



National Aeronautics and
Space Administration

John C. Stennis Space Center
Stennis Space Center, MS
39529-6000

SSTD-8070-0067-PIPE
Revision F
DECEMBER 2022

COMPLIANCE IS MANDATORY

John C. Stennis Space Center Standard High Pressure Industrial Water Piping “AG”

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12-30-2022
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1-4-2023
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Issued by

ISSUED CEF
Central Engineering Files

1-4-2023
Date

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Document History Log

Revision	Date	Originator/ Phone	Description
Basic	4/21/2004	K Patel / 2845	Initial Release – supersedes SSC STD 47-041 Rev. B. Formatted per SPG 1400.1. Updated national standards references. Included the allowance of mechanical couplings in accordance with specific ASTM standards used in place of flanges and fittings.
A	12/15/2005	D Dike / 2803	John C. Stennis Space Center (SSC) Central Engineering Files (CEF) Archive Note: This standard supersedes COE Contract 1544, Sections 44 and 45. In section 2.0, corrected spelling of “draw” to “drawn” in second sentence. In section 3.0, added sentence “Referenced documents are assume to be the latest revision unless otherwise specified.” Deleted reference to MIL-G-12803 because this information is covered in ASTM F104 which is already listed as a reference. Deleted reference to AWS B2.1 and replaced it with ANSI/ASME B1.20.1 to address pipe thread. Deleted reference to ASTM A515/A515M (pressure vessel plates). Added reference to ASTM A671 (steel pipe). In section 5.0, revised references in the table to reflect the changes in references listed above. In the 26” through 96” column, changed “Nom Pipe Size” to “ID Pipe Size.” Updated ASTM reference (A671) and added an asterisk to call attention to the note below the table. In the NOTES section of 5.0, added a sentence to the first paragraph to specify that the design engineer should determine if mechanical couplings are to be used, and if so, they should be restricted to pipe size under 20”. Added note to explain the asterisk added to the ASTM reference in the 26” through 96” column to specify that the referenced ASTM standard refers to the outside diameter of pipe, but this SSC standard refers to the inside diameter of pipe.

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B	4/28/2014	D Dike / 2803	Five year revision, referenced updated and added the following references: ASCE MOP 119, ASME PCC-1, AWWA M11, AWWA C210, AWWA C216, AWWA C222, NACE SP0188, SSPC-SP5/NACE No.1, SSPC-SP10/NACE No. 2, SSPC-SP11, SSTD-8070-0112-IDCODES and SSTD-8070-0124-IDCODES. Added SMA Approval. Revised section 5.0 (table and its associated notes) to update ASTM specification numbers; add coverage and include data for ASTM A671 Gr. CC70 pipe; add requirements for mitered elbows, tees, and custom reducers; allow ASME standard fittings and flanges up to 48” size; add post-weld heat treat requirements for selected pipe wall thicknesses; and add Notes 2-6 and #. Added Section 5.1 and 5.2
C	11/17/2015	D Dike / 2803	Updated references and acronyms. Administrative changes throughout document. Revised cover sheet to require approval from NASA SSC Center Operations Design & Construction Project Management Division, with concurrence from NASA SSC Engineering and Test Directorate, and NASA SSC Safety and Mission Assurance. Added SSC NDT Level III inspector approval to that of Authorized Inspector throughout document. Revised 2.0: Noted that specification line designator numbers shall conform to requirements of SSTD-8070-0112-IDCODES. Section 6.0, Requirements: Revised ½” thru 4” and 5” thru 24” pipe specifications to meet ASME B31.3 for 300 psig pressure rating; revised 26” thru 112” fitting specifications; revised 26” thru 112” flanges specifications; and updated welding requirements. Added 8.0, Definitions.
C-1	02.12.2016	R. Carol Wolfram 8-1146	Administrative change. Replaced “Test Operations” with “Test Complex” throughout document.
D	03.12.2018	D. Dike / 8-2803	Updated to allow ASTM A53 Grades A or B, Type S pipe for 5” through 24” nominal sizes. Minor administrative and format changes.

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E	04.10.2018	Patrick Mitchell 8-2246	Section 5.0: Changed requirement for pipe size 1/2" through 4" from “2000#” to “3000#” socket-weld fittings to align with ASME B16.11, Section 2.1, Pressure Ratings. (Note: 2000# fittings are commonly threaded and not socket-weld.)
F	12.19.2022	Son Le 8-3816	Updated references and acronyms. Minor administrative changes. Section 5.0, Requirements Table: Added “Specific Component” row in its entirety. Added Section 5.2.1: After application of lining or coating material is inspected and has met the specified acceptance criteria, 100 percent of the coated or lined surface area shall be tested in accordance with NACE SP0188. Mark all holidays and repair holidays per the coating manufacturer’s recommendations.

