

Standard Pneumatic Test Procedure Requirements for Piping Systems

AB-522

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FOREWORD

As provided for under Section 30(2) of the Pressure Equipment Safety Regulation, the Administrator in the pressure equipment discipline may accept pneumatic testing of pressure piping systems. The Administrator has issued Information Bulletin IB16-014 to establish that a standard pneumatic test of pressure piping systems may be conducted in accordance with the provisions of ABSA Document AB-522, "*Standard Pneumatic Test Procedure Requirements for Pressure Piping Systems*". AB-522 specifies requirements for establishing 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.

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). The acceptance of pneumatic testing of pressure piping may be done 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.

2.0 SCOPE

The requirements in this document apply to pressure testing of pressure piping systems in Alberta by an organization that holds a certificate of authorization permit to construct pressure piping.

3.0 DEFINITIONS

Alberta Quality Program (AQP): Quality program registered with ABSA that covers a defined scope such as piping fabrication, vessel fabrication, etc and has been reviewed and accepted by an ABSA Safety Codes Officer.

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

Design Pressure: The pressure authorized on the design registration.

DMT: Design Minimum Temperature.

MAWP: Maximum Allowable Working Pressure

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.

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

Pressure Equipment Safety Regulation (PESR): Alberta regulation issued under the Safety Codes Act.

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.

Pressure vessel: means a vessel used for containing, storing, distributing, processing or otherwise handling an expansible fluid under pressure.

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

Safety Codes Officer: means a safety codes officer, designated under the Safety Codes Act, in the pressure equipment discipline.

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:

30(1) All pressure piping leak tests must be conducted using the hydrostatic method.

30(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.

30(3) A pressure piping system shall not be tested at a temperature that is colder than its minimum design temperature.

30(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 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 providing:

- 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* document for detailed quality management system requirements.

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 up 1677 kJ of stored energy (equivalent to 0.5m³ internal volume and 2172 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 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 1677 kJ,
- ii) The pressure piping system is made of P-1 or P-8 materials,
- 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, and
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),
- v) Refer to the appropriate code of construction for possible additional requirements.

A job 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 1677 kJ stored energy threshold was calculated using the equation in ASME PCC-2, Part 5, Article 5.1, Mandatory Appendix II with the following pressure and volume parameters:

Test pressure: 2172 kPa (315 psi);
Volume: 0.5m³ (18 ft³);

Linear interpolation of the pressure-volume values is permitted providing that the stored energy value (1677 kJ) of the standard pneumatic test is not exceeded. See Appendix II of this document for example of interpolation.

7.0 PROCEDURE

The AQP holder must establish a pneumatic testing procedure for a pressure piping system that addresses all the safety considerations necessary to conduct the test safely and meet the requirements specified in this AB-522 document.

A sample standard pneumatic test procedure is described in Appendix IV of this AB-522 document.

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 limit for personnel during the pneumatic test. The minimum safe distance of 30 meters, based on PCC-2 Article 5.1 Mandatory Appendix III and using the standard pneumatic test values, may be used.

Alternatively, the AQP holder may, unless the hazard assessment suggests otherwise, reduce this safe distance limit by:

- installing properly designed and fabricated barriers capable of withstanding the sudden release of stored energy should the system fail, or
- placing the test item in an engineered enclosure, or
- calculating the minimum safe distance using another recognized standard, or
- taking other measures to minimize the risk of harm to personnel.

Design pressure, test pressure, test temperature, and design minimum temperature (DMT) 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 (1677 kJ).

The organization responsible for the test shall determine the stored energy value for the test 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 1677 kJ. Appendix III provides a method of calculating the stored energy for the test.

If the stored energy value does not exceed 1677 kJ and the standard procedure is accepted by an ABSA SCO, the test may proceed providing that all safety precautions and safe distance limits are adhered to.

If the stored energy value exceeds 1677 kJ for a specific test, the procedure for the specific test must be submitted to ABSA for review and acceptance.

