
WATER INDUSTRY SPECIFICATION

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UK Water Industry

Specification for hydrostatic pressure testing of polyethylene and polyethylene barrier water supply pipelines and sewer rising mains

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1. INTRODUCTION

BS EN 805 requires that every pipeline shall undergo a water pressure test prior to going into service to demonstrate the leaktightness of the installed system. This can be achieved by pressurising the constructed pipeline under controlled conditions to correctly specified test parameters and pass/fail criteria.

It is essential that every water supply pipeline and sewer rising main is tested, but hydrostatic pressure testing is a hazardous activity. It is the responsibility of all parties involved to ensure that this is carried out in a safe manner through assessment and management of risks, the application of safe systems of work and compliance with national legislation, regulation and guidance.

BS EN 805: 2025 permits the designer to specify a test procedure for pipes with viscoelastic behaviour.

This document specifies the UK test procedure for hydrostatic pressure testing of above and below ground pressure pipelines constructed from polyethylene or polyethylene barrier pipes.

This document does not explicitly state a requirement to comply with legislation. It follows the general principle that activities are to be designed to comply with all relevant statutes. Section 4 provides guidance on preparations for testing, choice of test section, and apparatus for testing to assist those planning and carrying out a hydrostatic pressure test. As such, Section 4 is written using the verbal form "should".

This document replaces WIS 4-01-03 Issue 1: March 2024 and WIS 4-01-03A Issue 1 Amendment 1 October 2024 which have been archived (withdrawn).

This issue of the WIS includes aspects / levels of detail not previously addressed. These include:

- testing of above ground pipelines;
- separation of test regimes for large and small diameter water supply pipelines;
- testing of pipelines above 180mm diameter
- testing of pipelines up to and including 180mm diameter
- testing of replacement pipelines
- more comprehensive testing of communication pipes forming part of service connections
- specific consideration of test pressures on valves and fittings
- an explanation of the nature of viscoelastic behaviour of PE and PE barrier pipelines

It also includes a requirement for the training and certification of organisations and individuals before they can undertake hydrostatic testing of PE and PE barrier pipelines.

Note 1: It is intended that a replacement for IGN 4-01-03: 2015 (in the form of a WIS) will be created to address the requirements for hydrostatic pressure testing of all water supply pipelines (both viscoelastic and non-viscoelastic). That document will delegate the detail of hydrostatic pressure testing PE and PE barrier pipe to this WIS (i.e. WIS 4-01-03).

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Note 2: For pipes of non-viscoelastic materials such as iron, steel, concrete and glass-reinforced polyester (GRP), the water loss method for hydrostatic pressure testing given in Section 10.4 of BS EN 805: 2025 applies. The water loss method is also advised by manufacturers of PVC-O pipes.

This document has been prepared on behalf of the Water UK Standards Board. Information contained in this specification is given in good faith. Water UK cannot accept any responsibility for actions taken by others as a result.

2. SCOPE

This document specifies the procedure for hydrostatic pressure testing of above and below ground water supply pipelines and sewer rising mains made of polyethylene pipes to BS EN 12201-2 or polyethylene barrier pipes (Type A) to BS 8588.

It also specifies simplified procedures for the hydrostatic pressure testing of replacement sections of, and service connections to, above and below ground water supply pipelines and sewer rising mains made of polyethylene pipes to BS EN 12201-2 or polyethylene barrier pipes (Type A) to BS 8588.

Note 1: Hydrostatic pressure testing of pipelines designed to operate in service at temperatures above 20°C are not covered by this document.

Note 2: Hydrostatic pressure testing of plumbing systems inside premises are not covered by this document.

Note 3: All references in this document to polyethylene pipe refer equally to Type A polyethylene barrier pipes.

3. PRINCIPLES OF THE TEST FOR POLYETHYLENE PIPELINES

3.1 Viscoelastic behaviour of polyethylene pipes

When subjected to internal hydrostatic pressures, pipes made of a viscoelastic material such as polyethylene creep under constant stress conditions (when internal pressure is applied and maintained) or suffer stress relaxation (when initial pressure is applied but not maintained).

When an initial pressure is applied but not maintained, the pressure in a polyethylene pipe under test will naturally decay as the pipe expands, so a simple pressure loss method is not appropriate (Marshall et al, 1995).

The pressure decay in a leaktight polyethylene piping system follows a linear relationship when plotted on a logarithmic scale, so any deviation from this line can be used as an indication that the pipeline is not leaktight.

Analysis of the measured values of pressure over the test period is used to reveal whether there is likely to be a leak in the pipeline.

Pipe sizes up to and including 63mm are manufactured from PE80 material (i.e. all service connection pipes and some small diameter network mains are PE80). Larger pipe sizes are manufactured from PE100 material. Refer to Appendix C for a more detailed description of the viscoelastic nature of polyethylene pipes.

3.2 Terminology

The terminology used in this document is consistent with BS EN 805: 2025 and product standards for plastic piping systems.

Allowable Operating Pressure (PFA): maximum hydrostatic pressure that a component is capable of withstanding continuously in service.

Design Pressure (DP): maximum operating pressure of the system or of the pressure zone fixed by the designer considering future developments but excluding surge.

Maximum Design Pressure (MDP): maximum operating pressure of the system or of the pressure zone fixed by the designer considering future developments.

Nominal Pressure (PN): numerical designation used for reference purposes related to the mechanical characteristics of the component of a piping system.

Note: For polyethylene pipes, PN corresponds to the Allowable Operating Pressure which can be sustained with water at 20° C with a design basis of 50 years and based on the minimum design coefficient. For most UK applications, PFA in bar corresponds to PN. Further information on this topic is given in IGN 4-32-18: 2003.

Replacement: construction of a new pipeline, on or off the line of an existing pipeline, where the function of the new pipeline system incorporates that of the old (source: BS EN ISO 11295: 2022).

Static Head (P₀): height, relative to an arbitrary reference level, of a column of water that can be supported by the static pressure at a given point.

System Test Pressure (STP): the hydrostatic pressure applied to a newly laid pipeline in order to ensure its integrity and tightness.

3.3 Overview of test methods

The following provides a brief overview of the different test methods covered in this document.

Table 1: Summary of test types

Test Type	Applicable to	System Test Pressure (STP)	Test Duration	Comments
New Pipeline	All new pipelines which can be completely isolated.	1.5 x MDP OR MDP + 5 bar (whichever is the lower of the two values). Min. > 0.7 x PN *	20 x t _p (where t _p = time to raise the pressure to STP) Min. = 60mins	Only appropriate where the section of pipeline to be tested can be completely isolated.
Replacement Pipeline	Replacement section of pipeline no more than 200m in length, up to and including DN180	15 bar (for SDR11 or SDR17)	10 mins	In conjunction with visual inspection. The replacement section should not be connected to the live main until this test has been successfully completed, to avoid

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	installed using a sliplining technique.			the risk of failure of components which are rated below that of the replacement PE pipe.
Service Connection	Service pipes up to DN32 for new service connections to new pipelines or replacement pipelines.	18 bar (for SDR11)	$8 \times t_p + 9$ min (where t_p = time to raise the pressure to STP) Max. = 13 mins	In conjunction with visual inspection. Service connections should be tested individually and not as part of the new pipeline. Tapping tees/ferrules should be installed, but not tapped, until this test has been successfully completed.

* Refer to Table 2 for appropriate STP based on Design Pressure and Pressure Rating (PN) of pipe.

Note: Testing of above ground pressure pipelines is covered in detail in Section 9 of this document. These are considered to be equivalent to New Pipelines in the above table.

3.3.1 New pipelines

In order to recognise the differences between testing large diameter pipelines and smaller diameter pipelines (e.g. mains installed on housing developments for potable water supply), the testing of new pipelines is covered in two parts in this document:

- Pipe sizes greater than 180mm diameter (see Section 5)
- Pipe sizes up to and including 180mm diameter (see Section 6)

The System Test Pressure (STP) for new pipelines is calculated from the Design Pressure (DP) of the pipeline according to the system requirements determined by the designer.

The section of main under test is filled from the lowest point in a controlled manner and allowed to thermally stabilise.

The pressure is raised to STP, the pump is shut off and the section of main under test is isolated. The time to raise the pressure to STP determines the length of the test. The pressure is measured and recorded over the test period.

The results are plotted on a logarithmic scale and the slope (n) of the plot between two time points is calculated using a simple equation. Slopes are compared as a ratio. The test is considered a "pass" if the ratio is within a defined range.

For the testing of replacement pipelines, see Sections 4, 5, 6 & 10 of this document.

3.3.2 Replacement pipelines

The test described in 3.3.1 is only appropriate where the section of pipeline under test can be completely isolated.

Where replacement (new) pipes are installed on the line of an existing pipeline (e.g. by using sliplining), a 10-minute test can alternatively be used. This short duration, high pressure test provides assurance when used in conjunction with visual inspection whilst recognising the need for a quick return to service.

The pressure is raised to STP and maintained by pumping over a period of 10 minutes. The pressure and flow are measured and recorded over the test period.

The reduction in flow as the test progresses is compared to reference data. The test is considered a “pass” if the reduction in flow is within a defined tolerance.

After connection to the existing pipeline, and its recommissioning, the joints between the replacement section and the existing main are visually inspected for signs of leaks.

For the testing of replacement pipelines, see Sections 4, 7 & 10 of this document.

Note 1: This test is intended for use on a replacement section of pipeline no more than 200m in length, typically coiled pipe up to and including DN180 installed using a trenchless technique. For longer lengths and larger diameters, the test described in 3.3.1 should be used.

Note 2: The replacement section is not connected to the live main until this test has been successfully completed. This is to avoid the risk of failure of components which are rated below that of the replacement polyethylene pipe either through design or wear and tear.

3.3.3 Service connections

Service connections to pressurised water mains are a potential source of leakage and should be visually inspected and tested.

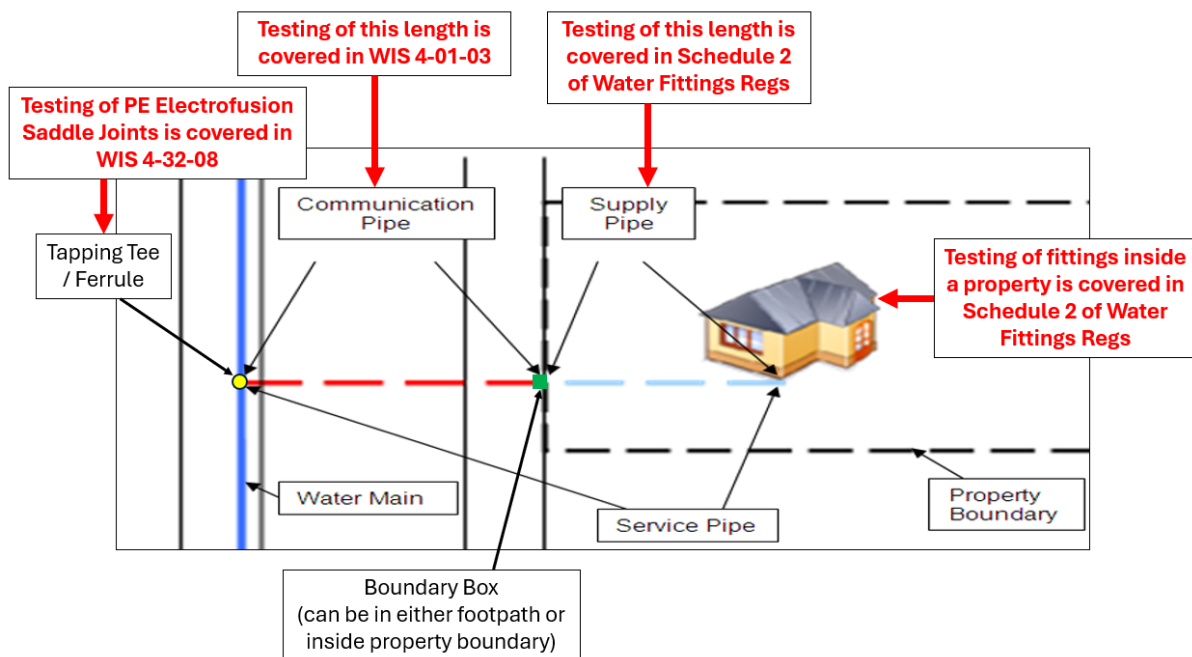


Fig. 1 Service connection

This short test has been designed to be quick and easy to conduct when used in conjunction with visual inspection, whilst recognising the need to minimise time to connect the services

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for the applicant (typically a developer).

As much air as possible is removed by filling at a rate of no less than 30 litres/min for 25mm and 40 litres/min for 32mm (with adequate venting). The pressure is then raised to the STP. The pump is shut off, and the pressure is measured and recorded over the test period.

The pressure readings are plotted on a logarithmic scale and the slope of plot (n) between two time points is calculated using a simple equation. The slopes (n1 and n2) are compared as a ratio. The test is considered a “pass” if the ratio is within a defined range.

For the testing of service connections, see Sections 4, 8 and 10 of this document.

Note 1: This test is intended for use on service pipes up to DN 32 for new service connections to new pipelines or replacement pipelines.

Note 2: Service connections should be tested individually (up to and including the boundary box) and not as part of the new pipeline. The services are made, but not tapped, until this test has been successfully completed.

3.3.4 Visual inspection for leakage

For polyethylene or polyethylene barrier pipes, leaks generally only occur at joints or welds. The integrity of most joints in the pipeline are assessed during the pressure test.

Where the pressure test indicates the presence of leakage, the pipeline should be depressurised to allow visual inspection. If there are no visible signs of water loss, a leak-noise correlator or other suitable leak detection method should be used.