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1.0 PURPOSE

This John C. Stennis Space Center (SSC) standard (SSTD) specifies materials and procedures to be used for the construction of systems as described below.

2.0 APPLICABILITY

This SSTD shall be used for specifying materials and components to be incorporated into piping system “AG” as designated on the Site-wide Operational and Repair Documentation (SORD) Drawing System. These piping system drawings are drawn in schematic form and are identified by system and specification line designator numbers. These line designator numbers shall conform to requirements of SSTD-8070-0112-IDCODES. The piping designator defined in SSTD-8070-0112-IDCODES for piping systems governed by this standard is “AG.”

3.0 REFERENCED DOCUMENTS

Referenced documents are assumed to be the latest version unless otherwise specified.

- ASCE MOP 119, *Buried Flexible Steel Pipe: Design and Structural Analysis*
- ASME B1.20.1, *Pipe Threads General Purpose (Inch)*
- ASME B16.11, *Forged Fittings, Socket-Welding and Threaded*
- ASME B16.21, *Nonmetallic Flat Gaskets for Pipe Flanges*
- ASME B16.47, *Series A Flanges*
- ASME B16.5, *Pipe Flanges and Flanged Fittings*
- ASME B16.9, *Factory-Made Wrought Steel Buttwelding Fittings*
- ASME B31.3, *Process Piping Guide*
- ASME Boiler and Pressure Vessel Code, Section VIII, *Rules for Construction of Pressure Vessels Division I*
- ASME PCC-1, *Guidelines for Pressure Boundary Bolted Flange Assembly*
- ASTM A53/A53M, *Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*
- ASTM A105/A105M, *Carbon Steel Forgings for Piping Applications*
- ASTM A106, *Seamless Carbon Steel Pipe for High-Temperature Service*
- ASTM A181/A181M, *Carbon Steel Forgings, for General-Purpose Piping*
- ASTM A193/A193M, *Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications*
- ASTM A194/A194M, *Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both*
- ASTM A234/A234M, *Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service*
- ASTM A350, *Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components*
- ASTM A671, *Electric-Fusion-Welded Steel Pipe for Atmospheric and Lower Temperatures*
- ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension*

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ASTM D522, *Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings*
 ASTM D570, *Standard Test Method for Water Absorption of Plastics*
 ASTM D870, *Standard Practice for Testing Water Resistance of Coatings Using Water Immersion*
 ASTM D4060, *Standard Test Method for Abrasion Resistance at Organic Coatings by the Taber Abraser*
 ASTM D4541, *Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers*
 ASTM E96, *Standard Test Methods for Water Vapor Transmission of Materials*
 ASTM F104, *Standard Classification System for Nonmetallic Gasket Materials*
 ASTM F1476-1, *Performance of Gasketed Mechanical Couplings for Use in Piping Applications*
 ASTM F1548-1, *Performance of Fittings for Use with Gasketed Mechanical Couplings Used in Piping Applications*
 ASTM G14, *Standard Test Method for Impact Resistance of Pipeline Coatings (Falling Weight Test)*
 ASTM G95, *Standard Test Method for Cathodic Disbondment Test of Pipeline Coatings (Attached Cell Method)*
 AWWA C208, *Dimensions for Fabricated Steel Water Pipe Fittings*
 AWWA C210, *Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings*
 AWWA C216, *Heat-Shrinkable Cross-Linked Polyolefin Coatings for Steel Water Pipe and Fittings*
 AWWA C222, *Polyurethane Coatings for Steel Water Pipe and Fittings*
 AWWA M11, *Steel Water Pipe – A Guide for Design and Installation*
 NACE SP0188, *Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates - Item No. 21038*
 SPR 1440.1, *SSC Records Management Program Requirements*
 SSPC-SP5/NACE No.1, *White Metal Blast Cleaning*
 SSPC-SP10/NACE No. 2, *Near-White Metal Blast Cleaning*
 SSPC-SP11, *Power-Tool Cleaning to Bare Metal*
 SSTD-8070-0005-CONFIG, *SSC Preparation, Review, Approval, and Release of SSC Standards*
 SSTD-8070-0013-WELD, *Classes of Welding Inspection*
 SSTD-8070-0015-WELD, *Gas Tungsten Arc Weld (GTAW) Procedure for Carbon Steel (ASME P-No. 1, Group 1 or 2)*
 SSTD-8070-0112-IDCODES, *Test Complex Line Designator Numbers*
 SSTD-8070-0124-IDCODES, *Identification of Piping Systems and Above-Ground Markers*

