas and sulfuric acid concentrations typical of sanitary sewers to provide superior durability and performance. The unique light grey resin color provides superior UV resistance as well as improving the pipe's interior visibility during post-installation inspection.

Triple Wall Design



Dual Wall Design



INDUSTRY STANDARDS IN SANITARY SEWERS

Superior Joint Performance
SaniTite HP pipe has a patented extended, reinforced bell with polymer composite bands and dual gaskets that add an additional factor of safety within each joint. The SaniTite HP joint performance exceeds the 10.8 psi (74.5 kPa) laboratory performance standards per ASTM D3212. SaniTite HP is tested to 15 psi (103.4 kPa) to provide additional redundancy and factor of safety for critical sanitary sewer installations. Third party certification of joint performance is available upon request.

In the field, each section of SaniTite HP may be tested by a low pressure air test, according to ASTM F1417. ASTM F1417 is a commonly used standard for diameters 12"-36" (300 mm-900 mm) and specifies that 3.5 psi (24.1 kPa) air pressure be held for a specified length of time based upon pipe diameter and length of run. For diameters greater than 30" (900 mm) SaniTite HP joint integrity may be validated by a joint isolation test.

Where an infiltration/exfiltration test is preferred, ASTM F2487 specifies a simplistic method of verifying proper joint performance.

Standard Tap Connections
A standard tapping product, such as INSERTA TEE®, is compatible with SaniTite HP.

Standard Repair Couplers
Testable repair couplers are available at ADS locations. PVC sleeve couplers are available for 12"-30" (300 mm-900 mm) dual wall pipe. Rubber repair couplers with stainless steel shear bands are available for 12"-60" (300 mm-1500 mm) diameters.

Diameter Range
SaniTite HP meeting ASTM F2736 and F2764 is currently manufactured in 20' (6 m) or 13' (4 m) lengths for diameters 12"-48" (300-1200 mm), while the 60" (1500 mm) diameter is manufactured in 20' (6 m) and 16.3' (5 m) lengths. The 20' (6 m) lengths aid in speed of installation and reduce the total number of joints. However, the 13' (4 m) lengths are complimentary for deeper projects where trench box conditions require a shorter pipe.


Joint Isolation Test


INSERTA TEE Tap


Repair Coupler


PVC Sleeve Coupler

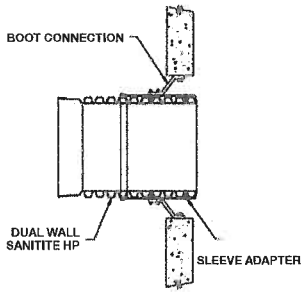
INDUSTRY STANDARDS IN SANITARY SEWERS

Standard Structure Connections

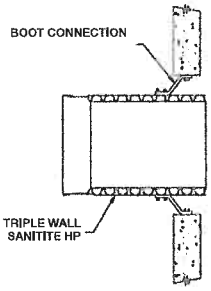
Sanitary sewer projects require superior watertight performance combined with a flexible connection solution that can withstand the rigor of installation. To meet varying regional requirements, ADS offers a wide selection of connectors to be used with independent standard resilient connectors meeting ASTM C923, such as A-Lok® and Press Seal®.

When connecting SaniTite HP pipe to a manhole, a smooth exterior surface on the pipe is required. ADS offers three ways to adapt dual wall pipe to these manhole connectors: a corrugated pipe adapter, a PVC Manhole Adapter or a polypropylene manhole sleeve adapter. For triple wall pipe, commonly used manhole connectors can connect directly to the pipe with no additional fittings or adapters.

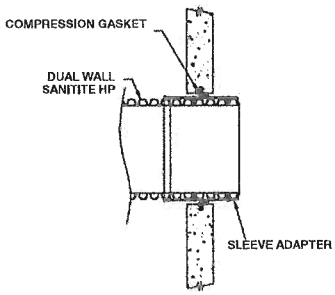
Boot Connection to Dual Wall Pipe



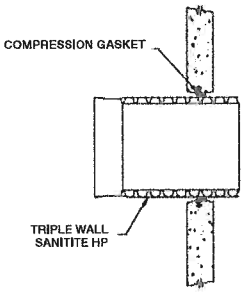
Boot Connection to Triple Wall Pipe



Compression Gasket Connection to Dual Wall Pipe



Compression Gasket Connection to Triple Wall Pipe



ADS SANITITE® HP 12"–60" SANITARY PIPE SPECIFICATION

SCOPE

This specification describes 12- through 60-inch (300 to 1500 mm) ADS SaniTite HP pipe for use in gravity-flow sanitary sewer applications.

PIPE REQUIREMENTS

ADS 12" – 30" (300 to 750mm) SaniTite HP dual pipe shall have a smooth interior and annular exterior corrugations; 30"-60" SaniTite HP triplewall pipe shall have smooth interior and exterior surfaces with annular inner corrugations.

- 12- through 30-inch (300 to 750 mm) dual wall pipe shall meet ASTM F2736
- 30- through 60-inch (750 to 1500 mm) triple wall pipe shall meet ASTM F2764
- 12- through 60-inch (300 to 1500 mm) pipe shall have a minimum pipe stiffness of 46 pii when tested in accordance with ASTM D2412
- Manning's "n" value for use in design shall be 0.012.

JOINT PERFORMANCE

Pipe shall be joined with a gasketed integral bell & spigot joint meeting the requirements of ASTM F2736.

12- through 60-inch (300 to 1500 mm) shall be watertight according to the requirements of ASTM D3212, with the addition of a 15 psi pressure requirement. Spigot shall have two gaskets meeting the requirements of ASTM F477. Gaskets shall be installed by the pipe manufacturer and covered with a removable, protective wrap to ensure the gaskets are free from debris. A joint lubricant available from the manufacturer shall be used on the gasket and bell during assembly.

12– through 60-inch (300 to 1500 mm) diameters shall have a reinforced bell with a polymer composite band installed by the manufacturer.

FITTINGS

Fittings and connections shall provide a watertight connection according to the requirements of ASTM D3212. Gaskets, when present, shall meet ASTM F477.

FIELD PIPE AND JOINT PERFORMANCE

To assure watertightness, field performance verification may be accomplished by testing in accordance with ASTM F1417 or ASTM F2487. Appropriate safety precautions must be used when field-testing any pipe material.

MATERIAL PROPERTIES

Polypropylene compound for pipe and fitting production shall be an impact modified copolymer meeting the material requirements of ASTM F2736 or ASTM F2764.

INSTALLATION

Installation shall be in accordance with ASTM D2321 and ADS recommended installation guidelines, with the exception that minimum cover in traffic areas for 12- through 48-inch (300 to 1200 mm) diameters shall be one foot (0.3 m) and for 60-inch (1500mm) diameters the minimum cover shall be 2-ft (0.6m) in single run applications. Backfill for minimum cover situations shall consist of Class 1 or Class 2 (minimum 90% SPD) material. Maximum fill heights depend on embedment material and compaction level; please refer to Technical Note 2.05.

PIPE DIMENSIONS

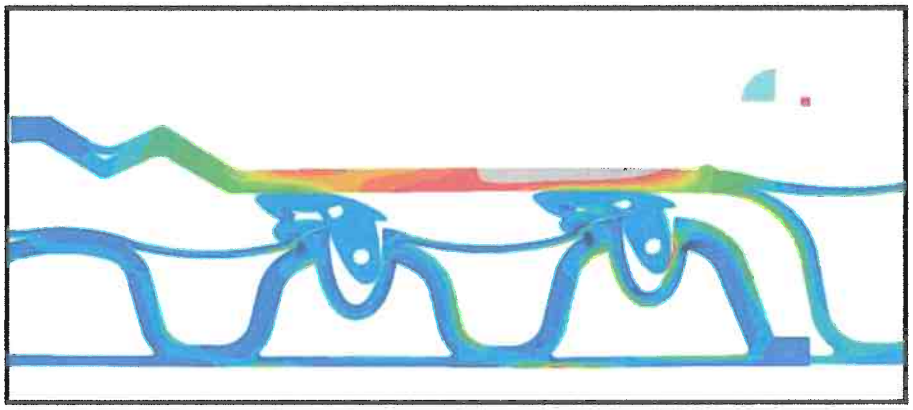
Nominal Diameter in. (mm)	12 (300)	15 (375)	18 (450)	21 (535)	24 (600)	30 (750)	36 (900)	42 (1050)	48 (1200)	60 (1500)
Average Pipe I.D. in. (mm)	12.1 (307)	14.9 (378)	18.0 (457)	21.1 (536)	24.1 (612)	30.1 (765)	35.7 (907)	41.8 (1062)	47.3 (1201)	59.3 (1506)
Average Pipe O.D. in. (mm)	14.5 (368)	17.6 (447)	21.2 (538)	24.8 (629)	28.0 (711)	35.4 (899)	41.1 (1044)	47.2 (1199)	53.8 (1367)	66.5 (1689)

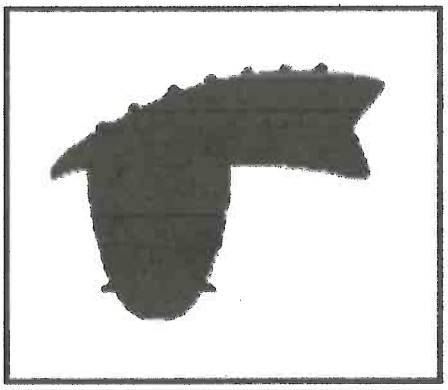
World Class Joint Performance

Design: Dual Gasket, Extended In-Line Bell & Spigot

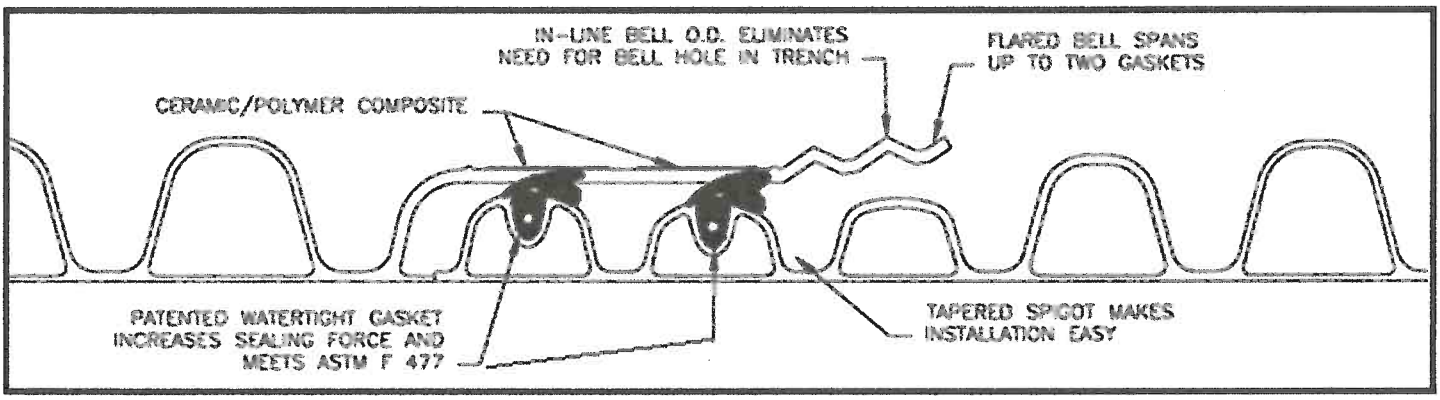
Lab Performance: ASTM D3212 Up to 10.8PSI
CSA B182.13 Up to 15PSI

Field Testable: ASTM F2487 (Hydrostatic), ASTM F1417 (Air-Test up to 3.5PSI)





ASTM F477 Gasket



Advanced Drainage Systems, Inc.
4640 Trueman Blvd. Hilliard, OH 43026

1-800-821-6710

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June 2, 2009

Mr. Terry McElfresh
Advanced Drainage Systems, Inc.
2650 Hamilton Eaton Road
Hamilton, Ohio 45011
Project No: 08143A-80

RE: Testing of 12", 15", 18", 24", 30", 36", 48" and 60" HP Sanitary Polypropylene Pipe to ASTM D3212-07

Dear Mr. McElfresh:

On May 13th, May 15th and May 29th, a FOPPE representative witnessed the performance testing of one sample of ADS smooth interior, polypropylene HP WT Sanitary pipe joints per ASTM D 3212-07 with the exception that the pressure portion of the test was conducted at 15 psi rather than the minimum requirement of 10.8 psi.

Sample Test:	One sample of 12", 15", 18", 24", 30", 36", 48" and 60" smooth interior, polypropylene plastic HP Sanitary pipe, with an integral PP bell. The bells are reinforced with a green advanced fiberglass/polymer composite. The joint incorporates an ASTM F477-08 compliant rubber gasket.
Pipe Marking:	A/H 12, 15, 18, 24, 30, 36, 48 and 60" I.D.
Sample Length:	44 inches (12", 15", 18" and 24") 64 inches (30", 36", 48" and 60")
Test performed:	**ASTM D3212-07 Standard Specification for Joints for Drain and Sewer Plastic Pipes using Flexible Elastomeric Seals**
Conclusion:	The A/H 12", 15", 18", 24", 30", 36", 48" and 60" HP Sanitary pipe complies with the performance requirements of ASTM D3212-07 while testing the pressure portion of the test at 15 psi.

The tests were conducted by ADS personnel and fully witnessed by a FOPPE representative. Any necessary measurements were taken by our personnel. Results are discussed in detail on the following pages. If you have any questions, please do not hesitate to call.

Respectfully submitted,

FOPPE TECHNICAL GROUP

Lawrence E. Foppe, P.E.
President

Project No: 08143A-80
Date: June 2, 2009

Test Performed:	**ASTM D3212-07 Standard Specification for Joints for Drain and Sewer Plastic Pipes using Flexible Elastomeric Seals.**
Section 3.1.1	Pipe Joint is push-on type
Section 4.2	A lubricant was used to assemble the joints
Section 5.1	General Requirements: The pipes and joint assemblies did not leak during internal and external hydrostatic tests as outlined in Section 7 of ASTM D3212. Procedure: Each test under pressure was performed for a minimum of 10 minutes at 15 psi. Each test under vacuum was conducted at 22 in Hg in vacuum. Each test procedure was followed as required in Section 7 of the Specification. The pressure was monitored continuously for the duration of each test. All calculations required were checked and verified by FOPPE's representative.
Section 5.2	All surfaces of the coupler were smooth and free of cracks, fractures and imperfections that could adversely affect the performance of the joint.
Section 5.4	The gasket was a continuous elastomeric ring and was the sole element responsible for making the joint flexible and watertight.
Section 5.7	The joint components were able to withstand the forces caused by the compression of the gasket when jointed.
Section 6.1	The dimensions of the joint components were gauged at sufficiently frequent intervals to assure dimensional control and satisfactory joint assembly per the manufacturer's standards. Dimensions of test specimens and the manufacturer's standards are listed below.
Conclusion:	The ADS 12", 15", 18", 24", 30", 36", 48" and 60" HP Sanitary polypropylene pipe complies with the performance requirements of ASTM D3212-07 while testing the pressure evaluations at 15 psi.

ADS SANITITE® HP 12"- 60" PIPE SPECIFICATION

Scope

This specification describes 12- through 60-inch (300 to 1500 mm) ADS SaniTite HP pipe for use in gravity-flow sanitary sewer applications.

Pipe Requirements

ADS 12" – 30" (300 to 750mm) SaniTite HP dual pipe shall have a smooth interior and annular exterior corrugations; 30"-60" SaniTite HP triple wall pipe shall have a smooth interior and exterior surfaces with annular inner corrugations.

- 12- through 30-inch (300 to 750 mm) dual wall pipe shall meet ASTM F2736
- 30- through 60-inch (750 to 1500 mm) triple wall pipe shall meet ASTM F2764
- 12- through 60-inch (300 to 1500 mm) pipe shall have a minimum pipe stiffness of 46 pii when tested in accordance with ASTM D2412.
- Manning's "n" value for use in design shall be 0.012.

Joint Performance

Pipe shall be joined with a gasketed integral bell & spigot joint meeting the requirements of ASTM F2736.

12- through 60-inch (300 to 1500 mm) shall be watertight according to the requirements of ASTM D3212, with the addition of a 15psi pressure requirement. Spigot shall have two gaskets meeting the requirements of ASTM F477. Gaskets shall be installed by the pipe manufacturer and covered with a removable, protective wrap to ensure the gaskets are free from debris. A joint lubricant available from the manufacturer shall be used on the gasket and bell during assembly.

12- through 60-inch (300 to 1500 mm) diameters shall have a reinforced bell with a polymer composite band installed by the manufacturer.

Fittings

Fittings and connections shall provide a watertight connection according to the requirements of ASTM D3212. Gaskets, when present, shall meet ASTM F477.

Field Pipe and Joint Performance

To assure watertightness, field performance verification may be accomplished by testing in accordance with ASTM F1417 or ASTM F2487. Appropriate safety precautions must be used when field-testing any pipe material.

Material Properties

Polypropylene compound for pipe and fitting production shall be an impact modified copolymer meeting the material requirements of ASTM F2736 or ASTM F2764.

Installation

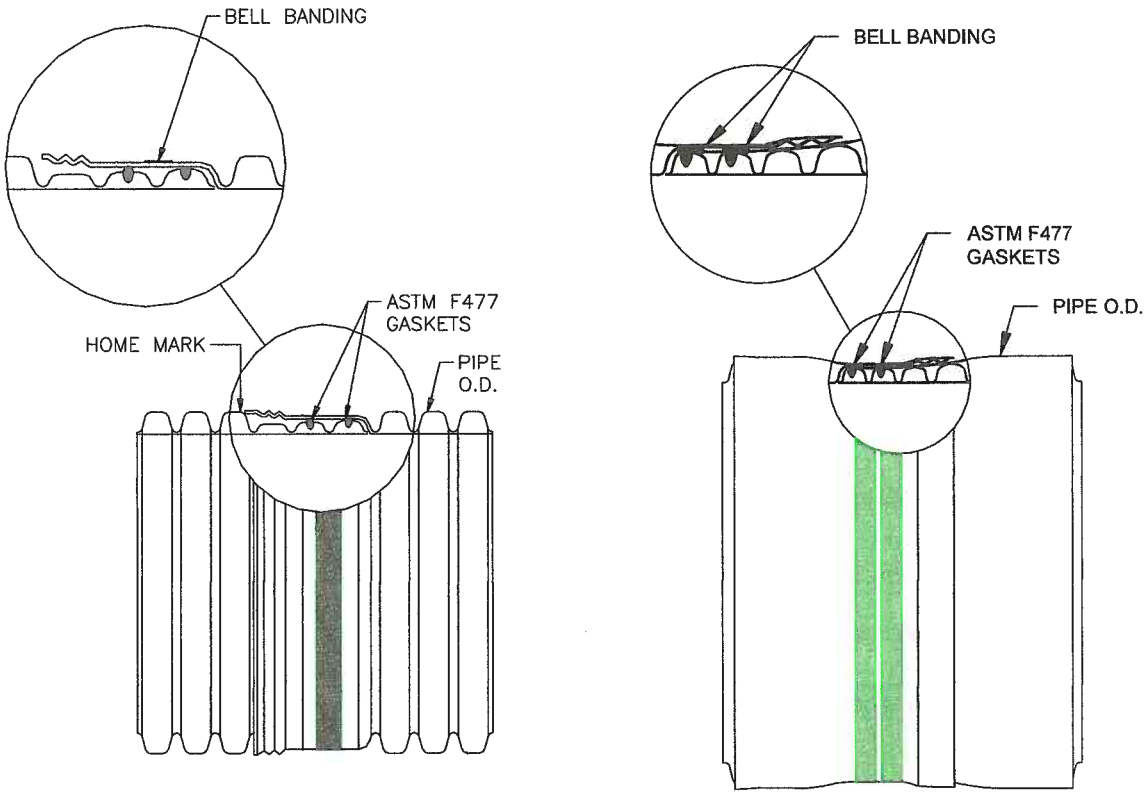
Installation shall be in accordance with ASTM D2321 and ADS recommended installation guidelines, with the exception that minimum cover in traffic areas for 12- through 48-inch (300 to 1200 mm) diameters shall be one foot (0.3 m) and for 60-inch (1500mm) diameters the minimum cover shall be 2-ft (0.6m) in single run applications. Backfill for minimum cover situations shall consist of Class 1 or Class 2 (minimum 90% SPD) material. Maximum fill heights depend on embedment material and compaction level; please refer to Technical Note 2.05.

Pipe Dimensions

Nominal Pipe I.D. in (mm)	12 (300)	15 (375)	18 (450)	21 (535)	24 (600)	30 (750)	36 (900)	42 (1050)	48 (1200)	60 (1500)
Average Pipe I.D. in (mm)	12.1 (307)	14.9 (378)	18.0 (457)	21.1 (536)	24.1 (612)	30.1 (765)	35.7 (907)	41.8 (1062)	47.3 (1201)	59.3 (1506)
Average Pipe O.D. in (mm)	14.5 (368)	17.6 (447)	21.2 (538)	24.8 (629)	28.0 (711)	35.4 (899)	41.1 (1044)	47.2 (1199)	53.8 (1367)	66.5 (1689)

SANITITE® HP 12" – 60" PIPE JOINT SYSTEM

(Joint configuration & availability subject to change without notice. Product detail may differ slightly from actual product appearance.)



TECHNICAL NOTES

SaniTite® HP – Sanitary Sewer Pipe Technical Support Documentation

2013

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TECHNICAL NOTE

Minimum and Maximum Cover Heights for SaniTite® HP Pipe for Sanitary Sewer

TN 2.05
May 2013

Introduction

The information in this document is designed to provide answers to general cover height questions; the data provided is not intended to be used for project design. The design procedure described in the *Structures* section (Section 2) of the Drainage Handbook provides detailed information for analyzing most common installation conditions. This procedure should be utilized for project specific designs.

The two common cover height concerns are minimum cover in areas exposed to vehicular traffic and maximum cover heights. Either may be considered "worst case" scenario from a loading perspective, depending on the project conditions.