Joints and welds which are not assessed during the pressure test, typically at each end of the test section, should be visually inspected for signs of leakage including damp patches on the surrounding ground.

4. GENERAL

4.1 Safety

In all hydrostatic pressure testing, there are dangers involved when high pressures are being employed. All applicable national health and safety regulations should be taken into account. Appropriate safe systems of work and risk assessment should be implemented and thorough risk assessment undertaken before pressure testing is commenced.

HSE guidance on safety requirements for pressure testing exists at www.hse.gov.uk/pressure-systems/index.htm. HSE documents GS4 “Safety requirements for pressure testing” and INDG261 “Pressure systems: A brief guide to safety” provide a useful entry point into the subject.

Testing should only be undertaken by organisations and individuals able to demonstrate their competence in this activity.

Only competent and trained persons who are aware of the risks should be allowed near any exposed part of the pipeline when it is under pressure.

Guidance is also available in BS EN 805: 2025 Section 10.

Specific hazards include, but are not limited to:

- High pressures can be dangerous if there is an unexpected pipeline failure.
- Forces on end fittings or thrust blocks during testing are high and insecurely anchored ends can lead to the end caps disengaging from the pipeline. Suitable temporary works should be installed.
- Residual air in the pipeline is compressed during testing and can lead to a massive and sudden release of stored energy if a failure occurs.
- Fluids other than potable water can introduce air or other gases into the pipeline.

Care should be taken to manage these hazards:

- For buried pipelines, the whole section should be backfilled before testing (see 4.2.1).
- End-load resistant fittings, temporary strutting, thrust blocks, backfilling or other means of securing the ends should be used to guard against separation of the pipe and fittings during the test.
- From the point of completing the risk assessment, no heavy loads/plant should be allowed to encroach on the area of the pipeline until completion of the pressure testing process.
- Test sections should be filled slowly from the lowest point to avoid any entrapped air being pressurised and storing energy.
- Air in the pipeline should be minimised through swabbing and the correct operation of valves.
- The impact of fluid on air content in the pipeline and on the environment when discharging after completion of the test should be considered.
- For above ground pipelines also see 9.10.

4.2 Preparations

4.2.1 Backfilling and anchoring

Prior to the pressure test, it is essential that:

- Any thrust blocks or other anchorages are sufficient to withstand the thrust forces generated at the test pressure - in particular at changes in direction.
- Concrete thrust blocks have been cured to develop adequate strength.
- End caps and any temporary blanking fittings are fully end load bearing or adequately anchored to prevent separation from the pipe when pressure is applied.
- The section of pipeline to be tested has been backfilled and compacted. This minimises any axial movement and limits temperature variance due to weather changes.

Joints and welds which are not assessed during the pressure test should be left exposed for visual inspection (see 3.3.4) and adequately supported and restrained.

Temporary supports or anchorage at the ends of the test section should not be removed until the test is completed and the pipeline depressurised.

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4.2.2 Choice of test section

The test sections should be selected so that after raising the pressure:

- the System Test Pressure (STP) can be achieved at the lowest point of each test section; and
- the pressure at the highest point of each test section is not less than the Design Pressure (DP), unless otherwise specified by the pipeline designer.

Figures 2(a) and 2(b) illustrate pressures at elevations along a test section

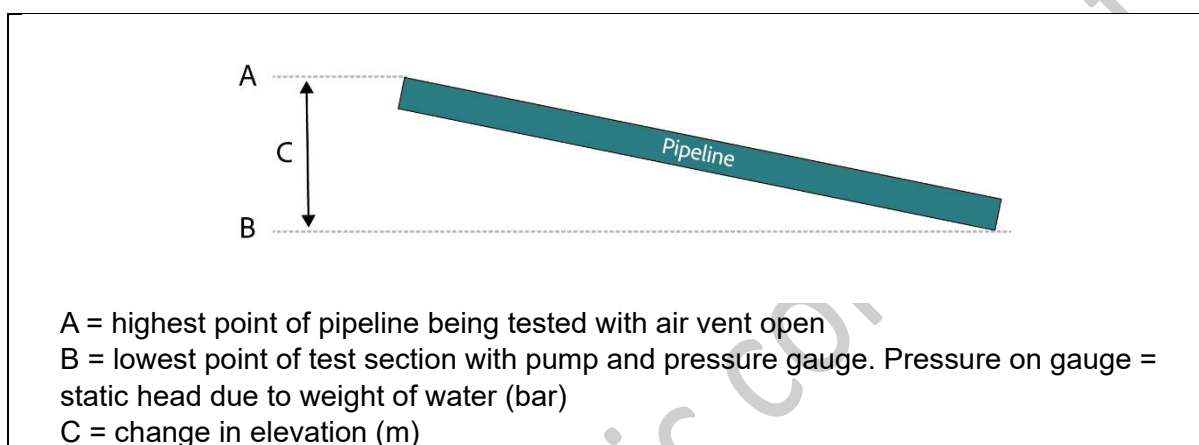


Fig. 2 (a) Pressures in test section - Pipeline filled, no pressure applied

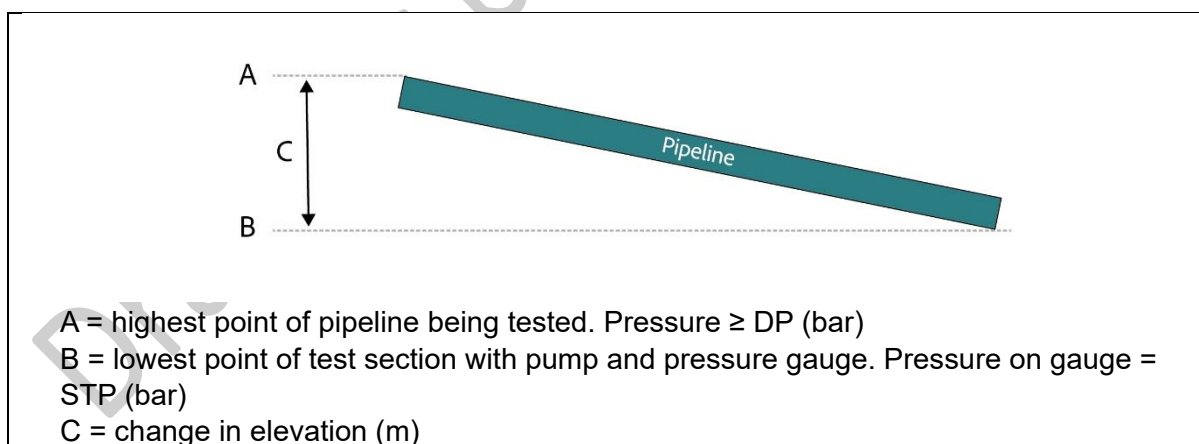


Fig. 2(b) Pressures in test section – Pipeline filled and pressure applied by pumping

There is no theoretical limit to the maximum length of section that can be tested, but consideration should be given at the planning stage to:

- The availability of water for testing (see 5.2) and the point of discharge after the test (see Clause 10).

- The number of joints and fittings in the proposed test section and the ability to efficiently identify the source of any leak detected.
- The ability to minimise air content in the test section.
- The overall time available in which to carry out the test as the time needed for the test is linked to the time (t_p) to pump the section up to STP (see 5.5).
- The pipe materials in the proposed test section.

It is best practice to test different materials separately and especially viscoelastic / non viscoelastic materials. Test sections should be selected accordingly.

Where short lengths of pipe of other materials and metallic fittings (e.g. a puddle flange) are present in a polyethylene pipeline, the detection of any leaks could be masked by the viscoelastic behaviour of polyethylene pipe. These lengths and any joints connecting them to the polyethylene pipeline should be left exposed and be visually inspected, with adequate support being provided to the joint during testing.

A pipeline to be tested may include products such as line and branch valves. It may also include one or more air valves and hydrants, which can perform important roles in purging air during filling of the system prior to testing and facilitating its drain down after testing. However, the capacity of each valve or hydrant to withstand the system test pressure at its individual location should be considered alongside that of the pipeline itself.

The pipeline designer should include in their selection criteria for such products the ability of each product to reliably withstand the pipeline's STP - taking account of the component with the lowest pressure rating amongst all the components comprising that product. For example, an air valve should be able to withstand a leaktightness pressure to the higher of the two values: 1.5 x allowable operating pressure (PFA), or allowable site test pressure (PEA); but a seat tightness equal to a differential pressure of 1.1 x PFA.

- (a) Intermediate line valves should be fully open during the test. Isolating valves at either end of the pipeline, and on branches, under test should be fully open with isolation provided by blank flanges on the outer face of each valve.
- (b) Testing against hydrants may be acceptable to more completely ensure the system's leaktightness but should only be contemplated where an individual hydrant can withstand, without damage, the system test pressure. The hydrant itself may be closed resulting in pressure testing of its component parts; or left open but with the hydrant cap screwed on and adequately secured.
- (c) As part of a competent design, air valves should be located at all high points to facilitate the removal of air during filling of the pipeline. It is also good practice to install an isolation valve beneath an air valve to allow it to be isolated, so that it can be removed for maintenance or replacement without needing to have an outage on the pipeline.

A decision should be made before commencing the test, whether, after filling the main and reducing the amount of air in the pipeline to an acceptable level, the air valves will then be isolated. If they are not, the air valves should not be isolated during the test either. However, non-self-sealing air vents should be closed.

Testing against non-isolated air valves may be desirable to more completely ensure the system's leaktightness but should only be contemplated where an individual air valve can

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withstand, without damage, the system test pressure. Any isolation of air valves should be removed immediately after the test's conclusion and before any attempt is made to drain the pipeline.

It is recommended that an air valve is included in all test sections of thin wall flexible pipes (e.g. PE pipes with wall thicknesses thinner than SDR21) in order to avoid the risk of the pipeline's collapse under an internal vacuum.

Note 1: For guidance on the test section for the 10-minute replacement pipeline test, see Note 1 to 3.3.2.

4.2.3 Choice of System Test Pressure (STP)

4.2.3.1 Values determined by the pipeline designer

When planning the pipeline project, the designer determines the design pressure (DP) and the maximum design pressure (MDP) for the system considering the intended use and future use of the pipeline.

For polyethylene pipes, MDP and DP can be assumed to be identical (see explanation in Note).

Each component to be used in construction of the pipeline should be specified so that the maximum hydrostatic pressure that the component is capable of withstanding continuously in service (PFA) is greater than the design pressure (DP) for the system i.e. $PFA > DP$.

Note: Where there is a short-term increase in pressure from a surge event, the associated energy is absorbed by the viscoelastic behaviour of the polyethylene material.

IGN 4-37-02: 1999 shows that the maximum pressure that a PE pipe is capable of withstanding during a surge event is two times its maximum rated pressure (PN) which it is capable of withstanding in long-term service.

When calculating MDP for polyethylene pipes and polyethylene barrier pipes, conforming to BS EN 12201-2 and BS 8588 respectively, no additional factors need be included to account for the effect of surge on the pipe. MDP and DP can be assumed to be identical.

Further information on choice of pressures ratings is given in IGN 4-32-18: 2003.

4.2.3.2 Calculation of System Test Pressure

The test is carried out at the System Test Pressure (STP).

To ensure the leaktightness of the pipeline is confirmed, the magnitude of STP needs to be greater than that of the Design Pressure of the system (DP).

(a) For a new pipeline

When testing a new polyethylene or polyethylene barrier pipeline (see 3.3.1), STP is calculated as follows:

- $STP = 1.5 \times MDP$ or $MDP + 5 \text{ bar}$ (whichever is the lower of the two values).
- For polyethylene pipes, $MDP = DP$ (see 4.2.3.1).

When planning a new polyethylene pipeline and at the design stage, the calculated value of STP should be checked as follows to confirm that the viscoelastic test procedure in this

document is suitable (see explanation in Note 1):

- If the calculated value of STP is $\geq 0.7 \times PN$, then this test procedure would deliver valid results and the test can proceed.
- If the calculated value of STP $< 0.7 \times PN$, the results would be invalid. Suitable adjustments to the pipeline design or test procedure (see Note 2) should be made prior to testing.

Example calculations and selection of STP are given in Table 2.

Note 1: Checking the calculated value of STP against PN is only used to confirm that the viscoelastic test procedure is suitable. It does not mean that STP is set to $0.7 \times PN$. STP is always calculated using the equation in 4.2.3.2 (a).

The viscoelastic behaviour of PE pipes occurs when the stress in the pipe wall exceeds a value determined by the strength of the PE material and the stiffness of the pipe.

The correct application of the pressure test is achieved when STP is greater than $0.7 \times PN$.

This ensures that the viscoelastic response is achieved, and the test delivers valid results.

Note 2: If $STP < 0.7 \times PN$, suitable adjustments should be made at the design stage to either the choice of pipe (review the pipe specification against the operating requirements) or the choice of STP.

Where it is not possible to reduce the pressure rating of the pipe, for example the pipe is selected to meet structural design requirements, the value of STP needs to be increased to at least $0.7 \times PN$. In this case, there is a risk that STP might exceed $1.5 \times PFA$ of other pipeline components, so great care needs to be taken to protect these by choice of test section to prevent damage during the pressure test.

(b) For a replacement pipeline

When testing a replacement pipeline (see 3.3.2) of polyethylene or polyethylene barrier pipe, SDR 11 or SDR17, up to DN 180: STP is 15 bar.

(c) For a service connection

When testing a service connection (see 3.3.3) of polyethylene or polyethylene barrier pipe, SDR 11, up to DN 32: STP is 18 bar.