4.0 DESIGN REQUIREMENTS

<u>Service</u>	<u>Design Pressure</u>	<u>Temperature Range</u>
Water	300 psig	32°F to 200°F

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5.0 REQUIREMENTS

Size	½" thru 4"	5" thru 24"	26" thru 112"		
Pipe (See Notes 3 and 4.)	ASTM A106 Gr. A or B, Sch. 40 Pipe, Threaded or Beveled Butt weld Ends (See Note 1.)	ASTM A53/A53M Gr. A or B Type S, Sch. 40, Beveled Butt weld Ends Only ASTM A106 Gr. A or B may be substituted. In sizes above 12 inch, do not use A106 in large quantities because it is less economical. (See Note 1.)	ASTM A671 Gr. CC60 or Gr. CC70. Pipe shall be Class 11, except for unburied pipe with wall thickness greater than .750" which shall be Class 21. Rolled with Beveled Seam Weld, Beveled Butt weld Ends Only. Seam welds shall be longitudinal; spiral welded pipe (having spiral or helical weld seams) is not permitted. Supersedes A155 Gr. K60 C1.I		
			Pipe ID or OD Size (in.)	Min. Wall (in.) (See Note 2.)	
			ASTM A671 Gr. CC60	ASTM A671 Gr. CC70	
			26 OD *	0.33 #	0.30
			30 OD *	0.36 #	0.33
			36 OD *	0.40 #	0.37
			42 OD *	0.45	0.40
			48 OD *	0.49	0.44
			54 ID	0.55	0.49
			66 ID	0.64 #	0.56
			72 ID	0.69	0.60
			75 ID	0.72	0.62
			84 ID	0.80	0.69
			96 ID	0.92 #	0.77
			102 ID	0.98	0.82
			112 ID	1.07	0.90
Fittings (See Notes 3 and 4.)	ASME B16.11 (socket-weld) 3000# ASTM A105/A105M (See Note 1.)	ASME B16.9 (butt weld) ASTM A234/A234M WPB or WPC (See Note 1.)	Mitered elbows made of Welded Segments per AWWA C208. For certain conditions stated in Note 6, the wall thickness of mitered elbows shall be increased to conform with requirements of ASME B31.3 para. 304.2.3. Mitered tees for branch connections with wall thicknesses and reinforcements in accordance with ASME B31.3 para. 304.3.1 thru 304.3.3. Tee fittings that do not fall within the scope of ASME B31.3 shall be designed in accordance with AWWA M11 and reinforcement by full wrapper or crotch plate shall be used. Mitered fitting material shall be same as that of adjoining pipe. ASME B16.9 fittings, with wall thickness equal to or heavier than adjoining pipe, are also allowed for sizes up to 48". Mitered fittings are required for sizes greater than 48". Material shall be ASTM A234/A234M WPC for ASME B16.9 fittings.		
	ASME B16.11 (screwed). For instrument connections only. (See Note 1.)	ASTM A105/A105M (See Note 1.)			

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Size	½" thru 4"	5" thru 24"	26" thru 112"
Flanges (See Notes 3, 4 and 5.)	ASME B16.5 (socket-weld) 300# ASTM A181/A181M Class 60 or 70, or A105/A105M (See Note 1.)	ASME B16.5 (weld neck) 300# ASTM A181/A181M Class 60 or 70, or A105/A105M (See Note 1.)	ASME B16.47 Series A Class 300, Welding Neck, Raised Face with Concentric or Spiral Serrations for nominal sizes from 26" to 60". ASTM A105/A105M or ASTM A350/A350M Grade LF2. Flat Face flanges may be used as required to match with valves. Wall thickness at butt-weld end of each flange shall match that of adjoining pipe or fitting.
Bolting (See Note 5.)	Studs: ASTM A193/A193M, Gr. B7 Nuts: ASTM A194/A194M, Gr. 2H (hex nuts)		
Gaskets	ASTM F104, ASME B16.21 (non-asbestos)		
Code Compliance	Design per ASME B31.3 unless otherwise noted. (See Note 2.)		
Pipe Thread	NPT per ASME B1.20.1		
Welding / Inspection	<p>Weld per SSTD-8070-0015-WELD, SSTD-8070-0039, or SSTD-8070-0137-WELD. For SSTD-8070-0137-WELD, backing rings shall be ground out followed by liquid penetrant or magnetic particle inspection of 100% of the ground out areas. If any unacceptable defects are found, all of the effected weldment regions and areas containing the defects shall be completely ground out, rewelded, and reinspected per SSTD-8070-0013-WELD, Class I.</p> <p>For pipe and fittings with applied inner liner, inner wall surfaces at weld joints shall be prepared in accordance with Section 5.1 or 5.2, whichever applies, prior to liner application.</p> <p>Inspect all weldments on buried pipe per SSTD-8070-0013-WELD, Class I.</p> <p>Inspect all longitudinal seam welds per SSTD-8070-0013-WELD, Class I.</p> <p>Inspect remaining (above-ground and unburied circumferential and fillet) welds per SSTD-8070-0013-WELD Class IIA.</p> <p>Post-weld heat treatment of girth and seam welds in accordance with ASME B31.3 is required for unburied pipe with wall thicknesses greater than 0.75" and for buried pipe with wall thicknesses greater than 1.00". This post-weld heat treatment requirement applies regardless of where the welds are produced; e.g., field welds are not exempt from this requirement.</p>		

