

Appendix C – Field Testing of Pipelines

(Normative)

C1 Scope

Appendix C is based on some of the test methods in AS/NZS 2566.2, section 6, and associated appendices. This appendix specifies suggested methods of test and their application to field testing of pipelines for the purpose of determining pipeline acceptability. Field testing includes leak or hydrostatic pressure testing, as appropriate, for pressure and non-pressure pipelines. Testing may also be carried out in accordance with the material-specific and application-specific test methods of AS/NZS 2032, AS/NZS 2033, and AS/NZS 2566.2.

C1.1 Purpose of field testing

The purpose of field testing is to:

- (a) Reveal the occurrence of faults in the laying procedure, for example, joints incorrectly installed or pipes damaged;
- (b) Reveal the occurrence of faults in the assembly procedure of pipeline components, for example, tapping bands, maintenance structures, frames, and covers;
- (c) In the case of pressure pipelines, determine that the pipeline will sustain a pressure greater than its design pressure without leakage;
- (d) In the case of non-pressure pipelines, determine that the pipeline satisfies the requirements for infiltration and exfiltration; and
- (e) Test the installed structural integrity of the pipeline.

Field testing is not intended to supplement or replace the test requirements of product standards.

C2 Non-pressure pipelines – Field leakage testing

Leakage testing is used to reveal locations of potential infiltration and exfiltration due to the inclusion of damaged pipes, seals, or incorrectly made joints in the pipeline at the completion of installation.

Leakage testing for acceptance of non-pressure pipelines shall be carried out by at least one of the following methods:

- (a) Low pressure air testing;
- (b) Hydrostatic testing

NOTE – Air tests provide qualitative data only, as air pressure losses cannot be related directly to water leakage rates.

For pipeline test sections installed below the water table, and for submarine pipelines, the test pressure used for the hydrostatic test, and for the air test, shall be increased to maintain the required differential between internal and external pressure.

A pipeline failing to meet the requirements of the air tests may be retested using the hydrostatic test method.

NOTE – Failure is still probable.

C2.1 Low pressure air test

The test length shall be acceptable where the gauged pressure exceeds 18 kPa (or not more than 7 kPa less than the pressure at the start of the test) for the time interval shown in table C1 after the shut-off of the air supply.

Table C1 is based on an air test pressure of 25 kPa (in excess of any external hydrostatic pressure due to groundwater) and, on this basis, air volume losses shall not exceed the greater of:

- (a) A rate of $0.0009 \text{ m}^3/(\text{min} \times \text{m}^2)$ of pipe wall area; and
- (b) A rate of $0.056 \text{ m}^3/\text{min}$, which is regarded as the lowest detectable individual air leak.

Column 2 and column 3 of table C1 give the times and lengths up to which (b) prevails over (a).

NOTE – For safety reasons air test pressures in excess of 50 kPa should not be applied.

Table C1 – Low pressure air and vacuum tests – Minimum time intervals for 7 kPa pressure change in pipeline

DN	Minimum time (minutes)	Maximum length for minimum time to apply (metres)	Test length (metres)				
			50	100	150	200	250
			Minimum test duration (minutes)				
80	1.5	231	1.5	1.5	1.5	1.5	1.6
100	2	185	2	2	2	2	3
150	3	123	3	3	3	5	6
225	4	82	4	5	8	10	13
300	6	62	6	9	14	18	23
375	7	49	7	14	22	29	36
450	9	41	10	21	31	41	52
525	10	35	14	28	42	56	70
600	11	31	18	37	55	73	92
675	13	27	23	46	70	93	116
750	14	25	29	57	86	115	143
900	17	21	41	83	124	165	207
1000	19	19	51	102	153	204	255
1050	20	18.8	56	112	169	225	281
1200	23	15	73	147	220	294	367
1500	28	12	115	230	344	459	574

NOTE –

The time interval may be reduced for a proportionate reduction in the allowable pressure drop. Where there is no detectable change in pressure after 1 hour of testing, the section under test shall be deemed acceptable.