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Table 2: Examples showing selection of STP for testing a new pipeline

Design Pressure (Dp) determined by the pipeline designer (bar)	Pipe classification (shows typical selection for Dp in Column 1)	Calculation of System Test Pressure (STP) (bar)		Pressure to activate viscoelastic response (bar)	Test Pressure selected (bar)	Valve classification (shows typical selection for Dp in Column 1)	Maximum Leaktightness Pressure against an Open Valve (bar)	Maximum Leaktightness Pressure against a Closed Valve (bar)	Maximum Seat Tightness Pressure of a Valve (bar)
		1.5 x Dp	Dp + 5						
1	2	3	4	5	6	7	8	9	10
1	PN6	1.5	6	4.2	4.2	PN6	12	8	6.6
2	PN6	3	7	4.2	4.2	PN6	12	8	6.6
3	PN6	4.5	8	4.2	4.5	PN6	12	8	6.6
4	PN6	6	9	4.2	6	PN6	12	8	6.6
5	PN6	7.5	10	4.2	7.5	PN6	12	8	6.6
6	PN6	9	11	4.2	9	PN6	12	8	6.6
7	PN8	10.5	12	5.6	10.5	PN10	17	12	11
8	PN8	12	13	5.6	12	PN10	17	12	11
9	PN10	13.5	14	7	13.5	PN10	17	12	11
10	PN10	15	15	7	15	PN10	17	12	11
11	PN12.5	16.5	16	8.75	16	PN16	25	20	17.6
12	PN12.5	18	17	8.75	17	PN16	25	20	17.6
13	PN16	19.5	18	11.2	18	PN16	25	20	17.6
14	PN16	21	19	11.2	19	PN16	25	20	17.6
15	PN16	22.5	20	11.2	20	PN16	25	20	17.6
16	PN16	24	21	11.2	21	PN16	25	20	17.6

Notes to Table:

- For pipelines with design pressures greater than 16 bar, the polyethylene pipe manufacturer can advise on suitable pipe classification.
- The STP selected in these examples are highlighted and also shown in Column 6.
- Where cells in Columns 9 and 10 are shaded orange, it may be necessary to consider specifying a valve with a higher nominal pressure rating.
- The above values relate to air valves and hydrants, as well as gate valves, etc.

4.2.4 Elevations along the test section

When testing a pipeline with high points along its section, the test equipment (gauge and logger) should ideally be located at the lowest point of the test section. Air vents should be located at all high points of the test section.

The pressure at the lowest point is achieved by a combination of the Static Head (the pressure due to the weight of water in the pipeline above the lowest point) and raising the pressure using a pump.

After filling the pipeline and before commencement of the test, pressure at the lowest point should be equal to Static Head (P_0) in bar.

After raising the pressure at the start of the test, the pressure at the lowest point should be equal to STP in bar (see 4.2.3.2).

If the test equipment (gauge and logger) is located higher than the lowest point on the pipeline, a correction needs to be made to ensure that the pressure at the lowest point meets but does not exceed these values.

The gauge pressure should be:

- After filling the pipeline and before commencement of the test

$$\text{gauge pressure} = P_0 - \left(\frac{\text{vertical distance between gauge and lowest point}}{10} \right) \quad (\text{Equation 1})$$

where P_0 (Static Head) is in bar and distance is in metres.

- After raising the pressure at the start of the test

$$\text{gauge pressure} = STP - \left(\frac{\text{vertical distance between gauge and lowest point}}{10} \right) \quad (\text{Equation 2})$$

where STP is in bar and distance is in metres.

To ensure that the pressure at the lowest point does not exceed STP, the pressures at the highest points are necessarily less than STP.

To ensure the leaktightness of the pipeline is confirmed, the test section should be selected so that, after raising the pressure at the start of the test, the pressure at the highest point in the test section is not less than the Design Pressure (DP), (see 4.2.2). If this is not possible, the test section should be further divided.

4.2.5 Testing pipelines where the pipe surface is exposed

Wherever possible, the pipeline should be backfilled prior to testing (see 4.2.1). Where this is not possible, pressure testing should not be undertaken if there is a risk that the temperature on the outer surface of the pipe during the test might exceed 20°C (see explanation in Note).

Refer to section 9 for details of testing above ground pipework.

Note: The allowable operating pressure for the pipe (PFA) would temporarily be reduced due to the increased temperature. There is a risk that pressuring the system to STP determined in accordance with 4.2.3.2 could lead to rupture of the PE pipe.

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4.2.6 Selection of testing media

Drinking water pipelines shall only be tested using potable water. Wherever possible, other pipelines should be tested with potable water. This will reduce the risk of air or other gases being introduced into the pipeline. It is recognised that this will not always be practical or cost-effective. Where other fluids, such as final effluent or raw water, are used for testing, the risks associated with using them should be thoroughly risk assessed.

5. TEST PROCEDURE FOR NEW PIPELINES (Pipe sizes greater than 180mm diameter)

This type of pipe is generally categorised as large diameter pipes (e.g. Trunk Mains) which can be laid over long lengths (i.e. several kilometres) and have a limited number of branch connections to them.

5.1 Test apparatus

Figure 3 shows the test equipment typically used for the pressure test.

Prior to the pressure test, it is essential that equipment is checked to be in good working order, calibrated and fitted correctly to the test section.

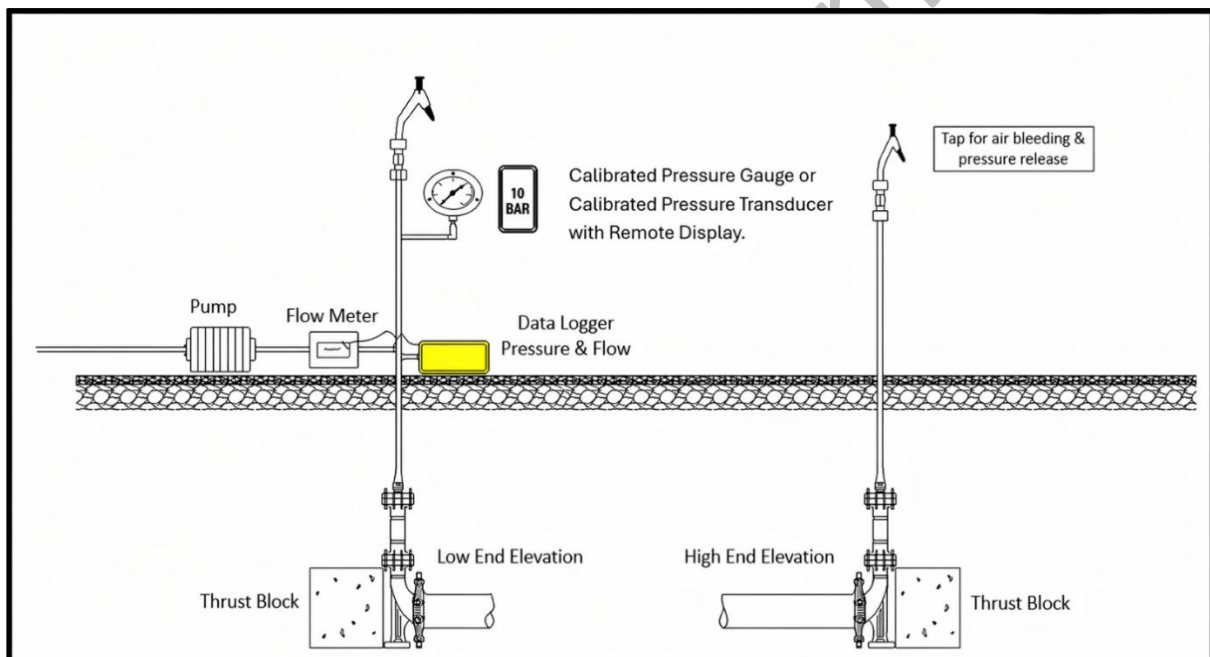


Fig. 3 Schematic of test apparatus layout

Air valves: Valves to facilitate the removal of air during filling.

Data logger system: a calibrated pressure transducer and logger (typically linked to a meter to record flow) with pressure recording interval of 0.01 bar or better and time recording interval of 10 seconds or better. Accuracy $\pm 0.2\%$ Full scale 0-50°C.

Flow meter:

For new pipelines (see 3.3.1), a calibrated flow meter with a resolution of 1 litre or better to measure and record the volume of water added as the pressure is raised to STP.

GPS: To allow test location to be identified and recorded. Where required, this is typically fitted to the data logger.

Pipeline fittings: Fittings to facilitate the filling and pumping of the water; swabs to purge air and for water removal: blank end plates (typically tapped); and hydrants or ferrules.

Pressure gauge: A calibrated digital pressure gauge with a 0.01 bar resolution or better. Accuracy $\pm 0.2\%$ Full scale 0-50°C.

Pump:

For new pipelines, a pump with the capacity to raise the pressure smoothly to System Test Pressure within 30 minutes.

The pump shall have a pressure control system that shall prevent the pipeline from being over-pressurised. There shall also be a suitable means of isolating the pump in accordance with section 5.5.

5.2 Filling the test section

Sufficient water should be available to fill and complete the test without interruption. The temperature of the fill water should not exceed 20°C. The volume of water to fill the test section should be established (see Note 1).

The main should be filled completely from the lower end, with all air valves open and an open valve at the highest point, at a sufficient speed to prevent the swab (when used) stalling, collapsing or getting trapped in the pipeline.

Care needs to be taken that, when filling the test section from the water supply system, the pressure at the lowest point of the test section does not exceed the Static Head (see Note 2).

If immediately after filling, leaks are apparent, the faults should be rectified. This might require emptying and refilling the pipeline.

After filling the test section and removing air (see 5.3), the valve at the highest point should remain open to ensure that the pressure is zero (i.e. no static head) at that point. The filled test section should be left in this unpressurised state for the minimum equalisation period in Table 3.

Table 3: Minimum period for temperature equalisation

Thickness, s (mm)	Minimum Temperature Equalisation Period, H (hours)
$s < 3$	1
$3 \leq s < 8$	3
$8 \leq s < 16$	6
$16 \leq s < 32$	10
$32 \leq s < 60$	16
$60 \leq s$	24

$s = DN / SDR$ (Equation 3)

Where,

s = Pipe wall thickness (mm)

DN = Pipe external nominal diameter (mm)

SDR = Pipe standard dimension ratio

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Note 1: Guidance on the volume of water needed to fill and raise the pressure in the test section to the System Test Pressure is given in Appendix A.

Note 2: If the pressure is accidentally raised above Static Head at the lowest point during filling, it is important that water is bled from the highest point of the test section to reduce the pressure. The pipe shall then be held at the Static Head pressure for a period of no less than $4 \times t$ (where t is the total time for which the pressure exceeded the static head at the lowest point) prior to commencing the test. Holding the test section at the System Test Pressure prior to commencing the test, or starting the test at a raised pressure, (i.e. pre-conditioning of the pipe) invalidates the test (see 5.4).

5.3 Removal of air

Due to the risks involved in testing where air is present in the test section (see 4.1), ideally all air should be removed from the test section during, and after, filling with water and before the start of the test procedure. The method of work should adequately describe methods for the removal of air.

To assist in this:

- Air valves should be functioning correctly.
- Air valves should not be closed during filling.
- Non-self-sealing air vents should be used to vent the pipeline and then closed before the start of the test.
- A foam swab should be used ahead of the water column to assist the removal of air.
- Swabbing should be carried out as one continuous operation and at sufficient velocity to prevent the swab stalling and getting trapped in the pipeline.
- Swabbing should be carried out from the lower end (i.e. uphill) and the swab should be removed prior to testing, where practical. The swab's removal should not however be attempted if this risks introducing more air into the pipeline thereby resulting in an initial air content prior to the test that is higher than that assessed as safe level at which to begin the test.

Practically, some trapped or entrained air might persist, and the procedure described in 5.4 provides a method of assessing residual air content prior to applying any pressure to the pipeline. The responsible parties should determine whether it is safe to conduct the pressure test with the volume of air assessed to be present.

The length and diameter of a pipeline under test influences stored energy that results from compression of any air remaining within the pipeline during testing. The location, and maximum spacing between, any air valves present in the test section should be considered when assessing whether to proceed with the test.

Additionally, air in the pipeline can impact on interpretation of the results (see 5.4). The presence of air in a test section markedly increases the pressure rise time (t_P) and consequently the period over which pressure decay readings need to be taken. It will also distort the interpretation of pressure decay results. To deliver a valid test result whilst minimising the overall duration of the test, the maximum air content in a pipeline prior to conducting a pressure test should be limited to 4% of the internal volume of the test section (at atmospheric pressure).

Where air content in a pipeline prior to conducting a pressure test exceeds 4% (at atmospheric pressure), the test should not proceed as the result would not be valid.

5.4 Raising test pressure and checking air content

The pressure in the test section shall not be increased above the Static Head (P_0) at any time prior to commencement of the test (see Note 1).

At the start of the test, the pressure shall be raised to STP by pumping in a controlled manner.

The time to raise the pressure to STP shall be no longer than 30 minutes (see Note 2).

The pressure change (rise) and the volume of water added shall be continuously logged (see Note 3).

Prior to commencement of the test and using Appendix A, the volume of water required to raise STP shall be calculated for percentage volumes of air from 0% to 4% (at atmospheric pressure). This is used to determine the volume of air present in the test section. The volume of water added to raise the pressure to STP shall be compared to the volume of water calculated to raise STP. If the actual volume of water added to raise the pressure to STP is more than predicted, it is likely that air is present.

The percentage of air in the system determines the next stage in the testing, as follows:

- For air content 0% - 4% and following a decision by the responsible parties (see 5.3), the test may proceed in accordance with 5.5 – 5.8.
- For air content > 4%, the test shall not proceed as the test would not be valid.