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Specific Component	<p>Vacuum and Air Release Valve:</p> <p>If used, combination air release and air-vacuum valves shall be designed, supplied, and installed in accordance with ANSI/AWWA C512 and ANSI/AWWA M51 with a 300 psig or higher design pressure. Valves shall be automatic float operated and designed to handle venting requirements during filling, draining, and normal operation under pressure. Combination valve design shall consider provisions for surge suppression, insect and debris intrusion, and floodwater inflow prevention. Any isolation valves installed on the inlet or outlet shall have a means of being locked open to prevent inadvertent and/or unauthorized closure. Combination valves shall be treated as safety devices and may only be circumvented when absolutely necessary and with prior approval from the Authority Having Jurisdiction (AHJ).</p> <p>The following manufacturers and models are preferred and approved for use on systems covered under this SSTD. Approved equals may be permitted with prior approval from the AHJ.</p> <ul style="list-style-type: none"> • Valve & Primer Corporation (APCO), Series 1900 • Val-Matic ®, Water Surge-Suppression Air Valves, Single or Dual Body, Model Series 100 or 200 • G&A Industries Kinetic Slow Closing Air/Vacuum Valve, Figure 931 or 931-7, with modifications to provide double guiding and prevent float contact with the body.
Testing (See Note 7.)	<p>Use of dished heads, blind flanges, and dished heads with bolting flanges welded to ends of pipe or fittings may be used as temporary closures for testing. (See Note 7.)</p> <p>Hydrostatic: Pressurize to 1.5 times designated system pressure.</p> <p>Pneumatic: Pressurize to 1.25 times designated system pressure.</p> <p>Pressure hold time shall be 10 minutes or as needed to inspect all weldments and mechanically connected joints, whichever is longer.</p> <p>No leakage or permanent deformation shall result.</p>

NOTES

¹ For pipe sizes ½” through 20”, mechanical couplings in accordance with ASTM F1476-1 and ASTM F1548-1 standards may be used in place of flanges and fittings. However, the use of mechanical couplings is restricted to pipe under 20” and should be determined by the design engineer on each project. Where these couplings are used, pipe material shall be ASTM A53/A53M, Gr. A or B, Type S, Sch. 40 or heavier wall pipe, or ASTM A106, Gr. B, Sch. 40 or heavier wall pipe with a minimum ultimate tensile stress of 60,000 psi and a minimum yield stress of 35,000 psi. Standard gaskets Grade “E” EPDM and Grade “T” Nitrile shall be used.

² All High Pressure Industrial Water (HPIW) pipes are also verified to meet ASCE Manual of Practice (MOP) 119 design guide. For ASTM A671 Grade CC60 pipes 72” in diameter and larger, MOP 119 is the more stringent design guide and determines the pipe wall thicknesses. For ASTM A671 Grade CC70 pipes 96” in diameter and larger, MOP 119 is the more

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stringent design guide and determines the pipe wall thicknesses. Use of pipe made of rolled plate of standard thicknesses that result in pipe wall thickness greater than listed minimum wall is permitted.