This table is based on the following equation:

$$T = 1.02D_1kLq$$

where

T = time for a 7 kPa pressure drop, in seconds

D_1 = pipeline internal diameter, in metres

q = allowable volume loss in cubic metre/minute/square metre taken as 0.0009 m³/min.m²

k = 0.054 D_1L but not less than 1

L = length of test section, in metres.

Columns 2 and 3 have been calculated with $k = 1.0$.

The appropriate air or vacuum test/pressure method for pipes larger than DN 750 should be established by reference to the specifier.

C2.1.1 Low pressure air test procedure

The procedure shall be as follows:

- (a) Pump in air slowly until a pressure of 25 +5,-0 kPa is reached. Where the pipeline is below the water table this pressure shall be increased to achieve a differential pressure of 25 kPa. In no circumstances should the actual pressure exceed 50 kPa;

NOTE – Rapid pressurisation may cause significant air temperature changes, which will effect the testing accuracy.

- (b) Maintain the pressure for at least 3.0 minutes;
- (c) Where no leaks are detected, shut off the air supply;
- (d) Where the pipeline fails the test, repressurise to 25 +5,-0 kPa and check for leaks by pouring a concentrated solution of soft soap and water over accessible joints and fittings;
- (e) Repair any defects, then repeat steps (a) to (c);
- (f) With the air supply shut off, monitor the pressure for the time intervals given in table C1.

The test length shall be acceptable where the pressure drops by 7 kPa, or less, over the required (tabulated) test period.

NOTE –

(1) The test length of pipeline should be restricted to pipeline sections between maintenance holes (the most convenient places for inserting test plugs or fixing temporary bulkheads). The method should not be used for test lengths in excess of 250 m and for pipe diameters larger than 1500 mm.

(2) The procedure for low pressure air testing of large diameter pipelines is potentially hazardous because of the very large forces to be resisted by temporary plugs or bulkheads and the serious consequences of accidental bulkhead blow-out. A relief valve, with a 50 kPa maximum setting, should be installed on all pressurising equipment.

C2.2 Hydrostatic test

The test length shall be acceptable where the specified allowable make up water is not exceeded. Where not specified, the allowable make up water shall be 0.5 L/hour per metre length per metre diameter.

C2.2.1 Hydrostatic test procedure

The procedure shall be as follows:

- (a) The test pressure shall be not less than 20 kPa, or 20 kPa above the groundwater pressure at the pipe soffit at its highest point, whichever is the greater, and not exceed 60 kPa at the lowest point of the section;
- (b) Steeply graded pipelines shall be tested in stages where the maximum pressure, as stated above, will be exceeded if the whole section is tested in one length;
- (c) The pressure shall be maintained for at least 2 hours by adding measured volumes of water where necessary;
- (d) Any visible leaks detected shall be repaired and the pipeline shall be retested.

C3 Pressure pipelines – Field hydrostatic pressure testing

The hydrostatic pressure test method shall be as specified.

Hydrostatic pressure testing requires selecting an appropriate configuration of method, pressure, and length of test section.

Test parameters and details shall be determined with due consideration to the following:

- (a) Pipe material;
- (b) Pipe diameter;
- (c) Length of test section;
- (d) Duration of the test;
- (e) Magnitude of test pressure and rate of pressurisation;
- (f) Presence of air in the pipeline;
- (g) Time required for saturation of porous liners;
- (h) Potential movement of pipeline thrust restraints;
- (i) Design pressure for thrust and anchor supports;
- (j) Accuracy of test equipment;
- (k) Ambient temperature changes during testing;
- (l) Presence of leaks in equipment used for testing or equipment attachment points (such as sealing plugs);
- (m) Potential for leaks in the pipeline.

NOTE – It is advisable to begin testing early in the pipeline installation to confirm adequacy of laying procedures and, where appropriate, to increase the length tested progressively as experience is gained.