Note 1: Any pipeline pressure above Static Head before the start of the test would mean that the time to raise the pressure to STP (t_p) would be lower than the true value to raise pressure from zero to STP. Subsequent pressure readings would not be taken at the correct time intervals and the test outcome would not be valid. Calculation of air content would also be affected.

Note 2: A shorter 'ramp-up' time (t_p) is preferred as this minimises the length of the overall test.

Note 3: The pressure should be the pipeline pressure not the pump pressure.

5.5 Data collection

After the System Test Pressure (STP) has been reached, the test section shall be isolated from the pump and the pump shut off.

The pressure change (decay) shall be continuously logged over a minimum pressure decay time, t_3 , where t_3 is determined by the time to raise the pressure (t_p) and is a minimum of $20 \times t_p$ (see Note).

Where $20 \times t_p$ is less than 1 hour, the length of the test must be extended to 75 minutes by taking a further pressure decay time, t_4 , see Appendix B. This will ensure that the time interval between t_3 and t_4 , is sufficiently long and that the terminal slope of the curve can be estimated reliably.

In that case, pressure decay times shall be recorded at the following 4 points (see Fig. 4):

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- $t_1 = 1 \times t_p$
- $t_2 = 8 \times t_p$
- $t_3 = 20 \times t_p$
- $t_4 = 75\text{mins}$ (where required)

Analysing the data whilst the test is in progress, can provide an early indication as to the presence of leaks and avoid potentially harmful events.

Note: Minimum test duration is given here. Additional data points could be taken to provide increased confidence in test results.

5.6 Data use

Figure 4 shows a typical pressure v time graph.

The Static Head on the pipeline (P_0) is a fixed value and does not decay over time (see 4.2.4). All pressures shall be displayed and analysed discounting the static head as shown in Equation 4.

$$\text{Pressure } P = \text{Gauge Pressure} - P_0 \quad (\text{Equation 4})$$

After STP has been reached and the test section isolated (time t_0), the pressure may fluctuate. Data collected in the period t_0 to t_1 (equal to t_p , see Figure 1) shall not be included in the analysis.

5.7 Analysis of results

5.7.1 Step 1 – Pressure data

The pressures (P_1 at t_p , P_2 at $8t_p$, P_3 at $20t_p$) shall be read from the graph at times (t_1 , t_2 , t_3). These pressures are used to calculate the rate of decay (see 5.7.3).

5.7.2 Step 2 - Correcting for creep during pressurisation time

During the time spent in raising the test section to STP (t_p), the polyethylene pipe creeps under the internal pressure. To account for this behaviour, a factor shall be added to each of the times (t_1 , t_2 , t_3) for calculating the rate of decay (see 5.7.3).

A factor of $0.4 \times t_p$ is added, such that the correct decay times (t_{c1} , t_{c2} , t_{c3}) are:

- $t_{c1} = (0.4 \times t_p) + (t_p)$
- $t_{c2} = (0.4 \times t_p) + (8t_p)$
- $t_{c3} = (0.4 \times t_p) + (20t_p)$

5.7.3 Step 3 - Calculating rates of decay

A graph of the pressures (P_1 , P_2 , P_3) against the corrected decay times (t_{c1} , t_{c2} , t_{c3}) shall be plotted on logarithmic axes.

Figure 5 shows a typical graph of pressure versus corrected decay times on logarithmic axes.

The rate of decay shall be calculated using the pressure change between the times t_{c1} and t_{c2} (slope n_1) and the pressure change between the times t_{c2} and t_{c3} (slope n_2) as shown in Equations 5 and 6.

$$n_1 = [\log(P_1) - \log(P_2)] / [\log(t_{c2}) - \log(t_{c1})] \quad \text{(Equation 5)}$$

$$n_2 = [\log(P_2) - \log(P_3)] / [\log(t_{c3}) - \log(t_{c2})] \quad \text{(Equation 6)}$$

Note 1: It may be necessary to take a fourth reading, see 5.5. Where this is required, refer to Appendix B for analysis requirements and pass/fail criteria.

Note 2: The value of n is dependent on numerous factors and cannot be used to determine leaktightness. For PE pipes, the value of n is typically in the range -0.07 to -0.1. A value of less than -0.06 might indicate pre-pressurisation of the pipeline. No great significance should be placed on the absolute value provided that it is within this range. For PE barrier pipes which exhibit less creep, the absolute values may be lower.

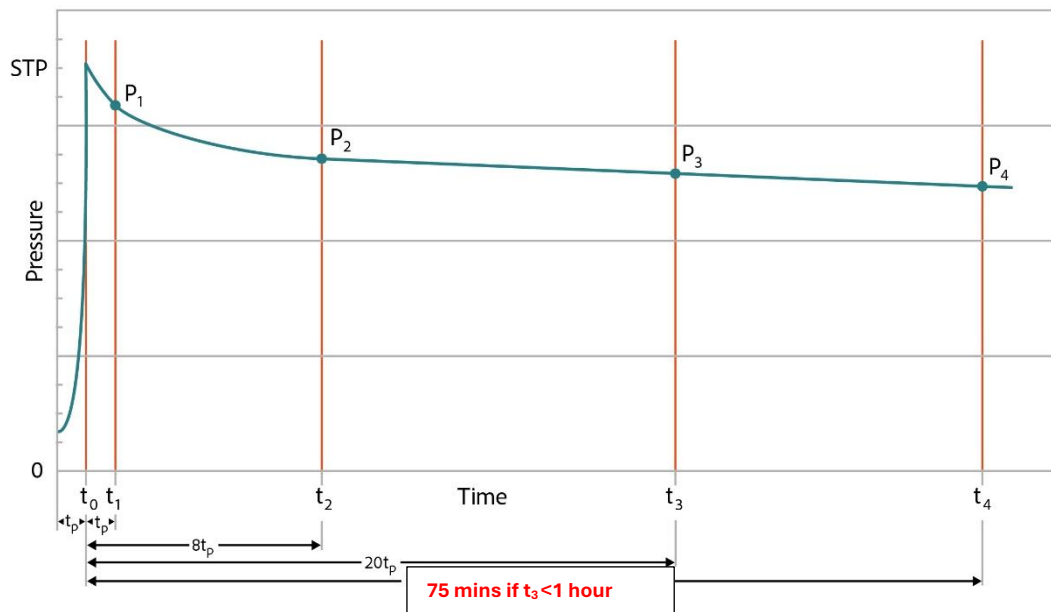


Fig. 4 Typical pressure v time graph (showing test extended to fourth reading)

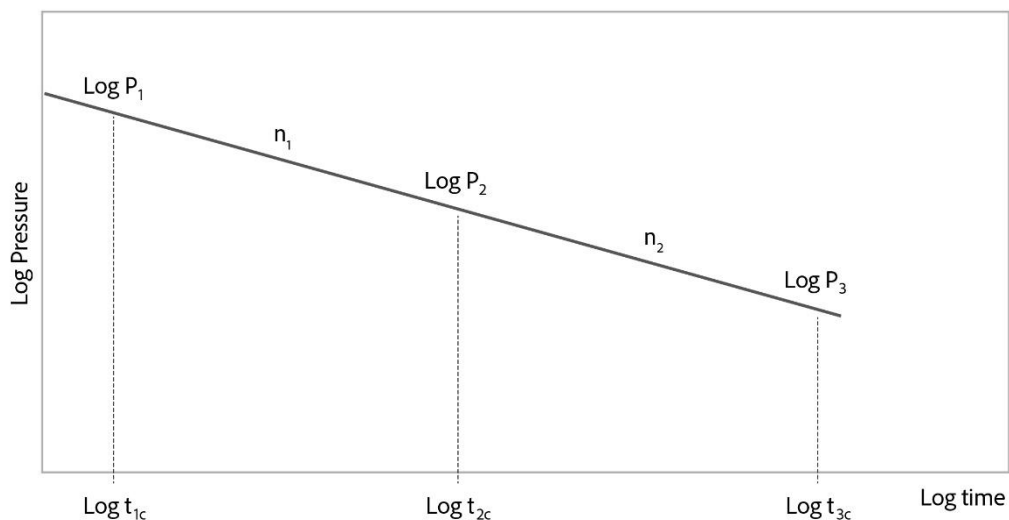


Fig. 5 Typical graph of pressure v corrected decay times on logarithmic axes

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5.7.4 Step 4 – Checking results against pass / fail criteria

n_2/n_1 is used to indicate whether there is leakage in the system as illustrated in Figure 6.

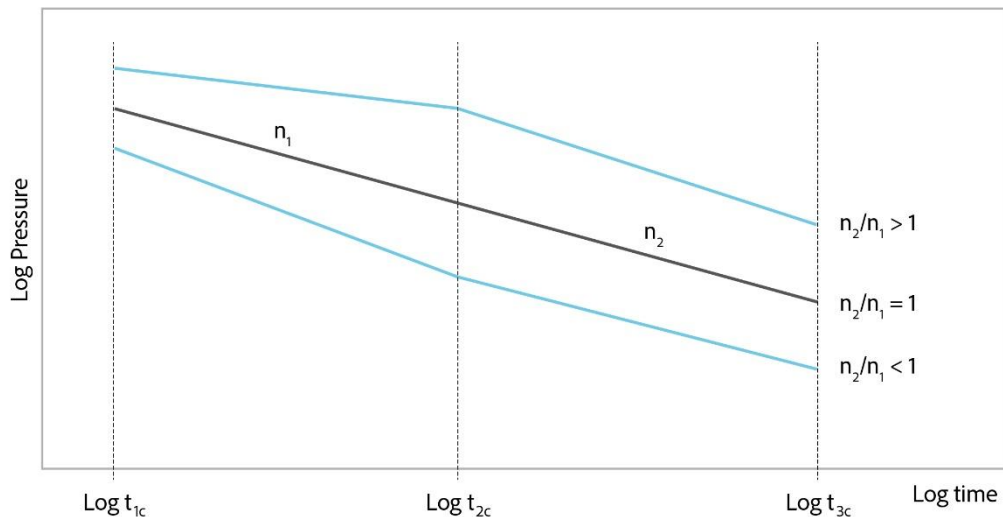


Fig. 6 Slopes n_1 and n_2

If n_2/n_1 lies between 0.75 and 1.25 (see Note 1), then the test is a pass.

If n_2/n_1 is near the upper limit (i.e. between 1.1 and 1.25), it is recommended that data is re-analysed to confirm that the result is within the pass envelope as follows:

- Plot all logged pressure data between t_1 and t_3 using a spreadsheet program.
- Determine power law trendlines for the two time periods t_{c1} to t_{c2} and t_{c2} to t_{c3} ; and
- Check n_2/n_1 against the pass criteria above.

If n_2/n_1 lies outside of the range 0.75 to 1.25, the pressure decay is unacceptable and could indicate the presence of leaks or air. The test shall be stopped and the following action taken:

- the test section shall be depressurised slowly (i.e. until the pressure at lowest point of the test section is returned to Static Head, see 5.2);
 - the pipeline shall be inspected for signs of leaks and air content checked and action taken to rectify the problem; and
 - the test shall be repeated after a period of no less than $4 \times t$ (where t is the total time to raise the pressure to STP and to carry out the first test), (see Note 2).

Note 1: The pressure decays with a constant power law slope. The slope is proportional to the leakage rate. In a leaktight system, n_2/n_1 is 1.0. Computer analysis has shown that, assuming air content of up to and including 4%, a 25% change in slope corresponds to the maximum allowable pressure loss specified in BS EN 805: 2025. The minimum value for n_2/n_1 is therefore 0.75 (75%) and the maximum value 1.25 (125%).

Note 2: This period between tests allows the pipe to recover its original dimensions. If this is not done, the effect is the same as starting the test at a raised pressure and the test is invalid.

Note 3: Where a fourth reading is taken, see 5.5 and Appendix B.

5.8 Recording of test results

A report shall be prepared for the test, containing as a minimum:

- The name, company and contact details of the person carrying out the test.
- The date, start and finish time, location including GPS co-ordinates.
- Plan of the site including elevations, and other significant features.
- Plan of the test section showing length, elevations, static head, location of air valves, test equipment and filling points.
- Details of the pipe under test – pipe materials, dimensions, pressure rating, fittings.
- The System Test Pressure (STP).
- Test equipment records including maximum range, precision and calibration history of flow meter and pressure gauges.
- All logged measurements of the pressure and flow and the volume of water added during the pressure rise phase.
- All logged measurements of the pressure during the pressure decay phase.
- Details of any analysis carried out in accordance with the method described in this document.
- Outcome of test (pass / fail).
- Causes of failure, if appropriate, and any remedial action taken.

5.9 Commissioning of Long Length Mains / “Dormant” Mains

Special consideration needs to be given to long length PE pipelines which may be constructed over a few years. This potentially results in significant periods of time between when the hydrostatic pressure testing of a section of pipeline is undertaken and when the pipeline is commissioned and put into service. Consequently, pipeline designers need to consider this in the design of such systems (see Note 1).

In addition to this, it is generally not feasible during the construction phase to pressure test the full length of pipeline in a single go. For ease of identifying any leaks, pipelines are generally broken down into sections up to about 1km in length (Note 2). As a consequence of this, the joints between test lengths and at connection points to operational pipelines (generally referred to as “Golden Joints”) are not subjected to a hydrostatic pressure test. Instead, they can only be inspected visually when the pipeline is in service under normal operating pressure to confirm there is no visible leakage.

Due to long pipelines being laid in third party land, it is usually not possible to leave excavations open for a number of years so that the “golden joints” can be inspected when the main is put into service.

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Note 1: BS 9295:2020 'Guide to the structural design of buried pipes' stipulates that the beneficial effects of re-rounding should only be addressed in the design "where [internal] water pressure is applied within one year of backfilling".