- ³ With the exception of existing in-service piping systems constructed, installed, and pressure tested prior to the issue date of Rev. B of this standard, all buried piping systems shall have applied exterior coating. With the exception of existing in-service piping systems constructed, installed, and pressure tested prior to the issue date of Rev. B of this standard, all piping systems and sections thereof that are 54-inch nominal size and larger shall have applied interior liner. Coating and liner that is applied off-site shall conform to requirements stated in Section 5.1 of this standard. Coating and liner that is applied in the field to installed piping systems shall conform to requirements stated in Section 5.2 of this standard.
- ⁴ For all pipe and fittings, tapered inside and outside diameter transitions shall be provided in pipe and fittings near butt weld joints as and where needed to provide matching inside and outside diameters at each butt weld joint. The inside and outside diameter matching tolerances and geometry of transitions shall conform to requirements of ASME B16.9.
- ⁵ When connecting flange joints, nuts and studs or bolts shall be torqued in accordance with ASME PCC-1
- ⁶ The wall thickness of mitered elbows shall be increased to conform to requirements of ASME B31.3 para. 304.2.3 if both of the following conditions exist: a.) Flow direction change through elbow exceeds 22.5 degrees, b.) The elbow or piping upstream and downstream of the elbow are not externally supported to react against maximum possible thrust (flow momentum transfer) loads at the elbow. External supports may include compacted fill or soil around pipe or elbows, concrete thrust blocks, and mechanical and structural pipe supports. When external supports are used and mitered elbow wall thickness is not increased to conform with ASME B31.3 para. 304.2.3, design analyses shall be provided to assure stresses do not exceed minimum yield stress and buried pipe shall be restrained in accordance with AWWA M11.
- ⁷ Dished heads welded to pipe or fittings and used as temporary closures for testing shall conform to requirements of ASME Boiler and Pressure Vessel Code, Section VIII, Div. 1, Figure 1-4 and ASME B31.3. Pressure rating of these dished heads shall be a minimum of that of the connecting pipe or the hydrostatic test pressure, whichever is greater. Blind flanges used for testing shall conform to ASME Boiler and Pressure Vessel Code, Section VIII, Div. 1, Figure UG-34 (j), and ASME B31.3. Dished heads with bolting flanges used for testing shall conform to ASME Boiler and Pressure Vessel Code, Section VIII, Div. 1, Figure 1-6, and ASME B31.3. Pressure rating of blind flanges and dished heads with bolting flanges shall be the same as that of the tested system. For all dished heads, the head configuration shall be ellipsoidal or torispherical. Where dished heads, blind flanges, and dished heads with bolting flanges are installed on vertical pipes or at high points in the piping system, they shall have provisions for venting air during filling of the system with water. Shop fabrication drawings and calculations to show compliance with referenced codes shall be provided.

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- * Existing pipe on site that was fabricated per SSC STD 47-041 (the standard that was superseded/replaced by this standard) has inside diameters equal to the dimensions shown. The current Nominal Pipe Size (NPS) convention for 14” through 48” NPS specifies the pipe outside diameter (O.D.) as being equal to the NPS. Commercially available piping is manufactured in accordance with this convention. When replacing existing pipe, the design should take into consideration that only a custom fabricated concentric reducer or fillet weld is feasible when welding old to new pipe. Fillet welds are permitted only for piping fabricated prior to the issue date of Revision B of this standard or where use of reducers is not practicable. Custom fabricated reducers shall conform to requirements of ASME B31.3 paragraph 304.6.1 and calculations to demonstrate compliance shall be provided for each design configuration.
- # For piping systems and piping fabricated, installed, tested, and in service prior to the issue date of Rev. B of this standard, 0.3125” min. wall is allowed for 26” and 30” pipe sizes, 0.375” min. wall is allowed for 36” pipe size, 0.625” min. wall is allowed for 66” pipe size, and 0.8125” min. wall is allowed for 96” pipe size. The currently listed minimum wall thicknesses are determined from ASME B31.3 or ASCE MOP 119, whichever results in the heavier wall thicknesses. A corrosion allowance of 1/8” and a plate fabrication tolerance of +/- 0.01” is applied for all ASME B31.3 determined minimum wall thicknesses.

5.1 Off-Site Shop-Applied Coating

Refer to Note 3 of the table in Section 5.0 for piping that is to have applied exterior coatings and internal liners.

Coating shall be plural component, polyurethane coating system (referred to as a polyurethane system).

Coating shall be applied in accordance with AWWA C222, and as modified herein.

The color of the inner lining material shall be “Sky Blue,” Pantone Number 284 C.

The color of the exterior coating material shall be “Aspen Green,” Pantone Number 5763 C.

Applicator shall comply with applicator qualifications specified herein.

Surfaces of steel pipe shall be prepared prior to application of coating and lining system.

Surfaces shall be prepared in a shop environment to SSPC-SP 5/NACE No. 1, White Metal Blast, 3.0 mil profile, minimum, or as required by the coating material manufacturer, whichever is greater.

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Polyurethane shall be a self-priming, plural component, 100 percent solids, non-extended polyurethane, suitable for burial or immersion, and shall be one (1) of the following approved products subject to review and acceptance of submitted product performance reports:

- a. Protec II, Futura Coatings, Hazelwood, Missouri;
- b. Durashield 210, Lifelast, Inc., Vancouver, Washington;
- c. Chemthane 2265, Chemline, Inc, St. Louis, Missouri; or,
- d. NASA approved equal.

