Pneumatic testing procedures

Format of pneumatic test procedure

1. Test procedures ≤ 1677 kJ stored within the pneumatic test limitations may be developed and submitted by a licensed contractor using an application-specific or standard pneumatic test procedure format.
2. Pneumatic test procedures > 1677 kJ that are not within the pneumatic test limitations shall be developed using an application-specific procedure. The application-specific procedure shall be developed and approved by a professional engineer and submitted to Technical Safety BC for acceptance **prior to conducting the test**. Submit via email:
   - Subject line: "Pneumatic Test Procedure Submission".
   - Attention: Engineering

Standard pneumatic test procedure

Licensed contractors who frequently perform pneumatic pressure tests may include an accepted pneumatic test procedure ≤ 1677 kJ that is within the stored energy, temperature and pneumatic test limitations in their quality control manual. The addition of the procedure will constitute a revision to the Quality Control Manual (QCM). The licence holder shall submit their QCM to Technical Safety BC for review and acceptance. Revisions are normally submitted to the regional boiler safety officer. The standard test procedure shall be acceptable for subsequent pneumatic tests within the limitations of the accepted procedure.

Witnessing of pneumatic test procedures

Where a safety officer witnesses a pneumatic test, the licence holder must establish a pneumatic testing procedure that addresses all the safety considerations necessary to conduct the test safely and ensure the safety of those present at the workplace (Workers Compensation Act Section 115 1(a)(i)).

The following outlines minimum procedure requirements for licence holders seeking acceptance of a pneumatic test procedure. Additional items may be required depending on the specific system, equipment, and code of construction.

- An overview of the process is found in a flow chart at the end of this document.

Definitions

1. an expansible fluid, or
2. a non-expansible fluid or thermal fluid with an operating temperature exceeding 121°C or a working pressure exceeding 1,100 kPa between 2 or more points.

application- specific test procedure	A job-specific test procedure, applicable to one site, created for a specific use.
design pressure	The pressure authorized on the design registration.
MAWP	maximum allowable working pressure.
pneumatic test	A pressure or tightness test where a gas – generally nitrogen or air – is the test medium.
pressure piping	A system of pipes, tubes, conduits, gaskets, bolts, and other components that have the sole purpose of conveying
pressure vessel	A vessel used for containing, storing, distributing, processing, or otherwise handling an expansible fluid under pressure.
professional engineer	A person who holds a degree in mechanical engineering accredited by the Canadian Engineering Accreditation Board and is registered as a professional engineer.
Quality Control Program (QCP)	A conformity assessment program registered with Technical Safety BC detailing the scope of work performed by the licensed contractor and establishing how all requirements of *The Act*, Regulations and applicable codes will be met. A written Quality Control Manual (QCM) is the document submitted to Technical Safety BC for acceptance.
safe distance	To prevent any injuries, safe distance is the minimum distance between all personnel and the equipment being tested. This distance is based on the potential blast wave distance and is maintained to minimize the risk of fragments of the vessel or piping impacting personnel.
standard pneumatic test	A leak test of a pressure system using air or nitrogen, conducted by an organization holding a Technical Safety BC contractor licence. The test must use a procedure referenced in the organization's Quality Control Manual (QCM) that is within the stored energy, temperature, and material limitations established in this document.

General

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. Where a hydrostatic test is considered to be impracticable, a pneumatic test in accordance with the construction code may be substituted. The licensed contractor must justify the rationale for, and seek acceptance from Technical Safety BC for the alternative test. Acceptable reasons for using a pneumatic test may include the following:

- the system cannot be readily dried and is used in services where traces of testing fluids cannot be tolerated
- the equipment is so designed or supported that it cannot be safely filled with water

Hazard identification

The procedure must identify environmental and operational hazards associated with pneumatic testing.

Roles and responsibilities

The procedure must identify the individual who is responsible for ensuring that the requirements of the procedure are properly implemented and empower all personnel with authority to stop work whenever hazardous conditions are identified.

Pneumatic test limitations

Identify that the scope of equipment is within the following test limitations:

- The stored energy value will not exceed 1677 kJ.
- The pressure system is made of P-1, P-8 material or a material acceptable to Technical Safety BC that conforms to a specification listed in the code of construction.
- The test medium is air or nitrogen.
- The testing will be conducted at a temperature of at least 17°C (30°F) above the design metal's minimum temperature.
- Any additional requirements appropriate to the code of construction.

Pneumatic test procedures that are not within the Pneumatic Test Limitations shall be developed using an application-specific procedure. The application-specific procedure shall be developed and approved by a professional engineer and submitted to for acceptance prior to conducting the test

The procedure must:

- Require that affected personnel fully understand the process, potential hazards, and protective measures.
- Describe the use of any specific personal protection equipment (PPE) that may be needed to safely perform or witness the test (e.g., face shields at a manifold station).