C3.1 Selection of test pressure

The hydrostatic test pressure at any point in the pipeline shall be:

- (a) Not less than the design pressure; and
 - (b) Not more than 25% above the rated pressure of any pipeline component.
- NOTE – The design pressure is the maximum system pressure at a point in the pipeline, considering future developments, static pressure, dynamic pressure, and an allowance for short-term surge pressure (water hammer), as determined by analysis.

Compressed air testing shall not be permitted for pressure pipe.

C3.2 Selecting test lengths

The pipeline length tested shall be either the whole, or a section (capable of being isolated), of the pipeline depending on the length and diameter, the availability of water, and the spacing between sectioning valves or blank ends.

The pipeline shall be divided into test sections such that:

- (a) The hydrostatic test pressure at any point in the pipeline is:
 - (i) Not less than the design pressure; and
 - (ii) Not more than 25% above the rated pressure of any pipeline component; and
- (b) Water is available for the test together with facilities for its disposal, in accordance with regulatory requirements, after the test.

NOTE –

- (1) Pipelines longer than 1000 m may need to be tested in several sections. Where

long lengths are to be tested, radio or other electronic means of communication between test operatives, to coordinate test procedures and thus minimise the test duration, is desirable.

(2) Long test sections may incorporate a large number of mechanical (that is, flanged) joints, which should be checked for leakage. The longer the test section the harder it is to locate a leak, or discriminate between a leak and the other effects, such as the absorption of air into solution under pressure.

C3.3 Pre-test procedures

The pre-test procedures are as follows:

- (a) All required temporary and permanent thrust blocks, or other pipeline thrust-resisting methods, including integral joint-restraint systems, shall be in place, and all concrete shall be adequately cured (normally a minimum of 7 days);
- (b) Blank flanges or caps shall be installed at the beginning and end of the test section. Testing shall not take place against closed valves unless they are fully restrained and it is possible to check for leakage past the valve seat. Mechanical ends that are not end load resistant shall be temporarily strutted or anchored, to withstand the test pressures without movement;
NOTE – Temporary supports should not be removed until the pipeline has been depressurised. All test personnel should be informed of the loading limits on temporary fittings and supports.
- (c) Where practicable, all bolted joints shall be left exposed to allow for re-tensioning during or after testing;
- (d) Compacted embedment and fill material shall be placed to leave all joints, service connections and ball valves exposed wherever possible;
- (e) For PE pipelines, the pressurising time shall not exceed 45 minutes;
NOTE – The pressurising time affects the duration of the PE pipeline test.
- (f) The test equipment shall be placed in position and checked for satisfactory operation;
- (g) The pump shall be of adequate size to raise and maintain the test pressure;
NOTE – A pump that is too small may increase the test duration or where too large it may be difficult to control the pressure.
- (h) Two calibrated test gauges shall be used to cross check gauge accuracy;
- (i) Slowly fill the test length of pipeline with water, preferably from the lowest point, ensuring air is vented at the high point valves. Allow a period, in the range of 3 hours to 24 hours, for the temperature of the test length and the test water to stabilise and for dissolved air to exit the system. The recommended rate of filling shall be based on a flow velocity of 0.05 m/s, calculated from the following equation:

$$Q_f \leq 12.5\pi D^2$$

where

Q_f = filling rate, in litres per second

D = pipe diameter, in metres

NOTE – The slow rate of 0.05 m/s avoids air entrainment when the filling water is cascading through downward gradients along the pipeline.