Coating shall be applied in one (1) coat by spray film, in accordance with manufacturer's written shop application requirements.

- Coating dry film total thickness shall be 35 mils, minimum and 40 mils maximum.
- Coating shall be air cured only. Oven or other accelerated cures will not be acceptable.
- Samples shall take the form of sheet, steel panel, or steel pipe as required for test procedure.
- A minimum of three (3) samples for each test performed or as required by the ASTM standard, whichever is more stringent, shall be prepared and tested.

For the coating and lining material and applications, documentation of the following tests shall be provided:

- a. Water absorption in accordance with ASTM D570, long term immersion.
 - Sample on which the testing is performed shall be sheet form having a 1 mm maximum thickness.
 - Water absorption shall be maximum 1.5 percent.
- b. Permeance in accordance with ASTM E96, method Water Procedure BW (Appendix XI).
 - Sample shall be supported in a manner to provide full circulation of air around test container for duration of test procedure.
 - Permeance shall be a maximum of 0.008 inch-pound.
- c. Cathodic disbondment in accordance with ASTM G95 for a duration of thirty (30) days at a potential of -3.00 volts.
 - Radius shall be measured from original holiday radius.
 - Cathodic disbondment shall be maximum 8 mm.
- d. Dry adhesion to steel in accordance with ASTM D4541.
 - Testing equipment shall be Delfesko Positest, and dollies shall be 14 or 20 mm, maximum, scored to metal substrate.
 - Minimum dry adhesion to steel shall be 3,000 psi.
- e. Wet adhesion to steel in accordance with ASTM D870 for a duration of thirty (30) days and sixty (60) days.
 - Testing equipment shall be Delfesko Positest and dollies shall be 14 or 20 mm, maximum, scored to metal substrate.

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- Samples shall be minimum 3/16-inch thick steel.
 - Acceptance criteria is that not greater than 10 percent loss of adhesion when compared to adhesion in an unexposed area of the same sample with pulls completed within twelve (12) to twenty-four (24) hours after removal and for an average of three (3) pulls per sample.
 - There shall be no blistering.
- f. Impact resistance in accordance with ASTM G14. Minimum resistance shall be 125 inch-pounds.
- g. Abrasion in accordance with ASTM D4060 using CS-17 wheel, 1,000 grams weight, and 1,000 revolutions. Maximum loss to abrasion shall be 85 mg.
- h. Tensile strength in accordance with ASTM D412. Minimum tensile strength shall be 4,000 psi.
- i. Flexibility in accordance with ASTM D522.
- Mandrel diameter shall be 3 inches, 180 degrees.
 - Sample shall be minimum 1/16 inch thick steel.
 - No cracking shall be a passing testing result.

All tests shall be documented as required by the ASTM test method, and shall include the following additional information:

- a. Sample panel preparation date and identification
- b. Surface preparation method and abrasive
- c. Surface preparation profile and peak count
- d. Coating lot and date of manufacture
- e. Coating thickness, minimum, maximum, and average
- f. Application spray gun and equipment used
- g. Application temperatures of coating materials and material temperature at the gun, ambient temperature, and panel surface temperature
- h. Periodic test data and/or observations for all tested samples and show all multiple measurements in both table and graph
- i. Calculations as required by the ASTM test method
- j. Digital photographic documentation of all visual assessments, test apparatus, and final panel condition using 4 megapixels minimum resolution

Polyurethane coating and lining shall be applied in the shop by an applicator having the following minimum qualifications:

- a. Equipment will be certified by the coating and lining manufacturer to meet the requirements for material mixing, temperature control, application rate, and ratio control for multi-part coatings.
- b. Equipment not meeting the written requirements of the coating and lining manufacturer shall be rejected for coating application until repairs or replacement of the equipment is

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made to the satisfaction of the National Aeronautics and Space Administration (NASA) Quality Assurance Representative.

c. Personnel responsible for coating and lining application shall have certification of attendance at the coating manufacturer's training class within the last three (3) years. The certified applicator shall:

- Be present during all coating application work; and,
- Have responsibility for controlling all aspects of the coating application.

d. Submit applicator qualifications to NASA prior to any coating activities.

5.1.1 *Coating and Lining Application Quality Assurance Manual*

Coating and lining manufacturer shall provide to NASA a copy of the manufacturer's coating and lining application quality assurance manual prior to beginning coating application. Strict conformance to the requirements of the manual will be required. Deviation from the requirements of the manual will be grounds for NASA to reject the applied coating.