Minimum Cover in Traffic Applications

Pipe diameters from 12- through 48-inch (300-1200 mm) installed in traffic areas (AASHTO H-25 or HS-25 loads) must have at least one foot (0.3m) of cover over the pipe crown, while 60-inch (1500 mm) pipes must have at least 24 inches (0.6m) of cover. The backfill envelope must be constructed in accordance with the *Installation* section (Section 5) of the Drainage Handbook and the requirements of ASTM D2321. The backfill envelope must be of the type and compaction listed in the *Installation* section of the Drainage Handbook, Appendix A-5, Table A-5-2. In Table 1 below, this condition is represented by a Class II material compacted to 90% standard Proctor density, although other material can provide similar strength at slightly lower levels of compaction. Structural backfill material should extend six inches (0.15m) over the crown of the pipe; the remaining cover should be appropriate for the installation and as specified by the design engineer. If settlement or rutting is a concern, it may be appropriate to extend the structural backfill to grade. Where pavement is involved, sub-base material can be considered in the minimum burial depth. While rigid pavements can be included in the minimum cover, the thickness of flexible pavements should not be included in the minimum cover.

Additional information that may affect the cover requirements is included in the *Installation* section (Section 5) of the Drainage Handbook. Some examples of what may need to be considered are temporary heavy equipment, construction loading , paving equipment and similar loads that are less than the design load, the potential of pipe flotation, and the type of surface treatment which will be installed over the pipe zone. Please note Table 1 and 2 are based on the installation of SaniTite HP under pavement using a uniform backfill type and compaction level, as depicted in Figure 1.

Table 1
Minimum Cover Requirements for ADS SaniTite HP with AASHTO H-25 or HS-25 Load

Inside Diameter, ID, in.(mm)	Minimum Cover ft. (m)
12 (300)	1 (0.3)
15 (375)	1 (0.3)
18 (450)	1 (0.3)
24 (600)	1 (0.3)
30 (750)	1 (0.3)

Inside Diameter, ID, in.(mm)	Minimum Cover ft. (m)
36 (900)	1 (0.3)
42 (1050)	1 (0.3)
48 (1200)	1 (0.3)
60 (1500)	2 (0.6)

Note: Minimum covers presented here were calculated assuming Class II backfill material compacted to 90% standard Proctor density around the pipe and a minimum of 6-inches (0.15m) structural backfill over the pipe crown, as recommended in Section 5 of the Drainage Handbook, with an additional layer of compacted traffic lane sub-base for a total cover as required. In shallow traffic installations, especially where pavement is involved, a good quality compacted material to grade is required to prevent surface settlement and rutting.

Maximum Cover

Wall thrust generally governs the maximum cover a pipe can withstand and conservative maximum cover heights will result when using the information presented in the *Structures* section (Section 2) of the Drainage Handbook. Table 2 below shows the material properties consistent with the expected performance characteristics for SaniTite HP materials for a 100-year design life.

The maximum burial depth is highly influenced by the type of backfill and level of compaction around the pipe. General maximum cover limits for ADS SaniTite HP used in sanitary sewer applications are shown in Table 3 for a variety of backfill conditions.

Table 3 was developed assuming pipe is installed in accordance with ASTM D2321 and the *Installation* section (Section 5) of the Drainage Handbook. Additionally, the calculations assume no hydrostatic load around the pipe, incorporate the maximum safety factors represented in *Structures* section of the Drainage Handbook, use material properties consistent with the expected performance characteristics for SaniTite HP materials, and assume the native (in-situ) soil is of adequate strength and is suitable for installation. For applications requiring fill heights greater than those shown in Table 2 or where hydrostatic pressure due to groundwater is expected, contact an ADS Engineer.

Table 2
ADS SaniTite HP Mechanical Properties

Resin	ASTM Specification	Tension Strain %	Factored Compressive Strain %	Initial		100-Year*	
				Fu (psi)	E (psi)	Fu (psi)	E (psi)
Polypropylene, Impact-modified copolymer	ASTM F2736 or ASTM F2764	2.5	3.7	3,500	175,000	1,000	27,000

**Values extrapolated from AASHTO LRFD Section 12 minimum material requirements*

Figure 1
ADS SaniTite HP Pipe Trench Detail (Sanitary Sewer)

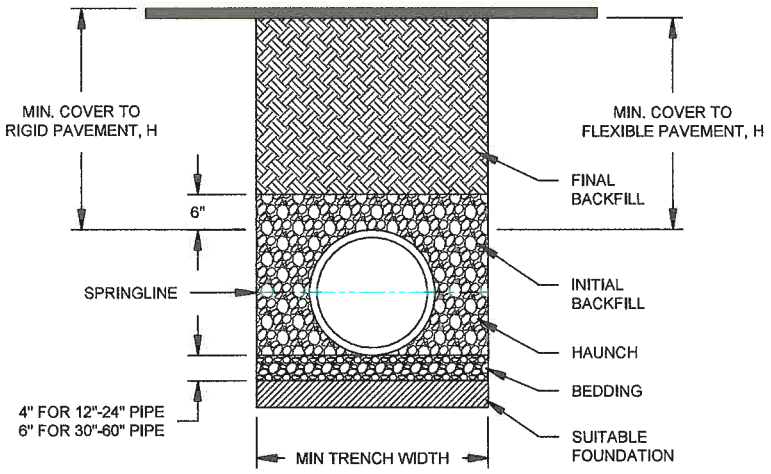


Table 3
Maximum Cover for ADS SaniTite HP Pipe for Sanitary Sewer, ft (m)

Diameter in (mm)	Class 1 Compacted	Class 2 95%	Class 2 90%
12 (300)	39 (11.9)	27 (8.2)	20 (6.1)
15 (375)	42 (12.8)	29 (8.8)	21 (6.4)
18 (450)	36 (11.0)	25 (7.6)	18 (5.5)
24 (600)	31 (9.5)	22 (6.7)	16 (4.9)
30 (750)	30 (9.1)	22 (6.7)	16 (4.9)
36 (900)	31 (9.5)	22 (6.7)	15 (4.6)
42 (1050)	33 (10.1)	23 (7.0)	17 (5.2)
48 (1200)	34 (10.4)	24 (7.3)	17 (5.2)
60 (1500)	32 (9.8)	22 (6.7)	16 (4.9)

Notes:

1. *Results based on calculations shown in the Structures section of the ADS Drainage Handbook (v19.5). Calculations assume no hydrostatic pressure and a density of 120 pcf (1926 kg/m^3) for overburden material.*
2. *Installation assumed to be in accordance with ASTM D2321 and the Installation section of the Drainage Handbook.*
3. *Backfill materials and compaction levels not shown in the table may also be acceptable. Contact ADS for further detail.*
4. *Material must be adequately "knifed" into haunch and in between corrugations. Compaction and backfill material is assumed uniform throughout entire backfill zone.*
5. *Compaction levels shown are for standard Proctor density.*
6. *For projects where cover exceeds the maximum values listed above, contact ADS for specific design considerations.*
7. *See ADS Standard Detail STD- 110 for additional details.*

TECHNICAL NOTE

Chemical Resistance of Polypropylene and Elastomers

TN 4.02
October 2009

The results reported herein are of testing performed on polypropylene (PP) material, compiled from multiple sources. A listing of sources is available at the conclusion of this document. Actual results may vary on the environmental conditions for each particular application. In evaluating the capability of polypropylene pipe, fittings, and manholes to withstand chemical attack, consideration should be given to the following:

1. The effect of an active substance on polypropylene is not as severe when contact is intermittent.
2. Increasing temperature increases chemical activity.
3. Internal pressure may affect the rate of penetration of a substance.
4. Excessive bending and other stresses resulting from improper installation may affect the life of polypropylene products. An example would be circumferential deflection beyond 50% or placing pipe directly on a large, sharp rock.

This listing contains accurate and reliable information to the best of our knowledge. The data contained herein is a compilation of studies conducted by various sources which Advanced Drainage Systems believes to be reliable. However, the information cannot be guaranteed because the conditions of use are beyond our control. The user of this information assumes all risk associated with its use.

Polypropylene

Test Procedure

Polypropylene specimens were placed in the relevant substance for a period of time without the application of mechanical stress. They were then tested for swelling or weight loss and subjected to tensile testing. In critical applications, it is suggested that greater reliance be placed on actual field experience or testing should be performed under similar conditions of stress, exposure, temperature and duration which can be related to the anticipated application. Data regarding resistance to chemicals not listed may be available by contacting an ADS representative.

Symbols used in the following table:	
Symbol	***Description***
+	specimen is resistant swelling < 3% or alternatively weight loss <. 0.5%, elongation of break not significantly changed
/	specimen has limited swelling 3 - 8% or alternatively weight resistance only loss 0.5 - 5%, and/or elongation at break decreased by < 50%
–	specimen is not resistant swelling > 8% or alternatively weight loss > 5%, and/or elongation a break decreased by> 50%
D	discoloration
*	or at the boil

Substance	POLYPROPYLENE		
	Concentration	68°F	140°F
Acetaldehyde		/	–
Acetic acid (glacial)	97%	+	/ (176°)
Acetic acid	50%	+	+ (176°)
Acetic acid	40%	+	
Acetic acid	10%	+	+
Acetone	100%	+	+
Acetophenone	100%	/	/
Acrylic emulsions		+	+
Aluminum chloride		+	+
Aluminum fluoride		+	+
Aluminum sulfate		+	+
Alums (all types)		+	+
Ammonia gas (dry)		+	+
Ammonia, aqueous	30%	+	
Ammonium carbonate	All	+	+
Ammonium chloride	All	+	+
Ammonium fluoride	20%	+	+
Ammonium hydroxide	28%	+	+
Ammonium metaphosphate		+	+
Ammonium nitrate	All	+	+
Ammonium persulfate	All	+	+
Ammonium sulphate	All	+	+
Ammonium sulphide	All	+	+
Ammonium thiocyanate		+	+
Amyl acetate	100%	/	–
Amyl alcohol	100%	+	/
Amyl chloride	100%	–	–
Aniline	100%	+	+
Anisole		/	/ to –
Antimony chloride		+	+
Aviation fuel (115/145 octane)	100%	/	–
Aviation turbine fuel	100%	/	–
Barium carbonate		+	+
Barium chloride		+	+
Barium hydroxide		+	+
Barium sulfate		+	+
Barium sulfide		+	+
Beer		+	+
Benzene	100%	/	–
Benzoic acid	all	+	+
Benzyl alcohol		+	+ (176°)
Benzyl chloride		/	–
Bismuth carbonate		+	+
Borax		+	+
Boric acid	all	+	+
Brine	saturated	+	+
Bromine, liquid	100%	–	
Bromine water	saturated	–	–
Butyl acetate	100%	–	–
Butyl alcohol		+	+
Calcium carbonate		+	+
Calcium chlorate		+	+
Calcium chloride	50%	+	+
Calcium hydroxide		+	+
Calcium hypochlorite bleach	20% (a)	+	/
Calcium nitrate	50%	+	+

Substance	POLYPROPYLENE		
	Concentration	68°F	140°F
Calcium phosphate	50%	+	
Calcium sulphate		+	+
Carbon dioxide (dry)	100%	+	+
Carbon dioxide (wet)	100%	+	+
Carbon disulphide		/	–
Carbon monoxide		+	+
Carbon tetrachloride	100%	–	–
Carbonic acid	All	+	+
Castor oil		+	
Cetyl alcohol (hexadecanol)	100%	+	
Chlorine, gaseous		–	–
Chlorine water		+	/
Chlorobenzene		–	–
Chloroform	100%	–	–
Chlorosulphonic acid		–	–
Chrome alum		+	+
Chromic acid	80% (a)	+	
Chromic acid	50% (a)	+	+
Chromic acid	10% (a)	+	+
Chromic/sulfuric acid	10%	–	–
Cider		+	+
Citric acid	10%	+	+
Citrus juices		+	+
Copper chloride	saturated	+	+
Copper cyanide	saturated	+	+
Copper fluoride	saturated	+	+
Copper nitrate	saturated	+	+
Copper sulphate	all	+	+
Cotton seed oil		+	+
Cuprous chloride	saturated	+	+
Cyclohexanol		+	+
Cyclohexanone		/	–
Decahydronaphthalene (Decalin)	100%	–	–
Detergents	2%	+	+
Developer solutions (photographic)		+	+
Dibutyl phthalate	100%	+	/ (– 212°)
Dichloroethylene	100%	+	
Diethanolamine	100%	+	+
Diisooctyl phthalate	100%	+	+
Dioxane		+	/
Emulsifiers		+	+
Ethanolamine	100%	+	+
Ethyl acetate	100%	/	/
Ethyl alcohol	96%	+	+
Ethyl chloride	100%	–	–
Ethyl dichloride	100%	/	
Ethylene glycol		+	+
Ethylene oxide	100%	/ (50°)	
Ethyl ether	100%	/	
Fatty acids (>C6)	100%	+	+
Ferric chloride	all	+	+
Ferric nitrate	saturated	+	+
Ferric sulfate	saturated	+	+

Substance	POLYPROPYLENE		
	Concentration	68°F	140°F
Ferrous chloride	saturated	+	+
Ferrous sulfate	all	+	+
Fluosilicic acid		+	+
Formaldehyde	40%	+	+
Formic acid	10%	+	+
Formic acid	100%	+	
Fructose		+	+
Fruit juices		+	+
Fual oil		+	+
Furfural		–	–
Gases liquor		–	
Gasoline	100%	/	–
Gearbox oil	100%	+	/
Gelatin		+	+
Glucose	20%	+	+
Glycerine	100%	+	+
Glycol		+	+
Hexane	100%	+	/
Hydrobromic acid	50% (a)	+	+
Hydrochloric acid	30% (a)	+	/
Hydrochloric acid	Up to 20%	+	+
Hydrofluoric acid	40%	+	+
Hydrofluoric acid	60% (a)	+	+
Hydrogen peroxide, aqueous	30%	+	
Hydrogen peroxide, aqueous	10%	+	/
Hydrogen peroxide, aqueous	3%	+	
Hydrogen sulfide		+	+
Hydroquinone		+	+
Ink		+	+
Iodine tincture		+	
Isooctane	100%	–	–
Isopropanol (isopropyl alcohol)	100%	+	+
Ketones		+	
Lactic acid	20%	+	+
Lanolin (wool fat)		+	+
Lead acetate	saturated	+	+
Linseed oil	100%	+	+
Lubricating oils	100%	+	/
Magenta dye, aqueous	2%	+	+ D
Magnesium carbonate	saturated	+	+
Magnesium chloride	saturated	+	+
Magnesium hydroxide	saturated	+	+
Magnesium sulfate	saturated	+	+
Magnesium sulfite	saturated	+	+
Meat juices		+	+
Mercuric chloride (corrosive sublimate)	40%	+	+
Mercuric cyanide	saturated	+	+
Mercurous nitrate	saturated	+	+
Mercury	100%	+	+
Methyl alcohol	100%	+	+
Methylbenzene		/	–

Substance	POLYPROPYLENE		
	Concentration	68°F	140°F
Methylene chloride	100%	+	
Methyl ethyl ketone	100%	+	/
Milk		+	+ (+ 212°)
Mineral oil	100%	+	/
Molasses		+	+
Motor oil (HD oil)	100%	+	/
Naphthalene	100%	+	+
Nickel chloride	saturated	+	+
Nickel nitrate	saturated	+	+
Nickel sulphate, aqueous	saturated	+	+
Nitric acid	70% (a)	–	–
Nitric acid	60%	+	–
Nitric acid	10%	+	+
Nitrobenzene		+	/
Oleic acid		+	/
Oleum			– (212°)
Olive oil	saturated	+	+
Oxalic acid, aqueous	50%	+	/
Paraffin	100%	+	/
Paraffin wax	100%	+	+
Perchloric acid	20%	+	–
Petrol	100%	/	–
Petroleum ether	100%	–	–
Phenol	100%	+	+ D
Phosphoric acid, aqueous	95%	+	+
Photographic developer		+	+
Potassium bicarbonate, aqueous	saturated	+	+
Potassium borate, aqueous	1%	+	+
Potassium bromate, aqueous	up to 10%	+	+
Potassium bromide, aqueous	saturated	+	+
Potassium carbonate, aqueous	saturated	+	+
Potassium chlorate, aqueous	saturated	+	+
Potassium chloride, aqueous	saturated	+	+
Potassium chromate, aqueous	40%	+	+
Potassium cyanide, aqueous	saturated	+	+
Potassium dichromate, aqueous	40%	+	+
Potassium ferricyanide and ferrocyanide, aqueous	saturated	+	+
Potassium fluoride, aqueous		+	+
Potassium hydroxide, aqueous	50%	+	+
Potassium nitrate, aqueous	saturated	+	+
Potassium perborate	saturated	+	+
Potassium perchlorate, aqueous	up to 10%	+	+
Potassium permanganate	20%	+	+
Potassium sulfate, aqueous		+	+
Potassium sulfide		+	+
Potassium sulfite		+	+
Propanol (propyl alcohol)	100%	+	+
Pyridine		+	
Silicone oil	100%	+	+
Silver nitrate		+	+
Soap solution, aqueous		+	+
Sodium acetate, aqueous	all	+	+

Substance	POLYPROPYLENE		
	Concentration	68°F	140°F
Sodium bicarbonate	saturated	+	+
Sodium bisulphate	saturated	+	+
Sodium bisulphite, aqueous	saturated	+	+
Sodium borate		+	+
Sodium bromide oil solution		+	+
Sodium carbonate, aqueous	saturated	+	+
Sodium chlorate, aqueous	saturated	+	+
Sodium chloride, aqueous	saturated	+	+
Sodium chlorite, aqueous	2%	+	+ (176°)
Sodium chlorite, aqueous	5%	+ (176°)	+
Sodium chlorite, aqueous	10%	+ (176°)	+
Sodium chlorite, aqueous	20%	+ (176°)	+
Sodium cyanide		+	+
Sodium dichromate		+	+
Sodium ferricyanide		+	+
Sodium ferrocyanide		+	+
Sodium fluoride		+	+
Sodium hydroxide, aqueous	50%	+	+
Sodium hydroxide, aqueous	10%	+	+
Sodium hypochlorite	20%	+	/
Sodium hypochlorite		+	
Sodium nitrate, aqueous		+	+
Sodium nitrite, aqueous		+	+
Sodium silicate		+	+
Sodium sulfate, aqueous	saturated	+	+
Sodium sulfide, aqueous	25%	+	+
Sodium sulfite, aqueous	saturated	+	+
Stannic chloride	saturated	+	+
Stannous chloride	saturated	+	+
Starch		+	+
Sugars and syrups		+	+
Sulfates of [calcium and magnesium]	saturated	+	+
Sulfates of [potassium and sodium]	saturated	+	+
Sulfur		+	+
Sulfuric acid	98% (a)	–	
Sulfuric acid	60%	+	/ (176°)
Sulfuric acid	50%	+	/
Sulfuric acid	10%	+	/
Sulfuric ether		+ to /	/*
Sulfur dioxide, aqueous	all	+	+
Sulfur dioxide, dry and moist	all	+	+
Sulfurous acid		+	+
Sulfur trioxide		–	wet, gas, dry
Sulfuryl chloride		–	
Syrup		+	+
Tallow		+	+
Tannic acid	10%	+	+
Tetrahydrofuran	100%	–	–
Tetralin	100%	–	–
Toluene	100%	–	–
Transformer oil	100%	+	/
Trichloroacetic acid	10%	+	+
Trichloroethylene	100%	+	+

Substance	POLYPROPYLENE		
	Concentration	68°F	140°F
Turpentine	100%	–	–
Urea, aqueous		+	+
Urine		+	+
Vegetable oil		+	+
Water, distilled		+	+
Wet chlorine gas			–
Whiskey		+	+
White paraffin	100%	+	/
White spirit	100%	/	–
Wine		+	+
Xylene	100%	–	–
Yeast		+	+
Zinc chloride	saturated	+	+
Zinc oxide		+	+
Zinc sulphate, aqueous	saturated	+	+

(a) May produce cracking in material under stress

Elastomers

Test Procedure

The criteria for the ratings of various elastomers presented here (Natural Rubber, SBR, and EPDM) were primarily volume swell resistance, compression set resistance, and aging resistance. The ratings were developed from specific data or general agreement of the sources identified in the corresponding table enclosed. Several important factors must be considered in the use of rubber parts in service, including:

1. The Temperature of Service: Greater temperatures increase the effect of all chemicals on polymers. The affect of the temperature varies with the polymer and the chemical.
2. Conditions of Service: A compound that swells badly might still function well as a static seal yet fail in dynamic applications.

