ASME PCC-2–2022
(Revision of ASME PCC-2–2018)

Repair of Pressure Equipment and Piping

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers
Two Park Avenue • New York, NY • 10016 USA

Date of Issuance: September 2, 2022

The next edition of this Standard is scheduled for publication in 2026.

ASME issues written replies to inquiries concerning interpretations of technical aspects of this Standard. Interpretations are published on the Committee web page and under http://go.asme.org/InterpsDatabase. Periodically certain actions of the ASME PCC Committee may be published as Cases. Cases are published on the ASME website under the PCC Committee Page at http://go.asme.org/PCCcommittee as they are issued.

Errata to codes and standards may be posted on the ASME website under the Committee Pages to provide corrections to incorrectly published items, or to correct typographical or grammatical errors in codes and standards. Such errata shall be used on the date posted.

The PCC Committee Page can be found at http://go.asme.org/PCCcommittee. There is an option available to automatically receive an e-mail notification when errata are posted to a particular code or standard. This option can be found on the appropriate Committee Page after selecting “Errata” in the “Publication Information” section.

The American Society of Mechanical Engineers
Two Park Avenue, New York, NY 10016-5990

Article 503
Test Devices for Localized Pressure or Tightness Testing of Welded Repairs

503-1 DESCRIPTION

503-1.1 General

(22) **503-1.1.1 Scope.** This Article provides general good advice for the use of mechanical devices used to isolate sections of piping systems or equipment nozzles and conduct a hydrostatic pressure or tightness test. Typical applications are

(a) testing the circumferential welds for the installation of a flange pair in a piping system

(b) testing the circumferential weld for the new installation or replacement of a flange on an existing pressure vessel or tank nozzle

(c) testing after the replacement or addition of new branches in piping systems

(d) isolating and testing piping assemblies that are prefabricated for field installation (e.g., in modular fabrication)

(22) **503-1.1.2 Types of Mechanical Devices for Testing Circumferential Piping and Nozzle Welds.** This Article describes the methods for use of four types of mechanical devices (see Figure 503-1.1.2-1) for isolation and testing of piping systems or equipment nozzles in preparation for testing.

(a) Type I — internal plug with unconnected external blind flange

(b) Type II — internal double-ended plug with external means of applying bolt load to the flange

(c) Type III — internal plug connected to an external blind flange

(d) Type IV — internal double-ended plug with no assembly load on flange

(22) **503-1.1.3 Types of Mechanical Devices for Testing Nozzle Neck to Shell or Head Welds, or Piping Branch Connections.** The following are the types of mechanical devices (see Figure 503-1.1.3-1) for isolation and testing of nozzles in pressure equipment and storage tanks, or branch connections in large diameter piping systems or pipelines:

(a) Type A — single-bolt internal device

(b) Type B — multibolt internal device

(c) Type C — exterior nozzle device

503-1.2 Definitions (22)

code hydrostatic leak test: a hydrostatic pressure test that meets the requirements of the applicable code, e.g., ASME B31.3.

full system hydrostatic pressure test: a pressure test that consists of the entire piping system being tested by the application of pressure to the test value. This test generates stresses due to pressure, flange assembly, weight of piping system and test fluid, and initial flange misalignment.

local hydrostatic test: a pressure test that consists of the application of pressure to the same or higher value as a full system hydrostatic pressure test at local regions around a weld in a piping system.

weld leak test: the application of a hydrostatic test pressure to the weld location that will allow the identification of any existing through-wall leak paths in the weld.

503-2 LIMITATIONS

503-2.1 Part 1 of This Standard

Part 1 of this Standard contains additional requirements and limitations. This Article shall be used in conjunction with Part 1.

