Notes on Hydrostatic Field Pressure Testing of PE Pipes

It has long been recognised that for field pressure testing of polyethylene (PE) pipelines it may be necessary to provide allowance for the fact that PE pipes are subject to creep under constant loading and will expand due to the action of internal test pressure. Recommendations such as found in Oy Wiik & Hoglund published literature[1] (1980), were developed in Scandinavia to account for the recorded pressure variations induced by volume expansion, especially with pipes up to DN1000.

In Australia, large diameter (e.g., DN500) pressure pipelines were being field pressure tested as long ago as the 1960's. AS 2033[i], Installation of Polyethylene Pipe Systems, first published in 1977, acknowledged this volume expansion phenomenon, but did not provide specific guidance for making allowances. The main emphasis was on visual inspection of joints for leakage. This is still the most effective method if practicable for any particular installation.

In the period since, various National and industry specifications and guidelines for PE pipe pressure testing have been developed, including IGN 4-01-03[ii] (U.K.), ASTM F2164[iii] (U.SA.), PPI TN46[iv] (U.S.A.), VAV P78 (Sweden)[v], EN 805[vi].

The latest revision of AS/NZS 4130[vii] – 'Polyethylene (PE) pipes for pressure applications' has extended the nominal pipe diameter (DN) range to include DN16 to DN2000. The absolute expansion volumes in the larger diameter pipes have necessitated a more detailed consideration of the pressure test procedures.

Where pipe volume expansion is a consideration, the hydrostatic pressure test method should either account for effects such as soil support or be independent of them.

Two methods that are independent of soil support influences are the modified rebound method, based on work within CEN, and the Swedish Water Works Association VAV P78 method, originally developed by Prof. Lars-Eric Janson. This latter method has been successfully used in Sweden since 1989 in a range of pipe diameters up to DN800 and lengths up to 3,000 m. The method has been applied widely in Australia and is described in various technical publications.

The modified rebound method was originally developed within CEN and has been subject to field trials in Australia and New Zealand as part of the AS/NZS 2033 considerations (LeHunt, Stahmer and Black 2001). It has the advantage that it is a quick test, but it cannot quantify the absolute volume of a leak in the event of failure. This method is however suitable for all pipe diameters. For this method, it is necessary to have a suitable diameter valve to allow the rate of pressure reduction required. Where it may be necessary to quantify a leak, or for referee purposes (e.g., to resolve an inconclusive test result), the method of Prof. Lars-Eric Janson (VAV P78) should be used.

[1] Wiik & Hoglund, Finnish company, now KWH Pipe.

Regarding other methods, ASTM F2164 is essentially a rebound method relying also on visual inspection to detect leaks. PPI (USA) TN-46 recommendations are similar to the modified rebound method and reference and quote AS/NZS 2566-2[viii]. The UK Water Industry IGN 4-01-03 (pressure decay) method is complex, requires an estimate of the uniformity of support given by the soil and does not provide data support for the curve slope coefficients to determine whether the result is a pass or fail.

AS/NZS 4130 applies to pipes for water, wastewater, irrigation, and other aqueous fluid applications. Where installed pipes are of small diameter (≤DN250)/short length and/or for a less critical application, a simplified method may be adopted. Similarly, for coiled pipes without joints, apart from end connections or pipes up to 100 m in length.

For pipelines where visual inspection of joints is not practicable, for long pipelines, or for larger diameters (i.e., ≥DN280), the following are the recommended procedures for field pressure testing.

The Swedish VAV P78 method has been adopted by Standards Australia in AS/NZS 2566.2 Buried flexible pipelines Part 2: Installation, AS/NZS 2033-Installation of PE pipelines, and by the Water Services Association of Australia (WSAA) in their Polyethylene Pipeline Code WSA 01 - 2004.

It is noted that the removal of both entrapped and dissolved air is critical to successful pressure testing. The presence of air can distort the test results and mask the presence of a leak. Entrapped air can be minimised using firm foam pigs and limiting the input flowrate of the test water to ≤0.05 m/s.

Care also needs to be taken with the increases in pipe volume due to thermal expansion resulting from increased material temperature, for example, where pipes are exposed during the test period.

These Notes relate to hydraulic pressure testing only (i.e., with water). Pneumatic testing (i.e., with compressed air) should be avoided due to OH&S concerns arising from the substantial energy stored in a compressed gas. AS/NZS 4130 covers PE pipes for use in fuel gas applications but testing for these applications is covered by various State Regulations and may involve exclusion zones and/or limited access areas. If required, information on both primary and secondary exclusion zones for both hydraulic and pneumatic pressure testing can be found in the APGA[ix] Code of Practice for Upstream Polyethylene Gathering Networks – CSG Industry.

