Standard Pneumatic Test Procedure Requirements for Piping Systems

AB-522

Edition 3, Revision 0 - Issued 2023-04-18

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FOREWORD

As provided for under subsection 30(2) of the Pressure Equipment Safety Regulation, the Administrator in the pressure equipment discipline has established that this ABSA document AB-522, "*Standard Pneumatic Test Procedure Requirements for Pressure Piping Systems*" specifies information that must be submitted when applying to establish a standard pneumatic test procedure which is permitted to be used to test certain pressure piping systems, when the test procedure is established as a part of the testing organization's quality management system and the test is carried out within the scope of a certificate of authorization permit.

A registered application-specific test procedure in accordance with AB-532 is required if the pneumatic test procedure does not conform to AB-522.

The AB-522 is scheduled to be reaffirmed again in 2028.

1.0 INTRODUCTION

This document outlines the quality management system and minimum procedure requirements for Alberta authorized organizations (an organization that holds a certificate of authorization permit to construct pressure piping) seeking acceptance of pneumatic testing of pressure piping in accordance with section 30(2) of the Pressure Equipment Safety Regulation (PESR). Pneumatic testing of pressure piping may be accepted on a case-by-case basis, or may be permitted when the test is conducted in accordance with a standard pneumatic test procedure for pressure piping systems in accordance with the authorized organization's quality management system. A standard pneumatic test procedure for pressure piping systems must include stored energy limitations established in accordance with this requirements document.

Pressure testing, in general, introduces hazards that must be identified and understood. Appropriate measures to manage the risk of a potential failure must be considered. Pneumatic testing is inherently more hazardous than a hydrostatic test of the same conditions of volume, pressure, and temperature. Appropriate safety precautions must be taken based on the stored energy contained in a pneumatic test.

ABSA policy documents are living documents that are reviewed periodically to ensure that they are aligned with current industry practices. We welcome any suggestions you have to improve this document.

Please provide your comments to:
Lou Petrusevski,
Design Survey Manager
Email: petrusevski@absa.ca

2.0 SCOPE

The requirements in this document apply to pneumatic testing of pressure piping systems in Alberta.

3.0 DEFINITIONS AND ACRONYMS

ABSA Safety Codes Officer (SCO) - means a safety codes officer, designated under the Act, in the pressure equipment discipline. [PESR 1(1)(ee)]

Alberta Quality Program (AQP) - a quality program that covers a defined scope such as piping fabrication, vessel fabrication, etc. for which a certificate of authorization permit has been issued per PESR Section 11.

ASME PCC-2 - Post Construction Committee document produced by an ASME ad hoc committee to identify generally accepted engineering standards for the inspection and maintenance of pressure equipment after it has been placed in service.

Design Pressure - The pressure authorized on the design registration.

Hydrostatic Test - A pressure or tightness test where liquid, typically water, is the test medium.

Maximum Allowable Working Pressure (MAWP) – maximum allowable working pressure means the pressure authorized on the design registration or a lesser pressure as indicated on the manufacturer's data report. [PESR 1(1)(v)]

PESR – means Pressure Equipment Safety Regulation, Alberta Regulation 49/2006

Pneumatic Test - A pressure or tightness test where a gas, generally nitrogen or air, is the test medium.

Pressure piping system - means pipes, tubes, conduits, fittings, gaskets, bolting and other components that make up a system for the conveyance of an expansible fluid under pressure and may also control the flow of that fluid. [PESR 1(1)(aa)]

Pressure vessel - means a vessel used for containing, storing, distributing, processing or otherwise handling an expansible fluid under pressure. [PESR 1(1)(cc)]

Safe Distance - The minimum distance between all personnel and the equipment being tested.

Standard Pneumatic Test - means a leak test of a pressure piping system using air or nitrogen, conducted by an organization that holds an Alberta certificate of authorization permit to construct pressure piping, using a procedure referenced in their QMS manual, and within the stored energy, temperature, and material limitations established in this document.