503-2.2 Additional Considerations and Limitations (22)

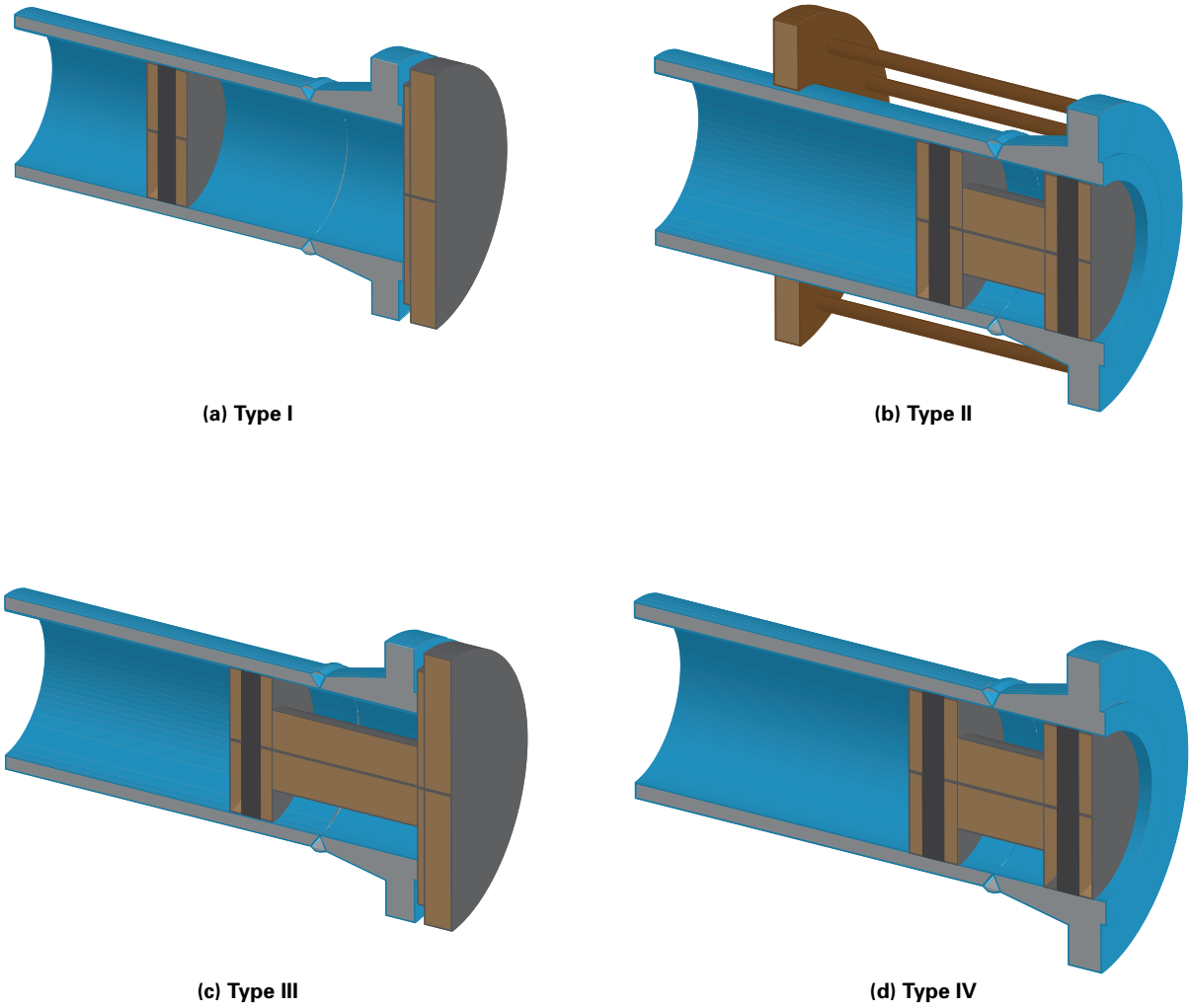
When using a weld test isolation device, the following limitations should be considered:

(a) The user is cautioned to ensure that the use of any device is done in accordance with the requirements of its manufacturer, and the isolation of any system for pressure or tightness testing is verified.

(b) There may be limitations by device manufacturers regarding pressure, size, and configuration.

