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Standard Test Method for Constant Tensile Load Joint Test (CTLJT)[1]

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1. Scope

1.1 The constant tensile load joint test (CTLJT) is designed to demonstrate that a joint in a plastic piping system is resistant to the effects of long-term creep.

1.1.1 The joint is subjected to an internal pressure at least equal to its operating pressure and a sustained axial tensile load for a specified time period, usually 1000 h. The joint shall not leak, nor may the pipe *completely* pull out for the test duration. The total axial stress is set by the referencing document.

1.1.2 Some typical conditions for testing of joints on polyethylene pipe are described in Appendix X1.

1.2 This test is usually performed at 73°F (22.8°C).

1.3 The CTLJT was developed to demonstrate the long-term resistance to pullout of mechanical joints on polyethylene gas pipe. The CTLJT has also been successfully applied to the evaluation of other components of plastic piping systems. These applications are discussed in Appendix X1.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *This standard 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 standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D638 Test Method for Tensile Properties of Plastics
D1600 Terminology for Abbreviated Terms Relating to Plastics
D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings
D2513 Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings
F412 Terminology Relating to Plastic Piping Systems

2.2 *ANSI Standard:*[3]

B31.8 Gas Transmission and Distribution Piping Systems

2.3 *Code of Federal Regulations:*[4]

OPS Part 192, Title 49

3. Terminology

3.1 *Definitions:*

3.1.1 *General*—Definitions are in accordance with Test Method D638 and Terminology F412, unless otherwise specified. Abbreviations are in accordance with Terminology D1600.

3.1.2 The gas industry terminology used in this test method is in accordance with the definitions given in ANSI B31.8 or OPS Part 192, Title 49, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *mechanical joint, Category 1*—a mechanical joint design that provides a seal plus a resistance to force on the pipe end, equal to or greater than that which will cause a permanent deformation of the pipe or tubing. **(D2513)**

3.2.2 *mechanical joint, Category 3*—a mechanical joint design that provides a seal plus a pipe restraint rating equivalent to the anticipated thermal stresses occurring in a pipeline. This category has a manufacturers' pipe-end restraint that allows slippage at less than the value required to yield the pipe. **(D2513)**

3.2.3 *pipe*—refers to both pipe and tubing.

4. Summary of Test Method

4.1 A joint is subjected to a sustained axial load for a specified period of time (usually 1000 h). The test duration and the actual test conditions (axial stress, internal pressure, test duration, and test temperature) are either specified by a referencing document or, for new or unique applications,

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from U.S. Government Publishing Office, 732 N. Capitol St., NW, Washington, DC 20401-0001, http://www.gpo.gov.

agreed upon between the user and the manufacturer. X1.2 contains a background discussion of axial stress values and axial load determination.

4.2 The joint is made to plastic pipe of the type, grade, size, and dimension ratio to be used in the final application. The axial tensile stress should be as high as possible, but shall be lower than the stress at which the plastic material continues to stretch and finally yields (the long-term yield strength) (see Note 1).

NOTE 1—During the first hours of a test, the pipe elongates measurably. Elongation continues for the duration of the test at a decaying rate.

4.3 A joint passes this test if it does not leak and does not pull out or allow slippage in excess of the manufacturers' specified design slippage during the test duration.

4.4 If a pipe in the test assembly yields before the specified minimum test time is attained, the total stress is above the long-term yield strength of that pipe and the test shall be performed again at a stress level calculated to be below the long-term yield strength of the pipe.

5. Significance and Use

5.1 This test method was designed to be used to validate the long-term resistance to pullout of joints designed for use in plastic natural gas piping systems.

5.2 This test method is used in addition to the short-term tests required by OPS Part 192.283b, Title 49. Informal versions of this test method are used by manufacturers and utilities to demonstrate that a joint is resistant to the effects of long-term creep and meets the requirements for classification as a Category 1 or a Category 3 joint in accordance with Specification D2513.