4.0 GENERAL

New construction codes require pressure testing of the system once fabrication is completed. If a pneumatic pressure test is selected, it shall be performed at the test pressure defined in accordance with the code of construction (usually 110% of the design pressure).

Section 30 of the Pressure Equipment Safety Regulation states:

> **Pressure piping tests**
>
> **30(1)** All pressure piping leak tests must be conducted using the hydrostatic method.
>
> **(2)** Despite subsection (1), the administrator may accept, for a specific pressure piping system, alternative test methods that are allowed in a code or standard that is declared in force.
>
> **(3)** A pressure piping system shall not be tested at a temperature that is colder than its minimum design temperature.
>
> **(4)** When conducting pressure tests, the ductile-to-brittle transition temperature and the possibility of brittle fracture must be considered by the contractor.

The hydrostatic test method is the mandated default, and preferred method of pressure testing. Hydrostatic testing presents a much lower safety hazard associated with the stored energy, compared to pneumatic testing. If it is not possible to perform a hydrostatic test, then alternative testing may be considered. The organization responsible for the test must justify the rationale to, and seek acceptance from ABSA for the alternative test. Appendix I of this document contains a flow chart which shows when a pressure test procedure must be submitted to ABSA for review and acceptance.

This requirements document applies to pneumatic testing of pressure piping systems. It is acceptable to conduct a pneumatic test of a pressure piping system that includes a pressure vessel, provided:

- the vessel has been previously tested;
- the MAWP of the vessel is greater than or equal to the piping design pressure;
- the test temperature will be at least 17°C (30°F) above the vessel MDMT; and,
- the volume of the vessel is included in the stored energy calculations for the pneumatic test.

5.0 QUALITY SYSTEM REQUIREMENTS

Refer to ABSA publication AB-518 *Pressure Piping Construction Requirements* for detailed quality management system requirements.

Pneumatic testing of pressure piping systems in Alberta may be undertaken only by an organization that holds a certificate of authorization permit to construct pressure piping.

If pneumatic testing is to be undertaken, the quality management system manual must describe the procedures to be followed to conduct the test in a safe manner. Provision for pneumatic testing of piping systems with up to 1,677 kJ of stored energy (equivalent to 0.5 m^3 internal volume and 2,172 kPa internal pressure) may be included as a standard testing procedure in the quality management system. ABSA's acceptance of the testing procedure can be obtained during the quality management system audit. For piping systems exceeding the pneumatic test limits specified in this standard pneumatic test procedure, a procedure must be developed in accordance with ABSA publication AB-532 *Design Registration Requirements for Application-Specific Pneumatic Test Procedures*, and submitted to ABSA for acceptance prior to conducting the test.

6.0 STORED ENERGY, MATERIAL, TEST MEDIUM, AND TEMPERATURE LIMITATIONS FOR A STANDARD PNEUMATIC TEST PROCEDURE

A standard pneumatic test procedure for pressure piping systems may be used with the following limitations:

i) The stored energy value will not exceed 1,677 kJ,
ii) The pressure piping system is made of materials comprising only the following:
   - P-No. 1 carbon steels
   - P-No. 8 stainless steels
   - P-Nos. 31, 32, 33, 34, and 35 copper and brass alloys
iii) The test medium is air or nitrogen,
iv) Testing will be conducted at a temperature at least 17°C (30°F) **above** the piping system design minimum temperature (***see note below***), and
v) Any additional requirements of the applicable code of construction.

Note: If the design minimum temperature is not specified, then the owner or his designee must establish the minimum test temperature, but in any case, the testing shall not be conducted at a temperature lower than 16°C (61°F).

An application-specific pneumatic test procedure must be submitted to ABSA for review and acceptance prior to the test when any of these limits are not met.

The 1,677 kJ stored energy threshold was calculated using the equation in ASME PCC-2, Part 5, Article 501, Mandatory Appendix 501-II, with the following pressure and volume parameters:

<u>Test Pressure</u>: 2,172 kPa (315 psi);
<u>Volume:</u> 0.5 m^3 (18 ft^3);

Table 1 of Appendix II provides additional permitted combinations of test pressure and volume, and linear interpolation is permitted between the provided values in order to provide for a maximum stored energy value of 1,677 kJ. Appendix II also provides an example of interpolation calculations.