The period of stabilisation will depend on pipe dimensions, length, material, longitudinal profile, and air exit points. For cement-mortar lined pipe, the pipeline

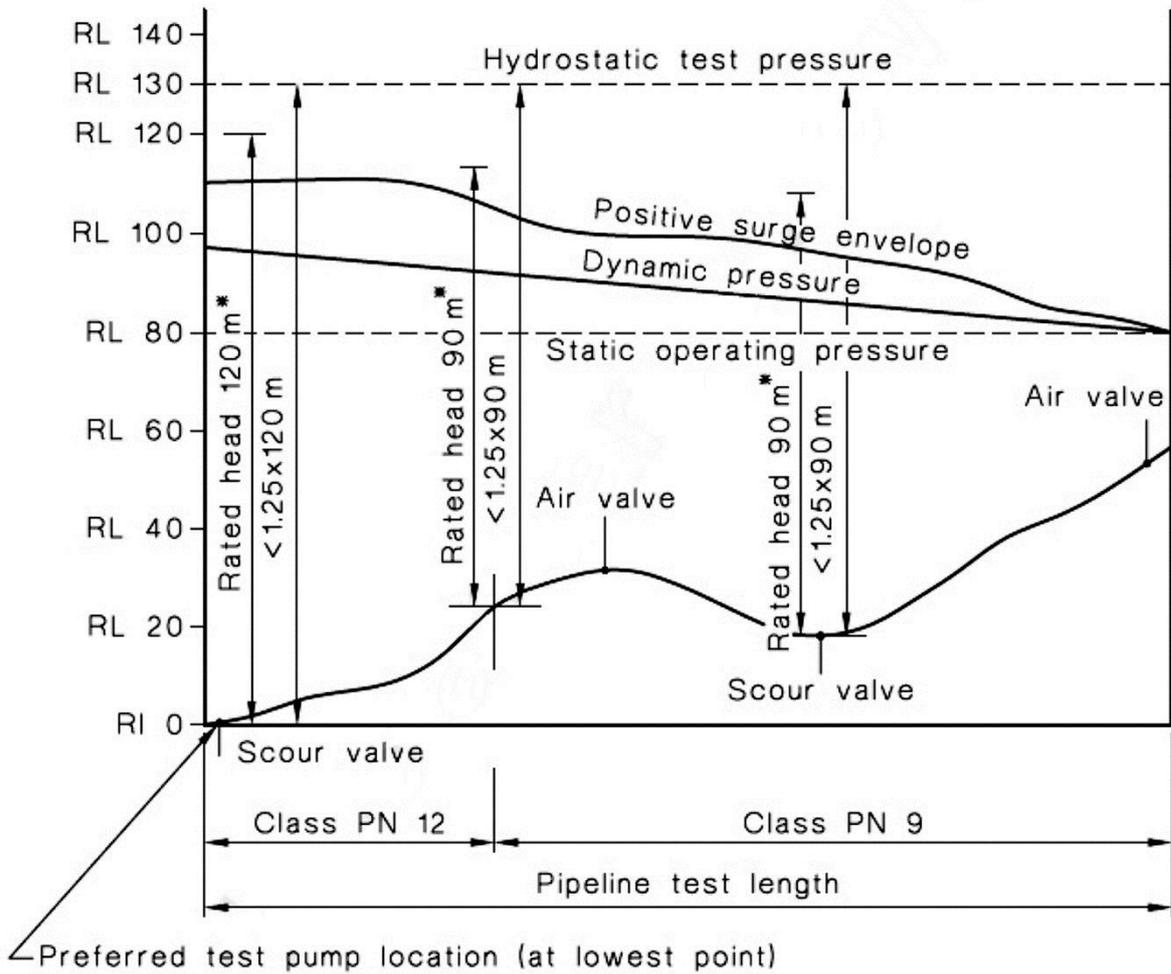
shall be filled at least 24 hours before the commencement of the test, to allow the lining to become saturated.

NOTE – A firm foam swab may be used ahead of the fill water to assist air removal especially where the pipeline undulates. Extract the swab at a high-point wash-out.

Typical pressure test equipment and location are shown in figures C1 and C2.

C3.4 Post-test procedures

After testing, pipelines shall be depressurised slowly. All air venting facilities shall be open when emptying pipelines. The test water shall be drained to an approved waterway and all connection points shall be reinstated.