Numbers used in the following table:	
Number	***Description***
1	Minor effect
2	Moderate effect
3	Static only
4	Not recommended
–	Insufficient data

Substance	Natural Rubber (NR, IR)	Styrene Butadiene (SBR, BR)	Ethylene Propylene (EPM, EPDM)
Acetaldehyde	2	3	1
Acetamide	4	4	1
Acetic acid, glacial	2	2	1
Acetic acid 30%	2	2	1
Acetic anhydride	2	2	2
Acetone	3	3	1
Acetophenone	4	4	1
Acetyl chloride	4	4	4
Acetylene	2	2	1
Acrylonitrile	4	4	4
Adipic acid	1	1	1
Alkazene (Dibromoethylbenzene)	4	4	4
Alum-NH3-Cr-K (aq)	1	1	1
Aluminum acetate (aq)	1	2	1
Aluminum chloride (aq)	1	1	1
Aluminum fluoride (aq)	2	1	1
Aluminum nitrate (aq)	1	1	1
Aluminum phosphate (aq)	1	1	1
Aluminum sulfate (aq)	1	1	1
Ammonia anhydrous	4	4	1
Ammonia gas (cold)	1	1	1
Ammonia gas (hot)	4	4	2
Ammonium carbonate (aq)	1	1	–
Ammonium chloride (aq)	1	1	1
Ammonium hydroxide (conc.)	4	4	1
Ammonium nitrate aq)	3	2	1
Ammonium nitrite (aq)	1	1	1
Ammonium persulfate (aq)	1	4	1
Ammonium phosphate (aq)	1	1	1
Ammonium sulfate (aq)	1	1	1
Amyl acetate (banana oil)	4	4	3
Amyl alcohol	2	2	1
Amyl borate	4	4	4
Amyl chloronaphthalene	4	4	4
Amyl naphthalene	4	4	4
Aniline	4	4	1
Aniline dyes	2	2	1
Aniline hydrochloride	2	4	2
Animal fats	4	4	2
Ansul ether (anesthetics)	4	4	3
Aqua regia	4	4	3
Aroclor, 1248	4	4	3
Aroclor, 1254	4	4	3
Aroclor, 1260	1	1	1
Arsenic acid	2	1	1
Arsenic trichloride (aq)	4	4	3
Askarel	4	4	4
Asphalt	4	4	4
Banana oil (amyl acetate)	4	4	3
Barium chloride (aq)	1	1	1
Barium hydroxide (aq)	1	1	1
Barium sulfate (aq)	1	1	1
Barium sulfide (aq)	1	2	1
Beer	1	1	1

Substance	Natural Rubber (NR, IR)	Styrene Butadiene (SBR, BR)	Ethylene Propylene (EPM, EPDM)
Beet sugar liquors	1	1	1
Benzaldehyde	4	4	1
Benzene	4	4	4
Bezene sulfonic acid	4	4	3
Benzine (Ligroin) (Nitrobenzine) (pet ether)	4	4	4
Benzoic acid	4	4	3
Benzoyl chloride	4	4	4
Benzyl alcohol	4	4	1
Benzyl benzoate	4	4	2
Benzyl chloride	4	4	4
Biphenyl (Diphenyl) (Phenylbenzene)	4	4	4
Blast furnace gas	4	4	4
Bleach solutions	4	4	1
Borax	2	2	1
Bordeaux mixture	2	2	1
Boric acid	1	1	1
Brine	1	1	1
Bromine-anhydrous	4	4	4
Bromine trifluoride	4	4	4
Bromine water	4	4	2
Bromobenzene	4	4	4
Binker oil	4	4	4
Butadiene	4	4	3
Butane	4	4	4
Butter (animal fat)	4	4	1
Butyl acetate	4	4	3
Butyl acetyl ricinoleate	4	4	1
Butyl acrylate	4	4	4
Butyl alcohol	1	1	2
Butyl amine	4	4	2
Butyl benzoate	3	2	2
Butyl carbitol	4	4	1
Butyl cellusolve	4	4	1
Butyl oleate	4	4	2
Butyl stearate	4	4	3
Butylene	4	4	4
Butyraldehyde	4	4	2
Calcium acetate (aq)	1	4	1
Calcium bisulfite (aq)	4	4	4
Calcium chloride (aq)	1	1	1
Calcium hydroxide (aq)	1	1	1
Calcium hypochlorite (aq)	3	3	1
Calcium nitrate (aq)	1	1	1
Calcium sulfide (aq)	2	2	1
Cane sugar liquors	1	1	1
Carbamate	4	4	2
Carbitol	2	2	2
Carbolic acid (phenol)	4	4	2
Carbon bisulfide	4	4	4
Carbon dioxide	2	2	2
Carbonic acid	1	2	1
Carbon monoxide	2	2	1
Carbon tetrachloride	4	4	4

Substance	Natural Rubber (NR, IR)	Styrene Butadiene (SBR, BR)	Ethylene Propylene (EPM, EPDM)
Castor oil	1	1	2
Cellosolve	4	4	2
Cellosolve acetate	4	4	2
Cellulube (Fryquel)	4	4	1
China wood oil (Tung oil)	4	4	3
Chlorine (dry)	4	4	4
Chlorine (wet)	4	4	3
Chlorine dioxide	4	4	3
Chlorine trifluoride	4	4	4
Chloroacetic acid	4	4	1
Chloroacetone	4	4	1
Chlorobenzene	4	4	4
Chlorobromomethane	4	4	2
Chlorobutadiene	4	4	4
Chlorododecane	4	4	4
Chloroform	4	4	4
O-Chloronaphthalene	4	4	4
1-Chloro-1-Nitro ethane	4	4	4
Chlorosulfonic acid	4	4	4
Chlorotoluene	4	4	4
Chlorox (sodium hypoochlorite NaOCl)	4	4	2
Chrome plating solutions	4	4	2
Chromic acid	4	4	3
Citric acid	1	1	1
Coal tar (creosote)	4	4	4
Cobalt chloride (aq)	1	1	1
Coconut oil	4	4	3
Cod liver oil	4	4	1
Coke oven gas	4	4	4
Copper acetate (aq)	1	4	1
Copper chloride (aq)	1	1	1
Copper cyanide (aq)	1	1	1
Copper sulfate (aq)	2	2	1
Cornoil	4	4	3
Cottonseed oil	4	4	2
Creosote (Coal tar)	4	4	4
Cresol	4	4	4
Cresylic acid	4	4	4
Cumene	4	4	4
Cyclohexane	4	4	4
Cyclohexanol	4	4	3
Cyclyohexanone	4	4	2
P-Cymene	4	4	4
Decalin	4	4	4
Decane	4	4	4
Denatured alcohol	1	1	1
Detergent solutions	2	2	1
Developing fluids	1	2	2
Diacetone	4	4	1
Diacetone alcohol	4	4	1
Dibenzyl ether	4	4	2
Dibenzyl sebacate	4	4	2
Dibromoethylbenzene (Alkazene)	4	4	4

Substance	Natural Rubber (NR, IR)	Styrene Butadiene (SBR, BR)	Ethylene Propylene (EPM, EPDM)
Dibutyl amine	4	4	3
Dibutyl ether	4	4	3
Dibutyl phthalate	4	4	2
Dibutyl sebecate	4	4	2
O-Dichlorobenzene	4	4	4
Dichloro-isopropyl ether	4	4	3
Dicyclohexylamine	4	4	4
Diesel oil	4	4	4
Diethylamine	2	2	2
Diethyl benzene	4	4	4
Diethyl ether	4	4	4
Diethylene glycol	1	1	1
Diethyl sebacate	4	4	2
Diisobutylene	4	4	4
Diisopropyl benzene	4	4	4
Diisopropyl ketone	4	4	1
Diisopropylidene acetone (Phorone)	4	4	3
Dimethyl aniline (Xylidene)	3	3	2
Dimethyl ether (methyl ether) (monomethyl ether)	4	4	4
Dimethyl formamide	4	4	2
Dimethyl phthalate	4	4	2
Dinitrotoluene	4	4	4
Dioctyl Phthalate	4	4	2
Dioctyl Sebecate	4	4	2
Dioxane	4	4	2
Dioxolane	4	4	2
Dipentene	4	4	4
Diphenyl (Biphenyl) (Phenylbenzene)	4	4	4
Diphenyl oxides	4	4	4
Dowtherm oil	4	4	4
Dry cleaning fluids	4	4	4
Epichlorohydrin	4	4	2
Ethane	4	4	4
Ethanolamine	2	2	2
Ethyl acetate	4	4	2
Ethyl acetoacetate	3	3	2
Ethyl acrylate	4	4	2
Ethyl alcohol	1	1	1
Ethyl benzene	4	4	4
Ethyl benzoate	1	1	1
Ethyl cellosolve	4	4	4
Ethyl cellulose	2	2	2
Ethyl chloride	4	4	3
Ethyl chlorocarbonate	4	4	2
Ethyl chloroformate	4	4	2
Ethyl ether	4	4	3
Ethyl formate	4	4	2
Ethyl mercaptan	4	4	3
Ethyl oxalate	1	1	1
Ethyl pentachlorobenzene	4	4	4
Ethyl silicate	2	2	1
Ethylene	3	3	2

Substance	Natural Rubber (NR, IR)	Styrene Butadiene (SBR, BR)	Ethylene Propylene (EPM, EPDM)
Ethylene chloride	4	4	3
Ethylene chlorohydrin	2	2	2
Ethylene diamine	1	2	1
Ethylene dichloride	4	4	3
Ethylene glycol	1	1	1
Ethylene oxide	4	4	3
Ethylene trichloride	4	4	3
Fatty acids	4	4	3
Ferric chloride (aq)	1	1	1
Ferric nitrate (aq)	1	1	1
Ferric sulfate (aq)	1	1	1
Fishoil	4	4	4
Fluorinated cyclic ethers	4	4	1
Fluorine (liquid)	4	4	4
Fluorobenzene	4	4	4
Fluoroboric acid	1	1	1
Fluorocarbon oils	2	2	1
Fluorolube	2	3	1
Fluorosilicic acid (hydrofluosilicic acid)	2	3	2
Formaldehyde (RT)	2	2	1
Formic acid	2	1	1
Freon 11	4	4	4
Freon 12	2	1	2
Freon 13	1	1	1
Freon 21	4	4	4
Freon 22	2	1	1
Freon 31	2	2	1
Freon 32	1	1	1
Freon 112	4	3	4
Freon 113	3	2	3
Freon 114	1	1	1
Freon 115	1	1	1
Freon 142b	2	2	2
Freon 152a	1	1	1
Freon 218	1	1	1
Freon C316	1	1	1
Freon C318	1	1	1
Freon 13B1	1	1	1
Freon 114B2	4	3	4
Freon 502	1	1	1
Freon TF	4	3	4
Freon T-WD602	4	3	2
Freon TMC	4	4	3
Freon T-P35	1	1	1
Freon TA	3	3	2
Freon TC	4	3	2
Freon MF	4	4	4
Freon BF	4	4	4
Fueloil	4	4	4
Fumaric acid	3	3	2
Furan, furfuran	4	4	3
Furfural	4	4	2
Fyrquel (cellulube)	4	4	1
Gallic acid	1	2	2

Substance	Natural Rubber (NR, IR)	Styrene Butadiene (SBR, BR)	Ethylene Propylene (EPM, EPDM)
Gasoline	4	4	4
Gelatin	1	1	1
Glouber's salt (aq)	2	4	2
Glucose	1	1	1
Glue	2	2	1
Glycerin	1	1	1
Glycols	1	1	1
Green sulfate liquor	2	2	1
Holowax oil	4	4	4
N-Hexaldehyde	4	4	1
Hexane	4	4	4
N-Hexene-1	4	4	4
Hexyl alcohol	2	2	3
Hydrazine	1	1	1
Hydraulic oil (petroleum)	4	4	4
Hydrobromic acid	1	4	1
Hydrobromic acid 40%	1	4	1
Hydrochloric acid (cold) 37%	2	2	1
Hydrochloric acid (hot) 37%	4	4	3
Hydrocyanic acid	2	2	1
Hydrofluroic acid (conc.) cold	4	4	3
Hydrofluoric acid (conc.) hot	4	4	4
Hydrofluoric acid - anhydrous	4	4	3
Hydrofluosilicic acid (fluosilicic acid)	2	3	2
Hydrogen gas	2	1	1
Hydrogen peroxide (90%)	4	4	2
Hydrogen sulfide (wet) cold	4	4	1
Hydrogen sulfide (wet) hot	4	4	1
Hydroquinone	2	4	2
Hypochlorous acid	2	4	2
Iodine pentafluoride	4	4	4
Iodoform	4	4	4
Isobutyl alcohol	1	2	1
Isooctane	4	4	4
Isophorone	4	4	3
Isopropyl acetate	4	4	2
Isopropyl alcohol	1	2	1
Isopropyl chloride	4	4	4
Isopropyl ether	4	4	4
Kerosene	4	4	4
Lacquers	4	4	4
Lacquer solvents	4	4	4
Lactic acid (cold)	1	1	1
Lactic acid (hot)	4	4	4
Lard	4	4	2
Lavender oil	4	4	4
Lead acetate (aq)	1	4	1
Lead nitrate (aq)	1	1	1
Lead sulfamate (aq)	2	2	1
Ligroin (Benzine) (Nitrobenzine) (pet ether)	4	4	4
Lime bleach	1	2	1
Lime sulfur	4	4	1
Lindol (hydraulic fluid)	4	4	1

Substance	Natural Rubber (NR, IR)	Styrene Butadiene (SBR, BR)	Ethylene Propylene (EPM, EPDM)
Linoleic acid	4	4	4
Linseed oil	4	4	3
Liquefied petroleum gas	4	4	4
Lubricatting oils (petroleum)	4	4	4
Lye2	2	1	–
Magnesium chloride (aq)	1	1	1
Magnesium hydroxide (aq)	2	2	1
Magnesium sulfate (aq)	2	2	1
Maleic acid	3	3	2
Maleic anhydride	3	3	2
Malic acid	3	3	2
Mercury chloride (aq)	1	1	1
Mercury	1	1	1
Mesityl oxide	4	4	2
Methane	4	4	4
Methyl acetate	3	3	1
Methyl acrylate	4	4	2
Methylacrylic acid	4	4	2
Methyl alcohol	1	1	1
Methyl bromide	4	4	4
Methyl butyl ketone (propyl acetone)	4	4	1
Methyl cellosolve	4	4	2
Methyl chloride	4	4	3
Methyl cyclopentane	4	4	4
Methylene chloride	4	4	3
Methyl ether (dimethyl ether) (monomethyl ether)	4	4	4
Methyl ethyl ketone	4	4	1
Methyl formate	4	4	2
Methyl isobutyl ketone	4	4	2
Methyl methacrylate	4	4	3
Methyl oleate	4	4	2
Methyl salicylate	3	3	2
Milk	1	1	1
Mineral oil	4	4	3
Monochlorobenzene	4	4	4
Monomethyl aniline	4	4	2
Monoethanol amine	2	2	1
Monomethyl ether (methyl ether) (dimethyl ether)	4	4	4
Monovinyl acetylene	2	2	2
Mustard gas	1	2	1
Naphtha	4	4	4
Naphthalene	4	4	4
Naphthalenic acid	4	4	4
Natural gas	2	2	4
Neats foot oil	4	4	2
Neville acid	4	4	2
Nickel acetate (aq)	1	4	1
Nickel chloride (aq)	1	1	1
Nickel sulfate (aq)	2	2	1
Niter cake	1	1	1
Nitric acid (conc.)	4	4	4
Nitric acid (dilute)	4	4	2

Substance	Natural Rubber (NR, IR)	Styrene Butadiene (SBR, BR)	Ethylene Propylene (EPM, EPDM)
Nitric acid - red fuming	4	4	4
Nitrobenzene	4	4	1
Nitrobenzene (petroleum ether)	4	4	4
Nitroethane	2	2	2
Nitrogen	1	1	1
Nitrogen tetroxide	4	4	3
Nitromethane	2	2	2
Octachlorotoluene	4	4	4
Octadecane	4	4	4
N-Octane	4	4	4
Octyl alcohol	2	2	3
Oleic acid	4	4	4
Oleum spirits	4	4	4
Olive oil	4	4	2
O-Dichlorobenzene	4	4	4
Oxalic acid	2	2	1
Oxygen - cold	2	2	1
Oxygen - (200°-400°F)	4	4	3
Ozone	4	4	1
Paint thinner, duco	4	4	4
Palmitic acid	2	2	2
Peanut oil	4	4	3
Perchloric acid	4	4	2
Perchloroethylene	4	4	4
Petroleum - below 250°F	4	4	4
Petroleum - above 250°F	4	4	4
Phenol (carbolic acid)	4	–	2
Phenylbenzene (biphenyl) (diphenyl)	4	4	4
Phenyl ethyl ether	4	4	4
Phenyl hydrazine	1	2	2
Phorane (diisopropylidene acetone)	4	4	3
Phosphoric acid - 20%	2	2	1
Phosphoric acid - 45%	3	3	1
Phoshorus trichloride	4	4	1
Pickling solution	4	4	3
Picric acid	2	2	2
Pinene	4	4	4
Pineoil	4	4	4
Piperidine	4	4	4
Plating solution - chrome	4	4	1
Polyvinyl acetate emulsion	2	4	1
Potassium acetate (aq)	1	4	1
Potassium chloride (aq)	1	1	1
Potassium cupro cyanide (aq)	1	1	1
Potassium cyanide (aq)	1	1	1
Potassium dichromate (aq)	2	2	1
Potassium hydroxide (aq)	2	2	1
Potassium nitrate (aq)	1	1	1
Potassium sulfate (aq)	2	1	1
Producer gas	4	4	4
Propane	4	4	4
i-Propyl acetate	4	4	2
n-Propyl acetate	4	4	2

Substance	Natural Rubber (NR, IR)	Styrene Butadiene (SBR, BR)	Ethylene Propylene (EPM, EPDM)
Propyl acetone (methyl butyl ketone)	4	4	1
Propyl alcohol	1	1	1
Propyl nitrate	4	4	2
Propylene	4	4	4
Propylene oxide	4	4	2
Pydraul, 10E, 29 ELT	4	4	1
Pydraul, 30E, 50E, 65E, 90E	4	4	1
Pydraul, 115E	4	4	1
Pydraul, 230E, 312C, 540C	4	4	4
Pyranol, transformer oil	4	4	4
Pyridine	4	4	2
Pyroligneous acid	4	4	2
Pyrrole	3	3	3
Radiation	3	3	2
Rapeseed oil	4	4	1
Red oil (MIL-H-5606)	4	4	4
RJ-1 (MIL-F-25558 B)	4	4	4
RP-1 (MIL-F-25576 C)	4	4	4
Sal ammoniac	1	1	1
Salicylic acid	1	2	1
Salt water	1	1	1
Sewage	2	2	2
Silicate esters	4	4	4
Silicone greases	1	1	1
Silicone oils	1	1	1
Silver nitrate	1	1	1
Skydrol 55	4	4	1
Skydrol 7000	4	4	1
Soap solutions	2	1	1
Soda ash	1	1	1
Sodium acetate (aq)	1	4	1
Sodium bicarbonate (aq)			
(baking soda)	1	1	1
Sodium bisulfite (aq)	1	2	1
Sodium borate (aq)	1	1	1
Sodium chloride (aq)	1	1	1
Sodium cyanide (aq)	1	1	1
Sodium hydroxide (aq)	1	1	1
Sodium hypochlorite (aq) (Clorox)	4	4	2
Sodium metaphosphate (aq)	1	1	1
Sodium nitrate (aq)	2	1	1
Sodium perborate (aq)	2	2	1
Sodium peroxide (aq)	2	2	1
Sodium phosphate (aq)	1	1	1
Sodium silicate (aq)	1	1	1
Sodium sulfate (aq)	2	2	1
Sodium thiosulfate (aq)	2	2	1
Soybean oil	4	4	3
Stannic chloride (aq)	1	1	1
Stannous chloride (aq)	1	1	1
Steam under 300°F	4	4	1
Steam over 300°F	4	4	3
Stearic acid	2	2	2

Substance	Natural Rubber (NR, IR)	Styrene Butadiene (SBR, BR)	Ethylene Propylene (EPM, EPDM)
Stoddard solvent	4	4	4
Styrene	4	4	4
Sucrose solution	1	1	1
Sulfite liquors	2	2	2
Sulfur	4	4	1
Sulfur chloride (aq)	4	4	4
Sulfur dioxide (dry)	2	2	1
Sulfur dioxide (wet)	4	4	1
Sulfur dioxide (liquified under pressure)	4	4	1
Sulfur hexafluoride	4	4	1
Sulfur trioxide	2	2	2
Sulfuric acid (dilute)	3	3	2
Sulfuric acid (conc.)	4	4	3
Sulfuric acid (20% oleum)	4	4	4
Sulfurous acid	2	2	2
Tannic acid	1	2	1
Tar, bituminous	4	4	3
Tartaric acid	3	4	2
Terpineol	4	4	3
Tertiary butyl alcohol	2	2	2
Tertiary butyl catechol	4	2	2
Tertiary butyl mercaptan	4	4	4
Tetrabromoethane	4	4	4
Tetrabromomethane	4	4	4
Tetrabutyl titanate	2	2	1
Tetrachloroethylene	4	4	4
Tetraethyl lead	4	4	4
Tetrahydrofuran	4	4	3
Tetralin	4	4	4
Thionyl chloride	4	4	3
Titanium tetrachloride	4	4	4
Toluene	4	4	4
Toluene diisocyanate	4	4	2
Transformer oil	4	4	4
Transmission fluid type A	4	4	4
Triacetin	2	2	1
Triaryl phosphate	4	4	1
Tributoxy ethyl phosphate	2	2	1
Tributyl mercaptan	4	4	4
Tributyl phosphate	2	4	2
Trichloroacetic acid	3	2	2
Trichloroethane	4	4	4
Trichlorethylene	4	4	4
Tricresyl phosphate	4	1	4
Triethanol amine	2	2	1
Triethyl aluminum	4	4	3
Triethyl borane	4	4	3
Trinitrotoluene	4	4	4
Trioctyl phosphate	4	4	1
Tung oil (China wood oil)	4	4	3
Turbine oil	4	4	4
Turpentine	4	4	4
Unsymmetrical dimethyl hydrazine (UDMH)	1	1	1

Substance	Natural Rubber (NR, IR)	Styrene Butadiene (SBR, BR)	Ethylene Propylene (EPM, EPDM)
Varnish	4	4	4
Vegetable oils	4	4	3
Versilube F-5O	1	1	1
Vinegar	2	2	1
Vinyl chloride	4	4	4
Wagner 21B brake fluid	2	1	1
Water	1	1	1
Whiskey, wines	1	1	1
White pine oil	4	4	4
White oil	4	4	4
Woodoil	4	4	4
Xylene	4	4	4
Xylidine (Di-methyl aniline)	3	3	2
Zeolites	1	1	1
Zinc acetate (aq)	1	4	1
Zinc chloride (aq)	1	1	1
Zinc sulfate (aq)	2	2	1
TT-T-656b	4	4	1
VV-B-680	2	1	1
VV-G-632	4	4	4
VV-G-671c	4	4	4
VV-H-910	2	1	1
VV-I-530a	4	4	4
VV-K-211d	4	4	4
VV-K-220a	4	4	4
VV-L-751b	4	4	4
VV-L-800	4	4	4
VV-L-820b	4	4	4
VV-L-825a type I	4	4	4
VV-L-825a type II	4	4	4
VV-L-825a type III	4	4	4
VV-O-526	4	4	4
VV-P-216a	4	4	4
VV-P-236	4	4	4
51-F-23	4	4	4
ASTM Method D-471 1 2 3	 4 4 4	 4 4 4	 4 4 4
MIL-L-644 B	3	3	3
MIL-L-2104 B	4	4	4
MIL-L-2105 B	4	4	4
MIL-G-2108	4	4	4
MIL-S-3136 B type I	4	4	4
MIL-S-3136 B type II	4	4	4
MIL-S-3136 B type III	4	4	4
MIL-S-3136 B type IV	4	4	4
MIL-S-3136 B type V	4	4	4
MIL-S-3136 B type VI	4	4	4
MIL-S-3136 B type VII	4	4	4
MIL-L-3150 A	4	4	4
MIL-L-3503	4	4	4
MIL-L-3545 B	4	4	4
MIL-C-4339 C	4	4	4
MIL-G-4343 B	4	4	3