7.0 TEST MANIFOLD AND OVERPRESSURE PROTECTION REQUIREMENTS

7.1 Manifold Design Registration Not Required

Any required manifold, valves, hoses, etc., that will be used for the pneumatic test shall be designed and constructed to the same code of construction as the pressure piping system to be tested, and shall be suited to at least the same design conditions as the piping system to be tested.

If such a manifold will be removed from the pressure piping system after the test and prior to the pressure piping system being placed into service, then the manifold design need not[1] be registered, either as a part of the piping, or separately as a fitting.

In any case, the manifold shall be inspected by the Owner, with that inspection being documented an AB-83 Pressure Piping Construction and Test Data Report.

7.2 Pressure Relief Device Required for Test

A pressure relief device (PRD) shall be provided for the test, and shall be capacity-certified with a category ‘G’ fitting CRN that is valid in Alberta.

Placement and attachment of the PRD shall include consideration for reaction forces and moments created by its potential operation.

The set pressure for the PRD shall meet the requirements of the code of construction for such a device, or if the code of construction does not establish a required set pressure for a relief device to protect during pneumatic testing, shall meet the requirements of paragraph 345.5.2 of ASME B31.3.

8.0 PROCEDURE

The AQP holder must establish a pneumatic testing procedure for a pressure piping system that addresses all the considerations necessary to conduct the test safely and meet the requirements specified in this document.

A sample standard pneumatic test procedure is provided in Appendix IV of this document.

[1] It should be noted that this is in contrast to the requirements of AB-532: Application-Specific Pneumatic Test Procedures, which requires design registration of testing manifolds for pneumatic tests within its scope.

The AQP holder is responsible to conduct an appropriate hazard assessment to ensure suitable engineered and administrative controls are in place to protect personnel during pneumatic testing. Consideration must be given to establishing the minimum safe distance requirement for personnel during the pneumatic test. A standard minimum safe distance of 30 meters may be used, which is based on ASME PCC-2, Article 501, Mandatory Appendix 501-III and calculated using the standard pneumatic test values, may be used. Refer to AB-532 for details.

Alternatively, the AQP holder may, unless the hazard assessment suggests otherwise, reduce this safe distance limit by one or more of the following:

- Installing properly designed and fabricated barriers capable of withstanding the sudden release of stored energy should the system fail
- Placing the test item in an engineered enclosure,
- Calculating the minimum safe distance using another recognized standard
- Taking other measures to minimize the risk of harm to personnel. Such measures shall be documented within the AQP holder's QMS, and shall be available for review on audit.

Design pressure, test pressure, test temperature, and design minimum temperature of the pressure equipment to be tested shall be established based on the code of construction and the approved engineering design.

The organization responsible for the test must verify that the stored energy value for the test does not exceed the stored energy limit for the standard pneumatic test (1,677 kJ). The stored energy value shall be determined in accordance with one of the methods described in Appendix II or Appendix III of this document. Appendix II provides two methods of determining the volume limit for a pneumatic test based on stored energy value of 1,677 kJ. Appendix III provides a method of calculating the stored energy for the test.

If the stored energy value does not exceed 1,677 kJ and the standard procedure is accepted by an ABSA SCO, the test may proceed provided that all safety precautions and safe distance limits are adhered to.