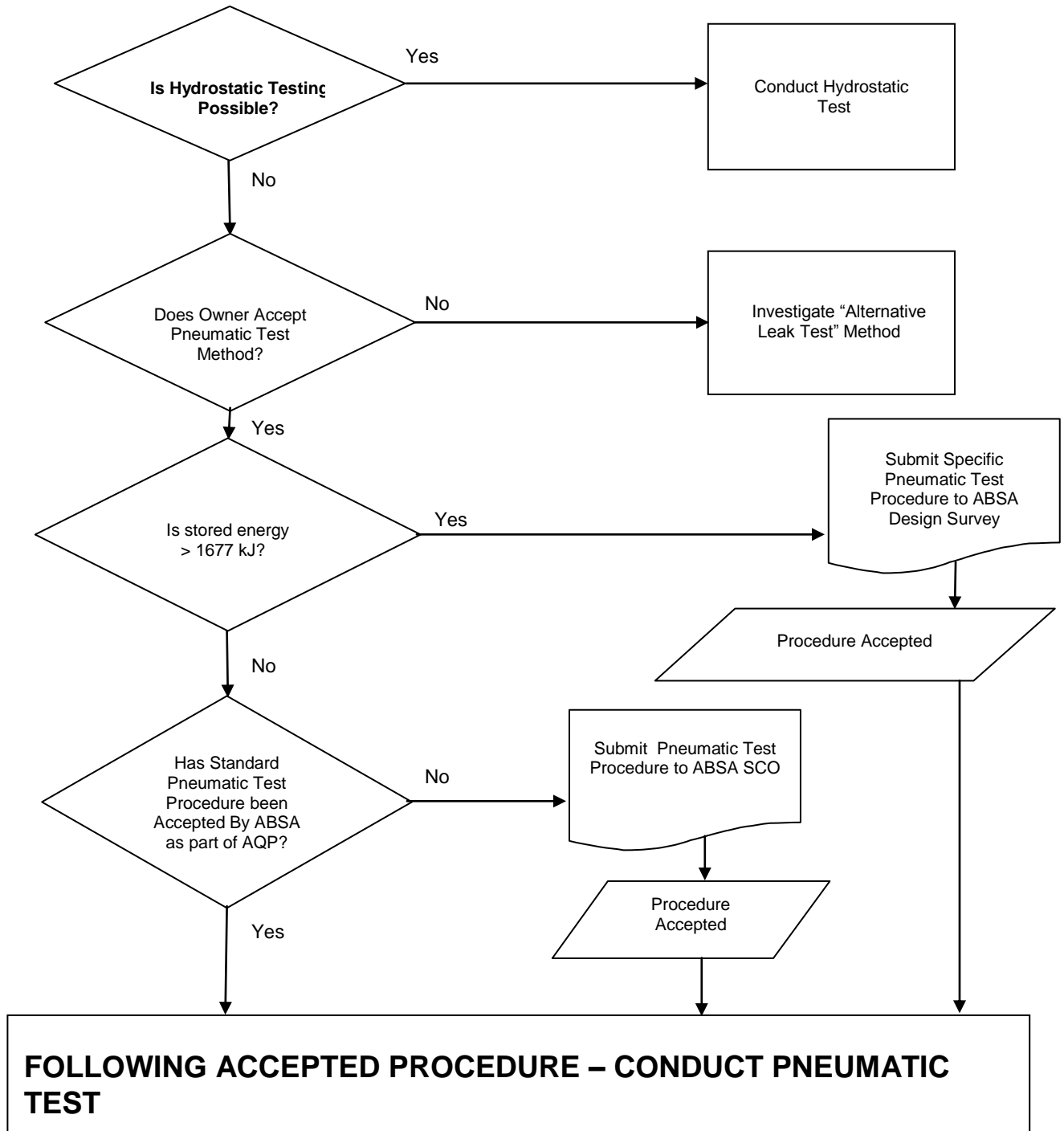
The test must be carried out following the requirements of the construction Code as applicable (for example, ASME B31.3-2008, paragraph 345.5) and any other relevant safety regulations such as the Occupational Health and Safety Regulation.

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 Procedure 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 relatively higher volume for lower pressure and conversely lower volume for higher pressure while maintaining the accumulated stored energy of 1677 kJ.

Step 1

Define piping system DESIGN PRESSURE (DP) and VOLUME (V) including volume of 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 (for example: 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, clause 5.10.3 of CSA B52).

