Post Installation

Leak Testing – Considerations for All Procedures

The intent of leak testing is to find unacceptable joint leakage in pressure or non-pressure piping systems. If leaks exist, they may manifest themselves by leakage or rupture. Leak tests of pressure systems generally involve filling the system or a section of the system with a liquid or gaseous fluid and applying internal pressure to determine resistance to leakage. Leak tests of non-pressure systems typically involve testing sections of the system or individual joints using end plugs or bulkheads to determine resistance to leakage.

Safety is of paramount importance when conducting pressurized internal fluid leak tests. Although routinely performed, leak tests may be the very first time a newly installed system or repair will be subjected to stress.

- *Even at relatively low internal pressures, leak testing with a pressurized internal fluid can generate very high forces that can be dangerous or even fatal if suddenly released by the failure of a joint or a system component or a testing component.*
- *Always take safety precautions when conducting pressurized fluid leak tests.*
- *Restrain pipe, components and test equipment against movement in the event of failure. Joints may be exposed for leakage inspection provided that restraint is maintained.*
- *Keep persons not involved in testing a safe distance away while testing is being conducted.*

Liquids such as water are preferred as test fluids because less energy is released if something in the test section fails catastrophically. During a pressure leak test, energy (internal pressure) is applied to stress the test section. If the test fluid is an incompressible liquid such as water, the energy applied to pressurize the liquid transfers primarily to the pipe and components in the test section. However, if the test fluid is a compressible gas, energy is applied to compress the gas as well as to stress the piping section. If a catastrophic failure occurs during a pressurized liquid leak test, the overall applied energy is much lower, and energy dissipation is rapid. However, if catastrophic failure occurs during a pressurized gas test, energy release is many times greater, much more forceful and longer duration.

- Where hydrostatic testing is specified, never substitute compressed gas (pneumatic) for liquid (hydrostatic) testing.
- *Test pressure is temperature dependent.* If possible, test fluid and test section temperatures should be less than 80ºF (27ºC). At temperatures above 80ºF (27ºC), reduced test pressure is required. Contact the pipe manufacturer for technical assistance with elevated temperature pressure reduction. Sunlight heating of exposed PE pipe especially black PE pipe can result in high pipe temperature. Before applying test pressure, allow time for the test fluid and the test section to

temperature equalize. Hydrostatic leak tests typically use cooler liquids so the liquid filled test section will tend to equalize to a lower temperature near test liquid temperature. Compressed gases used in pneumatic leak tests do not have similar temperature lowering effects, so it is more likely that test pressures will have to be reduced due elevated temperature effects when conducting pneumatic leak tests. Bursting can result if test pressure is not reduced for elevated test section temperature.

- *Leak Test Pressure and Duration* – The maximum allowable leak test pressure and leak test time including initial expansion, and time at leak test pressure should be in accordance with equation (5) and Tables 1 and 2.

(5)
$$P_{(T)} = \frac{2 \times HDS \times F_t \times H_T}{(DR - 1)}$$

WHERE

$P_{(T)}$ = Leak Test Pressure, psi (MPa), for Leak Test Time, T
T = Leak Test Time, hours
HDS = PE material hydrostatic design stress for water at 73°F (23°C), psi (MPa)
F_t = PE material temperature reduction factor
H_T = Leak test duration factor for leak test time, T
DR = Pipe dimension ratio

TABLE 2
Leak Test Duration Factor, "H_T"

Leak Test Pressure, $P_{(T)}$, psi (MPa)	Leak Test Time, T, hours	Leak Test Duration Factor, H_T
$P_{(8)}$	≤ 8	1.50
$P_{(48)}$	≤ 48	1.25
$P_{(120)}$	≤ 120	1.00

TABLE 3
PE Material Hydrostatic Design Stress

PE Material Designation	HDS for Water at 73°F (23°C), psi (MPa)
PE2606 (PE2406)	630 (4.3)
PE2708	800 (5.5)
PE3608 (PE3408)	800 (5.5)
PE3710 & PE4710	1000 (6.9)

Various PE materials can have different elevated temperature performance. Consult the PE pipe manufacturer for the applicable temperature reduction factor, "Ft".