Note 2: EN 805:2025 suggests a maximum of 3km. This should be considered with respect to the pipe diameter/volume and the ability to bring it up to test pressure within the defined time of 30mins.

6. TEST PROCEDURE FOR NEW PIPELINES (Pipe sizes up to and including 180mm diameter)

This type of pipeline is generally categorised as water distribution pipes (e.g. on new housing developments) and may have multiple branch connections from them.

6.1 Test apparatus

The test apparatus for testing new pipelines up to and including 180mm dia. is similar to the equipment described in Section 5.1. However, the size of the test pump is likely to be smaller.

6.2 Filling the test section

The procedure for filling new pipelines up to and including 180mm dia. is as described in Section 5.2.

Note: Hand Pumps are considered practical for raising the pressure to STP when the calculated volume to reach STP at 4% Air < 4.05 litres. A typical hand pump delivers approximately 1.35 L/min (i.e. 4.05 litres over a 3-minute ramp time), therefore not materially impacting the feasibility of achieving a 1-hour test duration.

6.3 Removal of air

The procedure for removing air from new pipelines up to and including 180mm dia. is as described in Section 5.3.

6.4 Raising test pressure and checking air content

The procedure for raising the test pressure for new pipelines up to and including 180mm dia. is as described in Section 5.4.

6.5 Data collection

The procedure for data collection for new pipelines up to and including 180mm dia. is as described in Section 5.5.

6.6 Analysis of results

The procedure for analysis of results from a pressure test on a new pipeline up to and including 180mm dia. is as described in Section 5.7.

6.7 Recording of test results

The procedure for recording of test results from a pressure test on a new pipeline up to and including 180mm dia. is as described in Section 5.8.

7. TEST PROCEDURE FOR REPLACEMENT PIPELINES

This type of test is specifically for replacement (new) pipes that are installed on the line of an existing pipeline (e.g. by using sliplining) which are no more than 200m in length and up to and including 180mm in diameter.

7.1 Test apparatus

The test apparatus for testing replacement pipelines is similar to the equipment described in

Section 5.1. However, it differs in respect of the following:

Flow meter:

- For the 10-minute replacement pipeline test, a calibrated flow meter with a resolution of 0.1 litre or better to measure and record the volume of water added as the pressure is raised to STP.

Pump:

- For the 10-minute replacement pipeline test, a pump with the capacity to raise and hold the pressure at STP over the test period and measure the volume of water added using a flow meter.

7.2 Filling the test section

The procedure for filling replacement pipelines is as described in Section 5.2.

7.3 Removal of air

The procedure for removing air from replacement pipelines is as described in Section 5.3.

7.4 Raising test pressure

The pressure shall be raised smoothly to System Test Pressure (STP) by pumping in a controlled manner.

The flow rate to hold the pressure at STP shall be checked to ensure that rate measurements can be taken consistently over the test period. This determines the next stage in the testing as follows:

- If after reaching STP, the flow rate drops to 0.06 litres / second or less (i.e. 0.6 litres in 10 seconds or less), the test may proceed.
- If after reaching STP, the flow rate does not drop to 0.06 litres / second or less, there is almost certainly a leak in the system which shall be identified and rectified and the test repeated.

7.5 Data collection

The pressure shall be maintained by pumping for 1 minute to stabilise the system prior to commencing the 10-minute test.

After stabilisation for 1 minute, the pressure shall be maintained by pumping for a test period of 10 minutes.

The pressure and the flow rate shall be continuously logged over the test period in 10-second increments.

The test is considered to be a “fail” if during the test:

- the maintained pressure changes by more than 0.1 bar on 2 consecutive data points (10-second increments); or
- the test period of 10 minutes is not achieved and/or data are not recorded for the full period.

In the case of a “fail”, the problems shall be identified and rectified before repeating the test.

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7.6 Analysis of results

7.6.1 Volume of water

The data from the 10-minute test shall be analysed in three stages of equal times (i.e. 3 mins 20 secs per stage).

The total volume of water input in each stage shall be calculated using flow rate and time to give V_1 , V_2 and V_3 for Stages 1, 2 and 3 respectively.

The test is considered to be a "fail" and problems shall be identified and rectified and the test repeated, if any of the following occur:

- a) Either $V_2 > V_1$ or $V_3 > V_2$.
- b) $V_1 < 0.2$ litres and V_2 is zero.
- c) $V_2 < 0.2$ litres and V_3 is zero.

Note: The volumes in (b) and (c) above assume that each stage is 3 minutes 20 seconds. Where this is not the case, the total volume of water input in the stage (V) shall be corrected such that the corrected volume $V_c = (V \times 3.33) / (\text{time taken for stage in minutes})$. The test is 'a fail' if $V_{2c} < 0.2$ litres and V_3 is zero or $V_{1c} < 0.2$ litres and V_2 is zero.

7.6.2 Checking results against pass / fail criteria

The percentage reduction in total volume of water input between Stage 2 and Stage 3 is used to indicate whether there is leakage in the system.

The percentage reduction in total volume between Stage 2 and Stage 3 is calculated using Equation 8.

$$\text{Percentage reduction} = \frac{(V_2 - V_3)}{V_2} \cdot 100 \quad (\text{Equation 8})$$

For test sections up to and including 150m in length, the minimum percentage volume reduction shall be 20%.

For test sections greater than 150m in length, the minimum percentage volume reduction shall be 18%.

If the percentage reduction is greater than or equal to these values and there is no visible leakage at the joints, then the test is a pass.

For values outside of this range, the reason shall be established, and action taken to rectify the problem.

7.7 Recording of test results

A report shall be prepared for the test in accordance with 5.8. After connection to the existing pipeline, the joints between the replacement section and the live main shall be visually inspected for signs of leaks.

8. TEST PROCEDURE FOR SERVICE CONNECTIONS

This type of test is specifically for use with service pipes up to DN 32 for new service connections to new pipelines or replacement pipelines, from the connection to the

distribution main up to and including the boundary box (see Fig. 1). (This length of pipe may also be referred to as a ‘communication pipe’.) The maximum length deemed to be a service connection for testing purposes is no more than 25m. Longer length service connections shall be tested in accordance with Section 6.

8.1 Test apparatus

The test apparatus for testing service connections is as described below.

Equipment:

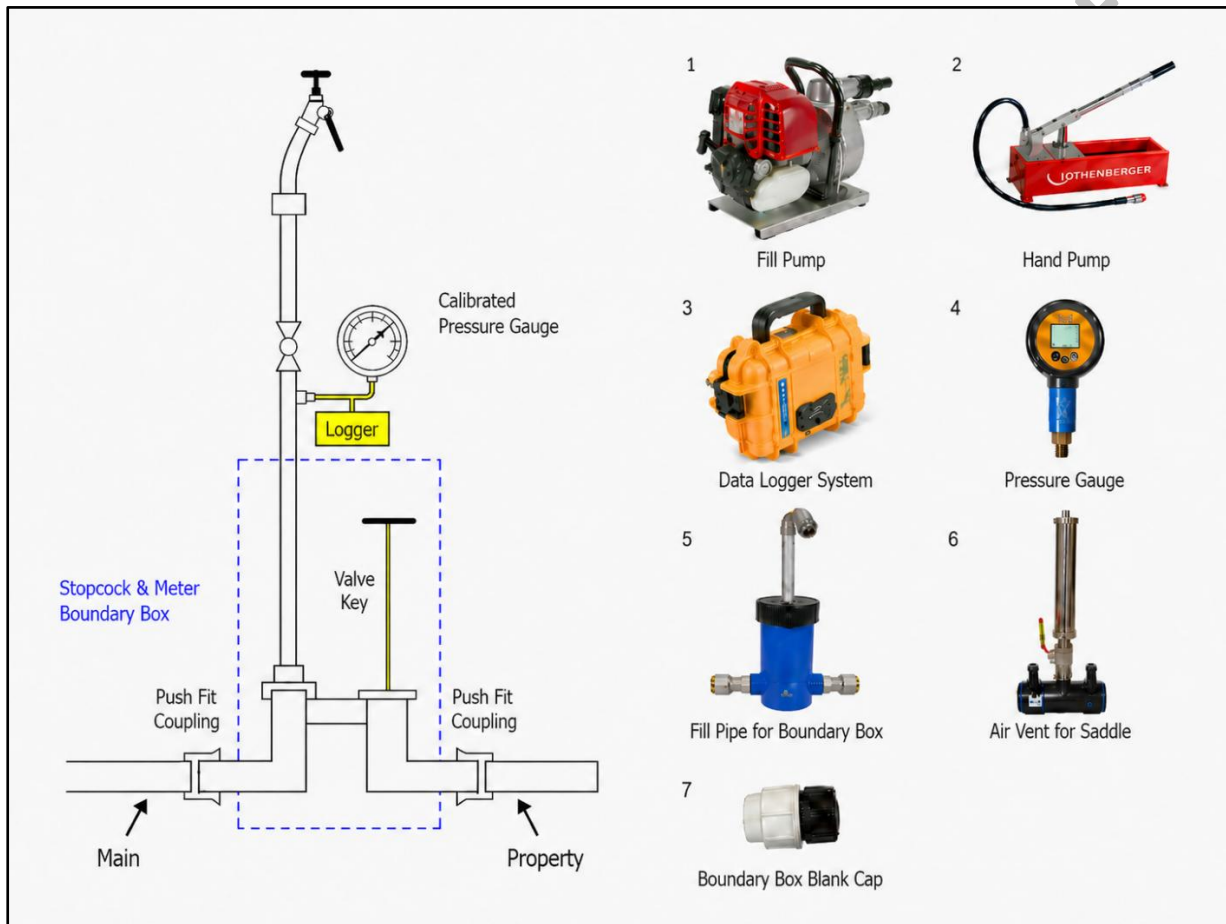


Fig. 7 Testing equipment for Service Connection Test

Test apparatus:

1. **Fill Pump** – Minimum 30 litres /min (25 mm) and 40 litres/min (32 mm)
2. **Hand Pump** – Raises pressure to STP
3. **Data Logger system** – Pressure: 0.001 bar; Time: 1 s; Accuracy $\pm 0.2\%$ FS
4. **Pressure Gauge** – Digital/analogue/app-based for live monitoring
5. **Fill Pipe for Boundary Box** – Connects to meter housing for controlled filling
6. **Air Vent for Saddle** – Connects to top tee for venting/debris prevention
7. **Boundary Box Blank Cap** – Secures and protects enclosure

Note: See 6.2 for details on the suitability of the use of hand pumps.

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8.2 Filling the test section

Before the test on the service pipe is commenced, the PE electrofusion welded saddle connection to the network main shall be tested in accordance with WIS 4-32-08.

The test section may then be filled from the water supply system.

8.3 Removal of air

Every effort should be made to remove the air whilst filling the service pipe.

This shortened test is effective only when there is minimal entrained air in the service pipe under test. This is achieved by introducing water into the service pipe at a rate of no less than 30 litres/min for 25mm dia. pipes, and 40 litres/min for 32mm dia. pipes, and using adequate venting.

8.4 Raising test pressure

Once the service pipe has been filled, the pressure shall be raised to STP by pumping in a controlled manner. The time to raise pressure to STP (t_p) shall not exceed 30 seconds.

Pressure testing service pipes is highly effective when combined with a visual inspection. This dual approach ensures that both internal and external issues are detected, providing a comprehensive assessment of the pipeline's integrity and operational readiness in the shortest possible time. By integrating pressure testing with visual inspection, potential problems can be identified and addressed promptly, ensuring the reliability and safety of the service pipes.

Note: Atmospheric temperature changes can have significant and adverse effects on the outcome of this test. It is, therefore, strongly recommended that the test is undertaken after the pipe has been covered or backfilled, with only the joints exposed.

8.5 Data collection

After STP has been reached, the test section shall be isolated and the pump shut off.

The pressure change (decay) shall be continuously logged over time t_3 , where t_3 is given by $(8 \times t_p + 9 \text{ min})$.

The first pressure reading shall be taken at time $t = t_p$ after the pump is switched off.

8.6 Analysis of results

8.6.1 Step 1 – Pressure data

The pressures (P1, P2, P3) shall be read from the graph at times (t_1, t_2, t_3), where

- $t_1 = 1 \times t_p$
- $t_2 = 8 \times t_p$
- $t_3 = 8 \times t_p + 9 \text{ min}$

These pressures are used to calculate the rate of decay.

Note: The values of t_1 , t_2 and t_3 have been determined empirically based on testing (see Appendix D). The maximum duration of a pressure test based on these values is 13 minutes.

8.6.2 Step 2 – Correcting for creep during pressurisation time

As described in 5.4.2, a factor of $0.4 \times t_p$ shall be added to t_1 , t_2 , t_3 to account for creep in PE pipe.

For the service connection test, the corrected decay times (t_{c1} , t_{c2} , t_{c3}) are:

- $t_{c1} = (0.4 \times t_p) + 1 \times t_p$
- $t_{c2} = (0.4 \times t_p) + 8 \times t_p$
- $t_{c3} = (0.4 \times t_p) + (8 \times t_p + 9 \text{ min})$

8.6.3 Step 3 – Calculating rates of decay

A graph of the pressures (P_1 , P_2 , P_3) against the corrected decay times (t_{c1} , t_{c2} , t_{c3}) shall be plotted on logarithmic axes.

The rate of decay is calculated using the pressure change between the times t_{c1} and t_{c2} (slope n_1) and the pressure change between the times t_{c2} and t_{c3} (slope n_2) as follows:

$$n_1 = [\log(P_1) - \log(P_2)] / [\log(t_{c2}) - \log(t_{c1})] \quad (\text{Equation 4})$$

$$n_2 = [\log(P_2) - \log(P_3)] / [\log(t_{c3}) - \log(t_{c2})] \quad (\text{Equation 5})$$

8.6.4 Step 4 – Checking results against pass / fail criteria

Where n_1 is greater than 0.1, the pipe shall be inspected for leaks.