Rejected coating and/or lining shall be removed to bare metal and reapplied using proper application methods in accordance with the quality assurance manual and the requirements of these specifications.

5.1.2 *Coating and Lining Application Quality Assurance*

Pipe temperature shall be between 50 and 100 degrees or 5 degrees above dew point during coating application, whichever is greater.

Coating and lining application shall be performed in an environmentally controlled shop area that meets or exceeds the written environmental application requirements of the coating manufacturer. Application in outdoor conditions will not be acceptable without adequate environmental shelter, environmental controls, and/or dehumidification.

Coating and lining applied under improper environmental conditions will be rejected and shall be removed to bare metal and reapplied under proper environmental conditions.

After application of lining or coating material is inspected and has met the specified acceptance criteria, 100 percent of the coated or lined surface area shall be tested in accordance with NACE SP0188. Mark all holidays and repair holidays per the coating manufacturer's recommendations.

Perform coating and lining repairs as specified herein.

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5.1.3 *Coating and Lining Holdback*

Coating and lining cutbacks or holdbacks shall be made straight and cut through the full thickness of the coating.

Cutbacks shall be completed in a manner that permits field coating of joints in accordance with the manufacturer's recommendations and as specified herein.

Holdbacks shall be as required for proper jointing of the pipe, considering welding requirements.

- Welded connection shall have a minimum 3 inches holdback.
- Holdbacks for the exterior coating shall be protected from corrosion.
- Holding primer for corrosion protection of cutbacks or holdbacks shall be compatible with the specified joint coating system and weld after backfill requirements, where applicable.

Approved holdback primers are:

- a. Tnemec Omnithane - suitable for joints, except joints subject to weld after backfill
- b. Tnemec 90E-92 Ethyle Silcate Inorganic Zinc Primer - suitable for all joints, including weld after backfill joints
- c. ICI Devoe Cathacoat 304V Ethyl Silicate Inorganic Zinc Primer - suitable for all joints, including weld after backfill joints

Holdback coating shall prevent corrosion of the prepared pipe ends for the duration of storage and construction and shall be recommended for buried exposures.

Primer shall not result in running or melting of the coating or cause toxic fumes when heated during welding on weld after backfill joints.

Application and thickness of holding primer shall be in accordance with the coating manufacturer's recommendations, but shall not impair the clearances required for proper joint installation.

Holdbacks for the interior lining system shall be abrasively blasted to near-white metal (SSPC-SP 10/NACE No. 2) or power tool cleaned to bare metal (SSPC-SP 11) prior to applying joint lining system.

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5.1.4 *Coating or Lining Repair*

Complete coating or lining repairs in accordance with the coating manufacturer’s written instructions and these specifications, whichever is stricter.

Minor repairs are repairs that are less than 3 inches in the greatest dimension. Major repairs are repairs that exceed 3 inches in the greatest dimension.

Minor coating repairs on any joint of pipe shall not exceed 1.5 repairs per 50 square feet of surface area. Two (2) or more repairs within a 3-inch diameter circle will be considered a single repair. Repairs for adhesion testing will not be included in the total number or repairs.

Major repairs shall not exceed one (1) per pipe joint and the combined area of the repairs shall not be greater than 10 percent of the pipe joint surface area. Pipes exceeding the maximum number or size of coating defects shall be stripped of coating, reblasted, and recoated.

Pipe arriving in the field with defects or repairs exceeding the maximum number or size of coating defects will be returned to the shop for recoating at the contractor's expense.

Minor repairs shall be repaired using coating repair kits of single use polyurethane coating kits using single use packaging that controls mix ratios. Coating manufacturer's polyurethane coating repair products are subject to NASA approval. For minor repairs, clean and feather the defect by power tool sanding with 80 grit or coarser sandpaper to roughen the existing coat and feather the defect edges 2-inches minimum. Apply a single coat of the specified patch coating material at the specified coating thickness. Repair coating adhesion shall be 50 percent of the specified coating adhesion.

For major repairs, the metal surface and surrounding coating shall be abrasively blasted in accordance with SSPC-SP 10/NACE No. 2, near white metal, or to equal in cleanliness and profile as the original surface preparation.

- Existing coating shall be feathered and roughened to the equivalent of 40 grit sandpaper.
- The same material as the pipeline coating shall be applied by using plural component spray equipment.

For all repairs, one (1) coat of the specified original coating material shall be applied over the repaired surface at the specified thickness.

Repair adhesion shall be equal to the specified coating adhesion.

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5.2 Field-Applied Coating And Lining

Refer to Note 3 of the table in Section 5.0 for piping that is to have applied exterior coatings and internal liners.