(c) Some devices may leave visible internal markings or other damage (scoring, grooves, etc.) that may not be acceptable for certain services. For example, localized marking may result in regions of high hardness that may not be acceptable in stress corrosion cracking services.

Figure 503-1.1.2-1
Hydrotest Device Types for Piping or Nozzles (22)



GENERAL NOTE: Reprinted with permission from Integrity Engineering Services, Dunsborough, Western Australia.

(d) Structural integrity of the piping system or pressure vessel is not being tested by this method as may be accomplished by the application of a full system hydrostatic pressure test.

(e) All devices will test the leak tightness of welds; however, not all devices will test the integrity of the weld by creating hoop and/or axial stresses that are normally produced by full system hydrostatic pressure tests.

(22) 503-3 DESIGN

(a) Table 503-3-1 should be considered for selection of the device Type I, Type II, Type III, or Type IV for circumferential welds. See also paras. 503-3.1 through 503-3.4.

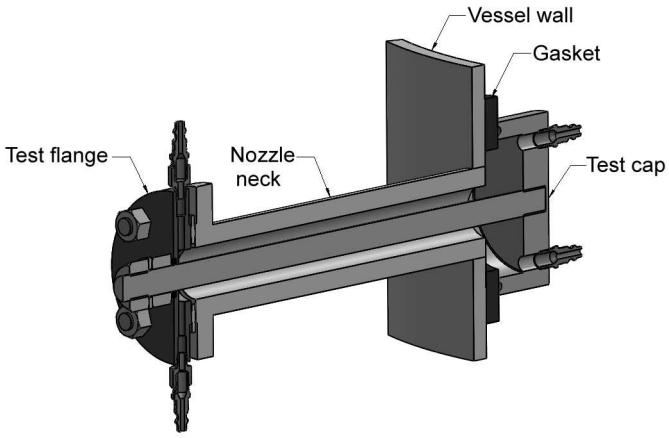
(b) Selection of device Type A, Type B, or Type C for nozzle neck to shell or head weld or piping branch connection should be made after consultation with the device manufacturer and/or service provider. Local hydrostatic testing of these joints typically does not create a state of stress similar to that created by a full hydrotest or when in service.

503-3.1 Type I — Internal Plug With Unconnected External Blind Flange

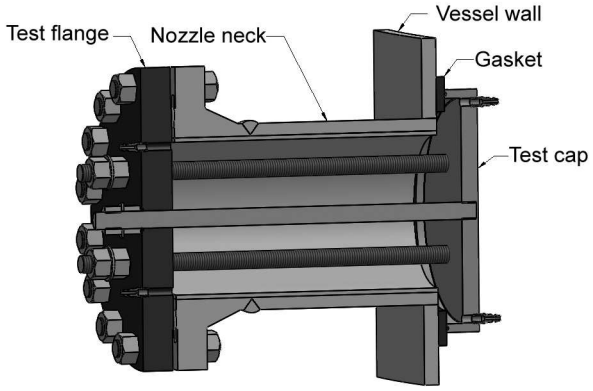
Type I devices are selected when there is a need to conduct a pressure test that provides similar loadings as developed by a full system hydrostatic pressure test.

(22)

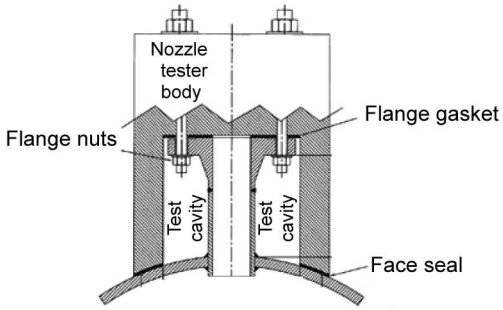
Figure 503-1.1.3-1
Hydrotest Device Types for Nozzles or Branch Connections



(a) Type A



(b) Type B



(c) Type C

GENERAL NOTE: Reprinted with permission from EST Group, Hatfield, PA, USA.

