

**Guidance for Field Hydrostatic Testing Of
High Density Polyethylene Pressure Pipelines:
Owner's Considerations, Planning, Procedures,
and Checklists
TN-46/2013a**

Foreword

This technical note was developed and published with the technical help and financial support of the members of the Plastics Pipe Institute. The members have shown their interest in quality products by assisting independent standard-making and user organizations in the development of standards, and also by developing reports on an industry-wide basis to help engineers, code officials, specifying groups, and users.

This technical note has been prepared to provide those responsible for the maintenance of existing HDPE pipelines with suggested general guidelines for the repair of those lines that have been subjected to third party or other unforeseen damage. These guidelines constitute a set of basic operations that have been demonstrated by test and experience to produce satisfactory repairs with commercially available materials. Each specific procedure must be acceptable to, and qualified by, the operator having legal responsibility for the performance of the piping system. This document was not intended to provide system design information. Go to the PPI website at www.plasticpipe.org for different system design documents.

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GUIDANCE FOR FIELD HYDROSTATIC TESTING OF HIGH DENSITY POLYETHYLENE PRESSURE PIPELINES :

OWNER'S CONSIDERATIONS, PLANNING, PROCEDURES, AND CHECKLISTS

Purpose of Field Testing:

Hydrostatic testing is universally known and accepted as the primary means of demonstrating the fitness for service of a pressurized component. It is the responsibility of the owner, through its agents (engineer, contractor, or hydro-test company) to develop its own safe and appropriate hydro-test plan, taking into consideration all the elements presented in this and other reference documents, in order to access and accept the installed pipeline from the contractor. After hydrotest, a pipeline or pressure vessel component may usually be expected to safely contain its intended operating pressure. However, even after a successful hydro-test, leakage or forced ruptures may occur later, for a variety of other reasons. The pre-commissioning hydro-test is simply one tool for evaluating a pipeline. The purposes of hydrostatic field testing of polyethylene pressure pipes using water are several, including:

- To access the installed structural integrity of the pipeline for acceptability.
- To try to reveal the occurrence of faults or defects in the pipe laying procedures, as exemplified by damaged pipe or fusion joints non-conforming to the qualified fusion procedures.
- To try to reveal the occurrence of faults in the assembly procedures for pipeline components, as exemplified by tapping bands or saddles, flange sets, or Mechanical Joint assemblies.
- To try to validate that the pipeline will sustain an acceptable level of over-pressure slightly greater than its design pressure, without leakage.

Note: Field testing is not intended to supplement or replace product standard test requirements.

The factors which affect the hydro-testing of HDPE pipe during commissioning procedures are: the creep characteristics of the PE pipe, the percentage volume of trapped air in the pipeline, and temperature variations. The self-limiting creep expansion of HDPE pipe is normal behavior for plastic materials when an internal pressure is applied, and is not an indication of a leak.

History:

Polyethylene pipe is a lower modulus visco-elastic material that dilates in diameter (creep-strains) when subjected to higher stress during hydrotest. This means that for a fixed volume of clean fill water, the hydrostatic pressure will decline slightly during the test time, as the polyethylene molecular chains stretch and align under high stress. This pressure decline does not mean the polyethylene is leaking. It is a visco-elastic material parameter that requires adjustments to the hydrostatic test procedure as compared to rigid elastic metallic pipes. This effect is more noticeable in larger diameter HDPE pipes, due to the large mass of clean fill water. Alternately, to hold constant pressure, an additional volume of make-up water will be required to fill the expanded volume of the stretched pipe diameter. Neither of the above two observations means that a leak is present in the pipeline.

There are two test methods which can be used, depending upon the objectives of the test program. The easiest and quickest method suitable for all pipe diameters is the Modified Rebound Method originally developed by Lars-Eric Janson in the 1980's. As a similar alternate, ASTM F2164 instructs to fill and then thermally stabilize the pipeline with no air entrapment, pressurize the pipeline at test pressure for 4-hours, slightly reduce the pressure, and then observe the pressure for one hour to remain essentially constant (within 5% variation) to achieve an acceptable test. The Plastic Pipe Institute's **Handbook of Polyethylene Pipe** describes general hydrostatic testing, based on ASTM F2164. (www.plasticpipe.org/pdf/chapter02.pdf)

The concept behind hydro-testing is to strain the pipe, fittings and appurtenances. Any defects from manufacturing or flaws from construction are typically forced by stress intensification to reveal themselves by weeping, leaking, or rupture. Any remaining defects are considered sub-critical within a tolerable flaw size limit, and should remain stable thereafter at the lower operating pressures. Hydro-testing provides the normal level of assurance for leak integrity and the absence of flaws that exceed an intolerable flaw size. Generally speaking, the higher is the ratio of test pressure to actual operating pressure, the more effective is the test, within material stress limits.