These Notes do not address the necessary procedures in preparing anchor blocks, restraints etc. or OH&S requirements. It is assumed an acceptable Safe Work Method Statement (SWMS) is in place before any testing is undertaken.

1. DIAMETER/SHORT LENGTH PRESSURE TESTING - SUMMARY

- Water entry to be at the lowest point in the pipeline.
- Fill pipeline. Restrict the rate of water entry to 0.05 m/s to avoid air entrapment in downward sloping pipe lengths.
- Flush/swab/vent all air from the pipeline.
- The Maximum System Test Pressure (STP) is 1.25 time the maximum working pressure of the pipeline or 1.25 times the PN rating of the pipe but is not to exceed 1.25 times the maximum allowable operation pressure (MAOP) of the lowest pressure rated pipe or fitting in the line.

- Apply the STP to the pipeline and allow to stand without makeup pressure.
- Where the pipe and fittings joints are accessible for inspection, and there is no evidence of leaks of the test water after at least 15 minutes, the section may be deemed to have passed the test.
- Where the joints are not accessible for inspection and the apparent loss of water after a minimum test period of 2 h is less than that calculated from the following equation, the section may be deemed to have passed the test.

  $Q < 0.14\ L.D.H$

  Where

  Q = allowable make-up water, l/h
  D = pipe internal diameter, m
  L = length of pipeline under test, km
  H = average test head over the length of the pipeline under test, m

2. REBOUND TEST METHOD - SUMMARY

- Water entry to be at the lowest point in the pipeline.
- Fill pipeline. Restrict the rate of water entry to 0.05 m/s to avoid air entrapment in downward sloping pipe lengths.
- Flush/swab/vent all air from the pipeline.
- **MAXIMUM SYSTEM TEST PRESSURE (STP)** at least 1.25 times maximum working pressure of pipeline or 1.25 times the PN rating of the pipe but is not to exceed 1.25 times the maximum allowable operation pressure (MAOP) of the lowest pressure rated pipe or fitting in the line.

PRELIMARY TEST PHASE

- Reduce pressure in the pipeline to atmospheric and let stand for 60 minutes.
- Raise the pressure to STP in less than 10 minutes and hold for 30 minutes, pumping as needed.
- Inspect for leaks, shut off pressure, let stand for 60 minutes.
- Measure pressure reading P60 > 70% STP.

MAIN TEST PHASE

- Quickly (<5 minutes) reduce pressure by ΔP, being in the range 10 -15% of STP.
- Measure and record the water volume bled out - ΔV
- Calculate Δ Vmax allowable if not already done.

Δ Vmax allowable = 1.2V Δ P {1/EW + D/t_eER}

where: -

1.2 = air allowance

V = pipe volume in litres

Δ P = pressure drop, kPa

D = pipe internal diameter, m

t_e = pipe wall thickness, m

ER = pipe material modulus, kPa (see Table 1)

EW = Bulk modulus of water, kPa (see Table 2)

- Observe and record the pressure rise for 30 minutes.

THE PIPELINE IS DEEMED TO PASS THE PRESSURE TEST IF:

- There are no leaks
- No components break
- The internal pressure rises or remains static over 30 minutes. If in doubt, leave for 90 minutes. The maximum allowable pressure drop in 90 minutes is 20 kPa.

IF THE PIPELINE FAILS:

- Locate and repair the leaks **and re-test**.
- If failure is marginal or doubtful, or if it is necessary to determine the leakage rate, use the Reference Test Method.

