PPI Guidelines for Qualification Testing of Mechanical Couplings for PE Pipes in Pressurized Water or Sewer Service
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Scope and Purpose:

The test methods given below apply to mechanical coupling products used to join butt-ends of polyethylene (PE) pipe made to AWWA C906 or 4" and larger pipes made to ASTM F714 and used in pressurized water service for force mains, sewers, and potable water.

Passing all test methods below provides reasonable assurance that the mechanical coupling product may be used successfully on PE pipe at the full pressure rating and capacity of the pipe. Testing other than what is contained herein may be required depending on the materials and design of the mechanical coupling. The mechanical coupling manufacturer is responsible for determining if additional testing is required.

The recommended test methods consider joint integrity and are intended for mechanical couplings that both seal and restrain butt-ends of pipe. If a manufacturer wishes to test only for sealing or only for restraining, an additional device for restraining or sealing is required for the in-service application.

Durability and corrosion issues are not addressed in this procedure. The coupling manufacturer must establish durability and corrosion resistance based on the coupling material and application.

Mechanical couplings for PE pipes must withstand not only the operating line pressure but also 'recurrent surges' to 1.5 times the rated pressure, 'occasional surges' to two times the rated pressure, axial loads imposed by temperature changes and axial loads caused by Poisson effect contraction. (See AWWA Standard C-906 for definitions of ''recurrent' and 'occasional' surges.)

The four test categories are: (1) 1000 Hour Pressure Test to verify sealing and resistance to steady-pressure and axial pulling forces. (2) Repeated Surge Test to verify long-term surge resistance for sealing and restraining. (3) Slow Cycling Test to verify resistance to creep and stress relaxation. (4) Short-term Pressure Test to provide a 1.5 safety factor against surge pressure in the coupling and restraining components.

These tests are for design qualification, and may not be applicable for manufacturing quality control tests. To verify compliance with applicable

specifications, the coupling manufacturer should establish appropriate manufacturing quality control tests.

Introduction

When mechanical couplings are used to join PE pipes to other PE pipes or to other types of pipe, pullout restraint must be provided. Water flow thrust forces that develop at bends or at end closures can push an unrestrained mechanical coupling device or an unrestrained directional fitting off the pipe end. Likewise, axial shortening from thermal contraction or from pressurizing (Poisson effects) may pull pipe out of an unrestrained mechanical coupling device.

Thermoplastic materials that are subjected to constant load may creep. Over time, creep may reduce the effectiveness of clamping or restraining systems and lead to a gradual reduction in resistance to pullout or leakage. Therefore, a time component is required in testing mechanical coupling devices for thermoplastic pipes. Long-term creep and stress relaxation effects may be modeled by slow pressure cycling tests that apply periods of high pressure, followed by non-pressure to enhance creep and stress relaxation.

Water service applications may have occasional or recurrent pressure surges. PE pipes have exceptional resistance to surge pressures. Mechanical couplings must also accommodate repeated surges. In this recommended testing procedure, surge resistance is modeled by rapid pressure cycling between an anticipated surge pressure and a baseline pressure. When the pipe is at baseline pressure for longer time periods, the pipe undergoes stress relaxation.

Fatigue tests are a means to accelerate aging and evaluate long-term performance. Traditional accelerated aging tests for PE pipes employ elevated temperature or stress, or aggressive chemical environments. These traditional means, however, can be improper for mechanical coupling devices made from non-PE materials. In this recommended testing procedure, fatigue from rapid pressure cycling provides a means to accelerate long-term testing without resorting to elevated temperature or stress, or aggressive chemicals.

The test methods given below are for design qualification of field-assembled or factory-assembled mechanical butt coupling devices that have been assembled in accordance with the manufacturer's established recommendations.

Mechanical Butt Coupling Description

A mechanical butt coupling is any mechanical device, used to couple (join) straight plain PE pipe ends to each other or to couple a plain PE pipe end to another type of pipe in such a manner as to develop a seal and restrain the ends together. Mechanical butt couplings may also be used to join pipe to fittings or

fittings to fittings, where the fittings have an end that is essentially a plain pipe end.

Test Methods

Testing must be conducted safely, however, this guide does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this guide to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use. These tests are intended for use by the manufacturer to verify or qualify a joint design or components of a joint design. These tests are not intended to be used in the field to test installed systems.

The test methods described herein are for design qualification and periodic quality assurance. They are not intended to be routine quality control tests. Manufacturers should determine appropriate quality control tests for their devices.