Where n_1 is less than this value, the ratio of n_2/n_1 shall be used to indicate whether there is leakage in the system.

If n_2/n_1 lies outside of the range 0.75 to 1.25, the pressure decay is unacceptable and could indicate the presence of leaks or air. The minimum value for n_2/n_1 is therefore 0.75 (75%) and the maximum value 1.25 (125%).

For all other values, the test shall be stopped and appropriate action taken (see 5.7.4).

Note: If any part is replaced or repaired the pipe shall be emptied completely and refilled or flushed through until all the air is expelled through the vent pipe before another attempt is made.

8.7 Recording of test results

A report shall be prepared for the test in accordance with 5.8.

9. TEST PROCEDURE FOR ABOVE GROUND PRESSURE PIPELINES

9.1 General

These requirements apply to above ground pipelines and temporarily exposed below ground pipelines.

The temperature of the pipeline outer surface shall not exceed 20°C during the hydrostatic pressure test. The maximum pipe surface temperature is the maximum value measured over any part of the exposed pipeline.

Note 1: Examples of pipelines installed above ground are within bridge decks and temporary overland bypass pipelines.

Note 2: The hydrostatic pressure test includes fill, conditioning, pressurisation and relaxation periods.

Note 3: The pipeline outer surface temperature is representative of the pipeline wall temperature.

9.2 Pipeline test temperature limits

Hydrostatic pressure testing should not be undertaken if there is a risk that:

- the temperature of the outer surface of the pipeline during the test may exceed 20°C.
- the ambient air temperature may reduce to a level that could adversely affect the testing equipment.

Hydrostatic pressure testing shall be stopped (**see also section 9.11**) if the temperature of the outer surface of the pipeline:

- Exceeds 20°C during the test.
- Increases by 1.5°C per 5 minutes during the first half an hour of the relaxation period. (Only applies if there is a risk of the outer surface temperature rising rapidly, e.g. smaller diameter pipelines during the initial pressure decay period.)

Note 1: For pipelines that are intended to be buried, wherever possible the pipeline should be backfilled prior to testing and tested in accordance with clause 4.2.1.

Note 2: Temperature increases during the relaxation period will pose the risk of over pressurisation of the pipeline.

9.3 Filling the test section

The requirements for filling new above ground pipelines is as described in Section 5.2, except for temperature equalisation / thermal stability – see 9.8.

In order to remove all air within the pipeline, it shall be filled in a controlled, slow manner from the lowest pipeline position, with air safely vented from the pipeline.

9.4 Removal of air

The procedure for removing air from above ground pipelines is as described in Section 5.3.

9.5 Raising test pressure and checking air content

The procedure for raising the test pressure for above ground pipelines is as described in

Section 5.4.

9.6 Data collection

The procedure for data collection for above ground pipelines is as described in Section 5.5.

9.7 Analysis of results

The procedure for analysis of results from a pressure test on an above ground pipeline is as described in Section 5.7.

9.8 Pipeline temperature equalisation

Following filling of the pipeline, it shall be left in an unpressurised state for the minimum temperature equalisation period in Table 3 to minimise:

- 1) The difference between the pipeline outer surface temperature and the temperature of the immediate surroundings (e.g. ambient air temperature).
- 2) Change of the pipeline outer surface temperature over time.

Note 1: The temperature of the pipeline outer surface should be at thermal equilibrium with the pipe contents.

Note 2: The temperature of the pipe surface shall be measured on the crown of the pipe at a point where the pipe will not be in shade for any part of the test period. Multiple points along the pipeline length shall be measured and recorded, where possible.

9.9 Recording of test results

The procedure for recording of test results from a pressure test on an above ground pipeline is as described in Section 5.8.

For exposed or above ground pipelines the outer surface temperature is expected to change during the test and sometime significantly. Therefore, the temperature shall be logged in frequent intervals.

9.10 Commissioning of above ground pipelines

For below ground pipelines clause 5.9 is applicable, with the exception of the 3rd paragraph of that clause.

9.11 Safety issues specific to above ground pipelines

The requirements of clause 4.1 *Safety* apply, with additional (non-exhaustive) consideration of the following:

- The project specific Risk Assessment and Method Statement should make provision for the pipeline being exposed and not buried.
- Above ground pipelines are exposed and more likely to experience wider temperature change and/or higher temperatures.

(Note: Buried pipelines are generally considered to be shielded from environmental factors that can result in these temperature characteristics.)

- The specific operating conditions of above ground pipework (e.g. foreseeable pipeline temperatures) should be carefully considered when planning the pipeline project and determining the design pressure (DP) and the maximum design pressure (MDP). This will affect the calculated system test pressure (STP).

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- Measures should be taken to ensure that during the test the pipeline outer surface temperature does not exceed 20°C, at any location on the surface of the pipeline, and that temperature change is limited, during the test. Measures can include:
 - choosing a suitable time of day e.g. when there is shading from adjacent buildings or trees;
 - conducting the test at night;
 - re-filling the pipeline with cold water by flushing it through;
 - proactively shielding the pipeline from direct sunlight.
- Above ground pipework is prone to expansion during the test due to no external soil restraint. Measures to manage this can include due consideration of the type of joints (e.g. end load bearing) and pipeline end restraints, during the design stage.
- Careful consideration must be given to appropriate measurement and monitoring of the temperature of the outer surface of the pipeline throughout the test.
- Applying a greater volume of water than that calculated for pressurisation, risks failure of the pipeline, either by ductile rupture during the test or the premature failure of the pipeline. If the pressure is considerably below the system test pressure (STP) at the calculated pressurisation volume, then the requirements of this annex may have not been followed correctly.
- From a safety perspective it is imperative that all air within the pipeline is removed. This may be achieved by controlled slow filling of the pipeline from the lowest pipeline position with air safely vented from the pipeline.
- A suitable exclusion zone adequately signed and guarded, should be identified and maintained throughout the test, taking into account potential failure of pipeline and release of pressurised contents.

10. PRESSURE RELEASE AND DISCHARGE OF WATER

When the pressure test has been satisfactorily completed, the test section should be depressurised slowly and the water discharged safely from the pipeline.

Note: Guidance on the disposal of water can be found in the 'Protocol for the disposal of contaminated water and associated wastes at incidents' jointly issued by Water UK, Environment Agency, NIEA, Natural Resources Wales, DWI, Fera, Defra's CBRN Recovery Team, NFCC National Resilience and available via <https://www.water.org.uk/>.

11. QUALITY ASSURANCE

11.1 Requirements

To claim compliance with this specification, pressure testing organisations shall operate a management control system for hydrostatic pressure testing practice to BS EN ISO 9001.

Organisations involved in hydrostatic pressure testing of PE & PE barrier pipelines in accordance with this specification shall ensure that all employees, agents, and subcontractors involved in such activities are trained and competent and hold a current

training certification / card all times whilst on the site and present it to the water undertaker's personnel on request.

Training shall be approved by a recognised industry body and delivered by registered training providers. Records of training shall be maintained on a training / skills register.

11.2 Quality Control System

The organisation shall ensure that hydrostatic pressure testing procedures as well as servicing and maintenance of hydrostatic pressure testing equipment are carried out in accordance with the requirements of this specification.

On each site where pipes and fittings are to be pressure tested in accordance with the requirements of this specification, a control system shall be established to supervise work affecting quality.

The installer shall establish and maintain procedures to show evidence of analysing work practices, capturing pressure testing records, pressure testing practice, tester identification, quality records, service reports and customer complaints. Electronic records from the data logging equipment shall be recorded and delivered to the client with site records in a format that provides full traceability, identification and location of each pipe length tested.

11.3 Maintenance, servicing and calibration of equipment

All equipment shall always be well maintained and kept in a clean condition both in stores and on site. Hydrostatic pressure testing equipment which may come into contact with wastewater assets (e.g. polyethylene rising mains) shall not be used on potable water mains unless it has been cleaned and adequately disinfected.

Contaminated equipment, shall always be stored, maintained and transported separately from equipment used on raw water or potable water pipelines.

The equipment shall be serviced and calibrated by authorized agents in accordance with the manufacturer's recommendations.

Calibration shall be carried out in accordance with BS EN ISO 10012. Written records of appropriate servicing and calibration details shall be kept.

12. REFERENCES

BS 8588 Polyethylene pressure pipe with an aluminium barrier layer and associated fittings for potable water supply in contaminated land. Size 20 mm to 630 mm. BSI.

BS EN 12201-2 Plastics piping systems for water supply, and for drains and sewers under pressure. Polyethylene (PE) – Pipes. BSI.

HSE Guidance Note GS4 Safety requirements for pressure testing.

HSE Leaflet INDG261 Pressure systems: A brief guide to safety.

Protocol for the disposal of contaminated water and associated wastes at incidents: jointly issued by Water UK, Environment Agency, NIEA, Natural Resources Wales, DWI, Fera, Defra's CBRN Recovery Team, NFCC National Resilience.

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Dated references:

The development of a mains pressure test for PE and PVC pressure pipes. GP Marshall, MW Birch, K Morley. 1995. (<https://plasticpipesconference.com/>)

BS EN 805: 2025 Water supply - Requirements for systems and components outside buildings. BSI, 2025.

BS EN ISO 11295: 2022 Plastics piping systems used for the rehabilitation of pipelines. Classification and overview of strategic, tactical and operational activities.

WIS 4-32-08: Issue 4: 2016 and Amendment 1: 2023. Specification for the fusion jointing of polyethylene pressure pipeline systems using PE80 and PE100 materials. Water UK.

IGN 4-01-03: Issue 2: 2015 Pressure testing of pressure pipes and fittings for use by public water suppliers. Water UK.

IGN 4-37-02: 1999 Design against surge and fatigue conditions for thermoplastic pipes. Water UK.

IGN 4-32-18: 2003 The choice of pressure ratings for polyethylene pipe systems for water supply and sewerage duties. Water UK.

APPENDIX A. ESTIMATE WATER INPUT VOLUME

A.1 Introduction

For new pipelines, the pressure should be raised smoothly to STP within 30 minutes. The estimated water input volume can be calculated (see A.2) to assist in the choice of pump and projected test duration.

A.2 Calculation of water input volume

Estimating the volume of water to be input in order to raise a pipeline to its System Test Pressure (STP) can be achieved in one of two ways:

- By following the methodology set out in this appendix and applying the equations included within it; or
- By using the online calculator tool which has been developed to sit alongside this specification.

The tool allows the user to input the nominal pipe diameter and wall thickness, SDR rating, length of pipe to be tested, the initial pressure (absolute) and the STP (absolute). It then calculates the volume of water required to pressurise the pipeline to the STP and also provides a value for the maximum volume of water to carry out a valid test (i.e. where the maximum air content at 1 bar absolute pressure is no greater than 4%).

A.3 Considering the effect of initial pressure

When undertaking a pressure test, the test equipment (gauge and logger) should ideally be located at the lowest point of the test section (see 4.2), although this is not always possible. Due to the difference in elevation between the highest and lowest points on the length of pipe to be tested, there will be some static head in the pipeline and this will influence the pressure test. This is different to pre-conditioning of a pipeline prior to commencing a test by raising the pressure in the pipeline above the static head pressure which is not acceptable and invalidates the pressure test (see 5.4).

In order to take account of the effect of static head within a system, all pressures must be converted to absolute pressure values (e.g. atmospheric pressure = 1bar. Initial pressure = static head in pipeline plus 1bar, etc.) and the percentage of air calculation must be modified to reflect the initial absolute pressure. This is because any air within the pipeline system will be compressed by the initial, static pressure within the pipe.

Section 5.3 states the maximum air content in a pipeline prior to conducting a pressure test should be limited to 4% of the internal volume of the test section (at atmospheric pressure). Consequently, because of the static pressure in the pipeline, the maximum allowable percentage air volume will be less than 4% and should be calculated in accordance with A.5.

A.4 Considering the effect of pipe wall temperature

This specification applies to both above and below ground water supply pipelines (and also sewer rising mains) made of polyethylene pipes.

In accordance with section 9.1, a temporarily exposed below ground pipeline should be considered to be subject to the same environmental temperature effects on its pipe wall in as a pipeline which is intended to be permanently installed above ground, during a hydrostatic test.

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The pipe wall temperature for buried polyethylene pipes is relatively consistent all year round due to the insulating effects of the backfill material. It is therefore reasonable to assume a pipe wall temperature of 10°C for buried pipe installations, unless better information exists.

The modulus of elasticity for PE varies with temperature and time and, therefore, it is not appropriate to specify a single value for each grade of PE for this parameter. Instead, it is more accurate to represent the modulus of elasticity as a series of formulae pertinent to PE100 and PE80 that relate to the temperature (see Table A.5 & A.6).