Substance	Natural Rubber (NR, IR)	Styrene Butadiene (SBR, BR)	Ethylene Propylene (EPM, EPDM)
MIL-L-5020 A	4	4	4
MIL-J-5161 F	4	4	4
MIL-C-5545 A	4	4	4
MIL-H-5559 A	2	1	1
MIL-F-5566	1	1	1
MIL-F-5602	4	4	4
MIL-H-5606 B (red oil)	4	4	4
MIL-J-5624 G JP-3, JP-4, JP-5	4	4	4
MIL-O-6081 C	4	4	4
MIL-L-6082 C	4	4	4
MIL-H-6083 C	4	4	4
MIL-L-6085 A	4	4	4
MIL-L-6086 B	4	4	4
MIL-L-6387 A	4	4	4
MIL-C-6529 C	4	4	4
MIL-F-7024 A	4	4	4
MIL-H-7083 A	2	1	1
MIL-G-7118 A	4	4	4
MIL-G-7187	4	4	4
MIL-G-7421 A	4	4	4
MIL-H-7644	2	1	1
MIL-L-7645	4	4	4
MIL-G-7711 A	4	4	4
MIL-L-7808 F	4	4	4
MIL-L-7870 A	4	4	4
MIL-C-8188 C	4	4	4
MIL-A-8243 B	2	1	1
MIL-L-8383 B	4	4	4
MIL-H-8446 B (MLO-8515)	4	4	4
MIL-L-8660 B	1	1	1
MIL-L-9000 F	4	4	4
MIL-T-9188 B	4	4	1
MIL-L-9236 B	3	3	3
MIL-L-10295 A	4	4	4
MIL-L-10324 A	4	4	4
MIL-G-10294 B	4	4	4
MIL-L-11734 B	4	4	4
MIL-O-11773	4	4	4
MIL-P-12098	2	1	1
MIL-H-13862	4	4	4
MIL-H-13866 A	4	4	4
MIL-H-13910 B	2	1	1
MIL-H-13919 A	4	4	4
MIL-L-14107 B	4	4	4
MIL-L-15017	4	4	4
MIL-L-15015 B	4	4	4
MIL-L-15019 C	4	4	4
MIL-L-15719 A	3	2	2
MIL-G-15793	4	4	4
MIL-F-16929 A	4	4	4
MIL-L-16958 A	4	4	4
MIL-F-17111	4	4	4
MIL-L-17331 D	4	4	4
MIL-L-17353 A	4	4	4
MIL-L-17672 B	4	4	4

Substance	Natural Rubber (NR, IR)	Styrene Butadiene (SBR, BR)	Ethylene Propylene (EPM, EPDM)
MIL-L-18486 A	4	4	4
MIL-G-18709 A	4	4	4
MIL-H-19457 B	4	4	1
MIL-F-19605	4	4	4
MIL-L-19701	4	4	4
MIL-21260	4	4	4
MIL-S-21568 A	2	1	1
MIL-H-22072	2	1	1
MIL-L-22396	4	4	4
MIL-L-23699 A	4	4	4
MIL-G-23827 A	4	4	4
MIL-G-25013 D	2	1	1
MIL-F-25172	4	4	4
MIL-L-25336 B	4	4	4
MIL-F-25524 A	4	4	4
MIL-G-25537 A	4	4	4
MIL-F-25558 B (RJ-1)	4	4	4
MIL-F-25576 C (RP-1)	4	4	4
MIL-H-25598	4	4	4
MIL-F-25656 B	4	4	4
MIL-L-25681 C	2	1	1
MIL-G-25760 A	3	3	4
MIL-L-25968	4	4	4
MIL-L-26087 A	4	4	4
MIL-G-27343	1	1	1
MIL-H-27601 A	4	4	4
MIL-G-27617	-	2	1
MIL-I-27686 D	2	1	1
MIL-L-27694 A	1	1	1
MIL-L-46000 A	4	4	4
MIL-H-46001 A	4	4	4
MIL-L-46002	4	4	4
MIL-H-46004	4	4	4
MIL-P-46046 A	2	1	1
MIL-H-81019 B	4	4	4
MIL-S-81087	1	1	1
O-A-548 a	2	1	1
O-T-634 b	4	4	4
P-S-661 b	4	4	4
P-D-680	4	4	4
TT-N-95 a	4	4	4
TT-N-97 b	4	4	4
TT-I-735 b	1	1	1
TT-S-735 type I	4	4	4
TT-S-735 type II	4	4	4
TT-S-735 type III	4	4	4
TT-S-735 type IV	4	4	4
TT-S-735 type V	4	4	4
TT-S-735 type VI	4	4	4
TT-S-735 type VI	4	4	4

Technical Resources

1. LyondellBasell. (August 2002). *Pro-fax* and *Moplen* Polypropylene Chemical Resistance. Product Brochure.

2. Dynalab Corp. (19 August 2009). Plastic Properties Technical Information [On-line]. Available: http://www.dynalabcorp.com/technical_info_plastic_properties.asp

3. Baxter Rubber Company (19 August 2009). Chemical Resistance Guide [On-line]. Available: http://www.baxterrubber.com/resistance.html

TECHNICAL NOTE

Abrasion Resistance of Polypropylene

TN 4.03
April 2012

Introduction

With the introduction of ADS High Performance (HP) polypropylene (PP) pipe for the storm drainage and sanitary sewer markets, it is necessary for designers to have confidence in polypropylene's expected performance in conditions where the effluent may carry debris or abrasive materials. To address designer's concerns, a comparative evaluation of whether polypropylene had similar abrasion resistance to high density polyethylene (HDPE) was undertaken. While it was initially hypothesized that polypropylene would have comparable, if not better, abrasion resistance, testing verification is essential. If it could be established that polypropylene and HDPE have similar resistance to abrasion, the more extensive history and test data for HDPE could be applied to polypropylene insofar that polypropylene would behave similarly to HDPE in abrasive environments. To test this hypothesis, two types of tests were conducted. The first test used Taber® abrading wheels directly on a sample of thermoplastic material. The second test, in order to more closely mimic drainage and sewer conditions, involved placing thermoplastic samples in water flow carrying abrasive sand. Both tests measured the mass loss over time and provide a direct comparison between the two materials.

Taber Abrasion Test

In April 2009, Polymer Diagnostics, Inc. conducted Taber abrasion testing on polypropylene, HDPE and PVC material samples in accordance with ASTM D3389 in order to determine the material's mass loss under direct abrasion. Although this test does not simulate pipe carrying effluent, the test still provides a standardized method for comparing the abrasion resistance, or hardness, of different materials.

Test Setup

Each material sample was mounted on a Taber Abrader Model 5130 where the sample is subjected to rub-wear action of an abrading wheel. An abrasion pattern of crossed arcs simulates abrasion of the material from all angles. Directly abrading material in this manner allows for quick results through accelerated testing in order to simulate long-term use, which may otherwise take years to compile.

The initial mass of each sample was recorded to determine the total mass loss of the respective material over the duration of the test. All samples were tested using a CS-10 abrasion wheel with 250 grams of force. The total test time was 40 hrs, allowing for 500 revolutions of the abrading wheel.

Results

Results in Table 1 indicate a greater mass loss of the PVC samples compared to both the polypropylene and HDPE samples. The mass loss of the HDPE sample was slightly higher than the polypropylene sample, but the proximity of values allows for the conclusion that both samples performed similarly. These results indicate a similarity between polypropylene and HDPE materials as it relates to material hardness. The final mass loss of PVC was 5 to 8 times that of polypropylene.

Table 1
Taber Abrasion Test Results for Material Mass Loss

Material	Start Mass (g)	End Mass (g)	Total Mass Loss (mg)
PP #1	30.6036	30.6034	0.2
PP #2	30.6868	30.6866	0.2
HDPE, 5% Carbon Black	31.6658	31.6655	0.3
PVC – white	50.8776	50.8759	1.7
PVC – gray	50.4187	50.4176	1.1

Abrasion Resistance in Water Flow

While a direct correlation between polypropylene and HDPE materials' abrasion resistance is supported by the Taber abrasion test results, a second test was conducted to confirm those results and simulate the abrasion resistance of a pipe's invert when carrying effluent with suspended abrasives.

ADS Facility Testing

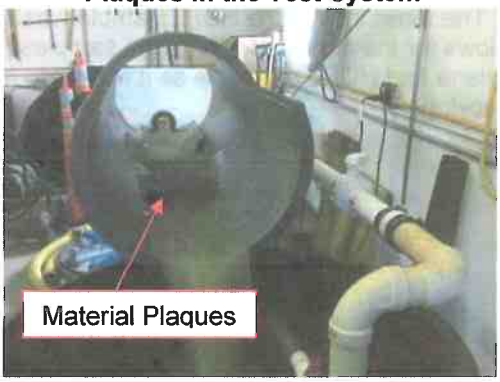
First, material plaques of both polypropylene and HDPE were cut and weighed to determine the initial mass of the sample. The samples were then scanned into AutoCAD in order to precisely measure the surface area that will be abraded. Additionally, each sample was inspected for any signs of abnormality including splitting, cracking, material thinning, etc. No abnormalities were noted and product was considered to be in good condition.

Next, a closed-loop test system was constructed in order to achieve a controlled flow rate over the samples. A constant hydraulic loading was established in the system, which consisted of a 2" grinder pump, 18" trough and a collection basin as shown in Figure 1. OK-110 sand was added to the water flow so a relatively heavy sand loading was obtained. The grinder pump, in conjunction with a mixing tee, was used to ensure the sand stayed in a suspended state in the mixture. The flow rate of sand/water mixture over the plaques was 3 ft/sec.

In the trough, four sample plaques, two of polypropylene and two of HDPE, were placed at the bottom of the trough in the flow path, shown in Figure 2. With the exception of removing the samples for weighing, the test unit allowed for continuous subjection of the samples to the slurry mixture.

Figure 1
Close-Loop Test System

Figure 2
Plaques in the Test System



Results

It was noted during visual inspections of the samples throughout the test that minor scouring of the samples was occurring. These observations affirmed that the test was successful in creating the desired abrasive conditions for sample analysis. Comparing results in Table 2 of the mass and thickness loss, polypropylene performed slightly better than HDPE. The second sample of HDPE was removed from testing as it was damaged during detachment operations for periodic examinations; subsequently resulting in a large loss of material not related to the abrasion testing. Even so, results for both HDPE samples indicate a higher material loss value compared to the polypropylene sample results. Ultimately, these results favor polypropylene over HDPE for constant flow applications where the effluent carries a high bed load.

Table 2
Material Loss Results

	Initial Weight (g)	Final Weight (g)	Time (hrs)	Loss (g/hr)	Surface Area (in^2)	Loss (mills/yr)
PP large sample	221.5	221.5	4029	0.00000	110.34	0.00
PP small sample	27.101	27.099	3483	0.00001	15.43	0.02
HDPE large sample	141	140.75	4029	0.00006	89.47	0.39
HDPE small sample	Damaged during examination					

Conclusions

Both tests indicate high abrasion resistance of polypropylene material. The Taber test indicated that polypropylene and HDPE behaved almost identical to direct rub-wear abrasion, and significantly better compared to PVC material. The test simulating abrasive water flow reaffirmed the Taber test results and indicated that polypropylene performs similarly or slightly better than HDPE. From these results it is reasonable to conclude that other abrasion resistance tests using HDPE samples are also representative of polypropylene material. With this relationship in mind, the tests outlined in the Drainage Handbook *Durability* section that are specific to HDPE and establish the material's superior resistance to abrasion compared to other pipe materials also support the argument for polypropylene's superior abrasion resistance.

TECHNICAL NOTE

SaniTite® HP Sanitary Sewer Pipe Repair Options

TN 5.13
May 2012

Introduction

ADS SaniTite HP for sanitary sewer is made of polypropylene (PP) resin making the pipe lightweight and very easy to handle. The attributes that make the pipe easy to use can also make it susceptible to abuse, possibly resulting in damaged pipe or joints. This technical note discusses some of the products available that can be used to repair damaged PP pipe or joints in the field.

Repair Options

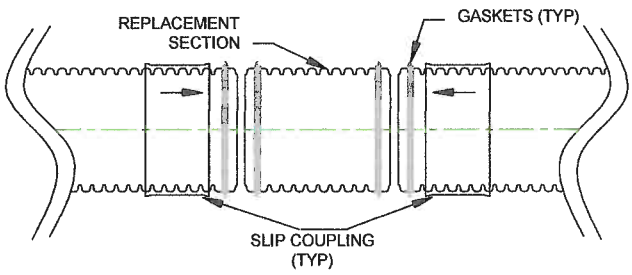
One of the primary considerations in selecting a repair method is the degree of joint performance required. For sanitary sewer applications, a watertight repair is always necessary in contrast to storm drain repairs that may have a less stringent joint performance. A commonly accepted industry maximum allowance specified for infiltration/exfiltration acceptance for sanitary pipelines is 200 gal/in-diam./mile of sewer/day, though regional specifications may vary and be as stringent as 50 gal/in-diam./mile of sewer/day.

The way in which a pipe can be accessed is another primary consideration which influences what type of repair alternative is selected. Pipe that is not yet buried, or can be easily excavated, can be repaired from the exterior. If the pipe is buried and cannot be conveniently excavated, an internal repair may be the best alternative. If the pipe is too small to enter, there are companies with remote controlled equipment that can install the product. Each situation must be considered individually.

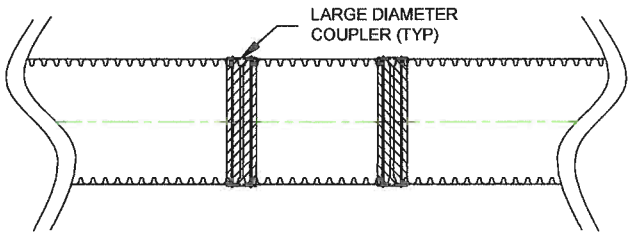
The repair options addressed below are divided into external repairs and internal repairs. During any pipe repair, backfill should be placed and compacted per project specifications to provide proper support for the pipe and coupler.

External Mechanical Repairs

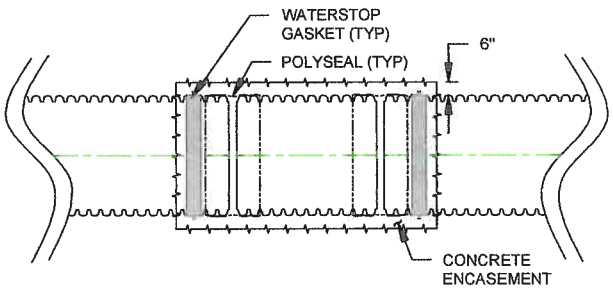
Slip Couplings 12- through 30-inch (300 – 750 mm) , provides a watertight repair that will meet most pressure testing requirements, when installed correctly. The slip coupling uses PVC bells with gaskets. The gaskets are placed in the valleys on either side of the section to be repaired and slip couplings are then slid over the gaskets. Due to the exterior gasket, the slip coupling can only be used on pipe with a corrugated exterior. PVC slip couplings are most commonly used with watertight smooth interior thermoplastic pipe products. *Note: This repair method cannot be used with the triple wall, smooth exterior profile pipe.*



Large Diameter Repair Coupler 12- through 60-inch (300 – 1500 mm) are ideal for repairs and alterations of large diameter sewer pipe. Repair couplers similar to those provided by Mission Rubber Company LLC, Fernco® or equal may be used on SaniTite HP pipe.



The couplers are used by removing the damaged section of pipe, replacing it with a new section and then sliding the coupler back around the joint, similar to the slip coupling above. The couplers stainless steel bands are then tightened to the manufactures recommendations. These rubber couplings are capable of meeting watertight field test requirements when installed per the manufacturer's recommendations.



Concrete Collar 12- through 60-inch (300 – 1500 mm), provides a water tight repair testable to most hydrostatic test with an appropriate leakage requirement. Installing a concrete collar involves building a form around the area to be repaired and encasing it in concrete. A *Mar Mac Polyseal Pipe Coupler* is wrapped around the repair area or joint prior to pouring the collar to keep the concrete from seeping into the pipe. *WaterStop* gaskets are installed outside of the *Polyseal* coupler towards the outside edge of the concrete collar. Typically, approximately 6" (0.15m) is excavated beneath the pipe to allow for proper application of the *Polyseal* coupler and concrete encasement. If the pipe itself is damaged, the damaged area shall be removed and a replacement pipe section spliced in prior to pouring the collar. This repair option may be employed for either dual wall or triple wall sanitary pipe.

Internal Repairs

Internal mechanical repair products generally consist of a flexible cylindrical gasket sleeve, which is expanded to conform to the inner wall of the pipe. The feasibility of this repair method depends on the size of the damaged section or joint and available access into the pipe. Internal mechanical seals slightly restrict the inside diameter of the pipe. This should be considered when assessing the risk of debris obstruction.

NPC Internal Joint Seal, 18- through 60-inch (450 – 1500 mm), consists of an EPDM rubber seal and stainless steel bands. The rubber seal is inserted into the pipe and positioned over the joint. A torque wrench is used to expand the bands against the inner wall of the pipe. The Internal Joint Seal is designed to seal joints – not repair damaged pipe sections. The damaged area of the pipe must be removed and a replacement section spliced in if necessary in order to use the Internal Joint Seal. This system may provide a watertight joint when installed as recommended. The manufacture should be contacted to verify the product meets the specific application requirements including test requirements, if specified. If pressure tests are required, NPC should be contacted to ensure that the product is suitable for the specific test criteria.

Internal mechanical seals will slightly restrict the inside diameter of the pipe. This should be considered when assessing the risk of debris obstruction.

Link Pipe Grouting Sleeve™, 12- through 60-inch (100 – 1500 mm), is a stainless steel grouting sleeve that is installed with an inflatable plug. The sleeve may be used to seal a joint or repair short sections of damaged pipe. The manufacture should be contacted to verify the product meets the specific application requirements including test requirements, if specified.

Internal chemical sealing is another method of internal joint repair using chemically activated gel or grout to minimize joint leakage. The grout is typically applied with specialized remote-controlled equipment. Test/seal packer is used to remotely seal a joint. The grouting chemicals are forced through the joint out into the surrounding soil where they gel with the soil. The gelled mass forms a waterproof collar around the pipe. The result is significantly reduced leakage. There are several types of chemical grouts available and the manufacturer should be contacted to review the specific situation and any joint tightness or pressure test criteria. Companies such as Avanti International, Strata Tech Inc., and Carylon Corporation manufacture and/or install chemical grout. Stephen's Technologies *New Life Coatings* and *NewLife Liner Systems* as well as Avast Hydro-Lining International, are examples of companies that offer cured in place epoxy lining

systems that have been effectively used with HDPE pipe. Most pipe diameters can be chemically grouted provided the grouting contractor has the appropriate equipment.

Manufacturer Contact Information

Contact the Regional Engineer or Application Engineering Department for assistance with other unique conditions or for contact information regarding any companies listed in this technical note.

Note: Thermoplastic pipe products are solely intended for the conveyance of fluids. Access into this product for maintenance, inspection, repair, or other reason should be done in strict accordance with OSHA recommendations for confined space entry.

TECHNICAL NOTE

Lining of Casings with SaniTite® HP Pipe

TN 5.18
August 2011

In sanitary sewer, it is often necessary to use trenchless technology methods to install a casing pipe under high volume roads, railroads or other sensitive areas where the ground surface cannot be disturbed. Methods of installing the casing pipe will vary based on the native soil conditions, groundwater location, length of installation and the precision required for the pipe line and grade. SaniTite HP is not designed to withstand the high compressive or tensile forces associated with trenchless placement; however SaniTite HP pipe can be used as a carrier pipe within a casing, provided open pits are used at each end of the tunnel operation to prevent bending of the pipe in place. When short sections of sanitary sewer require trenchless placement, commonly a smooth-walled steel pipe with protective coating is used as the casing pipe, with its wall thickness dependent on anticipated loading conditions as well as regional specifications. Common placement methods for steel casings include horizontal auger boring (HAB) or pipe jacking, but the casing placement method does not necessarily impact the carrier pipe installation, as long as adequate access is provided.

Sizing of the Casing Pipe

In some cases, the diameter of the casing pipe may be limited by the in-situ conditions, such as proximity to bedrock or the presence of weak native soils. Where in-situ conditions are not the limiting factor in casing sizing, the smallest possible diameter pipe is often desired and is contingent upon the carrier pipe's outside diameter, additional conduits, and support/bracing system required for the carrier pipes. Table 1 provides the maximum possible pipe outside diameter.

Table 1
Dimensions of HP Pipe Products

	Nominal Inside Diam. in (mm)	Max Outside Diam.* in (mm)
Dual Wall	12 (300)	14.6 (371)
	15 (375)	17.8 (452)
	18 (450)	21.4 (544)
	24 (600)	28.2 (716)
	30 (750)	35.6 (907)
Triple Wall	30 (750)	35.7 (907)
	36 (900)	41.4 (1052)
	42 (1050)	47.5 (1206)
	48 (1200)	53.9 (1369)
	60 (1500)	66.6 (1692)

* Contact ADS for additional guidance if anticipated OD values provided may not provide adequate clearance.

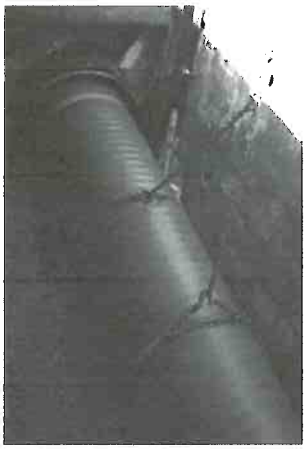
To ensure consistent line and grade over the life of the sanitary sewer, the pipeline is braced in the casing to prevent movement. Bracing systems can range from field-installed skids banded to the exterior of the pipe to manufactured casing spacers installed incrementally along the carrier pipe. The bracing system and the diameter of the casing are dependent on each other, where a specific casing spacer type may require a larger clearance around the carrier pipe, or vice-versa where a casing pipe diameter may limit the type of bracing that can be used. Additional information on bracing systems and installation is the *Casing Spacers and Skids* section of this document. No matter what bracing system may be used, minimum 1-inch should be left between the inside of the casing and the outside of the bracing. This clearance helps prevent the pipe/spacer system from getting wedged in the casing due to warped casing pipe or imperfections caused during trenchless operations.

Structural Requirements

In the case of trenchless casing pipe installations, the casing pipe being installed is typically designed such that the live and dead loads are carried solely by the casing pipe with no load being transferred to the carrier pipe. For cases where a deteriorating pipe is being sliplined or the design requires a load to be carried by the sewer pipe within the casing,

pipe suitability is often evaluated as if the casing pipe were not present and fill height and live loading recommendations are followed in the same manner as open-cut trench installations.