Sample and Specimen Size

To qualify a particular mechanical design, testing may not be required for each and every diameter size and DR. In general, testing should be conducted on sizes that define the intended service range, for example maximum and minimum DR and maximum and minimum diameter. If the intended service range is large, intermediate DR's and sizes should also be tested. The mechanical butt-coupling manufacturer should determine suitable pipe sizes and DR's that cover the range of the coupling design. At a minimum, the following guidelines are recommended for consideration:

Test the lowest and highest DR pipe for which the coupling is manufactured.

Test the smallest and largest diameters for which the coupling style is manufactured. The manufacturer of the coupling is to determine if testing is required on the intermediate sizes.

The number of specimens to be tested per coupling size and DR in Item 2 above should be determined by the coupling manufacturer. It is recommended that at least three specimens per diameter be tested in each of the test methods.

The test temperature for pipes that are intended for buried services below the frost line is 73 ^{o}F (23 ^{o}C). For above ground applications or applications where the fluid temperature is above 100 ^{o}F (38 ^{o}C),

additional tests at elevated temperatures up to 140 ^{o}F (60 ^{o}C) may be appropriate. For above ground applications, additional tests that are not discussed in this guide such as thermocycling (repeated cycling between low temperature/high axial load and high temperature/low axial load) may also be conducted.

Angular Deflection

Perform all pressure testing at the manufacturer's recommended maximum allowable angular deflection, for mechanical couplings that are recommended for angular deflection by the coupling manufacturer. Bracing or restraints may be required to hold pipe at angular deflection during testing.

Test Pressure

Test pressures given in each of the four test methods are for mechanical couplings designed for the full rated pressure of the pipe. Where the coupling is designed for less than the full rated pressure of the pipe, the test pressure may be adjusted accordingly. (The coupling manufacturer is responsible for notifying users of the rated pressure of the coupling.)

1. 1000-Hour Pressure Test at 73^{o}F (23^{o}C)

Warning – Take all precautions to ensure personal safety when conducting tests at high internal pressure.

The 1000-hour pressure test is used to test the capacity of the restraint and seals for over pressurization such as surge and for axial forces such as thermal contraction. The test shall be conducted at a pressure producing a stress equal to the hydrostatic design basis (i.e. 1600 psi for PE 3408 materials.)

1.1 Specimen Length

The mechanical coupling being tested is installed between two equal length sections of PE pipe. For 6" and smaller pipe, the length between end closures shall be five times the outside diameter but not less than 12". For pipes larger than 6", the minimum length shall be three times the outside diameter or 30" whichever is larger. End closures are attached mechanically or fused to the ends of the pipe sections. Restraint or blocking of end closures that would prevent the development of full end thrust load due to pressurization shall not be used.

1.2 Specimen Conditioning

Fill the specimen with water and condition in air for at least 16 hours or in water for at least 1 hour at the test temperature.

1.3 Pressurization

Maintain the test specimens at the pressure of two times the pipe's rated pressure (Working Pressure Rating, WPR) at the test temperature for a period of 1000 hours at the test temperature (73^{o}F, unless otherwise specified.)

1.4 Failure Definition

Failure is defined as any leakage through the joint or wall of the pipe or a coupling that breaks, slips off the pipe, tears the pipe, or otherwise disengages from the pipe. Remove the coupling and inspect the pipe surface. There shall be no surface damage to the pipe other than the ordinary marks and impressions due to the restraining device. Cracks, splits, or delaminations extending from any impressions will be considered failure.

2. Cyclical Pressure Test

Warning – Take all precautions to ensure personal safety when conducting tests at high internal pressure.

Cyclical testing is used to assess the mechanical coupling's resistance to surge pressures that may occur in water and force main sewer applications.

2.1 Specimen Preparation

As described above for the 1000-hour pressure test, end caps may be fused or attached to the plain ends of the pipe before or after coupling assembly. Other than the mechanical coupling, no restraint or blocking shall be applied to the specimen that would prevent the PE pipe from developing the full end thrust load due to pressurization.

2.2 Specimen Length

The mechanical coupling being tested is installed between two equal length sections of PE pipe. For 6" and smaller pipes, the specimen length between end closures shall be five times the outside diameter but not less than 12". For pipe sizes larger than 6" but not more than 20", the minimum length shall be three times the outside diameter or 30", whichever is larger. For pipe sizes greater than 20", the specimen length shall be three times the outside diameter but not greater than 72". Restraint or blocking of end closures that would prevent the development of full end thrust load due to pressurization shall not be used.

2.3 Conditioning

Fill the specimen with water and condition in air for at least 16 hours or in water for at least 1 hour at the test temperature.