Table A.5: Experimentally determined equations for modulus of elasticity PE100

Ramp up time (min)	Equation
1	$E_{pe} = 2402.6 - 43.338T$
2	$E_{pe} = 2141.6 - 41.763T$
3	$E_{pe} = 2001.2 - 40.627T$
4	$E_{pe} = 1906.6 - 39.75T$
5	$E_{pe} = 1836.2 - 39.035T$
6	$E_{pe} = 1780.4 - 38.434T$
7	$E_{pe} = 1734.4 - 37.914T$
8	$E_{pe} = 1695.5 - 37.457T$
9	$E_{pe} = 1661.9 - 37.049T$
10	$E_{pe} = 1632.3 - 36.681T$
11	$E_{pe} = 1605.9 - 36.645T$
12	$E_{pe} = 1582.2 - 36.037T$
13	$E_{pe} = 1560.7 - 35.752T$
14	$E_{pe} = 1541.1 - 35.488T$
15	$E_{pe} = 1523 - 35.24T$
16	$E_{pe} = 1506.2 - 35.008T$
17	$E_{pe} = 1490.6 - 34.79T$
18	$E_{pe} = 1476 - 34.584T$
19	$E_{pe} = 1462.4 - 34.389T$
20	$E_{pe} = 1449.6 - 34.203T$
21	$E_{pe} = 1437.4 - 34.026T$
22	$E_{pe} = 1426 - 33.858T$
23	$E_{pe} = 1415.1 - 33.696T$
24	$E_{pe} = 1404.8 - 33.542T$
25	$E_{pe} = 1394.9 - 33.394T$
26	$E_{pe} = 1385.5 - 33.251T$
27	$E_{pe} = 1376.5 - 33.114T$
28	$E_{pe} = 1367.99 - 32.982T$
29	$E_{pe} = 1359.6 - 32.855T$
30	$E_{pe} = 1351.7 - 32.731T$

where, T - Temperature (°C)

The outer surface temperature of an above ground pipeline should be measured during a hydrostatic pressure test to ensure that it does not exceed 20°C.

Table A.6: Experimentally determined equations for modulus of elasticity PE80

Ramp up time (min)	Equation
1	Epe = 1631.2 - 32.591T
2	Epe = 1441.2 - 29.843T
3	Epe = 1340 - 28.29T
4	Epe = 1272.3 - 27.16T
5	Epe = 1222 - 26.399T
6	Epe = 1182.3 - 25.743T
7	Epe = 1149.7 - 25.196T
8	Epe = 1122.22 - 24.729T
9	Epe = 1098.4 - 24.322T
10	Epe = 1077.6 - 23.961T
11	Epe = 1059 - 23.638T
12	Epe = 1042.4 - 23.346T
13	Epe = 1027.3 - 23.079T
14	Epe = 1013.5 - 22.834T
15	Epe = 1000.8 - 22.608T
16	Epe = 989.04 - 22.398T
17	Epe = 978.14 - 22.201T
18	Epe = 967.97 - 22.017T
19	Epe = 958.44 - 21.844T
20	Epe = 949.8 - 21.681T
21	Epe = 941.03 - 21.527T
22	Epe = 933.05 - 21.38T
23	Epe = 925.48 - 21.241T
24	Epe = 918.28 - 21.108T
25	Epe = 911.43 - 20.981T
26	Epe = 904.9 - 20.86T
27	Epe = 898.65 - 20.744T
28	Epe = 892.67 - 20.633T
29	Epe = 886.94 - 20.526T
30	Epe = 881.43 - 20.422T
where, T - Temperature (°C)	

Note: Appendix E reflects the testing methodology employed to determine these values.

A.5 Volume of water to fill the test section (unpressurised)

Where there is no air present, the volume of water to fill the unpressurised test section is equal to the internal volume of the pipe.

Therefore, volume of water to fill the test section (m³) is given by Equation A.1.

$$V_0 = \left(\pi \cdot \frac{d^2}{4} \cdot L \right) \quad \text{(Equation A.1)}$$

Where:

d = internal diameter of pipe (m)

L = length of test section (m)

(1 m³ = 1000 litres)

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Note: Where air is present in the unpressurised test section, the combined volumes of water and air equates to the internal volume of the test section.

A.6 Volume of water to raise pressure to STP

Note: Air is a very compressible fluid. Water is often assumed to be an incompressible fluid in hydraulic calculations, but it is actually compressible to a degree.

Once the test section has been filled (see A.4), the additional volume of water required to raise the pressure from the unpressurised state (i.e. gauge pressure equal to Static Head at the lowest point of the test section, see 4.2.4) to STP can be calculated using the online calculator tool.

Alternatively, the equations A.3 – A.5 can also be used to calculate the additional volume of water to raise the pressure to STP for any test section lengths and System Test Pressures (see A.7.1).

A.7 Using volume of water added to estimate percentage of air in system

If air is present, a larger volume of water is required to raise the pressure from the unpressurised state (i.e. gauge pressure equal to Static Head at the lowest point of the test section, see 4.2.4) to STP as the air is compressed.

The measured volume of water added can be used to estimate the volume of air in the test section. Prior to commencing the test, the volume of water corresponding to air content up to 4% (at atmospheric pressure) should be calculated and recorded. A flow meter and logger should be used to monitor the volume of water being added during the pressurisation phase.

Where the monitoring shows that the volume of water added is reaching the value corresponding to an air content of 4% (at atmospheric pressure) and STP has not been attained, the test should immediately be stopped as any results would be invalid and the system safely depressurised (see 5.3).

To calculate the change of the volume of the air content in pressures other than atmospheric, Boyle's Law can be used.

$$P_1V_1 = P_2V_2$$

P_1 : 1 bar (absolute pressure)

P_2 : Static Head (absolute pressure)

V_1 : Volume of air at 1 bar (absolute pressure)

V_2 : Volume of air at static head

When a maximum permissible air content (4%) is assumed at a pressure of P_1 , then the maximum air content at P_2 can be calculated using the equation:

$$V_2 = 4\%(1/P_2)$$

e.g. The max air content percentage of air at $P_2 = 2$ bar (absolute pressure) is 2%

A.8 Pipeline Pressurisation Volumes

A.8.1 Calculation of Pipeline Pressurisation Volumes

The pressurisation volume can be calculated using the formulae set out below or established using the calculator tool that is hosted on the Water UK website www.water.org.uk [add link on formal publication of this WIS].

$$PVol_{NoAir} = PipeVol * \Delta P * \left(\frac{1}{E_{Water}} + \frac{SDR-2}{E_{PE}} \right) \quad \text{(Equation A.3)}$$

$$PVol_{WithAir} = PrVol_{NoAir} + PipeVol * \frac{Air}{100} * \left(1 - \frac{StartP}{MaxP} \right) \quad \text{(Equation A.4)}$$

The Pipe Volume (PipeVol) can be calculated using the Equation A.5:

$$PipeVol = Pi * \left(\frac{DN}{2*1000} - \frac{s}{1000} \right)^2 * Length * 1000 \quad \text{(Equation A.5)}$$

where

Symbol	Description	Unit
PVol _{NoAir}	Pressurisation Volume when air is not present	Litres
PVol _{WithAir}	Pressurisation Volume when a percentage of air is present	Litres
DN	Pipe external diameter	mm
s ^a	Pipe Wall Thickness	mm
SDR	Standard dimension ratio (<i>Pipe OD / Wall thickness</i>)	-
Length ^b	Pipeline length	metres
StartP ^c	Start pressure (i.e. max static head at lowest elevation)	Bar
MaxP ^c	Maximum pressure	Bar
ΔP	(Maximum pressure – Start pressure)*10 ⁵	N/m ²
Air	Percentage of air present within the pipeline	-
E _w ^d	Modulus of elasticity for water	N/m ²
E _{PE} ^e	Modulus of elasticity for polyethylene	N/m ²

^a See 5.2

^b the pipeline length refers to the pipe length after the temperature equalisation period

^c The value for the Start and Maximum Pressure are to be entered in bar (absolute), for example:

StartP = 0 bar gauge = 1 bar absolute

MaxP = 10 bar gauge = 11 bar absolute

ΔP = MaxP – StartP= 11-1 = 10 bar = 1,000,000 N/m²

^d E_w = 2,050,000,000N/m² at 10°C

^e E_{PE} – see Tables A.5 & A.6

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A.8.2 Pipe Wall Thickness

The pipe wall thickness shall be calculated from Equation 3, except for the sizes and SDR values listed in Table A.7.

Table A.7: Wall Thickness for pipe diameters and SDR excluded from the SDR calculation.

DN - Nominal Diameter (mm)	SDR	Wall Thickness, s (mm) ^a
16	9	2.00
20	9	2.30
25	9	3.00
20	11	2.00
32	11	3.00
25	13.6	2
32	13.6	2.4
40	13.6	3
32	17	2
40	17	2.4
50	17	3
63	17	3.8
75	17	4.5
90	17	5.4
110	17	6.6
40	21	2.00
50	26	2
63	26	2.5

^a Wall Thickness values taken from BS EN 12201-2, as the values calculated from DN and SDR differ from minimum values specified by BS EN 12201-2.

APPENDIX B. EXTENDING THE DURATION OF A TEST**B.1 Data collection**

With reference to 5.2, if $20 \times t_p$ is less than 1 hour, the duration of the test shall be extended to 75 minutes by taking a further pressure decay time, t_4 .

B.2 Analysis

By taking a fourth pressure reading (P_4), a further n value (n_3) can be calculated using Equation B.1.

$$n_3 = [\log(P_3) - \log(P_4)] / [\log(t_{c4}) - \log(t_{c3})] \quad (\text{Equation B.1})$$

B.3 Pass / fail criteria

If n_3/n_1 and n_2/n_1 lie between 0.75 and 1.25, then the test is a pass.

Note: If the slope of the pressure decay curve, n , is less than 0.04, there is probably air in the system.

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APPENDIX C. VISCOELASTIC NATURE OF POLYETHYLENE PIPES

Polyethylene materials (PE80 and PE100) including barrier pipe used for pipe applications have what is commonly referred to as viscoelastic properties. As a result, they respond to an applied stress with both an elastic and time dependent viscoelastic response.

Consequently, when a polyethylene pipe is subjected to an internal pressure, a triaxial (hoop, radial and axial) state of stress will occur within the pipe wall. The magnitude of these stress values is dependent on the pipe including its wall thickness, the applied internal pressure and the method of end connection.

Unlike elastic materials such as steel, this viscoelastic property will result in a time dependant response to the applied stress (commonly referred to as 'creep'), resulting in a change of pipe dimensions (diameter and length depending on how the pipeline is terminated). The magnitude of the dimensional change is dependent on many factors, including (non-exhaustively):

- the pipe material
- the pipe SDR
- pipe temperature
- applied internal pressure
- external soil constraint
- the duration for which the pressure is applied (i.e. the change in length is dependent on the installation).

During a hydrostatic pressure test procedure, a polyethylene pipe will be filled with water and pressurised before being isolated from the water supply. It is common to find that a polyethylene pipe will have a gradual time dependent increase in dimension as a result of the applied internal hydrostatic pressure. The magnitude of the dimensional increase is dependent on (non-exhaustively) the:

- pipe material
- pipe SDR
- applied hydrostatic pressure
- temperature of the pipe material.

This gradual time dependent change in dimension will result in a decrease in the pipe's internal pressure. Due to the fixed water volume and increasing pipe dimension, the gradual change will continue to occur until a state of relative equilibrium is reached between the pipe and the decreasing hydrostatic pressure. This reduction in pressure due to material creep is normal and should not be directly attributed to leakage without undertaking the hydrostatic analysis detailed within this document and reviewing the test results.

This reduction in pressure is identified by the characteristic pressure decay curve associated with the hydrostatic pressure test for polyethylene pipelines. There are external considerations that will affect this pressure reduction, for example (non-exhaustively):

- Above ground pipelines without soil constraint will typically increase in dimension to a greater extent than buried pipelines with external soil constraint.
Note: This applies to both above ground pipelines and temporarily exposed below ground pipelines.
- Where the external soil embedment offers relatively little support or where the soil compaction is relatively low, the pipe dimensional increase will be greater compared to a pipe installation where the soil offers a high level of support and is well compacted.

Where a polyethylene pipeline is hydrostatically pressurised (without air in the pipeline), then this material creep manifesting itself as pipe expansion, will result in a gradual pressure reduction, which may be mis-interpreted as a pipeline leak. However, it is important to distinguish between pipe dimensional change due to creep, and leakage. When correctly applied, the polyethylene pipeline pressure test is intended to provide a robust method to distinguish between pipe dimensional change and leakage.

Graphical representation of some of the characteristics described above are shown in Figs. C1 and C2.