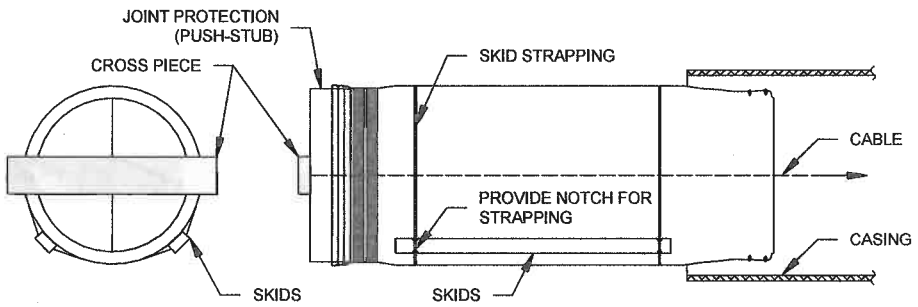
Installation Techniques



Often times the length of sewer section requiring a casing is less than 300ft when road or rail crossings are relatively narrow. For these circumstances, a typical method simply involves joining successive carrier pipe joints together outside of the casing while pushing the carrier pipe through the casing. It is recommended that a push stub or large blocking surface be used to push the pipe through the casing to avoid point loads damaging the pipe end.

A second method involves passing a cable through the casing and the first stick of pipe to pull the pipe in place. On the opposite end of the pipe a suitable cross piece is installed as well as protection for the pipe joint (push stub). The cable is pulled through the casing by a winch or other mechanical equipment thus bringing the carrier pipe inside the casing. Once a majority of the first pipe is inside the casing, the cross piece is disassembled and attached to the next pipe, joints are assembled and the operation begins again. See Figure 2 for an illustration of this method.

Figure 2
Pulling HP Pipe in Casing



Using casing spacers will help minimize the resistance between the two surfaces, possibly allowing for longer installations. Table 2 provides the maximum recommended thrust force on the joint. While push length values are provided for reference, specific installation conditions, including the casing pipe and spacer/blocking materials, will impact the allowable push length.

Table 2
Maximum Push Force on HP Products

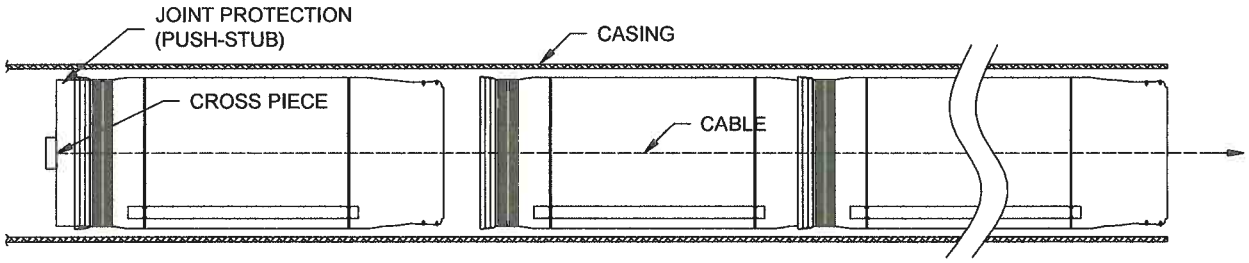
Nominal Inside Diam., in (mm)	Max Thrust Force, lbs (kN)	Push Length[1], ft (m)
12 (300)	1,500 (6.7)	400 (121)
15 (375)	2,000 (8.9)	400 (121)
18 (450)	3,000 (13.3)	400 (121)
24 (600)	4,500 (20.0)	400 (121)
30 (750)	4,500 (20.0)	400 (121)
36 (900)	9,000 (40.0)	300 (91)
42 (1050)	11,000 (48.9)	300 (91)
48 (1200)	12,000 (53.4)	300 (91)
60 (1500)	16,000 (71.2)	300 (91)

NOTES:
Push length is provided as general design guidance. Allowable push lengths should be calculated based on the project's installation conditions using the maximum thrust force values listed in this table. The push length values shown account for weight of HP pipe and a casing pipe w/ blocking resulting in a coefficient of static friction=0.7. Conditions or design values that vary from these assumptions will impact the actual thrust force on the joint and therefore the allowable push length.

Unlike some other pipe products where even short push lengths can cause over-homing, SaniTite HP does not require special joint blocks to be fabricated; however, joint restraints may aid in protecting the joint only when the joint thrust force may be high and longer installations are anticipated.

If maximum insertion forces are being exceeded, it is important to adjust the construction technique so as to not damage the carrier pipe. One solution is instead of joining adjacent pipes outside of the casing and pushing one long section, multiple, shorter sections are homed within the casing at the final location so as to avoid pushing the entire section of pipe. This technique can also be utilized when pulling sections into the casing as illustrated in Figure 3. It is important to note that access to the carrier pipe during joint assembly inside the casing is imperative for proper joint alignment.

Figure 3
Alterative Installation Method
(Used when maximum insertion forces are likely to be exceeded)

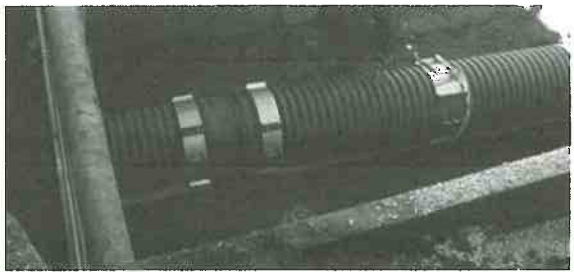


Casing Spacers and Skids

Skids may be attached to the carrier pipe to provide a sliding surface between the casing and the carrier pipe. It is important that the skids be notched where the straps are to provide a smooth sliding surface. Typically 2 to 4 skids are placed around the pipe. These skids run the length of the pipe, however should not be located in the spigot portion of the pipe as this may affect joint assembly. Wood blocks should never be wedged between the carrier pipe and the casing pipe.

Commercially available casing spacers may also be used to slide and guide the carrier pipe into the casing. When using dual wall sanitary pipe it is important that spacers be chosen that span at least two corrugations. Small sections of lumber may be used under the spacer to act as a bridge for the spacer to set on. Casing spacers are typically manufactured from polyethylene or a combination of stainless steel with polyethylene runners, but other non-corrodible materials are available. The benefits of using manufactured casing spacers include ease of installation with no banding tools needed, a lower coefficient of friction and ability to glide over rough spots or welded joints that may otherwise cause binding.

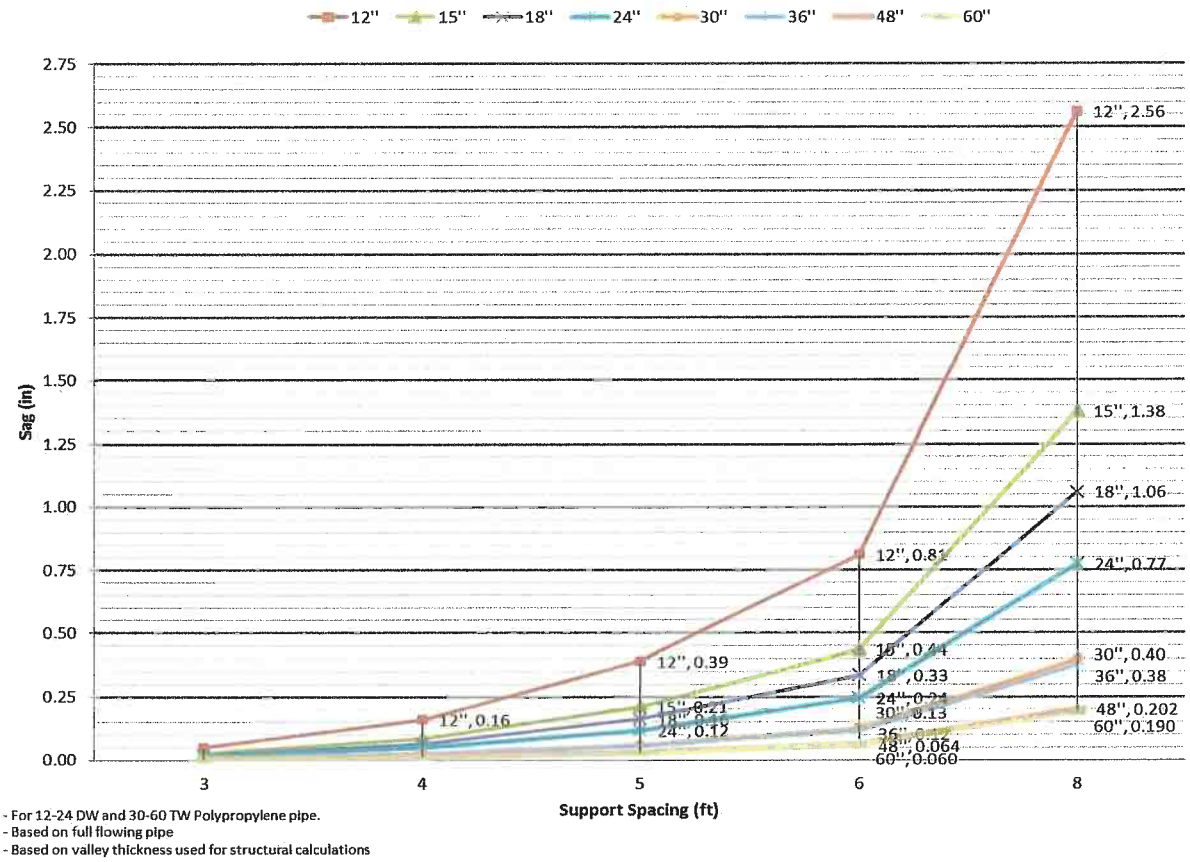
The casing spacer manufacturer should be contacted for exact sizing availabilities, but in general, molded plastic spacers provide shorter runner heights compared to stainless steel configurations. Other considerations including pipe diameter and weight will impact casing spacer selection. Because of the lightweight of SaniTite HP, molded plastic casing spacers can often withstand the weight expected from pipe and effluent in the system. Some casing spacer manufacturers are:



RACI (www.racispacers.com),
Cascade Waterworks Manufacturing (www.cascademfg.com),
Pipeline Seal & Insulator, Inc (www.pipelineseal.com), and
Advance Products & Systems, Inc. (www.apsonline.com)

Spacing between spacers or skids is a function of the long term unsupported settlement of flexible pipe. Commonly in sanitary sewer, hydraulics and prevention of depressions in the line are the primary considerations for determining an allowable grade deviation, not necessarily product deflection limitations. As a general guideline and as specified in some regions, the pipe grade should vary no more than 0.25-in from true grade. Based on this requirement, maximum unsupported distances for SaniTite HP 30"-60" pipe is 7ft and for 12"-24" pipe is 4ft. This recommendation is based on the conservative assumption that the sewer line will be flowing full for the duration of its service life. For cases where a specific settlement allowance exists or more accuracy is desired, Chart 1 below provides anticipated long-term settlement of the pipe under full-flow conditions based on spacer distance. If the necessary spacing cannot be achieved or is not practical, other methods to support the pipe invert may be used, including the use of skids in between supports or filling the void space with soil or grout material, at the discretion of the design engineer. Alternative design assumptions, such as lower flow capacities, will impact the anticipated settlement of the pipe and maximum unsupported length of pipe.

Chart 1
Unsupported Deflection of SaniTite HP



- For 12-24 DW and 30-60 TW Polypropylene pipe.
- Based on full flowing pipe
- Based on valley thickness used for structural calculations

Closure After Pipe Installation

Any post-installation testing required for the sewer pipe should be successfully completed before any backfilling or closure operations begin.

Filling the void space between the carrier pipe and the casing pipe shall be done at the discretion of the engineer. In some cases, fill material may cause the load to be distributed to the carrier pipe and affect performance if not initially

accounted for in structural design. Partial fill that supports the bottom ¼ of the pipe may sometimes be used if the invert of the pipe must be fully supported to ensure long-term grade elevation. Grout material, often a controlled low strength material (CLSM), also referred to as controlled density fill, CDF, or flowable fill is commonly utilized, with blown sand and gravel being other materials used to fill the void space as desired. CLSM will help provide uniform support on the sides of the pipe, maintain a consistent soil density, provide lateral support for the pipe, and eliminate point loads. For more information on flowable fill mix, refer to Technical Note 5.02: *Flowable Fill Backfill for Thermoplastic Pipe*. It is critical measures be taken to prevent flotation to maintain adequate line and grade of the carrier pipe. Grouting in layers thin enough, such that they don't float the pipe, helps tremendously. Each layer should be allowed to set up between pours. Contractors may have other techniques that will also prevent flotation such as the use of deadweight inside the pipe. Regardless of the method used, it is also important to avoid applying point loads to the pipe. For more information on flotation and anchoring methods, refer to Technical Note 5.05: *Pipe Flotation.*

When SaniTite HP pipe, or any flexible pipe, is used as a liner, it is very important not to use excessive grout pressure. In most circumstances, the joint, not the wall strength, will be the limiting factor for establishing a maximum allowable grouting pressure. Including a factor of safety, the recommended maximum grouting pressure for HP pipe products is 5 psi; this value may vary based on specific site conditions and specific products used. During the grouting operation, gauges should be used to monitor the grout pressure exerted on the pipe system. For some applications, hydrostatic head pressure may increase the expected pressure on the pipe from the grouting. Additional pressure may also result from the slope and/or diameter of the pipe, elevation changes between the pipe and the gauge, and other conditions that should be considered during the design. The sum of all pressures that will be exerted on the pipe should not exceed the recommended maximum pressure for the application.

Once the carrier pipe has been successfully placed and tested within the casing pipe and any backfilling procedures are complete, the ends of the casing are typically sealed to prevent infiltration. Bricks, grout or manufactured rubber end seals are typical methods for sealing the ends of the casing pipe. For installations where a high hydrostatic load is anticipated, a watertight seal, such as a rubber boot, may be necessary to protect the carrier pipe.

TECHNICAL NOTE

Post Installation Testing of SaniTite® HP

TN 5.17
February 2010

Introduction

Sanitary sewer is often tested after or during installation to ensure a sound installation was accomplished. Types of post installation field testing include deflection testing and joint testing. Specific testing required for the project will be found in the project specifications. This technical note is not meant to supersede any project specification, but should be used in conjunction with the project specification and national testing standards as it relates specifically to SaniTite HP pipe.

Deflection Testing

An important feature of any flexible pipe is its ability to deflect, or oval, under load without structural distress. Deflection allows the load to be transferred from the pipe to the surrounding backfill. The result is flexible pipe can withstand very high loads as a relatively light structure. Flexible pipe – including SaniTite HP – *must* deflect in order to mobilize the strength of the surrounding backfill.

According to current thermoplastic design procedures, deflection is defined as a service limit. The designer, considering all site conditions, will set this service limit in order to perform a proper design evaluation. Deflection in excess of this service limit does not necessarily result in strength limits being exceeded, i.e. system failure. For more information on service and strength limit states, see the *Structures* section of the Drainage Handbook. SaniTite HP can be expected to perform satisfactorily in most applications with 5% or 7.5% deflection and so it is typical of designers to choose a service limit in this range.

When testing for allowable deflection limits, the minimum inside diameter should be used when establishing mandrel sizing. The minimum inside diameter accounts for the allowable manufacturing tolerances. Table 1 lists the inside diameters that result from 5% and 7.5% deflection from the minimum inside diameter. Values listed in Table 1 should be used for sizing mandrels for deflection testing. Mandrels may be obtained from a variety of commercial suppliers.

Table 1
SaniTite HP Recommended Mandrel Settings

Pipe Type	Pipe Diameter	Minimum Inside Diameter	Inside Diameter with 5% Deflection	Inside Diameter with 7.5% Deflection
Dual Wall	12	11.90	11.31	11.01
	15	14.85	14.11	13.74
	18	17.93	17.03	16.59
	24	23.90	22.71	22.11
	30	29.79	28.30	27.56
Triple Wall	30	29.62	28.14	27.40
	36	35.40	33.63	32.75
	42	41.31	39.24	38.21
	48	47.31	44.94	43.76
	60	59.30	56.34	54.85

It is important to understand that mandrel testing is a go/no-go test. If any line were to not pass a mandrel, it is important to ascertain the cause. Obstructions in the line, not associated with deflection, may influence the test. Visual inspection is recommended in the event of a no-go result.

Joint Testing

Joint testing is an important part of any sanitary sewer system, both in testing for infiltration and exfiltration. Infiltration aids to estimate the amount of sewer water that will be conveyed to, and ultimately treated by, the waste water treatment plant. Exfiltration aids to estimate the loss of sewage water into the surrounding soil. The two primary ways of testing sewer pipe joints for infiltration and/or exfiltration is using air or water to create a constant pressure within the system.

Exfiltration Testing with Air

Air is a compressible gas and so it is extremely important one adheres to the appropriate safety regulations outlined in OSHA and project specifications. There are two primary national testing standards that may be applied to joint testing SaniTite HP: ASTM F1417 *Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air*, and ASTM C1103 *Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines*. When either standard is specified by the project plans, one should review the standards carefully and follow the testing procedure and safety precautions outlined. The below commentary on the ASTM testing procedures should be considered a summary and does not replace the testing procedures outlined in their respective specifications.

ASTM F1417 entails testing a run of pipe from one manhole to the next adjacent manhole. Inflatable plugs are positioned into the manholes and secured. Air is introduced into the pipe line and gradually builds pressure. Once the line has been pressurized and is stable at 4.0-psi, the pressure is decreased to 3.5-psi at which time the line must not lose more than 0.5- or 1.0-psi (whichever is specified by the design engineer) in the specified amount of time. Table 2 below summarizes the minimum time that must be reached for less than 0.5- or 1.0-psi of pressure drop, depending on the diameter and length of pipe being tested.

Table 2
Time to Pressure Drop for SaniTite HP (per ASTM F1417)

Pipe Diameter	Pressure Drop (psi)	Minimum Test Time (min:sec)	Length for Minimum Time, (ft)	Time for Longer Lengths, (sec)	Time for Length Shown, (min:sec)							
					100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft	450 ft
12	0.5	5:40	199	1.709 L	5:40	5:40	5:42	7:08	8:33	9:58	11:24	12:50
	1.0	11:20		3.418 L	11:20	11:20	11:24	14:15	17:05	19:56	22:47	25:38
15	0.5	7:05	159	2.671 L	7:05	7:05	8:54	11:08	13:21	15:35	17:48	20:02
	1.0	14:10		5.342 L	14:10	14:10	17:48	22:15	26:42	31:09	35:36	40:04
18	0.5	8:30	133	3.846 L	8:30	9:37	12:49	16:01	19:14	22:26	25:38	28:51
	1.0	17:00		7.692 L	17:00	19:13	25:38	32:03	38:27	44:52	51:16	57:41
24	0.5	11:20	99	6.837 L	11:24	17:57	22:48	28:30	34:11	39:53	45:35	51:17
	1.0	22:40		13.764 L	22:47	34:11	43:34	56:58	68:22	79:46	91:10	102:33
30	0.5	14:10	80	10.683 L	17:48	26:43	35:37	44:31	53:25	62:19	71:13	80:07
	1.0	28:20		21.366 L	35:37	53:25	71:13	89:02	106:50	124:38	142:26	160:15
36	0.5	17:00	66	15.384 L	25:39	38:28	51:17	64:06	76:55	89:44	102:34	115:23
	1.0	34:00		30.768 L	51:17	76:55	102:34	128:12	153:50	179:29	205:07	230:46
42[3]	0.5	19:54	57	20.942 L	34:54	52:21	69:49	87:15	104:42	122:10	139:37	157:04
	1.0	39:48		41.883 L	69:48	104:42	139:37	174:30	209:24	244:19	279:13	314:07
48[3]	0.5	22:47	50	27.352 L	45:35	68:23	91:11	113:58	136:46	159:33	182:21	208:09
	1.0	45:34		54.705 L	91:10	136:45	182:21	227:55	273:31	319:06	364:42	410:17
60[3]	0.5	28:20	40	42.738 L	71:14	106:51	142:28	178:05	213:41	249:18	284:55	320:32
	1.0	56:40		85.476 L	142:28	213:41	284:55	356:09	427:23	498:37	569:50	641:04

Data taken from ASTM F 1417[1] and Uni-Bell, Uni-B-6-98[3].
It may not be necessary to hold the test for the entire time period listed above when it is evident that the rate of air loss is zero or less than the allowable pressure drop and authorized by the approving authority[1].

When the pipe is large enough to be physically accessed, it may be desirable to test individual joints for safety reasons. In these cases, one may consider joint testing in accordance with ASTM C1103, also known as a joint isolation test. This test is typically done with air, though water may also be used, and involves the use of special testing equipment. The equipment consists of two inflatable bladders, placed on each side of the joint, creating an open center cavity between them. The bladders are inflated and then the center cavity is pressurized to 3.5 psi. The joint passes the test if the pressure is held for 5 seconds without dropping more than 1.0-psi. For all practical purposes, this is a go/no-go test. One advantage of this type of test is the ability for the installer to quickly test the joint immediately after installation, allowing for any corrective measures to be taken early on in the project.

Infiltration/Exfiltration with Water

Testing sanitary sewer joints via water infiltration or exfiltration is a common practice. For SaniTite HP, this testing should be conducted in accordance with ASTM F2487 *Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Corrugated High Density Polyethylene Pipelines,* or ASTM C969, *Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines*. These standards entail first observing the ground water conditions and, if applicable, measuring the infiltration rate of the ground water through the joints. If ground water is not applicable, then the line is filled with water and the leakage is observed through exfiltration.

For the infiltration test the ground water must be at least 2 feet above the crown of the pipe for the entire test section. If this groundwater condition is not present, exfiltration testing should be used. Measure the groundwater elevation and determine the average head, relative to the pipe invert, over the test section. All outlets discharging into the upstream manhole shall be plugged. Measure the infiltration leakage at the outlet of the test section. The leakage may be small and is best measured by timing the filling of a container of known volume or by directing the flow into a container for a specified time and measuring the volume. Weirs may also be used to measure the flow.

Exfiltration testing is appropriate when the groundwater condition is less than 2 feet above the crown of the pipe measured at the upstream end. All outlets discharging into the upstream end of the test section as well as the downstream end shall be plug. At the upstream manhole the test head shall be established at a minimum of 2 feet above the crown of the pipe or 2 feet above the existing ground water condition, which ever is higher. The leakage shall be measured over a timed test period of not less than 15 minutes and no more than 24 hours. Leakage may be measured through observation in a water column or by adding water at a known rate to satisfy a constant water elevation.