Examples:

1. What is the maximum leak test pressure for a DR 11 PE4710 pipe for a 24 hour leak test where the pipe temperature is 125°F (52°C)?

   Answer: From Table 1, "H_T" = 1.25, and from Table 2, HDS = 1000 psi. The PE pipe manufacturer provided a temperature reduction factor, "F_t", of 0.70.

$$P_{(24)} = \frac{2 \times 1000 \times 0.70 \times 1.25}{(11-1)} = 175\, psi$$

2. What is the maximum leak test pressure for a DR 13.5 PE2606 pipe for a 6 hour leak test where the pipe temperature is 68°F (20°C)? For a 96 hour leak test?

   Answer: From Table 1, "H_T" = 1.50 for a 6 hour leak test, and "H_T" = 1.00 for a 96 hour leak test; from Table 2, HDS = 630 psi. The PE pipe manufacturer provided a temperature reduction factor, "F_t", of 1.00.

$$P_{(6)} = \frac{2 \times 630 \times 1.00 \times 1.50}{(13.5-1)} = 151.2\, psi$$

$$P_{(96)} = \frac{2 \times 630 \times 1.00 \times 1.00}{(13.5-1)} = 100.8\, psi$$

The piping manufacturer should be consulted before using pressure testing procedures other than those presented here. Other pressure testing procedures may or may not be applicable depending upon piping products and/or piping applications.

Pressure System Leak Testing – Hydrostatic

Hydrostatic pressure leak tests of PE pressure piping systems should be conducted in accordance with ASTM F 2164[8]. The preferred hydrostatic testing liquid is clean water. Other non-hazardous liquids may be acceptable.

- *Restraint* –The pipeline test section must be restrained against movement in the event of catastrophic failure. Joints may be exposed for leakage examination provided that restraint is maintained.
- The testing equipment capacity and the pipeline test section should be such that the test section can be pressurized and examined for leaks within test duration time limits. Lower capacity testing and pressurizing equipment may require a shorter test section.

- Test equipment and the pipeline test section should be examined before pressure is applied to ensure that connections are tight, necessary restraints are in place and secure, and components that should be isolated or disconnected are isolated or disconnected. All low pressure filling lines and other items not subject to the test pressure should be disconnected or isolated.

For pressure piping systems where test pressure limiting components or devices have been isolated, or removed, or are not present in the test section, the maximum allowable test pressure for a leak test duration of 8 hours or less is 1.5 times the system design pressure at the lowest elevation in the section under test. If lower pressure rated components cannot be removed or isolated from the test section, the maximum test pressure is the pressure rating of the lowest pressure rated component that cannot be isolated from the test section. Test pressure is temperature dependent and must be reduced at elevated temperatures.

- The test section should be completely filled with the test liquid, taking care to bleed off any trapped air. Venting at high points may be required to purge air pockets while the test section is filling. Venting may be provided by bleed valves or equipment vents.
- The test procedure consists of initial expansion, and test phases. For the initial expansion phase, the test section is pressurized to test pressure and make-up test liquid is added as required to maintain maximum test pressure for four (4) hours. For the test phase, the test pressure is reduced by 10 psi. This is the target test pressure. If the pressure remains steady (within 5% of the target test pressure) for an hour, leakage is not indicated.
- If leaks are discovered, depressurize the test section before repairing leaks. Correctly made fusion joints do not leak. *Leakage at a butt fusion joint may indicate imminent catastrophic rupture. Depressurize the test section immediately if butt fusion leakage is discovered.* Leaks at fusion joints require the fusion joint to be cut out and redone.
- If the pressure leak test is not completed due to leakage, equipment failure, etc., the test section should be de-pressurized and repairs made. Allow the test section to remain depressurized for at least eight (8) hours before retesting.

Pressure System Leak Testing – Pneumatic

The Owner and the responsible Project Engineer should approve compressed gas (pneumatic) leak testing before use. Pneumatic testing should not be considered unless one of the following conditions exists:

- The piping system is so designed that it cannot be filled with a liquid;

  or

- The piping system service cannot tolerate traces of liquid testing medium.

The pressurizing gas should be non-flammable and non-toxic.