Field Hydro-testing of Polyethylene Piping and Pipelines:

Hydrostatic pressure testing requires adopting an appropriate combination of method, pressure, time duration and length of test section. The test parameters and test details usually are determined with due consideration for the following:

- Pipe material
- Pipe diameter and working pressure rating
- Length of test section
- Duration of the test
- Magnitude of the test pressure and planned rate of pressurization
- Presence of air in the pipeline
- Potential movement of pipeline thrust restraints
- Limiting pressure for thrust and anchor supports
- Accuracy of test equipment
- Ambient temperature changes during testing (stability of the temperature)
- Presence of small leaks in hydrotest equipment or connections used
- Potential for leaks in the pipeline

Note: It is advisable to begin testing early during the pipeline installation to confirm adequacy of the fusion, laying, embedment procedures, and then later to progressively increase the length of test section, as experience is gained. Polyethylene pipe lengths as long as 1000 meters, or 3000 feet, have been commonly tested.

Definitions: (Refer to [Appendix B](#))

Selection of Test Pressure:

The pipeline operator or owner is responsible for approving the type of test, the length of test, and the test parameters, as recommended by qualified advisors to the owner/operator. The hydrostatic pressure test is a leak test intended to validate the integrity of the pipeline. The test pressure is never less than the designed operating pressure. The maximum hydrostatic test pressure is based on the pipeline component with the lowest design pressure rating. The hydrostatic test pressure is usually between 1.25 times the nominal operating pressure and 1.5 times the Design Pressure Rating of this component. The maximum hydrostatic test pressure must be recorded at the lowest point along the pipeline, and must be compensated for temperatures other than 73°F.

The ASME Code for Pressure Pipe, in B31.4, requires the hydro-test at 1.25 times the MAOP (maximum allowable operating pressure) for steel pipe. Typically, for ductile, visco-elastic HDPE pipe, the hoop-stress during hydro-test should exceed 30% of the specified minimum yield stress (SMYS) but remain less than 42% of the SYMS. The following test pressure ratios for HDPE pipe may be used, as decided by the pipeline owner, depending upon the owner's needs and test objectives.

1.0 x Operating or Design Pressure

1.25 x Operating or Design Pressure

1.50 x Operating or Design Pressure

For example:

1.00x Design Pressure Rating for PE4710 (1000-psi pipe hoop-stress)

1.25 x Design Pressure Rating fro PE4710 (1250-psi pipe hoop-stress)

1.50 x Design Pressure Rating for PE4710 (1500-psi pipe hoop-stress)

The hydrostatic test pressure is a short-term test. The short-term tests for polyethylene pipe use the short-term strength (eg: stress intensity) of HDPE.

HDPE Material	HDS@73°F	Multiplier	Test Pressure Hoop-Stress
PE3608	800-psi	1.50	1200-psi (75%HDB)
PE4710	1000-psi	1.25	1250-psi (78%HDB)
PE4710	1000-psi	1.50	1500-psi (94%HDB)

Stress within straight pipe is simple, but stress in fittings is more complex. Within elbows, tees and wyes, the local stress intensifications can raise the local stress to higher stress values, unless the fabricated fittings are sufficiently wall thickened to compensate for geometric effects. The design pressure ratings of installed fittings should be recorded prior to hydro-test, and, the test pressure should be based on a multiplier times the pressure rating of the pipeline component with the lowest pressure rating in the test section at its elevation in the test section at the test temperature.

Many owners opt for intermediate test pressures giving hoop-stress intensities above 1000-psi hoop-stress. Again, the maximum hydrostatic test pressure is based on the pipeline component with the lowest design pressure rating. The hydrostatic test pressure is usually between 1.25 times the nominal operating pressure and 1.5 times the Design Pressure Rating of this component. The maximum hydrostatic test pressure must be recorded at the lowest point along the pipeline (or compensated for by water elevation head to a different point in the pipeline), and must be compensated for temperatures other than 73°F.

Three hydro-test parameters are: the hydrostatic test pressure, ratio of hydrostatic test pressure to actual operating pressure, and the pipe's estimated hoop-stress during test. These should be calculated and recorded as follows:

Hydro-test Pressure = _____-psi (approved by Authorizing Agent(s)) EQ-1

$R = \text{hydro-test pressure} / \text{operating pressure}$ EQ-2

Estimated pipe hoop-stress = $(\text{hydro-test pressure} \times (DR-1)) / 2$ EQ-3

Selection of Test Section Lengths:

The pipeline length tested shall be either the whole pipeline, or a section of the entire pipeline capable of being isolated, dependent upon the length and diameter, the availability of water, the disposability of the water, and the spacing between sectioning valves or blind flanged ends. Based upon elevations and distance, the pipeline shall be divided into test sections such that:

1. The hydrostatic test pressure at any point in the test section is (i) not less than the design pressure, and, (ii) not more than 25% to 50% above the design pressure rating of any pipeline component; and
2. Water is available for the test together with facilities for its disposal, in accordance with regulatory requirements, after test.