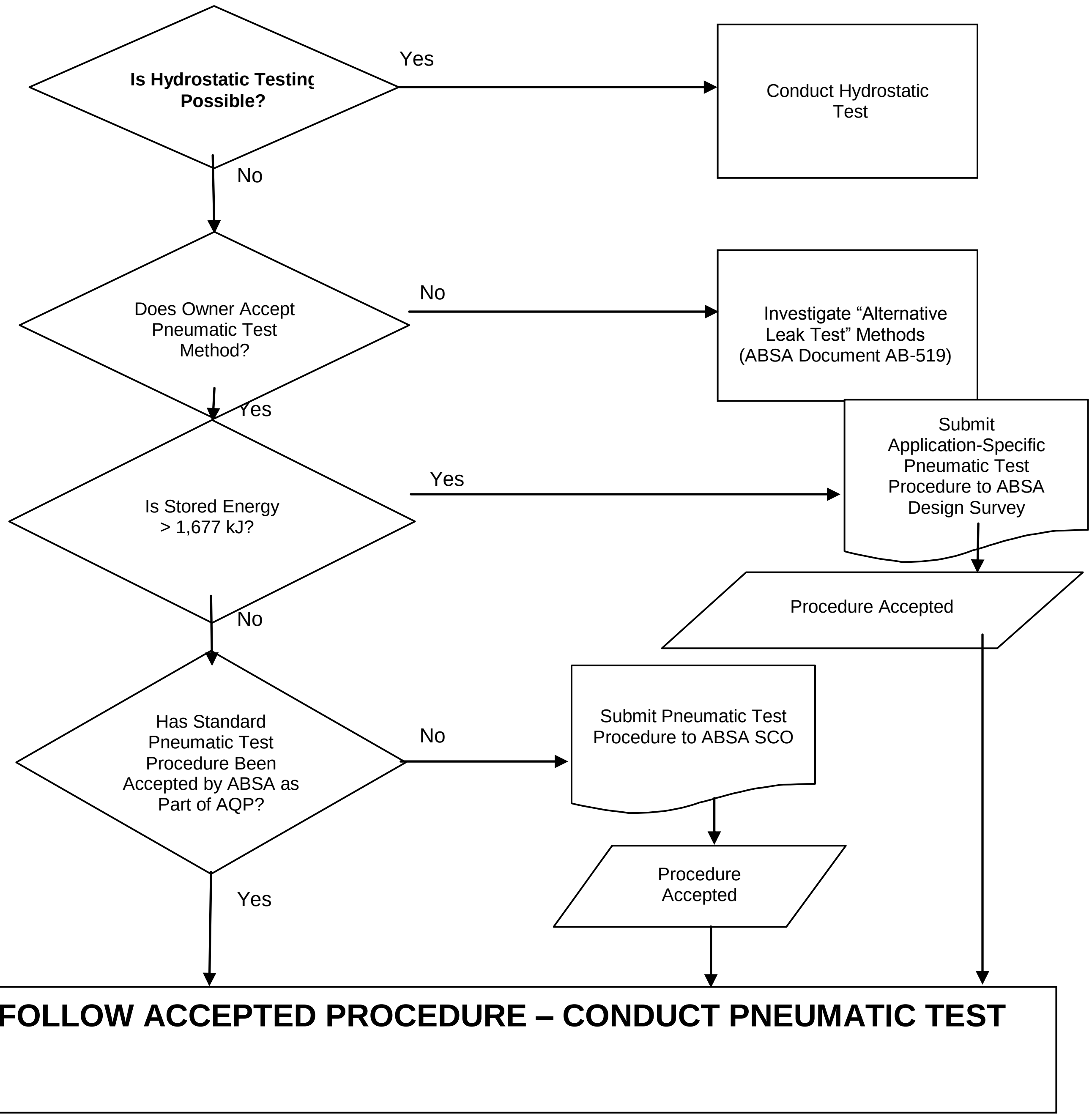
If the stored energy value exceeds 1,677 kJ for a given test, the test procedure must be submitted to ABSA for review and acceptance. Refer to AB-532 for details.

The test must be carried out following any requirements of the applicable code of construction (for example, ASME B31.3, paragraph 345.5), and of any other relevant safety regulations such as the Occupational Health and Safety Act and associated regulations.