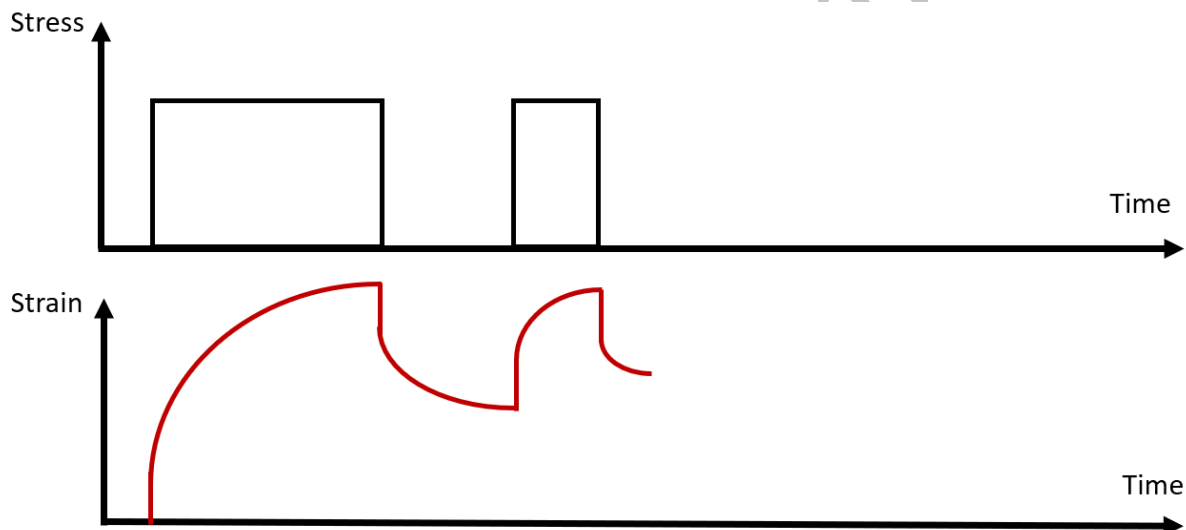


Fig. C1 Creep Recovery & Further Creep

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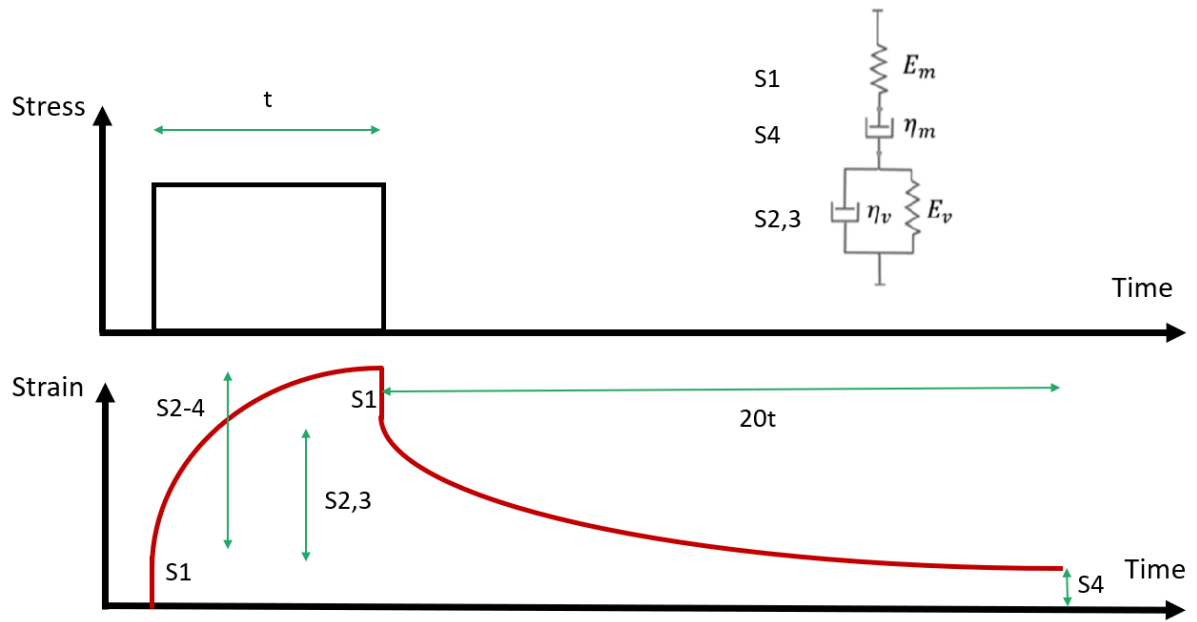


Fig. C2 Time dependant changes

APPENDIX D. SERVICE CONNECTION TEST TIMINGS (T1, T8, T8 + 9 MIN)**D.1 General**

This annex provides background to the choice of timing points T1, T8 and T8 + 9 minutes for the service connection pressure test in 8.6.1.

D.2 Rationale for replacing T20 with T8 + 9 minutes

The timing convention T1, T8 and T20 originates from Type II pressure testing of newly constructed water mains, which are typically used on larger diameter pipelines when backfilled. When the same timings are applied to short, small-diameter service connections that may be exposed at the time of testing, the later T20 reading becomes highly sensitive to rapid temperature changes and offers limited additional diagnostic value beyond T8.

Laboratory tests were conducted on 24No. samples of pipes of 25mm and 32mm diameter of lengths between 0.5m and 24m. Leaks were induced in the samples that were of the order of 5ml over 10 mins. The test data indicated that the accuracy of the results increased with test duration as indicated below:

- 58-67% accuracy for test durations of 8 x ramp + 3 mins;
- 88-96% accuracy for test durations of 8 x ramp + 6 mins;
- 96-100% accuracy for test durations of 8 x ramp + 9 mins

Consequently, the final timing point has been changed from T20 to T8 + 9 minutes to provide a short, controlled evaluation window in which pressure behaviour more reliably reflects the condition of the service connection rather than external thermal effects.

APPENDIX E. METHODOLOGY FOR MEASURING CREEP VALUES

E.1 General

This annex provides background to the method by which a number of polyethylene pipe samples were tested under controlled conditions at a range of temperatures to measure the creep which occurred in the pipe. From this information it has been possible to determine the modulus of elasticity of the PE (both PE80 and PE100) at different temperatures.

E.2 Methodology

The following steps should be followed to replicate the tests when measuring creep values:

- Testing was undertaken in a walk-in environmental chamber
- 1m long samples with end load resistant end caps were used (see Fig. E.1)
- The samples were positioned vertically and were freestanding
- Measurements were taken at the centre of the sample length
- Samples were filled with water with end caps fitted but no pressure applied
- Samples were then conditioned for at least 24 hours at the required temperature
- Temperature logger was employed to ensure temperature was maintained within 2°C
- Initial diameter was measured using a Pi tape in the middle of the pipe length
- Pressure (1.5 x design pressure ± 0.2 bar) was applied to the sample and timer started
- It is important that pressure is maintained throughout the duration of the test ± 0.2 bar
- Diameter was measured as a function of time over 1 hour
- Diameter was measured more frequently initially on application/release of pressure
- Important to log actual time for each measurement
- Target times of measurement (offset start time for each sample):
 - Under pressure: 0, 1, 2, 3, 5, 7, 10, 20, 30, 45, 58 minutes
 - Release pressure at 60 minutes (same timescale from start of test)
 - Further measurements: 60, 61, 62, 63, 65, 67, 70, 80 & 90 minutes
 - And then at 2, 3, 5, latest ~8 hours
- Strain = Change in Diameter / Initial Diameter
- Stress (MPa) = Pressure (bar) x 10 / (2 x (SDR-1))
- Pressure = 24 bar for PE100 and 18.75 bar for PE80 (both SDR11)
- Stress = 12 MPa for PE100 and 9.375 MPa for PE80
- Modulus of elasticity = Stress / Strain
- Plot a graph of modulus of elasticity as a function of time
- Apply a power law fit to the data

It is important to use accurate, calibrated equipment including pressure control, temperature logger and Pi tape for this purpose to ensure reliable data is obtained.



Fig E.1 – Photograph showing samples used for testing

The power law fit can then be used to provide modulus values for any time of pressurization up to 1 hour. **It should not be used for predicting modulus values for longer periods of time.** An example of the data obtained is provided below.

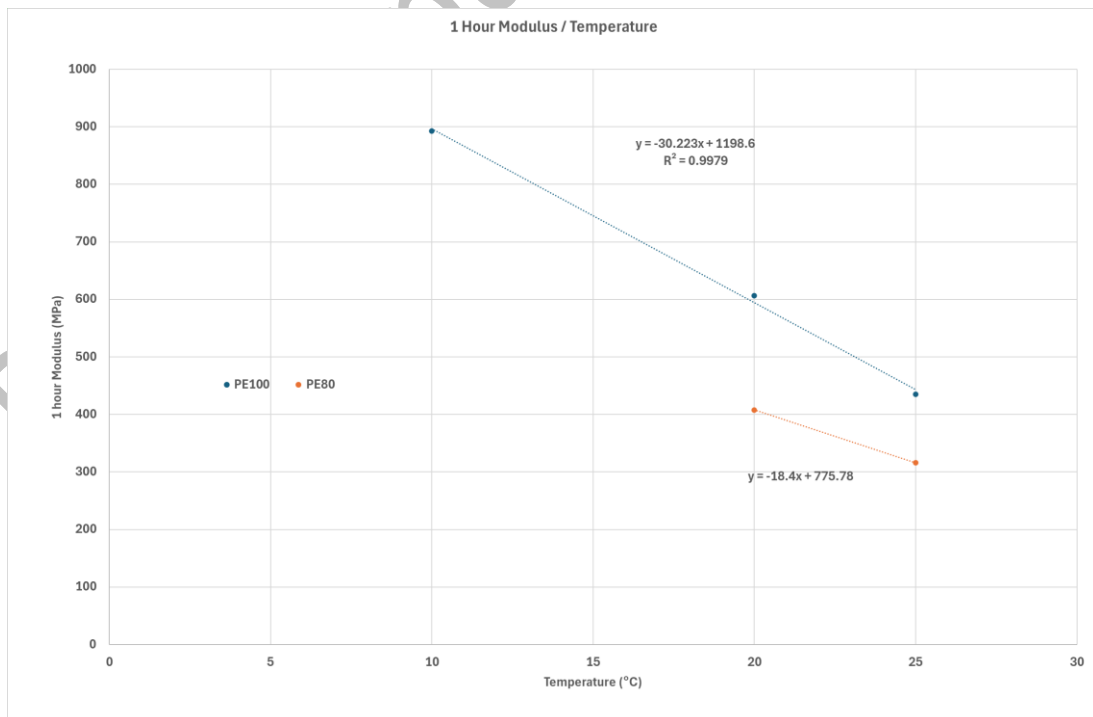


Fig. E.2 - Variation in Modulus of Elasticity value for Polyethylene with temperature

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If necessary, the same test can be used to compare results obtained for different materials, different stress levels etc.

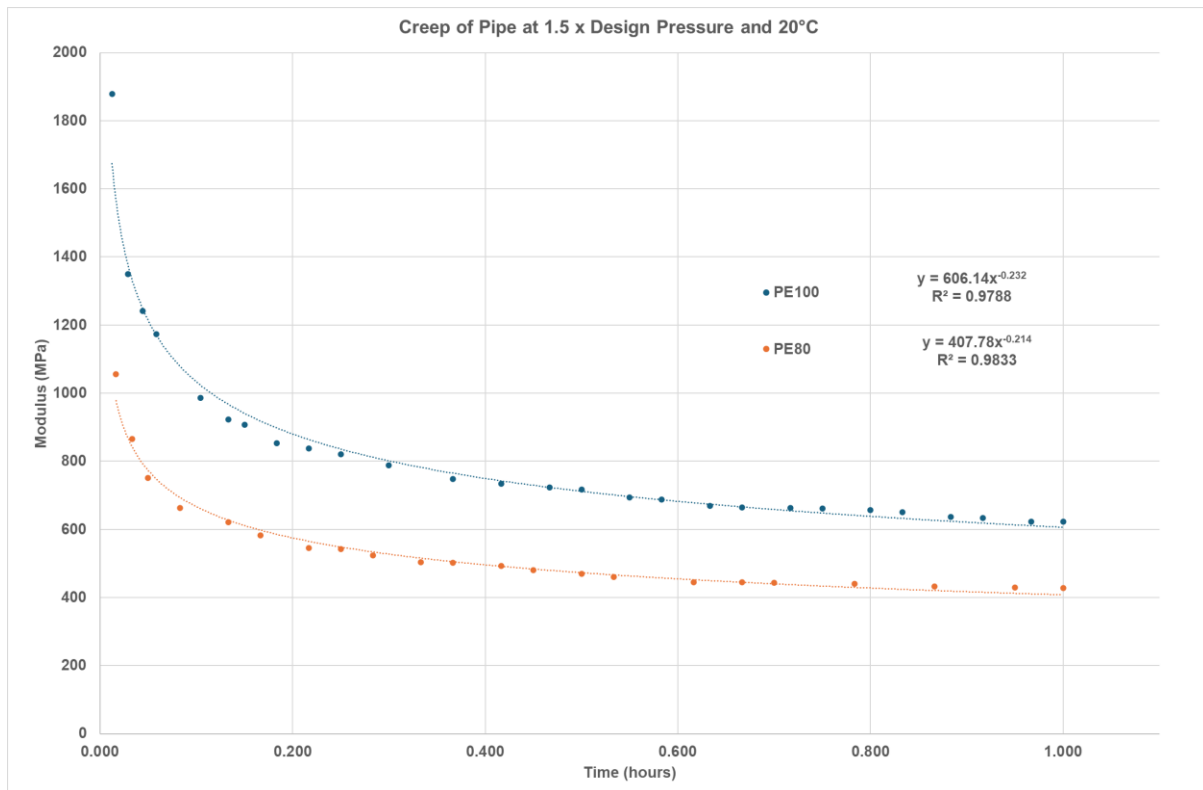


Fig. E.3 - Variation in Modulus of Elasticity value for Polyethylene with time at 20°C

Note: When determining the polyethylene material modulus values (as shown in the above chart) of a hydrostatically pressurised pipe evaluated within a laboratory environment, a relatively short pipe test sample was used with a small internal water volume, resulting in a corresponding short pressurisation ramp up period to reach the System Test Pressure, this ramp up period is significantly less than the typical 30 minute maximum pressurisation ramp up period associated with a pipeline hydrostatic pressure test. Consequently, the polyethylene material modulus value shown in the above chart have been established based on the material creep testing of a constantly pressurised pipe sample, following the point where the System Test Pressure has been achieved.

The method provided above can be obtained without sophisticated purpose-built equipment, although accurate temperature and pressure control is essential. Alternatively, creep can be measured using dedicated equipment to obtain automatic reproducible data. An example of this is provided within ISO11300-2 Annex C (expected to be published in 2026 and also available within ISO11296-4, which it will replace). The advantage of this alternative system is both greater accuracy of the strain measurement using LVDT transducers rather than PI tape and the ability to log more data points within the same time period. Although the method given within the ISO standard is aimed at longer term tests on thermoset materials and the option of wet or dry conditions, it is still applicable for testing dry thermoplastic specimens for shorter durations of 1 hour. Multiple specimens may also be tested as specified within this WIS to obtain an understanding of the reproducibility of results.