- *Restraint* – The pipeline test section must be restrained against movement in the event of catastrophic failure. Joints may be exposed for leakage examination provided that restraint is maintained.
- Leak test equipment and the pipeline test section should be examined before pressure is applied to ensure that connections are tight, necessary restraints are in place and secure, and components that should be isolated or disconnected are isolated or disconnected. All low pressure filling lines and other items not subject to the leak test pressure should be disconnected or isolated.
- *Leak Test Pressure* – For pressure piping systems where test pressure limiting components or devices have been isolated, removed, or are not present in the test section, the maximum allowable test pressure is 1.5 times the system design pressure for a leak test duration of 8 hours or less. If lower pressure rated components cannot be removed or isolated, the maximum test pressure is the pressure rating of the lowest pressure rated component that cannot be isolated from the test section. Leak test pressure is temperature dependent and must be reduced at elevated temperatures.
- The pressure in the test section should be gradually increased to not more than one-half of the test pressure; then increased in small increments until the required leak test pressure is reached. Leak test pressure should be maintained for ten (10) to sixty (60) minutes; then reduced to the design pressure rating (compensating for temperature if required), and maintained for such time as required to examine the system for leaks.
- Leaks may be detected using mild soap solutions (strong detergent solutions should be avoided), or other non-deleterious leak detecting fluids applied to the joint. Bubbles indicate leakage. After leak testing, all soap solutions or leak detecting fluids should be rinsed off the system with clean water.
- If leaks are discovered, depressurize the test section before repairing leaks. Correctly made fusion joints do not leak. *Leakage at a butt fusion joint may indicate imminent catastrophic rupture. Depressurize the test section immediately if butt fusion leakage is discovered.* Leaks at fusion joints require the fusion to be cut out and redone.
- If the pressure leak test is not completed due to leakage, equipment failure, etc., the test section should be de-pressurized and repairs made. Allow the test section to remain depressurized for at least eight (8) hours before retesting.

Pressure System Leak Testing – Initial Service

An initial service leak test may be acceptable when other types of tests are not practical, or where leak tightness can be demonstrated by normal service, or when initial service tests of other equipment are performed. An initial service test may apply to systems where isolation or temporary closures are impractical, or where checking out pumps and other equipment affords the opportunity to examine the system for leakage prior to full scale operations.

- *Restraint* – The pipeline section to be tested must be restrained against movement in the event of catastrophic failure. Joints may be exposed for leakage examination provided that restraint is maintained.

Test equipment and the pipeline should be examined before pressure is applied to ensure that connections are tight, necessary restraints are in place and secure, and components that should be isolated or disconnected are isolated or disconnected. All low pressure filling lines and other items not subject to the test pressure should be disconnected or isolated.

- *Leak test fluid* – The initial service leak test fluid will usually be the liquid or gas being transported in the pipeline. The leak test fluid may or may not need to be purged or flushed from the system.
- *Leak Test Pressure* – The piping system should be gradually brought up to normal operating pressure, and held at operating pressure for at least ten (10) minutes. During this time, joints and connections should be examined for leakage.
- If leaks are discovered, depressurize the test section before repairing leaks. Correctly made fusion joints do not leak. Leaks at fusion joints require the fusion to be cut out and redone. *Leakage at a butt fusion joint may indicate imminent catastrophic rupture. Depressurize the test section immediately if butt fusion leakage is discovered*.

Non-Pressure System Leak Testing

Pressure testing of non-pressure systems such as sewer lines should be conducted in accordance with ASTM F 1417[9].

Non-Testable Systems

Some systems may not be suitable for pressure leak testing. These systems may contain non-isolatable components, or temporary closures may not be practical. Such systems should be carefully inspected during and after installation. Inspections such as visual examination of joint appearance, mechanical checks of bolt or joint tightness, and other relevant examinations should be performed.

Considerations for Post Start-Up and Operation

Disinfecting Water Mains

Applicable procedures for disinfecting new and repaired potable water mains are presented in standards such as ANSI/AWWA C651[10] that uses liquid chlorine, sodium hypochlorite, or calcium hypochlorite to chemically disinfect the main. Disinfecting solutions containing chlorine should not exceed 12% active chlorine, because greater concentration can chemically attack and degrade PE.