REFERENCE PUBLICATIONS

ASME PCC-2 – Repair of Pressure Equipment and Piping, Part 5
ASME B31.3 Process Piping Code
Pressure Equipment Safety Regulation (AR 49/2006)

APPENDIX I: PNEUMATIC TESTING FLOW CHART



APPENDIX II: STANDARD PNEUMATIC TEST VOLUME LIMITS

Test procedure limits are calculated using method A or method B below, based on the design pressure and the volume of the system undergoing testing. The calculation outcome will result in a relatively higher volume for lower pressures, and conversely lower volume for higher pressures, while maintaining the accumulated stored energy of 1,677 kJ.

Step 1

Define piping system DESIGN PRESSURE (DP) and VOLUME (V) including volume of any vessels that will be tested with this piping system.

Step 2

Calculate piping system TEST PRESSURE (TP) using the rules from the code of construction, such as paragraph 345.5.4 of ASME B31.3; paragraph 538.4.2(e) of ASME B31.5; paragraph 137.5.5 of ASME B31.1 (for non-boiler external piping only); paragraph 937.4.4 of ASME B31.9, or clause 5.10.3 of CSA B52.

When the code of construction requires stress ratio correction for an elevated design temperature, the allowable stress at test temperature vs. the allowable stress at the design temperature ratio shall be used in the test pressure calculations.

Step 3

Use the value of TP defined in Step 2 to calculate the volume limit (V_1) for the test applying one of the following two methods: *(see nomenclature below)*

Method A:

If Imperial units are used, calculate V_1 using TP in psi:

$$V_1 = \frac{3436}{(TP + 14.7)\,[1 - (14.7 / (TP + 14.7))^{0.286}]} \quad [ft^3]$$

Or, if SI units are used, calculate V_1 using TP in kPa:

$$V_1 = \frac{670.8388}{(TP + 100)\,[1 - (100 / (TP + 100))^{0.286}]} \quad [m^3]$$

Method B:

Calculate V_1 using values from Table 1 and apply the following interpolation:

$$V_1 = V_B + \frac{(V_A - V_B) \times (TP_B - TP)}{TP_B - TP_A} \quad [ft^3] \text{ or } [m^3]$$

Note: ft^3 or m^3 must be used consistently for all units.

Where:

DP – Design pressure in psi or kPa
TP – Test pressure obtained from step 2, in psi or kPa
V – Total volume of the piping system including any vessels that form part of this system in ft^3 or m^3
TP_A – The first smaller pressure value from Table 1, than the value of TP
TP_B – The first larger pressure value from Table 1, than the value of TP
V_A – The corresponding volume listed in same row of Table 1 as TP_A
V_B – The corresponding volume listed in same row of Table 1 as TP_B
V – Calculated volume limit, in ft^3 or m^3

Table 1: Maximum Test Pressure and Volume Curves

Imperial Units

Test Pressure [psi]	Max Volume [ft^3]	
15	615.90	
20	441.00	
25	342.92	
30	273.68	
40	194.50	
50	145.27	
75	90.11	
100	66.07	*(values used for*
125	50.77	*example below)*
150	41.39	← TP_A & V_A
175	34.21	← TP_B & V_B
200	29.58	
225	25.80	
250	22.84	
275	20.47	
300	18.52	
315	18.0	
325	16.90	
350	15.52	
375	14.35	
400	13.33	
450	11.66	
500	10.35	
600	8.43	
700	7.10	
800	6.11	
900	5.37	
1000	4.73	
1500	2.97	
2000	2.21	

SI Units

Test Pressure [kPa]	Max Volume [m^3]
103	17.440
138	12.488
172	9.710
207	7.750
276	5.508
345	4.114
517	2.552
689	1.871
862	1.438
1034	1.172
1207	0.969
1379	0.838
1551	0.731
1724	0.647
1896	0.580
2068	0.524
2172	0.500
2241	0.478
2413	0.440
2586	0.406
2758	0.378
3103	0.330
3447	0.293
4137	0.239
4826	0.201
5516	0.173
6205	0.152
6895	0.134
10342	0.084
13790	0.063

For Volume Limit (V_1), method B is showing from 0 to 3 % lower values than method A.