Table 503-3-1
Device Type Selection Guidance

Test	Type I	Type II	Type III	Type IV
Code hydrostatic leak test; all stress components < 53 MPa (7.75 ksi)	Equivalent	Equivalent	Equivalent	Equivalent
Code hydrostatic leak test; circumferential stress > 53 MPa (7.75 ksi), longitudinal stress < 53 MPa (7.75 ksi)	Equivalent	Equivalent	Equivalent	Equivalent [Note (1)]
Code hydrostatic leak test; circumferential stress > 53 MPa (7.75 ksi), longitudinal stress > 53 MPa (7.75ksi)	Equivalent	Equivalent	Equivalent [Note (2)]	Not equivalent
Full system hydrostatic pressure test	Equivalent [Note (3)]	Equivalent [Note (4)]	Not equivalent	Not equivalent

NOTES:
(1) Type IV hydrostatic pressure may need to be increased to compensate for the lack of flange assembly circumferential stresses.
(2) Type III may be considered equivalent if the longitudinal pressure stresses are small relative to the flange assembly stresses (< 30%).
(3) Type I may be considered equivalent if the stresses due to weight and misalignment are not considered significant.
(4) Type II may be adjusted to achieve a longitudinal stress in excess of nominal flange assembly and pressure stress, in order to compensate for the lack of stresses due to weight and misalignment.

503-3.2 Type II — Internal Double-Ended Plug With External Means of Applying Bolt Load to the Flange

(a) Type II devices are selected when there is a need to conduct a pressure test that provides similar loadings as developed by a full system hydrostatic pressure test.

(b) Type II devices are the only devices within the scope of this Article that are capable of developing a stress field at the weld that may be equal to or more severe than the full system hydrotest (including self-weight-generated external loads).

(c) A calculation to determine the appropriate bolt load to be applied by the external loading mechanism shall be developed. This calculation should determine whether the developed longitudinal stresses at the weld meet or exceed the full system hydrotest stress field.

(d) When using this method, the flange strength shall be considered to ensure permanent deformation of the flange does not occur. See WRC 538 for further information.

(e) Application of the external loads should be accurately measured so as to not be greater than the yield stress of the piping material.

(22) 503-3.3 Type III — Internal Plug Connected to an External Blind Flange

(a) Type III devices are selected when there is a need to conduct a pressure test that provides similar loadings due only to pressure as developed by a full system hydrostatic pressure test.

(b) Stresses applied by a Type III device include hoop and a reduced axial due to assembly of the device and pressure.

(c) No external loadings are applied by this device.

503-3.4 Type IV — Internal Double-Ended Plug With No Assembly Load on Flange (22)

(a) Type IV devices are selected when there is a need to conduct a leak test that does not apply any additional loadings.

(b) Tests using a Type IV device may be considered equivalent to full system hydrostatic pressure test when the test pressure is defined as follows:

$$P_{\mathrm{He}} = \min\left[0.95 * 2S_y\, t/D;\ P_H + C_A P_C\right] \quad (1)$$

where

C_A = 3.0 for class 150 systems and 2.25 for class 300 systems
D = pipe outside diameter
P_C = flange class ceiling pressure according to ASME B16.5, Table A-1
P_H = hydrotest pressure
P_{He} = hydrotest pressure to create an equivalent stress field
S_y = the lowest specified minimum yield stress of the pipe system's components
t = pipe wall thickness

Consultation with the device manufacturer should be considered for using Type IV devices in services above Class 300 systems.

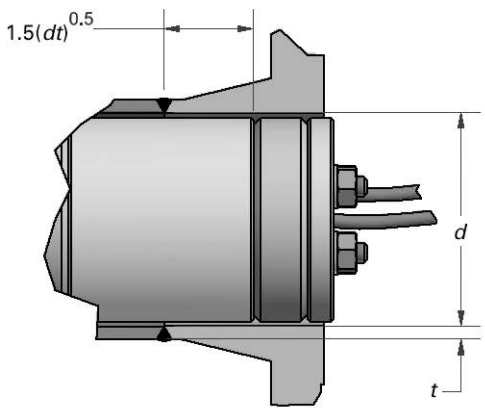
(c) Type IV devices do not apply any axial stresses.