Exclusion zone

The procedure must:

- Describe precautions to be taken so that unauthorized persons remain out of the test area during the test period.
- Prescribe a minimum safe distance to be maintained.
    - 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, unless the hazard assessment suggests otherwise, the licensed contractor may 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.
- Restrict access to the immediate area involving the pressure test (i.e., test shelter, manifolds, instruments) to only those who are actively engaged in the testing operation.

Pre-test checks and inspections

The procedure must describe a pre-test inspection to verify the following, where appropriate:

- The system is completed according to drawings and specifications.
- All visual inspections and non-destructive examinations required by the code of construction shall be completed and evaluated as acceptable.
- Parts of the system not being tested are adequately isolated.
- A pre-test inspection shall be made to verify proper assembly and tightness of connections, positioning of valves and all supports are installed as designed.
- Proper assembly, including tightness of connections, positioning of valves, over pressure protection and hangers and supports are in place as designed.
- There is no damage, misalignment or anything else out of place.
- All associated lockouts are in place.
- Any hoses are restrained or anchored and whip checks are in place.

Final preparation

The procedure must:

- Describe the test pressure value and verify that it is the minimum in accordance with the code of construction (usually 110% of the design pressure).
- Require that gauge(s) are calibrated and that the appropriate range is used (1.5 – 4 times of test pressure).
- Require that metal temperature is satisfactory at test time.
- Require that the safe distance, as identified in the test procedure shall be identified by placing appropriate barriers to restrict non-essential personnel from the test area.
- Require that overpressure protection is in place and set to the lesser of 50 psi or 10% above the test pressure.

Testing activities

The procedure must:

- Describe a graduated pressurization method to reach test pressure, including minimum durations to hold the pressure at each graduated step.

- Require that the test pressure be reduced to design pressure before examining for leakage.
- Require that if leaks are identified, the system shall be de-pressurized prior to proceeding with repairs or correction of the deficiency.
- Require that depressurization must take place in a controlled manner and the dangers of a confined space and possibility of asphyxiation from the test medium (such as nitrogen) are considered.

Documentation

The procedure must:

- Provide exhibits for all required forms and test reports. Detail a method for documenting the procedure as well as final results.
- Require authorization of the test report by the contractor and the owner's representative or safety officer.

Test pressure

Test pressures must be determined using the rules from the code of construction. The lowest permissible test pressure shall be used.

Stored energy calculation

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 developed and approved by a professional engineer. This approved procedure must be sent to Technical Safety BC Engineering for assessment and registration prior to starting the test.

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

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

Where:

E = stored energy in kJ
Pa = absolute atmospheric pressure, 101 kPa P_{at} = absolute test pressure in kPa
V = total volume under test pressure in m3

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 system DESIGN PRESSURE (DP) and VOLUME (V).

Step 2

Calculate system TEST PRESSURE (TP) using rules from the code of construction.

Step 3

Using the value of TP calculate the VOLUME LIMIT (V1) for the test applying one of the following two methods:

Method A

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

$$V1 = \frac{3436}{(TP + 14.7)\,[1 - (14.7/(TP+14.7))^{0.286}]} \text{ [ft3]}$$

Or, if SI (Standard Imperial) units are used, calculate V_1 using TP in kPa

$$V_1 = \frac{670.8388}{(TP + 100)\,[1 - (100/(TP+100))^{0.286}]} \text{ [m3]}$$

Method B

Calculate V1 using values from Table 1 and apply the following interpolation

$$V_1 = V_B + \frac{(V_A - V_B) \times (TP_B - TP)}{TP_B - TP_A} \text{ [ft3] or [m3]}$$

Where:

DP	design pressure in psi or kPa
TP	test pressure in psi or kPa
V	total volume of the pressure system in ft3 or m3
TP_A	the first smaller pressure value in Table 1 than the step 2 TP value

TP_B	the first larger pressure value in Table 1 than the step 2 TP value
VA	the corresponding Table 1 volume listed in same row as TPA
V_B	the corresponding Table 1 volume listed in same row as TPB
V	calculated volume limit in ft3 or m3

For Volume Limit (V_1), Method B shows from 0 to 3% lower values than Method A.

Table 1				
Imperial Units			SI Units	
Test			Test	
Pressure	Volume		Pressure	Volume
psi	ft3		kPa	m3
15	615.90		103	17.440
20	441.00		138	12.488
25	342.92		172	9.710
30	273.68		207	7.750
40	194.50		276	5.508
50	145.27		345	4.114
75	90.11		517	2.552
100	66.07		689	1.871
125	50.77		862	1.438
150	41.39	TP_A & V_A	1034	1.172
175	34.21	TP_B & V_B	1207	0.969
200	29.58		1379	0.838
225	25.80		1551	0.731

250	22.84		1724	0.647
275	20.47		1896	0.580
300	18.52		2068	0.524
315	18.0		2172	0.500
325	16.90		2241	0.478
350	15.52		2413	0.440
375	14.35		2586	0.406
400	13.33		2758	0.378
450	11.66		3103	0.330
500	10.35		3447	0.293
600	8.43		4137	0.239
700	7.10		4826	0.201
800	6.11		5516	0.173
900	5.37		6205	0.152
1000	4.73		6895	0.134
1500	2.97		10342	0.084
2000	2.21		13790	0.063