Cleaning

Pipelines operating at low flow rates (around 2 ft/sec or less) may allow solids to settle in the pipe invert. PE has a smooth, non-wetting surface that resists the adherence of sedimentation deposits. If the pipeline is occasionally subject to higher flow rates, much of the sedimentation will be flushed from the system during these peak flows. If cleaning is required, sedimentation deposits can usually be flushed from the system with high pressure water.

Water-jet cleaning is available from commercial services. It usually employs high pressure water sprays from a nozzle that is drawn through the pipe system with a cable.

Pressure piping systems may be cleaned with the water-jet process, or may be pigged. Pigging involves forcing a resilient plastic plug (soft pig) through the pipeline. Soft pigs must be used with PE pipe. Scraping finger type or bucket type pigs may severely damage a PE pipe and must not be used. Usually, hydrostatic or pneumatic pressure is applied behind the pig to move it down the pipeline. Pigging should employ a pig launcher and a pig catcher.

A pig launcher is typically a tee assembly or a removable spool. In the tee assembly, the main flow is into the tee branch and out through a run outlet. The opposite tee run outlet is used to launch the pig. The pig is fitted into the opposite tee run; then the run behind the pig is pressurized to move the pig into the pipeline and downstream. In the removable pipe spool, the pig is loaded into the spool, the spool is installed into the pipeline, and then the pig is forced downstream. (Note – Fully pressure rated wyes suitable for pig launching are generally not available.)

A pig may discharge from the pipeline with considerable velocity and force. The pig catcher is a basket or other device at the end of the line to safely receive or catch the pig when it discharges from the pipeline.

Squeeze-Off

Squeeze-off (or pinch-off) is a means of controlling flow in smaller diameter PE pipe and tubing by flattening the pipe between parallel bars. Flow control does not imply complete flow stoppage in all cases. For larger pipes, particularly at higher pressures, some seepage is likely. If the situation will not allow seepage, then it may be necessary to vent the pipe between two squeeze-offs.

PE gas pipe manufactured to ASTM D 2513[11] is suitable for squeeze-off; however, squeeze-off practices are not limited to gas applications. Squeeze-off is applicable to PE pressure pipe up to 16" IPS, and up to 100 psi internal pressure, and conveying various gases or liquids. Larger sizes and higher pressures may be possible if suitable commercial equipment is available. Manufacturers of squeeze-off equipment should be consulted for equipment applicability, availability and capabilities.

Squeeze-off is applicable ONLY to PE pipe and tubing. The pipe or tubing manufacturer should be consulted to determine if squeeze-off is applicable to his product, and for specific squeeze-off procedures.

Squeeze-off tools should comply with ASTM F 1563[12]. Typical squeeze-off tools use a manual mechanical screw or hydraulic cylinders, incorporate gap stops to prevent over-squeeze, and a mechanism to prevent accidental bar separation.

Closing and opening rate are key elements to squeezing-off without damaging the pipe. It is necessary to close slowly and release slowly, with slow release being more important. Squeeze-off procedures should be in accordance with ASTM F 1041[13] and should be qualified in accordance with ASTM F 1734[14].

Lower temperatures will reduce material flexibility and ductility, so in colder weather, closure and opening time must be slowed further.

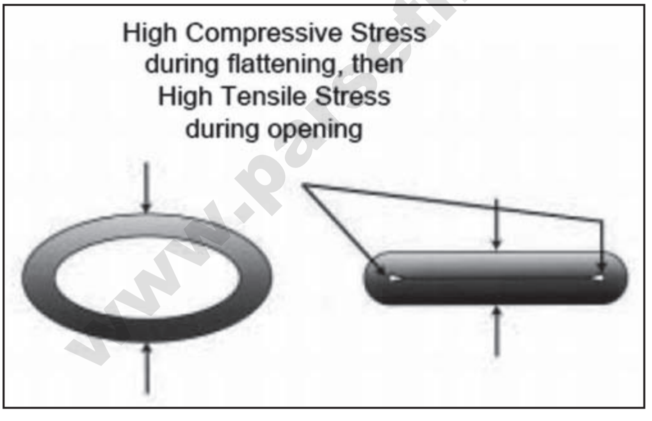

Figure 8 Squeeze-Off Stress

Testing of PE piping has shown that squeeze-off can be performed without compromising the expected service life of the system, or pipe can be damaged during squeeze-off. Damage occurs:

- If the manufacturer's recommended procedures are not followed, or
- If the squeeze is held closed too long, or

- From static electric discharge, or
- When closure stops are altered or circumvented, or
- By squeezing-off more than once in the same location.