503-4 FABRICATION (22)

This section covers the requirements for device installation.

(a) The minimum distance between the centerline of the circumferential weld to be tested and the seal location for any of the methods described in this Article should be

Figure 503-4-1
Hydrotest Device Seal Location



GENERAL NOTE: Reprinted with permission from EST Group, Hatfield, PA, USA.

greater than $1.5(dt)^{0.5}$ (see Figure 503-4-1), where d is the inner diameter of the pipe and T is the nominal pipe wall thickness.

A distance less than $1.5(dt)^{0.5}$ may be used with the appropriate engineering analysis provided, and with the acceptance of the owner.

(b) Ensure the interior of the piping system or pressure vessel is clean and free of any debris that may hinder the sealing and/or clamping action of the device.

(c) Additional pipe length may be required for installation of the device to account for potential damage caused by the device due to scoring, grooves, etc., as well as to allow all welds to be tested. In most cases, an additional 220 mm (9 in.) will suffice to allow for any potential damage to be removed and for all permanent piping to be tested. After testing, remove the additional length of pipe.

(22) 503-4.1 Type I – Internal Plug With Unconnected External Blind Flange

(a) Type I may be installed with or without a lanyard to prohibit movement into the pipe or pipeline (see Figures 503-4.1-1 and 503-4.1-2).

(b) For cases where a lanyard is used, a special blind flange from the device manufacturer may be required.

(c) The blind flange or piping section being tested shall contain openings such as threaded ports for filling and venting and for release of pressure. It is advisable to use a valve for pressure release.

(d) Operation (see Figure 503-4.1-3)

(1) Installation of a Type I device shall be in accordance with the manufacturer's and/or service provider's recommendations.

(2) Fill with a pressure test medium and complete the test.

503-4.2 Type II – Internal Double-Ended Plug With External Means of Applying Bolt Load to the Flange (22)

(a) A Type II device is a combination of a Type IV device with the means to apply a bolt load to the weld. This may be accomplished with a split ring flange that is capable of eliminating any linear movement along the O.D. of the pipe or nozzle (see Figure 503-4.2-1).

(b) Insert the Type IV device and secure to the I.D. of the piping or nozzle.

(c) Install the split ring flange not less than $1.5(dt)^{0.5}$ from the end of the hydrotest device (see Figure 503-4.2-1).

(d) Install a minimum of four bolts with nuts on the inside of each flange to apply a force to the weld to be tested. Apply torque to the bolt such that the resulting stress is equal to or greater than what would be applied by a full system hydrostatic pressure test.

(1) Determination of stress applied during test should be in accordance with the construction code.

(2) Applied bolt stress should not exceed 380 MPa (55 ksi), unless a higher stress is justified and calculation is in accordance with ASME PCC-1, Nonmandatory Appendix O.

(3) Bolt torque to achieve the target bolt stress should be calculated in accordance with ASME PCC-1.

(e) Fill and pressurize the hydrotest device to the desired pressure.

503-4.3 Type III – Internal Plug Connected to an External Blind Flange

(a) Install the device and assemble the flange joint. Apply torque such that the desired bolt stress is achieved; see ASME PCC-1.

(b) Fill with pressure test medium and complete the test.

503-4.4 Type IV – Internal Double-Ended Plug With No Assembly Load on Flange

(a) Engage the seals in accordance with the manufacturer's instructions.

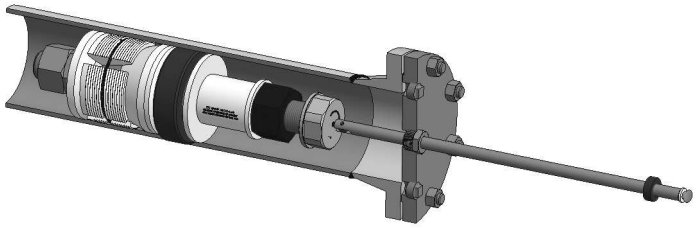
(b) Fill with pressure test medium and complete the test.