When the pipeline is longer than 3000-feet, the pipeline may need to be tested in several sections. Where long lengths are tested, radio, cell phone, or other communication means may be required between test operators for safety, to coordinate test activities and keep the test within desired time limits.

Very long test sections may incorporate a large number of mechanical and flanged connections, which must be checked for leakage. The longer the test section becomes, the harder it is to locate a leak or to discriminate between a leak and other effects such as entrapped air being dissolved into solution under pressure. Prior to testing execution, a pre-assessment should be made as to what the recorded pressure versus time curves should look like, and how to read or interpret the actual recorded pressure data, so that acceptance or corrective action can be taken by experienced, trained, and qualified operators.

Selection of Fill-Rate:

Slowly fill the test section of the pipeline with water at ambient temperature. Filling is ideally supplied from the lowest point such that the water's entry is submerged and under a "pool" of water inside the pipeline, thus avoiding frothing, air entrainment and air being dissolved into the test water. A slow, submerged, fill velocity will prevent air entrainment and dissolving when the water stream is cascading through downward slopes along the pipeline. Dissolved air can be eruptive leading to a large surge pressure event, and can disguise a possible leak. Obviously the high point air vents should be open and monitored. After filling, allow 3-hours to 24-hours for the system to reach thermal equilibrium, AND, to allow time for any dissolved air to "breathe" and exit the system vents. The period of stabilization will depend upon the volume of water within the pipeline. The recommended slow fill-rate Q, in gpm, is based on the pipe inside diameter D, in inches, and an axial filling velocity of less than 10-feet per min calculated as follows:

$$Q_{\text{gpm}} = 0.402 D^2_{\text{inches}}$$

A firm urethane foam pig or swab, pushed by the fill water, may be used to assist in air removal, especially where the pipeline undulates and air pockets may be trapped.

Pre-Testing Checklist :

- Prior to carrying out any testing activities, many precautions and considerations must be addressed.
- **THE PLASTIC PIPE INSTITUTE MAKES NO CLAIMS THAT THE LIST BELOW IS COMPREHENSIVE. THERE ARE OTHER CONSIDERATIONS FOR EACH PROJECT. EACH PIPELINE OWNER MUST DO ITS OWN DUE-DILLIGENCE TO COMPILE ITS OWN COMPREHENSIVE HYDROTEST MANUAL, PRE-TEST CHECKLIST, TEST PROCEDURES, AND ACCEPTANCE CRITERIA.**

TEST PLANNING

- Has all the pipeline construction been completed, inspected and signed off?
- Has it been verified by QA/QC that the proper pipe material, diameters, DR's, flange ratings, fittings ratings, are in accordance with the drawings and specifications?
- Has the last fusion joint been allowed to cool sufficiently to ambient temperature?
- Has the pipeline been cleaned of all construction debris and foreign matter?
- Are the facilities available for preparations for testing?
- Have local authorities/ citizens been notified of the intent to conduct hydro-testing?
- Are all foreign construction materials removed from the trench in contact with the HDPE pipe?
- Are there any point loads on any fittings? (remove them)
- Are the PE pipelines supported by backfill or otherwise restrained by sandbags to prevent lateral movement or axial contraction under test pressure?
- Where cast concrete has been used, has the concrete cured in excess of 7-days?
- Will the hydro-test be scheduled to occur in dry weather, so that leaks may be detected? (testing in wet weather or in water filled trenches is not recommended)
- Have the proper environmental and regulatory permits been obtained for access to sufficient volumes of fill water, post-test water analysis and treatment, and proper disposal of the test water?
- Has the pipeline elevation profile and filling procedure been analyzed for the fill velocity potential against dynamic surge pressure during filling, which might over-pressure local components, especially in low elevations?
- Has the volumetric rate of fill, fill method, and fill procedure been finalized?
- Has the rate of initial pressurization, prior to full pressure hydro-test, been finalized?
- Has the test plan manual been approved, circulated to all operators, and understood by all participants in pre-test safety and quality meeting? (sign-in sheet)
- Are some bolted joints going to be left exposed for visual inspection and possible re-torquing during or after testing?
- If desired, is compacted embedment and trench fill going to be placed so that certain specified joints, fittings, service connections, or valves are exposed, in accordance with the owners test plan?
- Have all high elevation points and lateral "dead-legs" been identified with provisions made to properly install adequately sized air vent valves of sufficient volume & pressure capacity? Has it been verified that all vent points are installed in the "open" position, for proper operation during filling? Blind-flanges may be used as high-point vents when they are snugly bolted and subjected to low filling pressure, such that trapped air is pushed out past the snug gasket, until the fill-water reaches it and sprays out, thus indicating that all air is expelled, followed by the mechanic fully torquing the flange per the approved bolting procedure with just static head against the blind.
- Has an emergency response plan been considered (as appropriate) in the event of a dramatic rupture during hydro-test?