Pipe known or suspected to have been damaged during squeeze-off should be removed from the system, or should be reinforced at the squeeze-off point using a full encirclement clamp and replacement repair scheduled.

Static Electricity Control – When pipe conveying a compressed gas is being flattened, the gas flow velocity through the flattened area increases. High velocity, dry gas, especially with particles present in the flow, can generate a static electric charge on pipe surfaces that can discharge to ground. *Before flattening the pipe, the tool should be grounded and procedures to control static charge build-up on pipe surfaces such as wetting surfaces with conductive fluids and applying conductive films or fabrics to ground should be employed.* Grounding and static control procedures should remain in place for the entire squeeze-off procedure.

Identify the squeezed-off area by wrapping tape around the pipe, or installing a full encirclement clamp over the area.

Squeeze-off procedures may be used for routine, scheduled changes to piping systems, or as an emergency procedure to control gasses or liquids escaping from a damaged pipe. For scheduled piping changes, ASTM F 1041 procedures that are qualified per ASTM F 1734 should be observed so that the pipe's service life is not compromised.

However, an emergency situation may require quickly flattening the pipe and controlling flow because the escaping fluid may be an immediate hazard of greater concern than damaging the pipe. *If an emergency situation requires rapid flattening, the pipe or tubing may be damaged.* When the emergency situation is resolved, a full encirclement clamp should be installed over the squeezed off area, and repair to replace the damaged pipe should be scheduled.

Conclusion

A successful piping system installation is dependent on a number of factors. Obviously, a sound design and the specification and selection of the appropriate quality materials are paramount to the long term performance of any engineered installation. The handling, inspection, testing, and safety considerations that surround the placement and use of these engineered products is of equal importance.

In this chapter, we have attempted to provide fundamental guidelines regarding the receipt, inspection, handling, storage, testing, and repair of PE piping products.

While this chapter cannot address all of the product applications, test and inspection procedures, or construction practices, it does point out the need to exercise responsible care in planning out these aspects of any job site. It is the responsibility of the contractor, installer, site engineer, or other users of these materials to establish appropriate safety and health practices specific to the job site and in accordance with the local prevailing codes that will result in a safe and effective installation.

References

1. PPI Material Handling Guide, Plastics Pipe Institute, Irving, TX.
2. ASTM F 894 Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe, ASTM, West Conshohocken, PA.
3. Gilroy, H.M., "Polyolefin Longevity for Telephone Service", Antec Proceedings, 1985.
4. PPI TN-36 General Guidelines for Connecting HDPE Potable Water Pressure Pipes to DI and PVC Piping Systems, Plastics Pipe Institute, Irving, TX.
5. PPI TR-19, Chemical Resistance of Thermoplastics Piping Materials, Plastics Pipe Institute, Irving, TX.
6. ASTM D 638 Standard Test Method for Tensile Properties of Plastics, ASTM, West Conshohocken, PA.
7. ASTM F 2634 Standard Test Method for Laboratory Testing of Polyethylene (PE) Butt Fusion Joints using Tensile-Impact Method, ASTM, West Conshohocken, PA.
8. ASTM F 2164 ASTM Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Hydrostatic Pressure, West Conshohocken, PA.
9. ASTM F 1417 Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low Pressure Air, ASTM, West Conshohocken, PA.
10. AWWA C651 Standard for Disinfecting Water Mains, AWWA, Denver, CO
11. ASTM D 2513 Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings, ASTM, West Conshohocken, PA.
12. ASTM F1563, Standard Specification for Tools to Squeeze-off Polyethylene (PE) Gas Pipe or Tubing, West Conshohocken, PA.
13. ASTM F1041, Standard Guide for Squeeze-off of Polyethylene Gas Pressure Pipe or Tubing, West Conshohocken, PA.
14. ASTM F 1734 Standard Practice for Qualification of a Combination of Squeeze Tool, Pipe, and Squeeze-Off Procedures to Avoid Long-Term Damage in Polyethylene (PE) Gas Pipe, ASTM, West Conshohocken, PA.