* for class of pipe, valve or fitting

NOT TO SCALE

Figure C1 – Typical pressure pipeline under field hydrostatic test

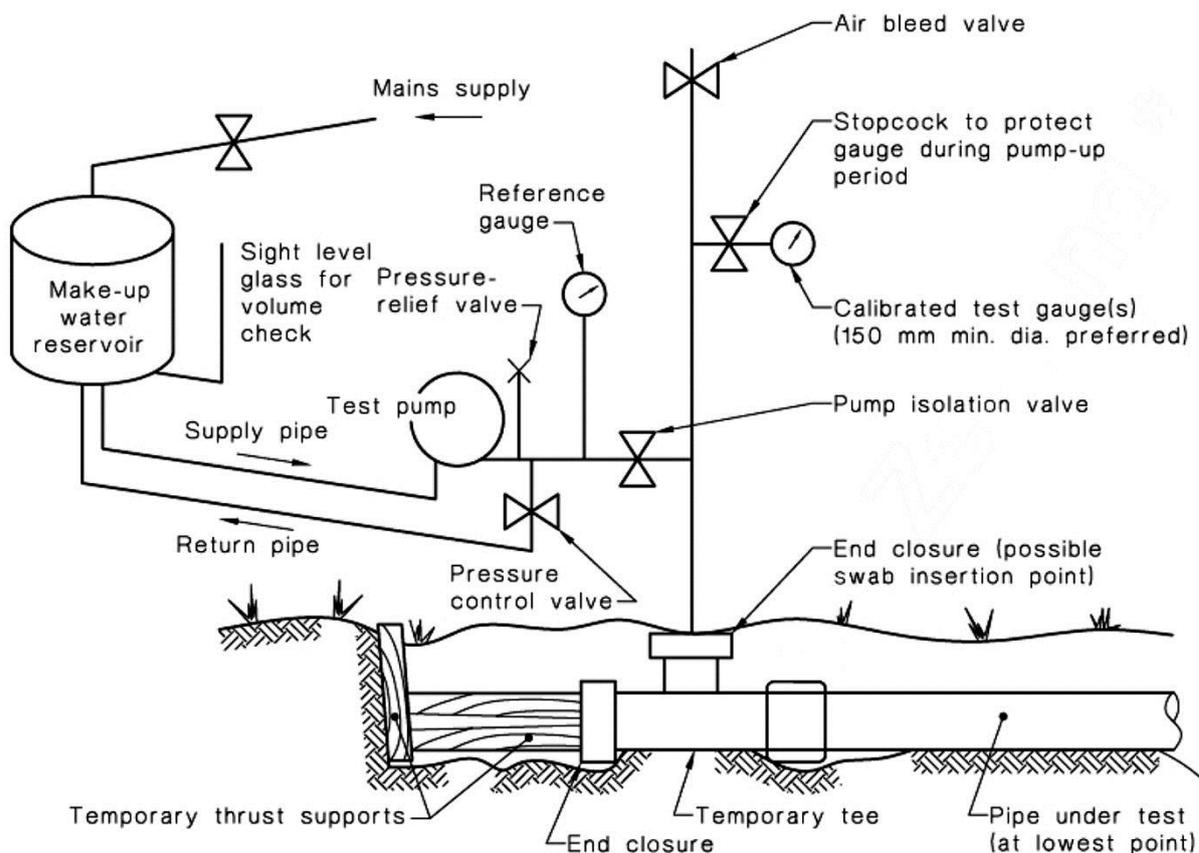


Figure C2 – Typical field pressure test equipment layout

C3.5 Constant pressure test (water loss method) – PVC, DI, GRP, and steel pipelines

This test is applicable for PVC, DI, GRP, and steel pipelines. The test length may be several kilometres in length (see C3.2).