See Figure 503-4.4-1.

503-4.5 Types A, B, and C – Hydrotest Device Types for Nozzle Welds or Piping Branch Connections (22)

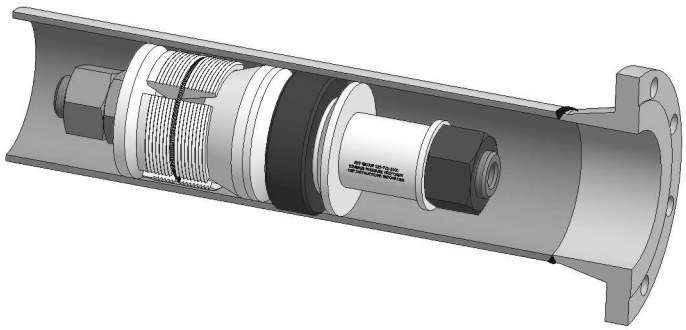
(a) Installation of Type A, Type B, or Type C devices shall be in accordance with the manufacturer's and/or service provider's recommendations.

Figure 503-4.1-1
Type I Hydrotest Device With Lanyard



GENERAL NOTE: Reprinted with permission from EST Group, Hatfield, PA, USA.

Figure 503-4.1-2
Type I Hydrotest Device Without Lanyard



GENERAL NOTE: Reprinted with permission from EST Group, Hatfield, PA, USA.

(b) Fill with pressure test medium, and complete the test.

503-5 EXAMINATION

503-5.1 Examination Prior to Initiation of the Hydrotest

(a) Any required volumetric examination should be completed prior to installation of the hydrotest device.

(b) The weld to be tested should be examined by PT or MT method.

(22) 503-5.2 Examination During the Hydrotest

(a) The minimum pressure of the hydrotest shall be monitored and shown to be stable for a minimum of 5 min or the time required by the construction code, whichever is greater, indicating there are no leaks from the weld being tested.

(b) After the test pressure has been maintained for the required duration, Visual Testing shall be performed on all welds during the test. The test pressure should be reduced to not less than the design pressure of the system being tested while performing this examination. Acceptance criteria shall be in accordance with the construction code or applicable in-service inspection code.

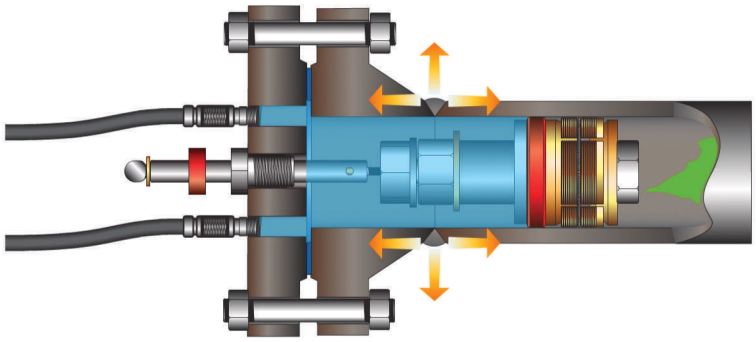
503-5.3 Examination Following Completion of the Hydrotest (22)

The interior and/or exterior of the pipe or pressure vessel should be examined for surface damage where the device clamps engaged with the interior and/or exterior wall. Any damage found may be analyzed for acceptance using engineering methods or applicable in-service inspection code.