Field application of polyurethane materials is not allowed. Pipe joints shall be field coated after pipe assembly and in accordance with AWWA C216 except as modified herein.

Weld after backfill is not allowed.

The color of the inner lining material shall be “Sky Blue,” Pantone Number 284 C.

Field joint coating shall be compatible with the shop-applied coating system.

All joints on pipe 24-inches in diameter or greater or coated with polyurethane coating system shall be coated with heat shrink sleeves.

A Nondestructive Testing (NDT) Level III inspector shall inspect the surface preparation and application of the joint lining and document application conditions. Additionally, the Contractor shall provide a third party National Association of Corrosion Engineers (NACE) level III inspector with experience with the applied coating and lining system on steel pipe, to inspect the surface preparation and application of the joint lining and document application conditions. Field lining surface preparation shall be per the joint lining manufacturer’s recommendations.

- Upon completion of welds and weld inspections, all interior surfaces at or near root pass penetrations shall be ground smooth so that there are no hidden surfaces or enclosed cavities on any interior walls of pipe and fittings.
- Where liner is to be applied, all interior surfaces at weldments shall be:
 - Ground smooth to surface finish; and,
 - Flush with adjoining base metals in accordance with liner manufacturer’s recommendations.

Lining system shall be:

- a. Carboline Plasite 4500 S
- b. Or NASA approved equal

Provide filler material for all push-on, flange, and coupling type joints and at all changes in outside diameter greater than 1/8 inch.

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- Filler material shall adhere to pipe and heat shrink sleeves.
- Size and type shall be as recommended by the sleeve manufacturer for type of pipe and joint.
- Filler material shall be of the appropriate thickness that no tenting or voids remain under the heat shrink sleeve.

Joint coating shall be a heat shrink, cross-linked polyolefin wrap or sleeve with a mastic sealant, 85-mils minimum thickness, suitable for pipeline operating temperature, as recommended by the manufacturer. Provide standard recovery sleeve for welded or bell and spigot steel pipe joints.

- High recovery sleeves shall be provided for flange joints and coupling style joints.
- Width of heat shrink sleeves shall be sufficient to overlap existing coating 3 inches minimum.
- Contractor shall consider sleeve shrinkage and joint profile in determining sleeve width required.
- Overlapping of two (2) or more heat shrink sleeves to achieve the necessary width on pipe joints will not be permitted without NASA approval.

Heat shrink sleeves shall be:

- a. Canusa, Toronto, Ontario, Canada
- b. Polyken (Berry Plastics), Franklin, Massachusetts
- c. Or NASA approved equal.

5.2.1 After application of lining or coating material is inspected and has met the specified acceptance criteria, 100 percent of the coated or lined surface area shall be tested in accordance with NACE SP0188. Mark all holidays and repair holidays per the coating manufacturer’s recommendations.

6.0 RECORDS AND FORMS

Records and forms required by the procedures of this standard shall be maintained in accordance with SPR 1440.1. For quality records refer to the SSC Master Records Index. All forms are assumed to be the latest edition unless otherwise specified and may be obtained from the SSC Electronic Forms repository or from the NASA SSC Forms Management Officer.

7.0 ACRONYMS

AHJ	Authority Having Jurisdiction
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials

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AWWA	American Water Works Association
COE	Corps of Engineers
HPIW	High Pressure Industrial Water
MOP	Manual of Practice
NACE	National Association of Corrosion Engineers
NASA	National Aeronautics and Space Administration
NDT	Nondestructive Testing
NPS	Nominal Pipe Size
NPT	National Pipe Taper
O.D.	Outside Diameter
psig	pounds per square inch gauge
SORD	Site-wide Operational and Repair Documentation
SPR	John C. Stennis Space Center Procedural Requirements
SSPC	Society for Protective Coatings
SSC	John C. Stennis Space Center
SSTD	John C. Stennis Space Center Standard

8.0 DEFINITIONS

Mitered Elbow: Elbow fitting (integral with or welded to the adjoining pipe system) formed by two (2) or more straight sections of pipe matched and joined in a plane bisecting the angle of junction so as to produce a change in direction.

Mitered Fitting: Fitting (integral with or welded to the adjoining pipe system) formed by two (2) or more straight sections of pipe matched and joined in one (1) or more planes that each bisect the angle of junction so as to produce a change in direction or one (1) or more branches each with a change in direction.

Mitered Tee: Tee fitting (integral with or welded to the adjoining pipe system) formed by two (2) or more straight sections of pipe matched and joined in planes that each bisect the angle of junction so as to produce a branch with a change in direction from a straight run of pipe.

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