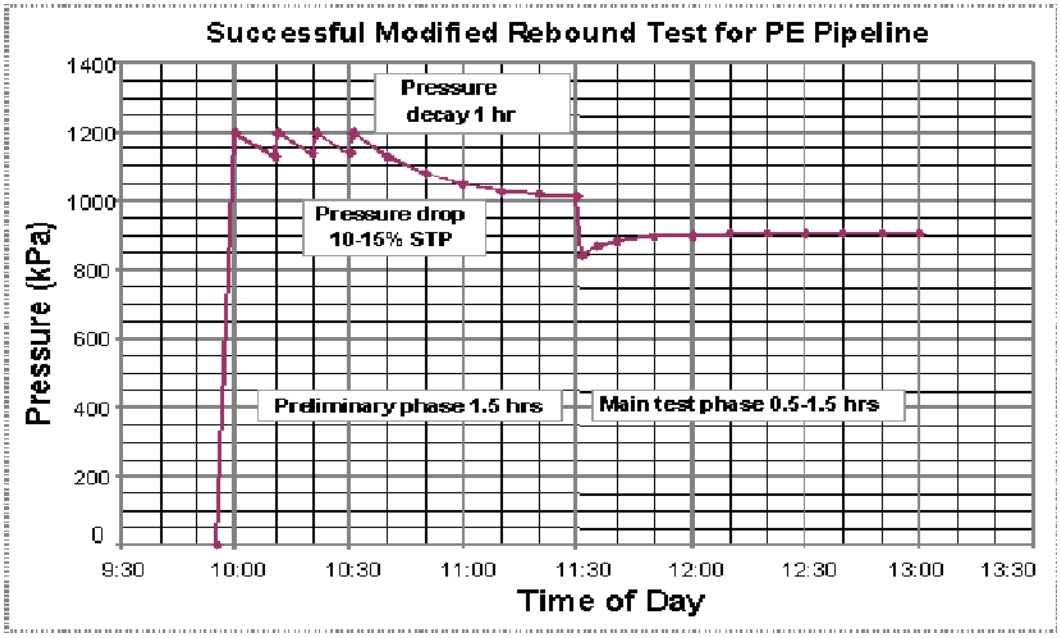
Table 1
PE Material Modulus E_R

TEMP °C	PE 80B – E Modulus (kPax10^{-3})			PE100 - E Modulus (kPax10^{-3})		
	1 Hour	2 Hours	3 Hours	1 Hour	2 Hours	3 Hours
5	740	700	680	990	930	900
10	670	630	610	900	850	820
15	600	570	550	820	780	750
20	550	520	510	750	710	680
25	510	490	470	690	650	630
30	470	450	430	640	610	600

Note: Table 1 assumes MDPE characteristics for PE 80B and HDPE for PE 100.

Table 2
Bulk Modulus E_w - Water

TEMPERATURE	BULK MODULUS (kPax10^{-3})
5	2080
10	2110
15	2140
20	2170
25	2210
30	2230



3. REFERENCE TEST METHOD SUMMARY

- Water entry to be at the lowest point in the pipeline.
- Fill pipeline. Restrict the rate of water entry to 0.05 m/s to avoid air entrapment in downward sloping pipe lengths.
- Flush/swab/vent all air from the pipeline.
- MAXIMUM SYSTEM TEST PRESSURE (STP) at least 1.25 times maximum working pressure of pipeline or 1.25 times the PN rating of the pipe but is not to exceed 1.25 times the maximum allowable operation pressure (MAOP) of the lowest pressure rated pipe or fitting in the line.

PRELIMINARY TEST PHASE

- Raise the pressure in the pipeline to STP, close off main.
- Allow the pipeline to settle for at least 12 hours. The pressure gauge will show a drop.
- Inspect for leaks.

MAIN TEST PHASE

- Raise pressure to STP and maintain for 5 hours.
- Measure and record the water volume to keep constant pressure between 2 hours and 3 hours after test start.
- Measure and record the water volume to keep constant pressure between 4 hours and 5 hours after test start.

THE PIPELINE IS DEEMED TO PASS THE PRESSURE TEST IF:

- $\Delta V(5h\text{-}4h) \leq 0.55 \Delta V(3h\text{-}2h) + V\text{leak } 1h$

where: -

Vleak 1h = 0.14 L.D.H

D = Pipe internal diameter, m

L = Test pipe length, km

H = Average test head, m

- There are no visible leaks
- No components break

IF THE PIPELINE FAILS:

- Repair and reinstate pipeline
- Re-test

REFERENCED STANDARDS

[i] AS/NZS 2033 *Installation of Polyethylene Pipe Systems*, Standards Australia/ Standards New Zealand.

[ii] UK Water Industry Information & Guidance Note IGN 4-01-03. *Pressure testing of pressure pipes and fittings for use by public water suppliers.*

[iii] ASTM F2164 *Standard Practice for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure*, American Society for Testing and Materials.

[iv] TN-46 *Guidance for Field Hydrostatic Testing Of High Density Polyethylene Pressure Pipelines: Owner's Considerations, Planning, Procedures, and Checklists,* Plastics Pipes Institute, USA.

[v] VAV P78, Svenskt Vattens Vattenbokhandel "Anvisningar för täthetsprovning av tryckledningar tillverkade av polyolefiner (PE, PP och PB)", Sweden.

[vi] EN 805:2000: *Water Supply: Requirements for Systems and Components Outside Buildings*, Comite Europeen de Normalisation.

[vii] AS/NZS 4130 *Polyethylene (PE) pipes for pressure applications*, Standards Australia/Standards New Zealand.

[viii] AS/NZS 2566.2 *Buried Flexible Pipelines Part 2: Installation*, Standards Australia/Standards New Zealand.

[ix] Code of Practice, Upstream Polyethylene Gathering Networks – CSG Industry,Australian Pipeline and Gas Association (APGA).

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