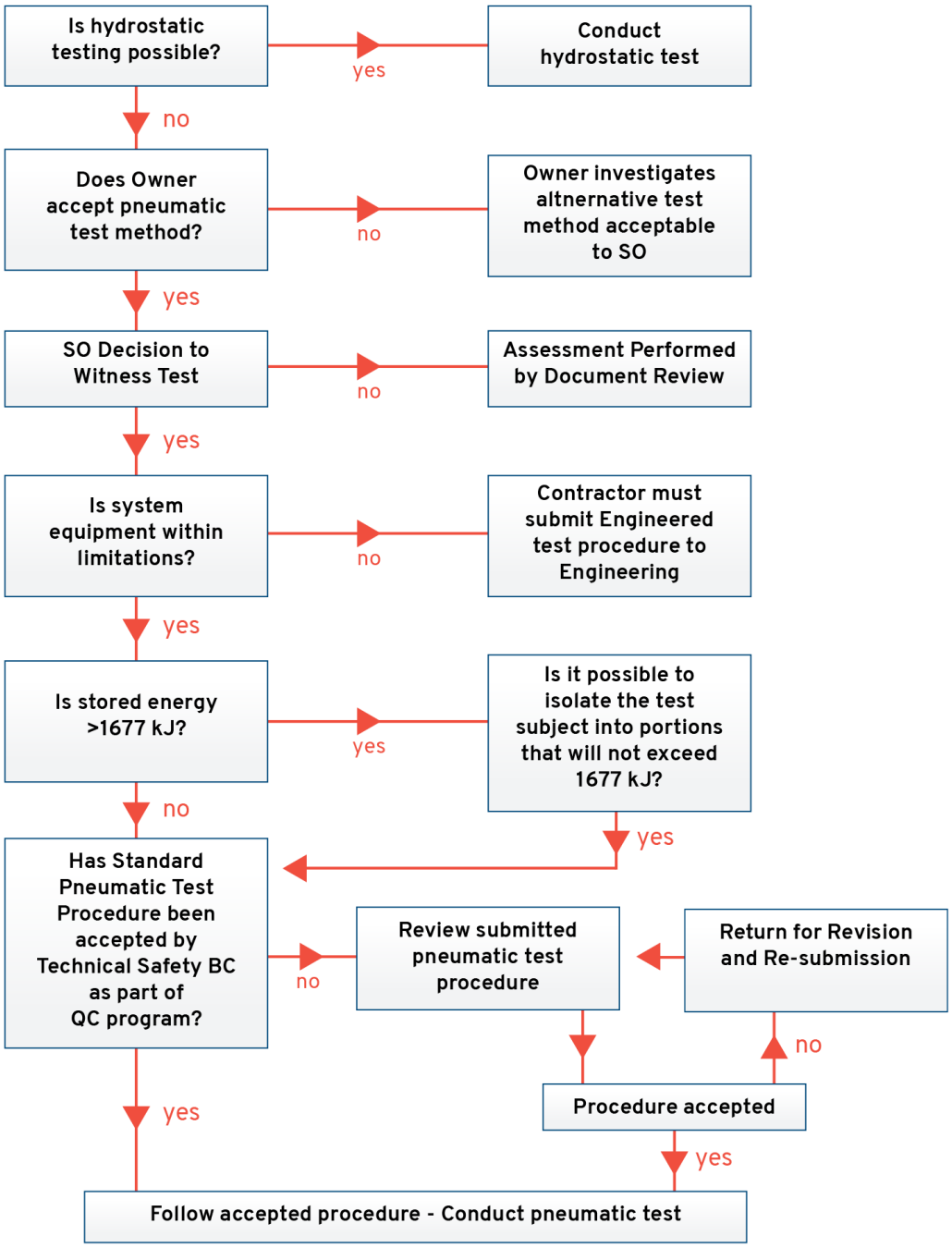
Step 4

Compare V and V1

If V ≤ V1, the test limits are within the 1677 kJ threshold and the procedure may be developed by the licensed contractor and submitted to a safety officer for review and acceptance.

If V ≥ V1, the pneumatic test procedure must be submitted via email for engineering assessment and registration.

Flowchart


Is hydrostatic testing possible?
yes
Conduct hydrostatic test
no
Does Owner accept pneumatic test method?
no
Owner investigates altnernative test method acceptable to SO
yes
SO Decision to Witness Test
no
Assessment Performed by Document Review
yes
Is system equipment within limitations?
no
Contractor must submit Engineered test procedure to Engineering
yes
Is stored energy >1677 kJ?
yes
Is it possible to isolate the test subject into portions that will not exceed 1677 kJ?
yes
no
Has Standard Pneumatic Test Procedure been accepted by Technical Safety BC as part of QC program?
no
Review submitted pneumatic test procedure
Return for Revision and Re-submission
no
Procedure accepted
yes
yes
Follow accepted procedure - Conduct pneumatic test