2.4 Cyclical pressurization

Cyclical pressurization consists of increasing the internal pressure of the pipe from the pipe's base pressure to a peak pressure equal two times the pipe's rated pressure (Working Pressure Rating, WPR). Base pressure is defined as the rated pressure for the tested DR at the test temperature (73^{o}F, unless otherwise specified). Bring the specimen from base pressure to peak pressure and back to base pressure at the rate of 6 to 10 cycles/min. A device for counting the cycles shall be built into the test device along with a method of detecting leakage and recording the number of cycles at leakage.

2.5 Minimum Number of Cycles

The minimum number of cycles for the test specimen is 1,000,000 cycles from base pressure to peak pressure.

2.6 Failure Definition

Failure is defined as any leakage through the joint or wall of the pipe or a coupling that breaks, slips off the pipe, tears the pipe, or otherwise disengages from the pipe. Remove the coupling and inspect the pipe surface. There shall be no surface damage to the pipe other than the ordinary marks and impressions due to the restraining device. Cracks, splits, or delaminations extending from any impressions will be considered failure.

3. Slow Cycling Pressure Test

Warning – Take all precautions to ensure personal safety when conducting tests at high internal pressure.

This test is intended to determine the effects of creep and stress relaxation on joint integrity. The slow cycling test is intended to model a connection that has been pressurized, and then allowed to be depressurized for an extended time period. This would simulate a system that after leak testing, is idle for a time before being placed in service, or a system that has been in service, and is then completely depressurized for maintenance or power loss or the like.

3.1 Specimen Preparation

As described above for the 1000-hour pressure test, end caps may be fused or attached to the plain ends of the pipe before or after coupling

assembly. Other than the mechanical coupling, no restraint or blocking shall be applied to the specimen that would prevent the PE pipe from developing the full end thrust load due to pressurization.

3.2 Specimen Length

The mechanical coupling being tested is installed between two equal length sections of PE pipe. Specimen length shall be the same as described in Section 2 of the "Cyclical Pressure Test".

3.3 Conditioning

Fill the specimen with water and condition in air for at least 16 hours or in water for at least 1 hour at the test temperature.

3.4 Cyclical pressurization

Cyclical pressurization consists of slow cycling between zero internal pressure and an internal test pressure of two times the pipe's rated pressure (Working Pressure Rating, WPR) at the test temperature (73^{o}F, unless otherwise specified). After conditioning, raise the specimen internal test pressure, maintain test pressure for eight (8) hours, and then reduce test pressure to zero (0) psi for sixteen (16) hours. A device for counting the cycles shall be built into the test device along with a method of detecting leakage and recording the number of cycles at leakage.

3.5 Minimum Number of Cycles

The minimum number of complete pressure/non-pressure cycles for the test specimen is 42.

3.6 Failure Definition

Failure is defined as any leakage through the joint or wall of the pipe or a coupling that breaks, slips off the pipe, tears the pipe, or otherwise disengages from the pipe. Remove the coupling and inspect the pipe surface. There shall be no surface damage to the pipe other than the ordinary marks and impressions due to the restraining device. Cracks, splits, or delaminations extending from any impressions will be considered failure.

4. Short-term Pressure Test

Warning – Take all precautions to ensure personal safety when conducting tests at high internal pressure.

The short-term pressure test assesses performance against mechanical failure of the joining components, when the coupling is subjected to 150 percent of the maximum permitted surge pressure for the pipe. The joint is pressurized and held for five seconds at three times the rated pressure of the pipe.

4.1 Specimen Length

The mechanical coupling being tested is installed between two equal length sections of PE pipe. The mechanical coupling being tested is installed between two equal length sections of PE pipe. Specimen length shall be the same as described in Section 2 of the “Cyclical Pressure Test”.

4.2 Specimen Conditioning

Fill the specimen with water and condition in air for at least 16 hours or in water for at least 1 hour at the test temperature.

4.3 Pressurization

Pressurize the specimen to three times the pipe’s rated pressure (Working Pressure Rating), unless test pressure has been specified otherwise as noted above. Hold the test pressure for five seconds and then depressurize the specimen.

4.4 Failure Definition

Failure is defined as any leakage during pressurization or within or after the five-second test interval or as a coupling that breaks, slips off the pipe, tears the pipe, or otherwise disengages from the pipe. Remove the coupling and inspect the pipe. There shall be no surface damage to the pipe other than the ordinary marks and impressions due to the restraining device. Cracks, splits, or delaminations extending from the impressions will be considered failure.