Note: When the code of construction requires stress ratio correction, 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:

Method A

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

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

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

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

Method B

Calculate V_1 using values from table 1 and apply the following interpolation

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

Where:

- DP – design pressure in psi or kPa
 TP – test pressure in psi or kPa
 V – total volume of the piping system including any vessels that form part of this system in ft³ or m³
 TP_A – the first smaller pressure value in the table 1 than the step 2 TP value
 TP_B – the first larger pressure value in the table 1 than the step 2 TP value
 V_A – the corresponding table 1 volume listed in same row as TP_A
 V_B – the corresponding table 1 volume listed in same row as TP_B
 V – calculated volume limit in ft³ or m³

For Volume Limit (V₁), Method B is showing from 0 to 3 % lower values than Method A.

Table 1

Imperial Units

Test Pressure	Volume
psi	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
125	50.77
150	41.39
175	34.21
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

TP_A & V_A
TP_B & V_B

SI Units

Test Pressure	Volume
kPa	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

Example how to apply interpolation:

$$TP = 160 \quad [\text{psi}]$$

Using Imperial units, we found in table 1 that:

$$TP_A = 150 \quad [\text{psi}]$$

$$TP_B = 175 \quad [\text{psi}]$$

$$V_A = 41.39 \quad [\text{ft}^3]$$

$$V_B = 34.21 \quad [\text{ft}^3]$$

Apply the following equation from Step 3 – Method B:

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

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

Step 4

Compare V and V_1 .

If $V \leq V_1$ the test limits 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.

APPENDIX III

The stored energy for the pneumatic test may be calculated using the method provided in PCC-2, Part 5, Article 5.1 Mandatory Appendix II:

If the calculated E is > 1677 kJ, the pneumatic test procedure must be submitted to Design Survey for review and acceptance prior to conducting the test.

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, 101 kPa

P_{at} = absolute test pressure in kPa

V = total volume under test pressure in m³

APPENDIX IV

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 5 and any other relevant safety regulations such as those issued by Workplace 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 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.
- b) Pressure Relief Device (PRD)
 - A PRD shall be provided
 - Set point of the PRD shall not be greater than Test Pressure + lesser of 345 kPa (50 psi) or 10% of the test pressure.
- 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 is the lesser of 170 kPa (25 psi) or $\frac{1}{2}$ of the Test Pressure. At this time the preliminary check shall be made. If leaks are identified 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% MAWP, 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 to design pressure after successful attainment of test pressure.

- Depressurization must take place in a controlled manner to avoid sub-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 the test medium such as nitrogen. This danger is especially high should a leak occur or at the time of depressurization.

APPENDIX V

Pressure testing of instrumentation systems comprised of tubing and compression fittings.

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.

For instrumentation tubing, the owner shall assess the potential consequence of a failure and identify the controls and/or 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, specifying minimum safe distances for the shop personnel as well as testing personnel
- Addressing the “line of fire”* (as defined at the end of this section) for personnel who will be conducting the leak test. Note: Typically the safe distances for pneumatic tests of instrumentation tubing will be considerably less than the safe distance for a threaded or welded systems due to its low risk of potential failure and low volume of the test piece.
- The primary concerns for the safe distance when testing instrumentation tubing are the “line of fire” and proper anchoring of the test system.
- Verification that all fittings were marked, installed, tightened and gap checked according to manufacturer’s installation procedure.
- Pressurization of the tubing being tested must follow the requirements as outlined in Appendix IV of this procedure.
- If any leaks are detected during the pressurization the system must be de-pressured before any tightening of leaking joint(s). All pressurization steps must be repeated after performing the any repair.
- All joints must be leak tested. An appropriate leak test solution such as “snoop” is generally used.
- Care shall be taken to ensure testing personnel stay out of the “line of fire” of the connections being tested while conducting the “snoop” test. The “snoop” test is to follow the snoop supplier’s recommended procedure.

* The “line of fire” is defined as the area where either unsecured tubing would travel from the reactionary force if a fitting failed or where the gas stream would project in the event of a breach of containment.

8.0 REVISION LOG

Rev #	Date	Description
Edition 1	2012-02-20	Editorials to the entire document
Edition 2	2012-06-28	Editorials to the entire document
Revision 1	2016-10-24	Editorials to the Foreword section of the document