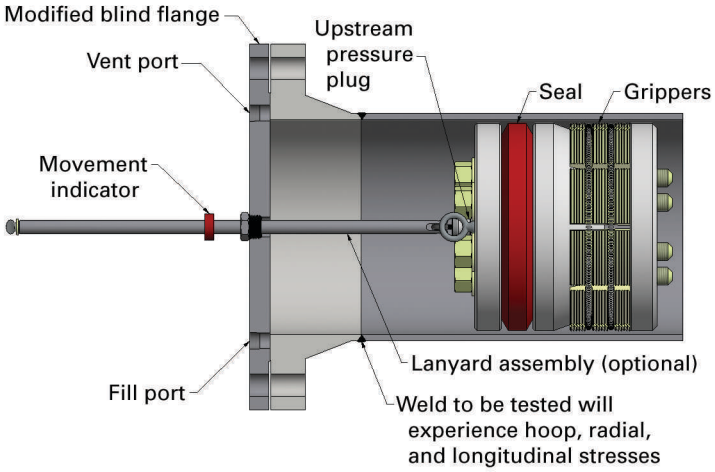
503-6 TESTING

In the context of this Article, this section is not applicable.

Figure 503-4.1-3
Type I Typical Installations



(a)



(b)

GENERAL NOTE: Reprinted with permission from EST Group, Hatfield, PA, USA.

(22) 503-7 REFERENCES

The following is a list of publications referenced in this Article. Unless otherwise specified, the latest edition shall apply.

ASME 16.5, Pipe Flanges and Flanged Fittings: NPS ½ through NPS 24 Metric/Inch Standard

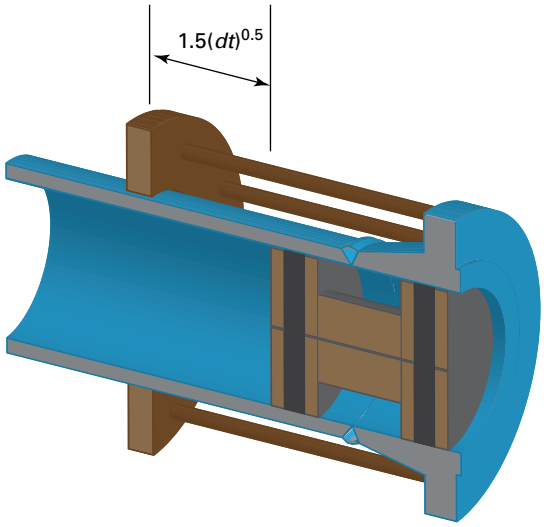
ASME B31.3, Process Piping

ASME PCC-1, Pressure Boundary Bolted Flange Joint Assembly

Brown, Warren. "Comparison Between Full System Hydrotest and Local Hydrotest Methods for Pipe Butt Welds." Paper presented at the 47th ASME Pressure Vessels and Piping Conference, Paris, France, July 2013. doi:10.1115/PVP2013-97182. (http://proceedings.asmedigitalcollection.asme.org/proceeding.aspx?articleid=1815372&resultClick=3)
Publisher: The American Society of Mechanical Engineers (ASME). Two Park Avenue, New York, NY 10016-5990 (www.asme.org)

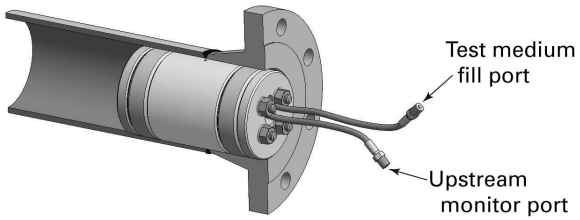
Brown, Warren. "Determination of Pressure Boundary Joint Assembly Bolt Loads." Welding Research Council Bulletin 538 (February 2014). (https://www.forengineers.org/wrc-538.html)
Publisher: Welding Research Council (WRC), P.O. Box 201547, Shaker Heights, OH 44120 (www.forengineers.org/welding-research-council)

Figure 503-4.2-1
Location of Split Ring Flange



GENERAL NOTE: Reprinted with permission from Integrity Engineering Services, Dunsborough, Western Australia.

Figure 503-4.4-1
Type IV Device



GENERAL NOTE: Reprinted with permission from EST Group, Hatfield, PA, USA.

INTENTIONALLY LEFT BLANK

ASME PCC-2–2022

ISBN 978-0-7918-7506-3