Manholes shall be tested separately and independently of the pipe line to the requirements established in the project specifications. When water level is measured in the manhole for the exfiltration test, the leakage associated with the manhole shall be subtracted from the overall leakage of the test section to establish a pass or fail grade for the pipe.

Allowable Leakage

The allowable leakage rate for SaniTite HP is 50 gallons/in-dia/mi-pipe/day for both infiltration and exfiltration when done in accordance with ASTM F2487, C969 and this technical note. In the event the average groundwater head exceeds 6 feet in the infiltration test, the allowable leakage shall be increased by the ratio of the square root of the average groundwater head to the square root of the 6 feet head. In the event the average head exceeds 3 feet in the exfiltration test, the allowable leakage shall be increased by the ratio of the square root of the average test head to the square root of the 3 feet head. Table 3 below summarizes the equations needed to calculate the adjusted leakage allowance with increase head pressures.

Table 3
Adjusted Leakage Allowance for Increased Head Pressures[5]

Infiltration	Exfiltration
$\text{Allowable Leakage} = 50 \times \frac{\sqrt{\text{Average Groundwater Head}}}{\sqrt{6}}$	$\text{Allowable Leakage} = 50 \times \frac{\sqrt{\text{Test Head}}}{\sqrt{3}}$

Conclusion

ADS SaniTite HP is intended for gravity flow sanitary sewer applications and may be tested for deflection and joint tightness as discussed in this technical document. It is important to note that the testing procedures are no different than for other sanitary sewer products currently being used in the market. This document does not purport to address the safety concerns associated with testing SaniTite HP. Any questions associated with testing SaniTite HP can be directed to your local representative.

References

1. ASTM F1417, *Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air*, ASTM, 2005
2. C1103, *Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines*, ASTM, 2003
3. Uni-B-6-98, *Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe,* Uni-Bell PVC Pipe Association, 1998
4. ASTM F2487, *Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Corrugated High Density Polyethylene Pipelines,* ASTM, 2006
5. ASTM C969, *Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines*, ASTM, 2002

Contractors may have other techniques that will also prevent flotation such as the use of deadweight inside the pipe. Regardless of the method used, it is also important to avoid applying point loads to the pipe. For more information on flotation and anchoring methods, refer to Technical Note 5.05: *Pipe Flotation*.

When HP pipe, or any flexible pipe, is used as a liner, it is very important not to use excessive grout pressure. In most circumstances, the joint, not the wall strength, will be the limiting factor for establishing a maximum allowable grouting pressure. Including a factor of safety, the recommended maximum grouting pressure for HP pipe products is 5 psi; this value may vary based on specific site conditions and specific products used. During the grouting operation, gauges should be used to monitor the grout pressure exerted on the pipe system. For some applications, hydrostatic head pressure may increase the expected pressure on the pipe from the grouting. Additional pressure may also result from the slope and/or diameter of the pipe, elevation changes between the pipe and the gauge, and other conditions that should be considered during the design. The sum of all pressures that will be exerted on the pipe should not exceed the recommended maximum pressure for the application.

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USACE / NAVFAC / AFCEC / NASA **UFGS-33 30 00 (May 2018)**

Preparing Activity: USACE **Superseding**
UFGS-33 30 00 (April 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2018
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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2018
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SECTION 33 30 00

SANITARY SEWERAGE
05/18

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NOTE: This guide specification covers the requirements for piping and appurtenant structures for an exterior sanitary sewer system.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

For corrosive soils select materials, coatings or cathodic protection systems in accordance with UFC 3-230-01. When cathodic protection is used include Section 26 42 13.00 20 CATHODIC PROTECTION BY GALVANIC ANODES.
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NOTE: For Army and Air Force, impress current cathodic protection(ICCP) may be used. When ICCP is used include Section 26 42 17.00 10 CATHODIC PROTECTION SYSTEM (IMPRESSED CURRENT.
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PART 1 GENERAL

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NOTE: In areas where problems with root penetration are anticipated, specify pipe which has the kind of

joint which will successfully resist root penetration. Generally speaking, the more watertight the joint, the greater the resistance to root penetration will be. Rubber-gasketed and compression-type joints are considered to give the best performance for this application.

When using plastic pipe in areas with contaminated soil or groundwater, consult with the manufacturer regarding permeation of pipe walls. When pipe is installed in contaminated soil or groundwater consult with the manufacturer regarding selection of appropriate gasket material based on type and concentration of contaminants and refer to AWWA C605.

Plastic pipe is subject to temperature limitations which must be observed.

Use caution if considering concrete pipe for septic flows. Depending on septicity, these pipes may not be satisfactory.

Give special attention in the design stage of project to plastic pipe materials, particularly with respect to superimposed external loads which could cause excessive deflection of the pipe. The degree of sidefill compaction should be considered realistically, particularly in marginal cases.

Where different classes, strengths, etc., of pipe are required for different sections of long pipelines due to significant differences in external loading, expand or modify the applicable paragraphs of this specification accordingly. Show the limits for each class, strength, etc., either on the project drawings or appropriately describe them in the applicable paragraph of the project specification.

Pipe joints: When more than one type of joint is applicable for the specified piping, permit each as a Contractor's option except where watertight joints are necessary or in areas where root penetration problems are anticipated. In these cases, rubber-gasketed or compression-type, or solvent-cemented joints are preferred. Use fuel resistant joint gaskets when required.

It may be necessary to modify chemical requirements for cement under certain conditions. Sulfate resistance is required for concrete pipe when pipe is carrying sulfate-bearing waters, or when pipe is buried in soil containing sulfates. Specify Type II (moderate sulfate resisting) cement when water-soluble sulfates (as S04) in the soil are in the range of 0.1 to 0.2 percent and, for water, are in the range of 150 to 1000 parts per million. Specify Type V (sulfate resisting) cement when soils contain in excess of 0.2 percent water-soluble

sulfate and water samples contain in excess of 1000 parts per million. In areas where reactive aggregates are known to occur, specify low alkali cement.

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1.1 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONCRETE PIPE ASSOCIATION (ACPA)

ACPA 01-102	(2000) Concrete Pipe Handbook
ACPA 01-103	(2000) Concrete Pipe Installation Manual

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION (AREMA)

AREMA Eng Man	(2017) Manual for Railway Engineering

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4	(2016) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C105/A21.5	(2010) Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	(2017) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115/A21.15	(2011) Flanged Ductile-Iron Pipe With

	Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C151/A21.51	(2017) Ductile-Iron Pipe, Centrifugally Cast
AWWA C153/A21.53	(2011) Ductile-Iron Compact Fittings for Water Service
AWWA C302	(2016) Reinforced Concrete Pressure Pipe, Noncylinder Type
AWWA C600	(2017) Installation of Ductile-Iron Mains and Their Appurtenances
AWWA C605	(2014) Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings
AWWA C606	(2015) Grooved and Shouldered Joints
AWWA C900	(2016) Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 In. Through 60 In. (100 mm Through 1,500 mm)
AWWA M9	(2008; Errata 2013) Manual: Concrete Pressure Pipe

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(2013) Pipe Threads, General Purpose (Inch)
ASME B1.20.2M	(2006; R 2011) Pipe Threads, 60 Deg. General Purpose (Metric)
ASME B16.1	(2015) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B18.2.2	(2015) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B18.5.2.1M	(2006; R 2011) Metric Round Head Short Square Neck Bolts
ASME B18.5.2.2M	(1982; R 2010) Metric Round Head Square Neck Bolts

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A307	(2014; E 2017) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A47/A47M	(1999; R 2014) Standard Specification for

	Ferritic Malleable Iron Castings
ASTM A48/A48M	(2003; R 2012) Standard Specification for Gray Iron Castings
ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM A563	(2015) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A563M	(2007; R 2013) Standard Specification for Carbon and Alloy Steel Nuts (Metric)
ASTM A746	(2009; R 2014) Standard Specification for Ductile Iron Gravity Sewer Pipe
ASTM C12	(2017) Standard Practice for Installing Vitrified Clay Pipe Lines
ASTM C1214	(2013) Standard Test Method for Concrete Pipe Sewerlines by Negative Air Pressure (Vacuum) Test Method
ASTM C1214M	(2013) Standard Test Method for Concrete Pipe Sewerlines by Negative Air Pressure (Vacuum) Test Method (Metric)
ASTM C1227	(2013) Standard Specification for Precast Concrete Septic Tanks
ASTM C1244	(2011; R 2017) Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill
ASTM C1244M	(2011; R 2017) Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill (Metric)
ASTM C14	(2015) Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe
ASTM C14M	(2014) Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe (Metric)
ASTM C150/C150M	(2018) Standard Specification for Portland Cement
ASTM C1644	(2006; R 2017) Standard Specification for Resilient Connectors Between Reinforced Concrete On-Site Wastewater Tanks and Pipes
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C270	(2014a) Standard Specification for Mortar

	for Unit Masonry
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C361	(2016) Standard Specification for Reinforced Concrete Low-Head Pressure Pipe
ASTM C361M	(2016) Standard Specification for Reinforced Concrete Low-Head Pressure Pipe (Metric)
ASTM C425	(2004; R 2013) Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings
ASTM C443	(2012; R 2017) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C443M	(2012; R 2017) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets (Metric)
ASTM C478	(2018) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM C478M	(2018) Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric)
ASTM C700	(2013) Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
ASTM C76	(2018) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C76M	(2018) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM C828	(2011) Low-Pressure Air Test of Vitrified Clay Pipe Lines
ASTM C923	(2008; R 2013; E 2016) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals
ASTM C923M	(2008b; R 2013) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals (Metric)
ASTM C94/C94M	(2017a) Standard Specification for Ready-Mixed Concrete

ASTM C969	(2017) Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
ASTM C969M	(2017) Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines (Metric)
ASTM C972	(2000; R 2011) Compression-Recovery of Tape Sealant
ASTM C990	(2009; R 2014) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C990M	(2009; R 2014) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants (Metric)
ASTM D1784	(2011) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2241	(2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2321	(2018) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D2412	(2011) Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASTM D2464	(2015) Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2466	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2467	(2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2996	(2017) Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced

	Thermosetting-Resin) Pipe
ASTM D2997	(2015) Centrifugally Cast "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D3034	(2016) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3139	(1998; R 2011) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3212	(2007; R 2013) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D3262	(2016) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe
ASTM D3350	(2012) Polyethylene Plastics Pipe and Fittings Materials
ASTM D3753	(2012; E 2013) Glass-Fiber-Reinforced Polyester Manholes and Wetwells
ASTM D3840	(2014) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Fittings for Nonpressure Applications
ASTM D4101	(2017) Standard Classification System and Basis for Specification for Polypropylene Injection and Extrusion Materials
ASTM D412	(2016) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D4161	(2014) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals
ASTM D624	(2000; R 2012) Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM F1417	(2011a) Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low Pressure Air
ASTM F2736	(2013; E 2014) Standard Specification for 6 to 30 in. (152 To 762 mm) Polypropylene (PP) Corrugated Single Wall Pipe And Double Wall Pipe
ASTM F2764/F2764M	(2017; E 2017) Standard Specification for

	6 to 60 in. [150 to 1500 mm] Polypropylene (PP) Corrugated Double and Triple Wall Pipe and Fittings for Non-Pressure Sanitary Sewer Applications
ASTM F477	(2014) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F667/F667M	(2016) Standard Specification for 3 through 24 in. Corrugated Polyethylene Pipe and Fittings
ASTM F714	(2013) Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
ASTM F758	(2014) Smooth-Wall Poly(Vinyl Chloride) (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage
ASTM F794	(2003; R 2014) Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
ASTM F894	(2013) Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
ASTM F949	(2015) Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings

INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS (IAPMO)

IAPMO Z1000	(2013) Prefabricated Septic Tanks

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.27	(N0v 2016) Scaffolds and Roope Descent Systems

UNI-BELL PVC PIPE ASSOCIATION (UBPPA)

UBPPA UNI-B-6	(1998) Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe

1.2 SUBMITTALS

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality,

with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" following a submittal item indicates that the submittal is required for the Sustainability eNotebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING. Locate the "S" submittal under the SD number that best describes the submittal item.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Contractor's License; G[, [_____]]

SD-02 Shop Drawings

Installation Drawings; G[, [_____]]

SD-03 Product Data

Precast Concrete Manholes

Frames, Covers, and Gratings

Gravity Pipe

Pressure Pipe

Precast Concrete Septic Tanks; G[, [_____]]

SD-06 Test Reports

Precast Concrete Sewer Manhole Test; G[, [_____]]

Hydrostatic Sewer Test; G[, [_____]]

Infiltration Tests And Exfiltration Tests; G[, [_____]]

Negative Air Pressure Test; G[, [_____]]

Low-Pressure Air Tests; G[, [_____]]

Tests For Pressure Lines; G[, [_____]]

Deflection Testing

Concrete Pipe Test; G[, [_____]]

SD-07 Certificates

Portland Cement

Gaskets

Pre-Installation Inspection Request; G

Post-Installation Inspection; G

1.3 QUALITY CONTROL

1.3.1 Installer Qualifications

Install specified materials by a licensed underground utility Contractor licensed for such work in the state where the work is to be performed. Verify installing Contractor's License is current and state certified or state registered.

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery and Storage

Check upon arrival; identify and segregate as to types, functions, and sizes. Store off the ground in a manner affording easy accessibility and not causing excessive rusting or coating with grease or other objectionable materials.

1.4.1.1 Piping

Inspect materials delivered to site for damage; store with minimum of handling. Store materials on site in enclosures or under protective coverings. Store plastic piping and jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes and fittings free of dirt and debris.

[1.4.1.2 Cement, Aggregate, and Reinforcement

****

NOTE: Delete this paragraphs if cast-in-place concrete is not used.

Select 03 30 00 for projects with large amounts of cast-in-place concrete work.

Select 03 30 53 for projects with small amounts of cast-in-place concrete work.

For Army, Use 03 30 00.00 10 in place of 03 30 00.

****

As specified in Section [03 30 00.00 10 CAST-IN-PLACE CONCRETE][03 30 00 CAST-IN-PLACE CONCRETE][03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE].

]1.4.2 Handling

Handle pipe, fittings, and other accessories in such manner as to ensure delivery to the trench in sound undamaged condition. [Take special care not to damage linings of pipe and fittings; if lining is damaged, make satisfactory repairs.] Carry, do not drag, pipe to trench. Store solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install the plastic pipe in accordance with the manufacturer's recommendation and discard those materials if the storage period exceeds the recommended shelf life. Discard solvents in use when the recommended pot life is exceeded.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Sanitary Sewer Gravity Pipeline

[Provide [mains and laterals] [[_____] mm inch lines] of [clay pipe] [concrete pipe] [ductile-iron pipe] [polypropylene pipe] [or] [polyvinyl chloride (PVC) plastic pipe]. Provide building connections [[_____] mm inch lines] of [clay pipe] [concrete pipe] [or] [polyvinyl chloride (PVC) plastic pipe].] [Provide new and modify existing exterior sanitary gravity sewer piping and appurtenances. Provide each system complete and ready for operation. The exterior sanitary gravity sewer system includes equipment, materials, installation, and workmanship as specified herein more than 1.5 m 5 feet outside of building walls.]

2.1.2 Sanitary Sewer Pressure Lines

Provide pressure lines of [ductile iron pressure pipe] [concrete pressure pipe] [or] [polyvinyl chloride (PVC) plastic pressure pipe].

2.2 MATERIALS

****

NOTE: Show the following information on the project drawings:

Location of all new pipelines, diameter of pipe, fittings and appurtenances including but not limited to valves, fire hydrants, yard hydrants, thrust blocks, restrained joints and details where

necessary;

Location, size, and type of service of existing connecting, intersecting, or adjacent pipelines and other utilities;

Paved areas and railroads which pass over new pipelines;

Profile, where necessary to show unusual conditions

Invert elevations at beginning and end of pipelines and at manholes or similar structures;

Where different materials are required, show the material, class or thickness of pipe and limits where class or thickness must be different for different sections of pipeline;

Details for manholes, septic tank(s), and sewage absorption trench;

Bedding conditions, where different from those specified in the appropriate specification ;

Location and size of thrust blocks on pressure lines

Location of flanged joints on pressure sewers;

Location of mechanical joints on ductile-iron piping (when used on only part of the system).

****

Provide materials conforming to the respective specifications and other requirements specified below. Submit manufacturer's product specification,standard drawings or catalog cuts.

2.2.1 Gravity Pipe

2.2.1.1 Clay Piping

2.2.1.1.1 Clay Pipe and Fittings

****

NOTE: Tables of trench loadings, trench backfill loads, and supporting strengths of clay pipe are included in the Vetrified Clay Pipe Engineering Manual (2015 edition) of the National Clay Pipe Institute. The required strength of clay pipe can be derived from these tables when depth of trench is known.

Specify "bell-and-spigot piping only" in areas where corrosion problems may be anticipated with the stainless steel parts of the couplings used for plain-end piping.

****

ASTM C700, [standard strength] [extra strength] [bell-and-spigot piping

only].

2.2.1.1.2 Clay Piping Jointing Materials

Use ASTM C425.

2.2.1.2 Concrete Gravity Sewer Piping

2.2.1.2.1 Concrete Gravity Pipe and Fittings

****

NOTE: The D-load (load per linear meter foot of diameter) must be calculated on the basis of project conditions to determine the applicable Class or strength of pipe. The Concrete Pipe Design Manual (2011 edition) of the American Concrete Pipe Association contains design information and methods by which the applicable Class or strength of pipe can be determined when depth of trench is known.

It may be necessary to modify chemical requirements for cement under certain conditions. Sulfate resistance is required for concrete pipe when pipe is carrying sulfate-bearing waters, or when pipe is buried in soil containing sulfates. Specify Type II (moderate sulfate resisting) cement when water-soluble sulfates (as S04) in the soil are in the range of 0.1 to 0.2 percent and, for water, are in the range of 150 to 1000 parts per million. Specify Type V (sulfate resisting) cement when soils contain in excess of 0.2 percent water-soluble sulfate and water samples contain in excess of 1000 parts per million. In areas where reactive aggregates are known to occur, specify low alkali cement.

Delete requirement for tongue-and-groove pipe (concrete pipe) when not allowed for the project.

****

Provide [nonreinforced concrete pipe conforming to ASTM C14M ASTM C14, Class [_____]][reinforced concrete pipe conforming to ASTM C76M ASTM C76, Class [_____]]. Provide circular pipe with elliptical reinforcement having a readily visible line at least 300 mm 12 inches long painted or otherwise applied on the inside and outside of the pipe at each end so that when the pipe is laid in the proper position, the line will be at the center of the top of the pipe. Provide fittings and specials conforming to the applicable requirements specified for the pipe including the strength of the pipe. [Use pipe and fittings containing [Type II] [Type V] [low alkali cement] cement conforming to ASTM C150/C150M.]

2.2.1.2.2 Jointing Materials for Concrete Gravity Piping

Provide gaskets and pipe ends for rubber gasket joint conforming to ASTM C443M ASTM C443. Use gaskets suitable for use with sewage.

Submit certificates of compliance stating that the fittings or gaskets used for waste drains or lines designated on the plans as [_____] are [oil] [_____] resistant.

2.2.1.3 Ductile Iron Gravity Sewer Pipe and Associated Fittings

2.2.1.3.1 Ductile Iron Gravity Pipe and Fittings

****

NOTE: ASTM A746 also contains design information and methods by which the required Thickness Class of Pipe can be determined when depth of trench is known.

Delete requirements for and references to push-on joints for ductile-iron gravity sewer pipe and associated fittings when the greater deflection afforded by the mechanical joint is considered necessary throughout.

****

Provide ductile iron pipe conforming to ASTM A746 with cement-mortar lining in conforming to AWWA C104/A21.4, Pressure Class [_____]. Provide push-on joints conforming to AWWA C111/A21.11.

2.2.1.4 PVC Gravity Sewer Piping

2.2.1.4.1 PVC Gravity Pipe and Fittings

[ASTM D3034, SDR 35, or ASTM F949 with ends suitable for elastomeric gasket joints.] [ASTM F794, Series 46, for ribbed sewer pipe with smooth interior, size 200 mm 8 inch through 1200 mm 48 inch diameters.]

2.2.1.4.2 PVC Gravity Joints and Jointing Material

Provide joints conforming to ASTM D3212. Gaskets are to conform to ASTM F477.

2.2.2 Pressure Pipe

2.2.2.1 Concrete Pressure Piping

2.2.2.1.1 Concrete Pressure Pipe and Fittings

****

NOTE: Delete reference to AWWA C302 within brackets when pressure rating greater than 310 kPa 45 psi is required.

It may be necessary to modify chemical requirements for cement under certain conditions. Sulfate resistance is required for concrete pipe when pipe is carrying sulfate-bearing waters, or when pipe is buried in soil containing sulfates. Specify Type II (moderate sulfate resisting) cement when water-soluble sulfates (as S04) in the soil are in the range of 0.1 to 0.2 percent and, for water, are in the range of 150 to 1000 parts per million. Specify Type V (sulfate resisting) cement when soils contain in excess of 0.2 percent water-soluble sulfate and water samples contain in excess of 1000 parts per million. In areas where reactive aggregates are known to occur, specify low alkali

cement.

For concrete pressure piping, ASTM C361M C361 covers pipe for up to 37.5 m 125 feet of hydrostatic head, approximately 379 kPa 55 psi; AWWA C302 covers pipe and fittings for 310 kPa 45 psi pressure rating, 30 m 100 feet of hydro-static head) only. ASTM C361M ASTM C361 contains tables giving design requirements for pipe in all combinations of 30 and 37.5 m 100 and 125 feet of hydrostatic head with 1.5, 3.0, 4.5, 6.0 m 5, 10, 15, and 20 feet of earth cover. Where higher pressure ratings are necessary, piping conforming to AWWA C300, C301, or C303 should be specified.

****

Provide pipe conforming to [AWWA C302 or to] ASTM C361M ASTM C361. Design pipe for hydrostatic head of [30] [38] m [100] [125] feet and external loading of [1.5] [3.0] [4.5] [6.0] m [5] [10] [15] [20] feet of earth cover. Provide circular pipe with elliptical reinforcement having a readily visible line at least 300 mm 12 inches long painted or otherwise applied on the inside and outside of the pipe at each end so that when the pipe is laid in the proper position, the line will be at the center of the top of the pipe. [Use [Type II] [Type V] [low alkali] cement conforming to AWWA C302 in manufacturing pipe and fittings] Provide fittings.

2.2.2.1.2 Jointing Materials for Concrete Pressure Piping

****

NOTE: Use first bracketed wording when pressure rating greater than 310 kPa 45 psi is not required. Use second bracketed wording when pressure rating greater than 310 kPa 45 psi is required.