C3.5.1 Procedure

The procedure shall be as follows:

- (a) Close all valves apart from the test pump input and pressurise the test length to the specified test pressure (STP) – (see C3.1);
- (b) Apply and then maintain the test pressure by the addition of measured and recorded quantities of make-up water at regular intervals over a period, in the range of 1 hour to 12 hours;
- (c) Where pressure measurements are not made at the lowest part of the test length, make an allowance for the static head, between the lowest point of the pipeline and the point of measurement, to ensure that the test pressure is not exceeded at the lowest point.

The quantity of make-up water necessary to maintain the test pressure shall comply with the following equation:

$$Q \leq 0.4LDH$$

where

- Q = allowable make-up water, in litres per hour
- L = length of the test length, in kilometres
- D = nominal diameter of the test length, in metres
- H = average test head over length of pipeline under test, in metres

NOTE – The make-up water is not a leakage allowance, but is an allowance to cover the effects of the test head forcing small quantities of entrapped air into solution. Normally the test should last for a minimum of 2 hours and be concluded within 5 to 8 hours. The make-up water requirement should reduce with time as air goes into solution. Where, after 12 hours the make-up water still exceeds the allowable limit, testing should cease and the cause of loss investigated.

C3.5.2 Acceptance

- (a) The test length shall be acceptable where there is no failure of any thrust block, pipe, fitting, joint, or any other pipeline component;
- (b) There is no physical leakage;
- (c) The quantity of make-up water necessary to maintain the test pressure complies with C3.5.1.

C3.6 Constant pressure test (water loss method) for viscoelastic pressure pipelines

This test is applicable to PE, PP, and ABS pressure pipelines. The test lengths may be several kilometres in length.

NOTE – This method is based on VAV P78, as outlined in AS/NZS 2566.2, Appendix A.

C3.6.1 Procedure

The procedure shall be as follows:

- (a) Purge the air from pipeline;
- (b) Apply the specified test pressure (STP) (see C3.1) to the test length;
- (c) Shut off main and allow pressure to settle for 12 hours (pressure will drop significantly);
- (d) Re-apply and maintain test pressure for 5 hours by successively pumping a sufficient amount of water;
- (e) Measure and record water volume (V_1 in litres) required to maintain this pressure between Hour 2 and Hour 3;
- (f) Measure and record water volume (V_2 in litres) required to maintain this pressure between Hour 4 and Hour 5;
- (g) Calculate:

$$0.55 V_1 + Q$$

where Q is the allowable make-up volume obtained from C3.5.1.

C3.6.2 Acceptance

The test length shall be acceptable where:

- (a) The test length shall be acceptable where there is no failure of any thrust block, pipe, fitting, joint, or any other pipeline component;
- (b) There is no physical leakage; and
- (c) $V_2 \leq 0.55 V_1 + Q$.

C3.7 Pressure rebound method for viscoelastic pressure pipelines

This test is applicable to PE, PP, and ABS pressure pipelines up to and including DN 315, where a short test time is required.

NOTE – This test is based on BS EN 805:2000, Appendix A (refer to AS/NZS 2566.2).

C3.7.1 Pressure measurement rig

The test rig shall be a recently calibrated pressure transducer, data logger, and check pressure gauge that has a dial of at least 100 mm diameter and a pressure range that places the specified test pressure (STP) (see C3.1) in the range 35% to 70% of the gauge's full scale. The transducer and the check gauge shall read within $\pm 5\%$ of each other. If they do not agree within this tolerance, the equipment shall be recalibrated or replaced.