Note: The formula to calculate volume limit (V_1) represents the formula of an exponential curve. Therefore, in order to get precise volume limit values (V_1) it is required to follow Method A. Method B (Table 1) is a simplified approach and represents a linear interpolation of the exponential curve. For a given test pressure, the volume limit values (V_1) obtained by methods A and Method B will be different.

Example: How to apply interpolation:

TP = 160 [psi] (from step 2 above)

Using Imperial units, we find in Table 1 that:

TP_A = 150 [psi]
TP_B = 175 [psi]
V_A = 41.39 [ft^3]
V_B = 34.21 [ft^3]

Apply the following equation from Step 3 – Method B:

$$V_1 = V_B + \frac{(V_A - V_B) \times (TP_B - TP)}{TP_B - TP_A} \quad [ft^3] \text{ or } [m^3]$$

$$V_1 = 34.21 + \frac{(41.39 - 34.21) \times (175 - 160)}{175 - 150} \quad [ft^3] \quad \rightarrow \quad V_1 = 38.5\ [ft^3]$$

Step 4
Compare V and V_1.

If $V \leq V_1$ the test parameters meet the standard pneumatic test procedure limits.
If $V > V_1$ the pneumatic test procedure must be submitted to Design Survey for review and acceptance in accordance with AB-532.

APPENDIX III: STORED ENERGY CALCULATIONS

The stored energy for a pneumatic test may be calculated using the below method from ASME PCC-2, Part 5, Article 501, Mandatory Appendix 501-II.

If the calculated E is > 1,677 kJ, the pneumatic test procedure must be submitted to Design Survey for review and acceptance prior to conducting the test. Refer to AB-532 for details.

The stored energy may be calculated using the following formula providing that nitrogen or air is used as the test medium:

$$E = 2.5 \times P_{at} \times V\ [1 - (P_a / P_{at})^{0.286}]$$

Where:
E = Stored energy, in kJ
P_a = Absolute atmospheric pressure, equal to 101 kPa
P_{at} = Absolute test pressure, in kPa (not gauge pressure)
V = Total volume under test pressure, in m^3

APPENDIX IV: SAMPLE STANDARD PNEUMATIC TEST PROCEDURE

The test must be carried out following the requirements of the construction code as applicable. Reference should be made to ASME B31.3, paragraph 345.5; ASME PCC-2, Article 501; and any other relevant safety regulations such as those issued by Occupational Health and Safety.

a) Precautions:
  - Pneumatic testing involves the hazard of released energy stored in compressed gas in the event of a breach of containment.
  - Care must be taken to minimize the chance of brittle fracture during the pneumatic leak test. Test temperature is important in this regard, as low temperatures can increase the chance of brittle fracture, and must be considered when the designer chooses the material for construction.
  - Parts of mechanically assembled systems must not be adjusted while the system is under pressure.
  - Adequate anchoring shall be provided for equipment to be tested.
  - Calibrated pressure gauges shall be used during the test.
  - Valves shall be used to isolate the system equipment from the pressure source.

b) Testing Manifold and Pressure Relief Device (PRD):
  - Any supplementary valves, piping, hoses, etc., required for the test shall be inspected and accepted by the Owner's inspector, with acceptance documented on an AB-83 form.
  - A PRD shall be provided
  - The set point of the PRD shall not be greater than the test pressure, plus the lesser of 345 kPa (50 psi) or 10% of the test pressure.
  - Designs shall include consideration for reaction forces and moments created by the operation of PRDs.
  - It is not permitted to use a pressure regulator instead of a certified PRD.

c) Test Fluid:
  - If not air, the gas shall be nonflammable and nontoxic.