****

Provide gaskets as specified in [the referenced specification for the pipe] [ASTM C361M ASTM C361] and are suitable for use with sewage.

2.2.2.2 Ductile Iron Pressure Piping

****

NOTE: Ductile iron pipe is used for sizes 75 mm 3 inches to 1600 mm 64 inches.

****

2.2.2.2.1 Ductile Iron Pressure Pipe and Fittings

Provide [push-on-joint] [mechanical joint] [flanged] ductile-iron pipe conforming to AWWA C151/A21.51, [Pressure Class [_____]] [Thickness Class [_____]]. Provide fittings conforming to AWWA C110/A21.10 or AWWA C153/A21.53. [Provide fittings with push-on joint ends conforming to AWWA C111/A21.11.] Use fittings which have a pressure rating at least equivalent to that of the pipe. Pipe and fittings are to have cement-mortar lining conforming to AWWA C104/A21.4, standard thickness.

2.2.2.2.2 Ductile Iron Pressure Joints and Jointing Materials

a. Joints, general: Use [push-on joints] [or] [mechanical joints] for pipe and fittings except as otherwise specified in this paragraph. [Use

mechanical-joints where indicated.] [Use flanged joints where indicated.] [Joints made with sleeve-type mechanical coupling may be used in lieu of push-on joint.] [[Grooved] [or] [shouldered] type joints may be used in lieu of push-on joint [or flanged joint], except where joint is buried.]

b. Push-on joints: Shape of pipe ends and fitting ends, gaskets, and lubricant for joint assembly are to conform to AWWA C111/A21.11.

c. Mechanical joints: Dimensional and material requirements for pipe ends, glands, bolts and nuts, and gaskets are to conform to AWWA C111/A21.11.

d. Flanged joints: Provide bolts, nuts, and gaskets for flanged connections as recommended in the Appendix to AWWA C115/A21.15. Provide flange for setscrewed flanges of ductile iron, ASTM A536, Grade 65-45-12, and conforming to the applicable requirements of ASME B16.1, Class 250. Provide 190,000 psi tensile strength, heat treated, and zinc-coated steel setscrews for setscrewed flanges. Conform gasket for setscrewed flanges to the applicable requirements for mechanical-joint gaskets specified in AWWA C111/A21.11. Design of setscrewed gasket are to provide for confinement and compression of gasket when joint to adjoining flange is made.

****

NOTE: At the text below, delete "or steel" when middle ring of cast iron only is considered necessary due to anticipated corrosion problems. Delete requirement for strength of steel when steel is not allowed as a material for middle ring.

At the text below, minimum numbers of bolts for each pipe size should be as follows:

75 mm 3 inch	3
100 mm 4 inch	4
150 mm 6 inch	5
200 mm 8 inch	6
250 mm 10 inch	7
300 and 350 mm 12 and 14 inch	8
400 mm 16 inch	9
450 mm 18 inch	10
500 mm 20 inch	12
550 mm 22 inch	13

600 mm 24 inch	**14**

****

e. Joints made with sleeve-type mechanical couplings: Provide couplings designed to couple plain-end piping by compression of a ring gasket at each end of the adjoining pipe sections. Provide couplings consisting of one middle ring flared or beveled at each end to provide a gasket seat, two follower rings, two resilient tapered rubber gaskets, and bolts and nuts to draw the follower rings toward each other to compress the gaskets. The middle ring and the follower rings are to be true circular sections free from irregularities, flat spots, and surface defects; the design is to provide for confinement and compression of the gaskets. The middle ring is to be of cast-iron [or steel], and the follower rings are to be of malleable iron or ductile iron. Cast iron couplings are to conform to ASTM A48/A48M and not be less than Class 25. Malleable iron couplings are to conform to ASTM A47/A47M. Ductile iron couplings are to conform to ASTM A536. [Steel is to have a strength not less than that of the pipe.] Gaskets are to be designed for long life and resistance to set after installation and meet the applicable requirements specified for gaskets for mechanical joint in AWWA C111/A21.11. Bolts are to be track-head type; bolts and nuts are to be either of the following: bolts conforming to the tensile requirements of ASTM A307, Grade A, with nuts conforming to the tensile requirements of ASTM A563M ASTM A563, Grade A; or round-head square-neck type bolts conforming to ASME B18.5.2.1M and ASME B18.5.2.2M with hex nuts conforming to ASME B18.2.2. Bolts are to be 16 mm 5/8 inch in diameter; minimum number of bolts for each coupling are to be [_____] [for [_____] mm inch pipe [,[_____] for [_____] mm inch pipe,] and [_____] for [_____] mm inch pipe]. Bolt holes in follower rings are to be of a shape to hold fast the necks of the bolts used. Sleeve-type mechanical couplings are not to be used as an optional method of jointing except where pipeline is adequately anchored to resist tension pull across the joint.

f. [Grooved] [and] [Shouldered] Type Joints: [Grooved pipe ends] [Shouldered pipe ends] and couplings are to conform to AWWA C606. Joint dimensions are to be as specified in AWWA C606 for rigid joints.

2.2.2.3 PVC Pressure Pipe and Associated Fittings

Pipe, couplings and fittings are to be manufactured of materials conforming to ASTM D1784, Class 12454B.

2.2.2.3.1 Pipe and Fittings Less Than 100 mm 4 inch Diameter

2.2.2.3.1.1 Screw-Joint

Provide pipe conforming to dimensional requirements of ASTM D1785, Schedule 80, with joints meeting requirements of 1.03 Mpa 150 psi working pressure, 1.38 Mpa 200 psi hydrostatic test pressure, unless otherwise shown or specified. Provide fittings for threaded pipe conforming to requirements of ASTM D2464, threaded to conform to the requirements of ASME B1.20.2MASME B1.20.1 for use with Schedule 80 pipe and fittings. Pipe couplings when used, are to be tested as required by ASTM D2464.

2.2.2.3.1.2 Push-On Joint

****

NOTE: Use AWWA C110/A21.10 or AWWA C153/A21.53 and AWWA C111/A21.11, for joints on 3 inch or larger piping.

****

ASTM D3139, with ASTM F477 gaskets.[Fittings for push-on joints are to be iron conforming to AWWA C110/A21.10 or AWWA C153/A21.53 and AWWA C111/A21.11 with a cement-mortar lining conforming to AWWA C104/A21.4, standard thickness.]

2.2.2.3.1.3 Solvent Cement Joint

Provide pipe conforming to dimensional requirements of ASTM D1785 or ASTM D2241 with joints meeting the requirements of 1.03 Mpa 150 psi working pressure and 1.38 Mpa 200 psi hydrostatic test pressure. Fittings for solvent cement jointing are to conform to ASTM D2466 or ASTM D2467.

2.2.2.3.2 Pipe and Fittings 100 mm 4 inch Diameter And Larger

Provide pipe conforming to AWWA C900 and be plain end or gasket bell end, Pressure Class [150 (DR 18)] [ ], with cast-iron-pipe-equivalent OD. Fittings are to be gray-iron or ductile-iron conforming to AWWA C110/A21.10 or AWWA C153/A21.53 and AWWA C111/A21.11 with a cement-mortar lining conforming to AWWA C104/A21.4, standard thickness. Fittings for pipe to pipe push-on joint ends are to conform with AWWA C900.

2.2.2.4 High Density Polyethylene Pipe (HDPE)

ASTM F894, Class 63, size 450 mm 18 inch through 3000 mm 120 inch. ASTM F714, size 100 mm 4 inch through 1200 mm 48 inch, will have pipe stiffness greater than or equal to 1170/D for cohesionless material pipe trench backfills. For all PE pipes, the polyethylene are to be certified by the resin producer as meeting the requirements of ASTM D3350, cell Class 334433C or higher. Fittings for High Density Polyethylene Pipe are to meet the same material specifications as the pipe class. Joints for HDPE meeting ASTM F894 will be rubber gasket joints conforming to ASTM F477. HDPE meeting ASTM F714 will have fused joints in accordance with manufacturer's instruction.

2.2.2.5 Reinforced Plastic Mortar Pipe (RPMP)

Reinforced plastic mortar pipe are to be produced be in accordance with ASTM D3262 and have an outside diameter equal to ductile iron pipe dimensions from 450 mm 18 inch to 1200 mm 48 inch. The inner surface of the pipe is to have a smooth uniform continuous resin-rich surface liner. The minimum pipe stiffness is to be 248 kPa 36 psi. RPMP is to be in accordance with ASTM D3262. Fittings for RPMP: ASTM D3840. Joints for RPMP: Bell and spigot gasket coupling utilizing an elastomeric gasket in accordance with ASTM D4161 and ASTM F477.

2.2.2.6 Reinforced Thermosetting Resin Pipe (RTRP)

RTRP pipe: ASTM D3262. Fittings for RTRP: ASTM D3262. Joints for RTRP: Bell and spigot type utilizing an elastomeric gasket in accordance with ASTM F477.

2.2.2.6.1 Filament Wound RTRP-I

RTRP-I is to conform to ASTM D2996, except pipe is to have an outside diameter equal to cast iron outside diameter or standard weight steel pipe. The pipe is to be suitable for a normal working pressure of 1.03 MPa 150 psi at 22.8 degrees C 73 degrees F. The inner surface of the pipe is to have a smooth uniform continuous resin-rich surface liner conforming to ASTM D2996.

2.2.2.6.2 Centrifugally Cast RTRP-II

RTRP-II is to conform to ASTM D2997. Pipe is to have an outside diameter equal to standard weight steel pipe.

2.2.2.7 Dual Wall and Triple Wall Polypropylene

Provide 300 to 750 mm12 to 30 inch polypropylene pipe having a smooth interior and annular exterior corrugations, in compliance with ASTM F2736. Provide 750 to 1500 mm30 to 60 inch polypropylene pipe having a smooth interior and exterior surfaces with annular inner corrugations, in compliance with ASTM F2764/F2764M. Pipe is suitable for gravity flow only and is to have a minimum pipe stiffness of 46 psi when tested in accordance with ASTM D2412. Pipe sizes 300 to 1500 mm 12- through 60-inch diameters are to have a reinforced bell, manufacturer's pre-installed polymer composite band or a manufacturer's compatible pipe polymer composite band.

2.2.3 Piping Beneath Railroad Right-of-Way

Where pipeline passes under the right-of-way of a commercial railroad, piping is to conform to the specifications for pipelines conveying nonflammable substances in AREMA Eng Man, except as otherwise specified in this paragraph. For casing pipe provide ductile-iron pipe in lieu of cast-iron soil pipe. Ductile-iron pipe is to conform to and have strength computed in accordance with ASTM A746.

2.2.4 Cement Mortar

Provide cement mortar conforming to ASTM C270, Type M with Type II cement.

2.2.5 Portland Cement

****

NOTE: Type II cement normally will be specified, but Type V cement will be specified when the soils contain in excess of 0.2 percent water-soluble sulfate as SO(4), or the waste water contains in excess of 1000 parts per million sulfates. Type I cement may be permitted when it can be assured that the water soluble sulfates in the soil will be less than 0.1 percent and the waste water will contain less than 150 parts per million sulfates over the design life of the project.

****

Submit certificates of compliance stating the type of cement used in manufacture of concrete pipe, fittings, septic tanks, and precast manholes. Provide portland cement conforming to ASTM C150/C150M, Type [II] [V] for concrete used in concrete pipe, concrete pipe fittings, septic tanks, and manholes and type optional for cement used in concrete cradle,

concrete encasement, and thrust blocking. [Use air-entraining admixture conforming to ASTM C260/C260M with Type V cement.] [,Use a cement containing less than 0.60 percent alkalies where aggregates are alkali reactive, as determined by Appendix XI of ASTM C33/C33M.]

2.2.6 Portland Cement Concrete

****

NOTE: When ready-mix concrete conforming to ASTM C94/C94M is not economically available, rewrite this paragraph to permit use of concrete mixed onsite. Specify concrete aggregates conforming to ASTM C33/C33M and concrete consisting of 1 part portland cement, 2-1/2 parts sand, and 5 parts gravel, with just enough water for workable consistency

****

Provide portland cement concrete conforming to ASTM C94/C94M, compressive strength of 28 MPa 4000 psi at 28 days, except for concrete cradle and encasement or concrete blocks for manholes. Concrete used for cradle and encasement is to have a compressive strength of 17 MPa 2500 psi minimum at 28 days. Protect concrete in place from freezing and moisture loss for 7 days.

2.2.7 Precast Concrete Manholes

Provide precast concrete manholes, risers, base sections, and tops conforming to ASTM C478M ASTM C478[and be manufactured in accordance with Section 03 42 13.00 10 PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION; base and first riser are to be monolithic].

2.2.8 Glass-Fiber-Reinforced Polyester Manholes

Glass-Fiber-Reinforced Polyester Manholes are to conform to ASTM D3753.

2.2.9 Gaskets and Connectors

Provide gaskets for joints between [manhole] [wastewater tanks]sections conforming to ASTM C443M ASTM C443. Resilient connectors for making joints between [manhole] [wastewater tanks] and pipes entering manhole are to conform to ASTM C923M[ASTM C1644] [ASTM C923 or ASTM C990M ASTM C990].

2.2.10 External Preformed Rubber Joint Seals

An external preformed rubber joint seal is an accepted method of sealing cast iron covers to precast concrete sections to prevent ground water infiltration into sewer systems. All finished and sealed manholes constructed in accordance with paragraph entitled "Manhole Construction" are to be tested for leakage in the same manner as pipelines as described in paragraph entitled "Leakage Tests." The seal is to be multi-section with a neoprene rubber top section and all lower sections made of Ethylene Propylene Diene Monomer (EPDM) rubber with a minimum thickness of 1.5 mm 60 mils. Each unit is to consist of a top and bottom section and have mastic on the bottom of the bottom section and mastic on the top and bottom of the top section. The mastic is to be a non-hardening butyl rubber sealant and seal to the cone/top slab of the manhole/catch basin and over the lip of the casting. Extension sections are to cover up to two more adjusting rings. Properties and values are listed in the following table:

Properties, Test Methods and Minimum Values for Rubber used in Preformed Joint Seals				
Physical Properties	Test Methods	EPDM	Neoprene	Butyl Mastic
Tensile, kPa psi	ASTM D412	12,6841840	15,1322195	--
Elongation, percent	ASTM D412	553	295	350
Tear Resistance, N/mm ppi	ASTM D624 (Die B)	49280	29160	--
Rebound, percent, 5 minutes	ASTM C972 (mod.)	--	--	11
Rebound, percent, 2 hours	ASTM C972	--	--	12

[2.2.11 Precast Concrete Septic Tanks

Provide precast concrete septic tanks risers, base sections, and tops conforming to ASTM C478MASTM C1227 and be manufactured in accordance with Section 03 42 13.00 10 PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION; base and first riser are to be monolithic.

][2.2.12 Glass-Fiber-Reinforced Polyester Septic Tanks

Glass-Fiber-Reinforced Polyester Septic Tanks are to conform to IAPMO Z1000.

]2.2.13 Septic Tank Piping

PVC pipe and fittings. [Provide NSF/ANSI 46 certified effluent filter on the outlet pipe.]

2.2.14 Siphon for Septic Tank

PVC or Polyethylene,of an approved standard design, and prompt and positive in action.

2.2.15 Sewage Absorption Field Materials

[Pipe is to be perforated corrugated polyethylene tubing conforming to ASTM F667/F667M.] [Pipe is to be perforated PVC pipe conforming to ASTM F758.] [Chambers are to be high density polyethylene conforming to IAPMO PS 63]

2.2.16 Frames, Covers, and Gratings for Manholes

[Submit certification on the ability of frame and cover to carry the imposed live load.] Frame and cover are to be cast gray iron, ASTM A48/A48M, Class 35B, cast ductile iron, ASTM A536, Grade 65-45-12, or reinforced concrete, ASTM C478 ASTM C478M. Frames and covers are to be circular [with] [without] vent holes. Size are to be [as indicated on the plans] [for 24 inch opening]. Stamp or cast the words "Sanitary Sewer" into covers so that it is plainly visible.

2.2.17 Manhole Steps

[Zinc-coated steel] [as indicated] conforming to 29 CFR 1910.27 [with a plastic or rubber coating pressure-molded to the steel is to be used. Provide plastic coating conforming to ASTM D4101, copolymer polypropylene. Rubber is to conform to ASTM C443M ASTM C443, except shore A durometer hardness is to be 70 plus or minus 5.] Aluminum steps or rungs will not be permitted. Steps are not required in manholes less than 1.2 m 4 feet deep.

2.2.18 Manhole Ladders

Provide a steel ladder where the depth of a manhole exceeds 3.6 m 12 feet. The ladder is not to be less than 406 mm 16 inches in width, with 19 mm 3/4 inch diameter rungs spaced 305 mm 12 inches apart. The two stringers are to be a minimum 10 mm 3/8 inch thick and 51 mm 2 inches wide. Galvanize ladders and inserts after fabrication in conformance with ASTM A123/A123M.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Installation Drawings

Submit Installation Drawings showing complete detail, both plan and side view details with proper layout and elevations.

3.2 INSTALLATION

Backfill after inspection by the Contracting Officer. Before, during, and after installation, protect plastic pipe and fittings from any environment that would result in damage or deterioration to the material. Keep a copy of the manufacturer's instructions available at the construction site at all times and follow these instructions unless directed otherwise by the Contracting Officer.

3.2.1 Connections to Existing Lines

****

NOTE: For Navy, Use BMS B-5.2.19 to determine Installation requirements for connecting to existing sanitary sewer lines and incorporate into this paragraph. In accordance with BMS B-5.2.19 a Utility Connection Permit must be submitted during design.

****

Obtain approval from the Contracting Officer before making connection to existing line. Conduct work so that there is minimum interruption of service on existing line.

3.2.2 General Requirements for Installation of Pipelines

These general requirements apply except where specific exception is made in the following paragraphs entitled "Special Requirements."

3.2.2.1 Location

****

NOTE: Horizontal and vertical separation distances

must be in accordance with the Recommended Standards for Wastewater Facilities, State or local requirements.

****

Terminate the work covered by this section at a point approximately 1.5 m 5 feet from the building[, unless otherwise indicated]. Install pressure sewer lines beneath water lines only, with the top of the sewer line being at least 0.60 m 2 feet below bottom of water line. When these separation distances can not be met, contact the Contracting Officer for direction.

3.2.2.1.1 Sanitary Piping Installation Parallel with Water Line

3.2.2.1.1.1 Normal Conditions

Install sanitary piping or manholes at least 3 m 10 feet horizontally from a water line whenever possible. Measure the distance from edge-to-edge.

3.2.2.1.1.2 Unusual Conditions

When local conditions prevent a horizontal separation of 3 m 10 feet, the sanitary piping or manhole may be laid closer to a water line provided that:

a. The top (crown) of the sanitary piping is to be at least 450 mm 18 inches below the bottom (invert) of the water main.

b. Where this vertical separation cannot be obtained, construct the sanitary piping with AWWA-approved ductile iron water pipe pressure and conduct a hydrostatic sewer testwithout leakage prior to backfilling.

c. The sewer manhole is to be of watertight construction and tested in place.

3.2.2.1.2 Installation of Sanitary Piping Crossing a Water Line

3.2.2.1.2.1 Normal Conditions

Lay sanitary sewer piping by crossing under water lines to provide a separation of at least 450 mm 18 inches between the top of the sanitary piping and the bottom of the water line whenever possible.

3.2.2.1.2.2 Unusual Conditions

When local conditions prevent a vertical separation described above, use the following construction:

a. Construct sanitary piping passing over or under water lines with AWWA-approved ductile iron water pressure piping and conduct a hydrostatic sewer testwithout leakage prior to backfilling.

b. Protect sanitary piping passing over water lines by providing:

(1) A vertical separation of at least 450 mm 18 inches between the bottom of the sanitary piping and the top of the water line.

(2) Adequate structural support for the sanitary piping to prevent excessive deflection of the joints and the settling on and breaking of the water line.

(3) That the length, minimum 6.1 m 20 feet, of the sanitary piping be centered at the point of the crossing so that joints are equidistant and as far as possible from the water line.

3.2.2.1.3 Sanitary Sewer Manholes

No water piping shall pass through or come in contact with any part of a sanitary sewer manhole.

3.2.2.2 Earthwork

****
NOTE: Earthwork requirements, including bedding, for pipe trenches and utility structures are covered in Section 31 00 00 EARTHWORK.
****

****
NOTE: For Navy, earthwork requirements or pipe trenches, including bedding, are covered in Section 31 23 00.00 20 EXCAVATION AND FILL. The applicable requirements which are set forth in Section 31 23 00.00 20 EXCAVATION AND FILL must be incorporated into the project specification. The specifier should verify the current appropriate specification and revise as necessary.
****

Perform earthwork operations in accordance with Section 31 00 00 EARTHWORK 31 23 00.00 20 EXCAVATION AND FILL.

3.2.2.3 Pipe Laying and Jointing

Inspect each pipe and fitting before and after installation; replace those found defective and remove from site. Provide proper facilities for lowering sections of pipe into trenches. Lay nonpressure pipe with the bell [or groove] ends in the upgrade direction. Adjust spigots in bells [and tongues in grooves] to give a uniform space all around. Blocking or wedging between bells and spigots [or tongues and grooves] will not be permitted. Replace by one of the proper dimensions, pipe or fittings that do not allow sufficient space for installation of joint material. At the end of each work day, close open ends of pipe temporarily with wood blocks or bulkheads. Provide batterboards not more than 7.50 m 25 feet apart in trenches for checking and ensuring that pipe invert elevations are as indicated. Laser beam method may be used in lieu of batterboards for the same purpose. Construct branch connections by use of regular fittings or solvent cemented saddles as approved. Provide saddles for PVC pipe conforming to Table 4 of ASTM D3034.

3.2.3 Special Requirements

3.2.3.1 Installation of Clay Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the requirements of ASTM C12 for pipe laying. Make joints with a compression joint material specified for clay pipe joints and assemble in accordance with the recommendations of the manufacturer of the pipe.