C3.7.2 Procedure

The test procedure has the following three phases:

- (a) A preliminary phase in which the pipeline is —
 - (i) Depressurised and allowed to relax after the C3.3 pre-test procedure
 - (ii) Pressurised quickly to the test pressure and maintained at this pressure for a period of time without further water being added
 - (iii) The pressure is allowed to decay by viscoelastic creep, and
 - (iv) Provided the pressure drop does not exceed a specified maximum, the pressure test can proceed to the second phase;
- (b) A phase in which the volume of air remaining in the pipeline is assessed against an allowable maximum;
- (c) The main test phase in which the pipeline is maintained at the test pressure for a period of time and decay due to viscoelastic creep commenced. The creep is interrupted by a rapid reduction of the pressure in the pipeline to a specified level. This rapid reduction in pressure results in contraction of the pipeline with an increase (rebound) in pressure. If, during the rebound period, the pressure versus time record shows a fall in pressure, the pipeline fails the test.

C3.7.3 Preliminary phase

The procedure shall be as follows:

- (a) Reduce pressure to just above atmospheric at the highest point of the test length, and let stand for 60 minutes. Ensure no air enters the line;
- (b) Raise the pressure smoothly to STP in less than 10 minutes. Hold the pressure at STP for 30 minutes by pumping continuously, or at short intervals as needed. Do not exceed STP;
- (c) Inspect for leaks during the 30 minute period, then shut off pressure;
- (d) Allow the pressure to decay for 60 minutes;
- (e) Measure the pressure remaining at 60 minutes (P_{60});
- (f) If $P_{60} \leq 70\%$ of STP the test is failed. The cause shall be located and rectified. Steps (a) to (e) shall be repeated. If $P_{60} > 70\%$ of STP, proceed to the air volume assessment.

C3.7.4 Air volume assessment

The procedure shall be as follows:

- (a) Quickly (<5 min) reduce pressure by ΔP (10%–15% of STP);
- (b) Measure water volume bled out (ΔV);
- (c) Calculate $\Delta V_{\text{max allowable}}$ as follows:

$$\Delta V_{\text{max allowable}} = 1.2 \times V \times \Delta P (1/E_W + D/E_R)$$

where

- 1.2 = air allowance
- V = pipe volume, in litres
- ΔP = measured pressure drop, in kilopascals
- D = pipe internal diameter, in metres
- E_R = pipe material modulus, in kilopascals (see table C2)
- E_W = bulk modulus of water, in kilopascals (see table C3);

- (d) If $\Delta V > \Delta V_{\text{max allowable}}$ the test has failed. The cause shall be located and rectified. The preliminary phase shall be repeated. If $\Delta V \leq \Delta V_{\text{max allowable}}$, proceed to the main test phase.

NOTE – ΔV and ΔP should be measured as accurately as possible, especially where the test length volume is small.

C3.7.5 Main test phase

Observe and record the pressure rise for 30 minutes.

In the event of failure, locate and repair leaks. If failure is marginal or doubtful, or if it is necessary to determine leakage rate, use a reference test (see C3.6).

NOTE – Figure C3 gives an example of a full pressure test with the main test phase extended to 90 minutes.

Table C2 – Pipe E material modulus for PE 80B and PE 100

Temp (°C)	PE 80B – E Modulus (kPa×10 ³)			PE 100 – E Modulus (kPa×10 ³)		
	1 h	2 h	3 h	1 h	2 h	3 h
5	740	700	680	990	930	900
10	670	630	610	900	850	820
15	600	570	550	820	780	750
20	550	520	510	750	710	680
25	510	490	470	690	650	630
30	470	450	430	640	610	600

Table C3 – Bulk modulus E_w – Water

Temperature (°C)	Bulk Modulus (kPa $\times 10^3$)
5	2080
10	2110
15	2140
20	2170
25	2210
30	2230