d) Test Pressure:
  - The test pressure shall be in accordance with the code of construction (usually 110% of the design pressure)

e) Preparation:
  - The safe distance, as identified in the test procedure, shall be identified by placing appropriate barriers.
  - All staff associated with or conducting a pneumatic pressure test shall be deemed competent by the organization conducting the test.
  - A pre-test safety meeting should be conducted to ensure all personnel present on the site that may be exposed are aware of the hazards, mitigations, and emergency response plan.
  - All visual inspections and non-destructive examinations required by the code of construction shall be completed and evaluated as acceptable.
  - A pre-test inspection shall be made to all connections to verify proper assembly and tightness, positioning of valves, overpressure protection, and control of the test medium.

f) Pressurization Procedure:
- The pressure shall be gradually increased until the pressure reaches the lesser of 170 kPa (25 psi), or ½ of the test pressure. At this time a preliminary check shall be made. If leaks are identified then the system shall be de-pressured and repairs made to correct the deficiency prior to proceeding.
- Thereafter, the pressure shall be gradually increased in steps until the test pressure is reached (i.e. 25%, 50%, 75% of MAWP, followed by test pressure). The pressure shall be held at each step long enough to equalize the piping strains. The safe distance identified in the procedure must be observed during this portion of the test. If leaks are identified, the system shall be de-pressured and repairs made prior to proceeding. Re-pressurization must follow all of the above steps.
- The test pressure shall then be reduced to the design pressure before examining for leakage.

Note: The safe distance must be observed from after the preliminary test until the system pressure is reduced from the required test pressure back to the equipment's design pressure.

- Depressurization must take place in a controlled manner to avoid cooling due to the refrigeration effect, to equalize pipe strains, and to be cautious about the vented test fluid.
- The procedure must address the dangers of confined space and the possibility of asphyxiation from a test medium such as nitrogen. This danger is especially high should a leak occur, or at the time of depressurization.

g) Removal of Testing Manifold:
- Any supplementary valves, piping, hoses, etc., required for the test shall be removed after testing is complete.

APPENDIX V: TESTING OF INSTRUMENTATION TUBING SYSTEMS

Pressure testing of threaded and welded piping presents different hazards than instrumentation systems constructed of tubing and compression fittings. The amount of stored energy in instrumentation tubing systems is generally very low. The primary concerns for the safe distance when testing instrumentation tubing are the “line of fire” and proper anchoring of the test system.

For instrumentation tubing, the owner shall assess the potential consequences of a failure and identify any required controls and precautions in the test procedure to prevent personnel injury. The owner is responsible to provide competent personnel to oversee the testing.

The procedure shall include:

- Verifying proper anchoring of the tubing, and specifying minimum safe distances for the shop personnel as well as testing personnel
- Addressing line-of-fire[2] hazards for personnel who will be conducting the leak test
- Verification that all fittings were marked, installed, tightened, and gap-checked according to the manufacturer’s installation procedure
- Pressurization of the tubing as outlined in Appendix IV of this procedure
- Complete depressurization of the system before adjusting or tightening any joints, if any leaks are detected; all pressurization steps must be repeated after performing any such adjustment the any repair
- Leak-testing of all joints, generally by means of a bubble test which makes use of a leak-testing solution to emphasize leaks by producing bubbles
- Care shall be taken to ensure testing personnel stay out of the line of fire of connections being subjected to bubble testing; bubble testing shall follow the recommendations of the bubble solution supplier

Note: Typically the safe distances required for pneumatic tests of instrumentation tubing will be considerably less than the safe distance for threaded or welded systems, due to its low risk of potential failure and low volume of the test piece.

[2] The “line of fire” is defined as the area where either unsecured tubing could travel from a reactionary force if a fitting fails, or where the gas stream would be expected to project in the event of a breach of containment.

8.0 REVISION LOG

Edition #	Rev #	Date	Description
1		2012-02-20	Editorials to the entire document.
2		2012-06-28	Editorials to the entire document.
2	1	2016-10-24	Editorials to the Foreword section of the document.
2	2	2019-07-31	Updated definitions, and several revisions in the text.
3	0	2023-03-24	Editorials to the entire document. Scope revised to Include non-ferrous materials copper and brass. New Section 7 related to manifold and PRD requirements.