3.2.3.2 Installation of Concrete Gravity Sewer Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the provisions for rubber gasket jointing and jointing procedures of ACPA 01-103 or of ACPA 01-102, Chapter 9, "Installation, Inspection and Construction Testing." Make joints with the gaskets specified for concrete gravity sewer pipe joints. Clean and dry surfaces receiving lubricants, cements, or adhesives. Affix gaskets to pipe not more than 24 hours prior to the installation of the pipe. Protect gaskets from sun, blowing dust, and other deleterious agents at all times. Before installation of the pipe, inspect gaskets and remove and replace loose or improperly affixed gaskets. Align each pipe section with the previously installed pipe section, and pull the joint together. If, while pulling the joint, the gasket becomes loose and can be seen through the exterior joint recess when the pipe is pulled up to within 25 mm 1 inch of closure, remove the pipe and remake the joint.

3.2.3.3 Installation of Concrete Pressure Lines

Unless otherwise specified, install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the laying and joining requirements specified in the guide specifications for installation of pipe given in AWWA M9, Chapter 14, "Guide Specifications for Installation of Pipe."

3.2.3.3.1 Joints

Make joints with the gaskets specified for concrete pressure pipe joints, using an approved lubricant recommended by the pipe manufacturer. Assemble these joints in accordance with the joining requirements specified in the guide specifications for installation of pipe given in AWWA M9, Chapter 14, "Guide Specifications for Installation of Pipe," and with the recommendations given for laying the pipe in AWWA M9, Chapter 6, "Installation by Trenching or Tunneling -- Methods and Equipment."

3.2.3.3.2 Pipe Anchorage

Provide concrete thrust blocks (reaction backing) for pipe anchorage. Size and position thrust blocks as indicated. Use concrete conforming to ASTM C94/C94M having a minimum compressive strength of 13.80 MPa 2,000 psi at 28 days; or use concrete of a mix not leaner than one part cement 2 1/2 parts sand, and 5 parts gravel, having the same minimum compressive strength.

3.2.3.4 Installation of Ductile Iron Gravity Sewer Pipe

Unless otherwise specified, install pipe and associated fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the requirements of AWWA C600 for pipe installation and joint assembly.

****

NOTE: At the text below, delete requirements for and references to push-on joints for ductile-iron gravity sewer pipe and associated fittings when the greater deflection afforded by the mechanical joint is considered necessary throughout.

****

a. [Make push-on joints with the gaskets and lubricant specified for this type joint and assemble in accordance with the applicable requirements of AWWA C600 for joint assembly.] Make mechanical-joints with the gaskets, glands, bolts, and nuts specified for this type joint and assemble in accordance with the applicable requirements of AWWA C600 for joint assembly and the recommendations of Appendix A to AWWA C111/A21.11.

****

NOTE: At the text below, delete the paragraph except when required. See AWWA C105/A21.5 for guidance on selecting Class of polyethylene film.

****

b. Exterior protection: Completely encase buried ductile iron pipelines with polyethylene tube or sheet in accordance with AWWA C105/A21.5, using [Class A] [Class C] polyethylene film.

3.2.3.5 Installation of Ductile-Iron Pressure Lines

Unless otherwise specified, install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the requirements of AWWA C600 for pipe installation, joint assembly, and valve-and-fitting installation.

a. [Make push-on joints with the gaskets and lubricant specified for this type joint and assemble in accordance with the applicable requirements of AWWA C600 for joint assembly.] Make mechanical-joints with the gaskets, glands, bolts, and nuts specified for this type joint; assemble in accordance with the applicable requirements of AWWA C600 for joint assembly and the recommendations of Appendix A to AWWA C111/A21.11. [Make flanged joints with gaskets, bolts, and nuts specified for this type joint. Make flanged joints up tight, taking care to avoid undue strain on flanges, fittings, and other accessories. Align bolt holes for each flanged joint. Use full size bolts for the bolt holes; use of undersized bolts to make up for misalignment of bolt holes or for any other purpose will not be permitted. Do not allow adjoining flange faces to be out of parallel to such degree that the flanged joint cannot be made watertight without overstraining the flange. When flanged pipe or fittings have dimensions that do not allow the making of a proper flanged joint as specified, replace it by one of proper dimensions.] [Assemble joints made with sleeve-type mechanical couplings in accordance with the recommendations of the coupling manufacturer, as approved.] [Make [grooved] [and] [shouldered] type joints with the couplings previously specified for this type joint connecting pipe with the [grooved] [or] [shouldered] ends specified for this type joint and assemble in accordance with the recommendations of the coupling manufacturer, as approved. [Groove pipe in the field only with approved groove cutting equipment designed especially for the purpose and produced by a manufacturer of grooved joint couplings; secure approval for field-cut grooves before assembling the joint.]]

****

NOTE: Delete the text below except when required. See Foreword to AWWA C105/A21.5 for guidance on selecting Class of polyethylene film.

****

b. Exterior protection: Completely encase buried ductile iron pipelines with polyethylene tube or sheet in accordance with AWWA C105/A21.5, using [Class A] [Class C] polyethylene film.

c. Pipe anchorage: Provide concrete thrust blocks (reaction backing) for pipe anchorage. Size and position thrust blocks as indicated. Use concrete conforming to ASTM C94/C94M having a minimum compressive strength of 13.80 MPa 2,000 psi at 28 days; or use concrete of a mix not leaner than one part cement, 2 1/2 parts sand, and 5 parts gravel, having the same minimum compressive strength.

3.2.3.6 Installation of PVC Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the requirements of ASTM D2321 for laying and joining pipe and fittings. Make joints with the gaskets specified for joints with this piping and assemble in accordance with the requirements of ASTM D2321 for assembly of joints. Make joints to other pipe materials in accordance with the recommendations of the plastic pipe manufacturer.

3.2.3.7 Installation of PVC Pressure Pipe

Unless otherwise specified, install pipe and fittings in accordance with AWWA C605. AWWA C605 includes requirements such as excavation, installation, and placement of apputenances.

3.2.3.7.1 Pipe Less Than 100 mm 4 Inch Diameter

3.2.3.7.1.1 Threaded Joints

Make by wrapping the male threads with joint tape or by applying an approved thread lubricant, then threading the joining members together. Tighten the joints with strap wrenches which will not damage the pipe and fittings. Tighten the joint no more than 2 threads past hand-tight.

3.2.3.7.1.2 Push-On Joints

Bevel the ends of pipe for push-on joints to facilitate assembly. Mark pipe to indicate when the pipe is fully seated. Lubricate the gasket to prevent displacement. Exercise care to ensure that the gasket remains in proper position in the bell or coupling while making the joint.

3.2.3.7.1.3 Solvent-Weld Joints

Comply with the manufacturer's instructions.

3.2.3.7.2 Pipe 100 mm 4 inch Diameter And Larger

Make push-on joints with AWWA C900 pipe with intrgral elastomeric gasket . For pipe-to-pipe push-on joint connections, use only pipe with push-on joint ends having factory-made bevel. For push-on joint connections to fittings, use cut spigot end of pipe off square, marked to match the manufacturer's insertion line and beveled to match factory supplied bevel. . Use an approved lubricant recommended by the pipe manufacturer for push-on joints. Assemble push-on joints for pipe-to-pipe joint connections in accordance with the requirements of AWWA C605. Assemble push-on joints for connection to fittings in accordance with the requirements of AWWA C605 for

joining PVC pipe to fittings and accessories and with the applicable requirements of AWWA C600 for joint assembly. Make mechanical-joints or flanged jointswith the gaskets, glands, bolts, nuts, and internal stiffeners specified for this type joint and assemble in accordance with the requirements of AWWA C605 for joining PVC pipe to fittings and accessories or with the applicable requirements of AWWA C600 for ductile iron joint assembly, and with the recommendations of Appendix A to AWWA C111/A21.11. Cut off spigot end of pipe for mechanical-joint or flanged jointconnections and do not bevel.

3.2.3.7.3 Pipe Anchorage

Provide concrete thrust blocks (reaction backing) for pipe anchorage. Size and position thrust blocks as indicated. Use concrete conforming to ASTM C94/C94M having a minimum compressive strength of 13.80 MPa 2,000 psi at 28 days; or use concrete of a mix not leaner than one part cement, 2 1/2 parts sand, and 5 parts gravel, having the same minimum compressive strength.

3.2.3.8 Installation of Dual Wall and Triple Wall Polypropylene

Install pipe in accordance with "General Requirements for installation of Pipelines" of this section, with the polypropylene pipe manufacturer's recommendations, and with the requirements of ASTM D2321 for laying and joining pipe and fittings. Place a minimum of 150 mm 6 inches of Class 1 or Class 2 backfill over the crown of the pipe with minimum 90 percent compaction.

3.2.3.9 Pipeline Installation Beneath Railroad Right-of-Way

Where pipeline passes under the right-of-way of a commercial railroad, install piping in accordance with the specifications for pipelines conveying nonflammable substances in AREMA Eng Man.

3.2.4 Concrete Work

****

NOTE: Delete this paragraphs if cast-in-place concrete is not used.

Select 03 30 00 for projects with large amounts of cast-in-place concrete work.

Select 03 30 53 for projects with small amounts of cast-in-place concrete work.

For Army, Use 03 30 00.00 10 in place of 03 30 00.

****

Cast-in-place concrete is included in Section [03 30 00.00 10 CAST-IN-PLACE CONCRETE] [03 30 00 CAST-IN-PLACE CONCRETE] [03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE]. Support the pipe on a concrete cradle, or encased in concrete where indicated or directed.

3.2.5 Manhole Construction

Construct base slab of cast-in-place concrete or use precast concrete base sections. Make inverts in cast-in-place concrete and precast concrete bases with a smooth-surfaced semi-circular bottom conforming to the inside

contour of the adjacent sewer sections. For changes in direction of the sewer and entering branches into the manhole, make a circular curve in the manhole invert of as large a radius as manhole size will permit. For cast-in-place concrete construction, either pour bottom slabs and walls integrally or key and bond walls to bottom slab. No parging will be permitted on interior manhole walls. For precast concrete construction, make joints between manhole sections with the gaskets specified for this purpose; install in the manner specified for installing joints in concrete piping. Parging will not be required for precast concrete manholes. Perform cast-in-place concrete work in accordance with the requirements specified under paragraph entitled "Concrete Work" of this section. Make joints between concrete manholes and pipes entering manholes with the resilient connectors specified for this purpose; install in accordance with the recommendations of the connector manufacturer. Where a new manhole is constructed on an existing line, remove existing pipe as necessary to construct the manhole. Cut existing pipe so that pipe ends are approximately flush with the interior face of manhole wall, but not protruding into the manhole. Use resilient connectors as previously specified for pipe connectors to concrete manholes.

3.2.6 Miscellaneous Construction and Installation

3.2.6.1 Connecting to Existing Manholes

Connect pipe to existing manholes such that finish work will conform as nearly as practicable to the applicable requirements specified for new manholes, including all necessary concrete work, cutting, and shaping. Center the connection on the manhole. Holes for the new pipe are be of sufficient diameter to allow packing cement mortar around the entire periphery of the pipe but no larger than 1.5 times the diameter of the pipe. Cut the manhole in a manner that will cause the least damage to the walls.

3.2.6.2 Metal Work

3.2.6.2.1 Workmanship and Finish

Perform metal work so that workmanship and finish will be equal to the best practice in modern structural shops and foundries. Form iron to shape and size with sharp lines and angles. Do shearing and punching so that clean true lines and surfaces are produced. Make castings sound and free from warp, cold shuts, and blow holes that may impair their strength or appearance. Give exposed surfaces a smooth finish with sharp well-defined lines and arises. Provide necessary rabbets, lugs, and brackets wherever necessary for fitting and support.

3.2.6.2.2 Field Painting

After installation, clean cast-iron frames, covers, gratings, and steps not buried in concrete to bare metal, remove mortar, rust, grease, dirt, and other deleterious materials and apply a coat of bituminous paint. Do not paint surfaces subject to abrasion.

3.2.7 Sewage Absorption Trench Construction

Grade trenches uniformly with no slope. [Lay perforated pipe with the perforations downward.] [Comply with the chamber manufacturer's instructions.]

3.2.8 Installations of Wye Branches

Install wye branches in an existing sewer using a method which does not damage the integrity of the existing sewer. Do not cutinto piping for connections except when approved by the Contracting Officer. When the connecting pipe cannot be adequately supported on undisturbed earth or tamped backfill, support on a concrete cradle as directed by the Contracting Officer. Provide and install concrete required because of conditions resulting from faulty construction methods or negligence without any additional cost to the Government. Do not damage the existing sewer when installing wye branches in an existing sewer.

3.3 FIELD QUALITY CONTROL

The Contracting Officer will conduct field inspections and witness field tests specified in this section. Be able to produce evidence, when required, that each item of work has been constructed in accordance with the drawings and specifications.

[3.3.1 Tests

****
NOTE: Select the tests that are applicable to the work being performed and the desired testing standard. Delete the testing paragraphs that are not required or not applicable to the type of work being performed.
****
Perform field tests and provide labor, equipment, and incidentals required for testing[, except that water and electric power needed for field tests will be furnished as set forth in Section [_____]].

3.3.1.1 Hydrostatic Sewer Test

****
NOTE: This paragraph is for conflicts between the sanitary sewer line and waterline when unusual conditions are encountered.

Refer to state standard for minimum test pressure or if state standards are not applicable use a minimum test pressure of 200 kPa 30 psi.
****

When unusual conflicts are encountered between sanitary sewer and waterlines a hydrostatic pressure sewer test will be performed in accordance with the applicable AWWA standard for the piping material or AWWA C600[with a minimum test pressure of [_____]].

3.3.1.2 Leakage Tests for Nonpressure Lines

Test lines for leakage by either [infiltration tests and exfiltration tests,] [negative air pressure tests] [or by low-pressure air tests]. When necessary to prevent pipeline movement during testing, place additional backfill around pipe sufficient to prevent movement, but leaving joints uncovered to permit inspection. When leakage or pressure drop exceeds the allowable amount specified, make satisfactory correction and retest pipeline section in the same manner. Correct visible leaks regardless of

leakage test results.

3.3.1.2.1 Infiltration Tests and Exfiltration Tests

[3.3.1.2.1.1 Precast Concrete Pipe Sewer Lines

Test leakage of precast concrete pipe in accordance with ASTM C969M ASTM C969. The allowable leakage limit is located in ASTM C969M ASTM C969. Make calculations in accordance with the Appendix to ASTM C969M ASTM C969.

][3.3.1.2.2 Negative Air Pressure Test

[3.3.1.2.2.1 Concrete Pipe

****
NOTE: This test method covers testing of 4 to 36-in. diameter circular concrete pipe sewerlines utilizing gasketed joints.
****

Test concrete pipe test in accordance with ASTM C1214M ASTM C1214. The allowable vacuum loss is located in ASTM C1214M ASTM C1214 Make calculations in accordance with the Appendix to ASTM C1214M ASTM C1214.

][3.3.1.2.2.2 Precast Concrete Manholes

****
NOTE: This test method is used for testing concrete manhole sections utilizing mortar, mastic, or gasketed joints.

This test method is intended to be used as a preliminary test to enable the installer to demonstrate the condition of the concrete manholes prior to backfill.

Misuse of the test criteria in ASTM C1244 or ASTM C1244M may cause permanent damage to the system being tested.
****

Test precast concrete sewer manhole test in accordance with ASTM C1244M ASTM C1244. The allowable vacuum drop is located in ASTM C1244M ASTM C1244 Make calculations in accordance with the Appendix to ASTM C1244M ASTM C1244.

]]3.3.1.2.3 Low-Pressure Air Tests

3.3.1.2.3.1 Clay Pipelines

Test clay pipe in accordance with ASTM C828. The allowable pressure drop is located in ASTM C828. Make calculations in accordance with the Appendix to ASTM C828.

3.3.1.2.3.2 PVC Pipelines

Test PVC pipe in accordance with UBPPA UNI-B-6. The allowable pressure drop is located in UBPPA UNI-B-6. Make calculations in accordance with the Appendix to UBPPA UNI-B-6.

3.3.1.2.3.3 Dual Wall and Triple Wall Polypropylene

Test polypropylene pipe in accordance with ASTM F1417 or UBPPA UNI-B-6. The allowable pressure drop is located in ASTM F1417 or UBPPA UNI-B-6 depending on the chosen test procedure. Make calculations in accordance with the Appendix to ASTM F1417 or UBPPA UNI-B-6 depending on the chosen test procedure.

[3.3.1.3 Tests for Pressure Lines

Test pressure lines in accordance with the applicable standard specified in this paragraph[, except for test pressures. For hydrostatic pressure test, use a hydrostatic pressure 345 kPa 50 psi in excess of the maximum working pressure of the system, but not less than 690 kPa 100 psi, holding the pressure for a period of not less than one hour. For leakage test, use a hydrostatic pressure not less than the maximum working pressure of the system]. Leakage test may be performed at the same time and at the same test pressure as the pressure test.

[3.3.1.3.1 Ductile-Iron Pressure Pipe

Test ductile-iron pressure pipe in accordance with the requirements of AWWA C600 for hydrostatic testing. Leakage on ductile-iron pipelines with mechanical-joints [or push-on joints] are not to exceed the amounts given in AWWA C600[; no leakage will be allowed at joints made by any other methods].

][3.3.1.3.2 Concrete Pressure Pipe

Test concrete pressure pipes in accordance with the recommendations in AWWA M9. The leakage rate is dependent upon the type of concrete pressure used and the diameter of the pipe. The allowable leakage rate is indicated in AWWA M9, chapter titled, "Hydrostatic Testing and Disinfection of Mains".

][3.3.1.3.3 PVC Pressure Pipe

Test PVC pressure pipe in accordance with the requirements of AWWA C605 for hydrostatic and leakage tests. The quantity of water that must be supplied during testing is not to exceed the quantity of water calculated in accordance with AWWA C605 to maintain the specified test pressure within 34 kPa5 psi.

]]3.3.1.4 Deflection Testing

****

NOTE: Specify deflection testing only when warranted by scope or size of project.

****

Perform a deflection test on entire length of installed plastic pipeline on completion of work adjacent to and over the pipeline, including leakage tests, backfilling, placement of fill, grading, paving, concreting, and any other superimposed loads determined in accordance with ASTM D2412. Deflection of pipe in the installed pipeline under external loads is not to exceed 4.5 percent of the average inside diameter of pipe. Determine whether the allowable deflection has been exceeded by use of a pull-through device or a deflection measuring device.

3.3.1.4.1 Pull-Through Device

This device is to be a spherical, spheroidal, or elliptical ball, a cylinder, or circular sections fused to a common shaft. Space circular sections on the shaft so that the distance from external faces of front and back sections will equal or exceed the diameter of the circular section. Pull-through device may also be of a design promulgated by the Uni-Bell Plastic Pipe Association, provided the device meets the applicable requirements specified in this paragraph, including those for diameter of the device, and that the mandrel has a minimum of 9 arms. Ball, cylinder, or circular sections are to conform to the following:

a. A diameter, or minor diameter as applicable, of 95 percent of the average inside diameter of the pipe; tolerance of plus 0.5 percent will be permitted.

b. Homogeneous material throughout, is to have a density greater than 1.0 as related to water at 4 degrees C 39.2 degrees F, and a surface Brinell hardness of not less than 150.

c. Center bored and through-bolted with a 6 mm 1/4 inch minimum diameter steel shaft having a yield strength of not less than 483 MPa 70,000 psi, with eyes or loops at each end for attaching pulling cables.

d. Suitably Back each eye or loop with a flange or heavy washer such that a pull exerted on opposite end of shaft will produce compression throughout remote end.

3.3.1.4.2 Deflection Measuring Device

Sensitive to 1.0 percent of the diameter of the pipe being tested and be accurate to 1.0 percent of the indicated dimension. Prior approval is required for the deflection measuring device.

3.3.1.4.3 Pull-Through Device Procedure

Pass the pull-through device through each run of pipe, either by pulling it through or flushing it through with water. If the device fails to pass freely through a pipe run, replace pipe which has the excessive deflection and completely retest in same manner and under same conditions.

3.3.1.4.4 Deflection measuring device procedure

Measure deflections through each run of installed pipe. If deflection readings in excess of 4.5 percent of average inside diameter of pipe are obtained, retest pipe by a run from the opposite direction. If retest continues to show a deflection in excess of 4.5 percent of average inside diameter of pipe, replace pipe which has excessive deflection and completely retest in same manner and under same conditions.

[3.3.1.5 Dye Test

Perform a dye test from the projects sanitary sewer point of connection to the first downstream manhole on the next active sanitary sewer branch main. Use nontoxic non-staining sewer tracing dye. Test results are to be noted in the daily Construction Quality Control (CQC) Report as required in 01 45 00.00 10 Quality Control.

a. Continue testing until it can be visually confirmed by way of the dye

that the sewer connection is appropriate or until deficiencies are discovered.

b. During the test, monitor the storm drainage system downstream from the project, either manholes or outfalls, for any sign of cross-connection.

][3.3.1.6 Smoke Test

Perform a smoke test on the relevant portion of the sewer system. Test results are to be noted in the daily Construction Quality Control (CQC) as required in 01 45 00.00 10 Quality Control.

a. Continue testing until it can be visually confirmed that the projects sanitary sewer point of connection has not been cross-connected to the storm drainage system.

b. During the test, monitor the storm drainage system, either manholes or outfalls, for any sign of cross-connection.

]][3.3.2 Field Tests for Cast-In-Place Concrete

****

NOTE: Delete this paragraphs if cast-in-place concrete is not used.

Select 03 30 00 for projects with large amounts of cast-in-place concrete work.

Select 03 30 53 for projects with small amounts of cast-in-place concrete work.

For Army, Use 03 30 00.00 10 in place of 03 30 00.

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Field testing requirements are covered in Section [03 30 00.00 10 CAST-IN-PLACE CONCRETE][03 30 00 CAST-IN-PLACE CONCRETE][03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE]

][3.3.3 Inspection

Check each straight run of pipeline for gross deficiencies by holding a light in a manhole; the light must show a practically full circle of light through the pipeline when viewed from the adjoining end of line.

3.3.3.1 Pre-Installation Inspection

Prior to connecting the new service, perform pre-installation inspection after trenching and layout is complete. Submit pre-installation inspection request for field support at least [14] [_____] days in advance. The Installation's Utilities Field Support personnel will perform the pre-installation inspection.

3.3.3.2 Post-Installation Inspection

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NOTE: For Navy, contact Installation staff to determine if dye testing or smoke testing is required by either state,local,or Navy requirements

at the specific project location.
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Perform a post-installation inspection after connection has been made and before the connection is buried. Submit post-installation inspection request for field support at least [14] [_____] days in advance. The Installation's Utilities Field Support personnel will perform the post-connection inspection.[During the post-installation inspection the Contractor will be responsible for performing a [dye test] [smoke test].]

] -- End of Section --