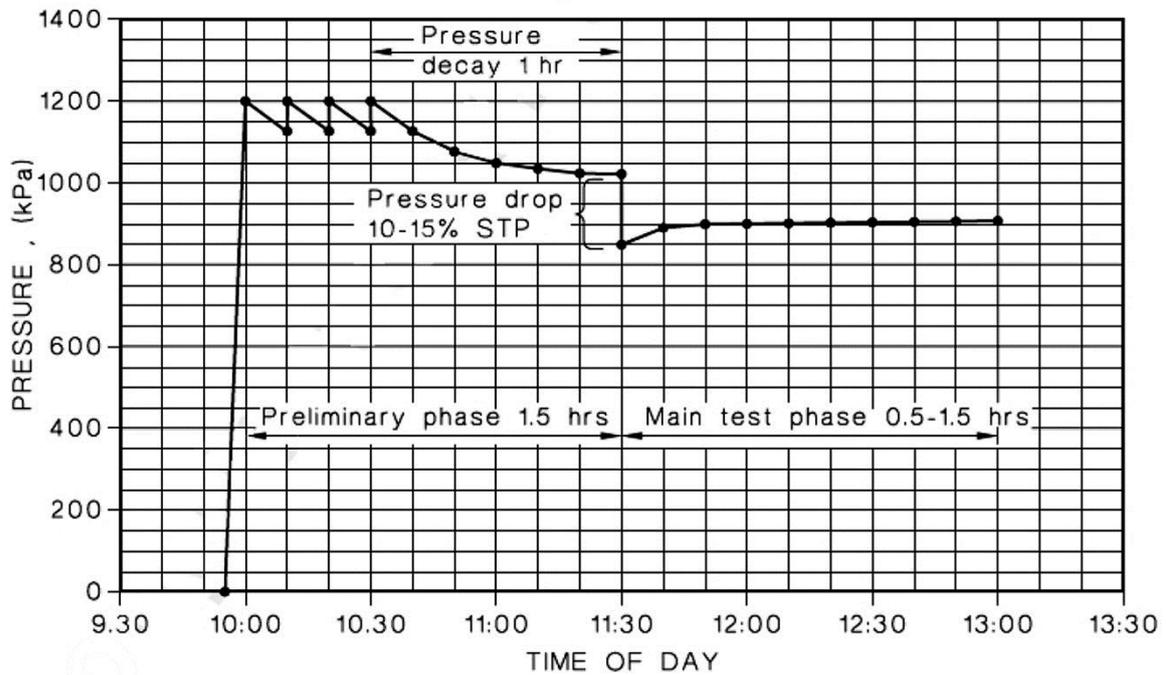


Figure C3 – Typical successful modified rebound test for a PE pipeline

C3.7.6 Acceptance

The test length shall be acceptable if:

- (a) There is no failure of any thrust block, pipe, fitting, joint, or any other pipeline component;
- (b) There is no physical leakage;
- (c) The pressure rises or remains static in the 30-minute period.

If doubt exists about the pressure recovery, the monitoring period may be increased to 90 minutes, and any pressure drop that does occur shall not exceed 20 kPa over the 90-minute period.

If the pressure drops by more than 20 kPa during the 90-minute extended period, the test fails.

Repetition of the main test phase shall only be done by carrying out the whole test procedure, including the relaxation period of 60 minutes described in C3.7.3.

C3.8 Visual test for small pressure pipelines

This test is applicable for small pipelines of all materials (less than 200 m in length), and pipelines where pipeline joints have been left exposed for the test operation (such as coiled pipe).

C3.8.1 Procedure

The procedure shall be as follows:

- (a) The test pressure (see C3.1) shall be applied and the test section isolated by closing the high point air release valves and the pump feed valve;
- (b) The test section shall be visually inspected for leakage at all joints, especially bolted joints, all fittings, service connections, and ball valves;
- (c) Pressure gauges shall be checked to ensure that pressure has not fallen significantly indicating an undetected leak;
- (d) Any detected leak shall be repaired and the section shall be retested;
- (e) Where no leak is detected, high point air release valves shall be opened, the pipeline shall be depressurised to slowly drain the line into an approved waterway and all connection points shall be reinstated.

C3.8.2 Acceptance

The test length shall be acceptable where:

- (a) There is no failure of any thrust block, pipe, fitting, joint, or any other pipeline component;
- (b) There is no physical leakage; and
- (c) There is no pressure loss indicative of a leak.