5.3 This test method may also be applicable for the determination of the effects of a sustained axial load on joints or other components of plastic piping systems designed for other applications. Test parameters and the internal pressurizing fluid, if any, should be listed in the referencing document.

5.4 Documents that reference this test method for products other than joints shall specify test conditions and performance requirements. In general, such products pass this test if they maintain their structural integrity, do not leak, and perform to specification during and after the test.

6. Apparatus

6.1 *Loading Methods:*

6.1.1 Any loading method that maintains the correct, in-line tensile load on the joint (within ±2 %) for the test duration is acceptable. Loading methods successfully employed for all size loads include lever arms, hydraulic cylinders, and air cylinders.

6.1.2 Dead weight (a pile of scrap steel or iron) has worked well for loads up to 1 ton (907 kg) (see Note 2).

NOTE 2—To provide an adequate stress level for ⅝ in. DR 7 PE tubing, about 200 lb (90 kg) are required. Pipe 2 in. SDR11 PE requires about 2000 lb (907 kg).

6.1.3 Hydraulic and air-powered loading frames have been constructed to provide up to 50 000 lb (22 680 kg) for tests on 3-in. IPS through 8-in. IPS joints. The stroke of the cylinder should be adequate for the material being tested.

6.2 *Applied Axial Load Determination Monitoring*—The applied axial load shall be maintained to within ±2 % of the calculated value.

6.2.1 Dead weight is weighed before the start of a test.

6.2.2 In systems with air or hydraulic cylinders, a load-cell and indicator may be used between the cylinder and the test assembly. An alternative is to accurately establish the relationship between inlet pressure and the force generated by a cylinder and then to monitor a pressure gage placed in the pressurization line to the cylinder during the test.

6.3 *Pressure Gage*—Each assembly shall have a pressure gage to monitor internal pressure on the test assembly. The gage shall be able to measure the test pressure to within an accuracy of 1 % or better.

6.4 *Test Assembly:*

6.4.1 The test assembly is capped and verified to be leak tight. Attachment devices that ensure straight line axial loading shall be used at each end to attach the test assembly to the loading device. The test assembly may contain more than one joint of the size under evaluation (see Note 3).

NOTE 3—There are many configurations possible with the wide variety of joints that are available. If the mechanical joint to be tested is suitable for the purpose, it can be used to cap the pipe ends.

6.4.2 The minimum length is three pipe diameters between fittings (stiffener ends). Elongation is proportional to specimen length. It is important to allow sufficient space in the apparatus to provide for anticipated elongation of the test specimen for the duration of the test.

7. Precautions and Safety Considerations

7.1 Each test fixture and joint assembly shall be designed to safely accommodate a sudden unexpected failure in any part of the test assembly. Both fixture and joint(s) shall be regularly inspected for safety. Joint pullouts usually occur unexpectedly and proceed from start to finish in seconds. Failure may be accompanied by the sudden release of the internal pressure or a falling test assembly, or both.

7.2 It is strongly recommended that water be used as the pressurizing fluid when testing systems that may fail in a brittle manner (specifically PVC systems). If that is not possible, the test specimens shall be placed in a strong chamber at all times when pressurized (see Note 4).

NOTE 4—For example, after 938 h of uneventful testing, one 6-in. IPS transition joint rapidly pulled apart. There was no indication of pipe movement when inspected 5 min before failure.

8. Test Specimens

8.1 *Pipe Specimen Selection:*

8.1.1 For tests of fittings intended for use in natural gas distribution systems, the pipe supply used for the tests shall have a print line signifying that it was manufactured to the requirements of Specification D2513.

8.1.2 Pipe specimens used for fittings tests shall meet the dimensional requirements of the referencing document. (See

Note 5.) The dimensions of the pipe specimens selected for use in an evaluation shall be known and reported.

NOTE 5—Some fittings may perform well with pipe of the nominal outside diameter and wall thickness and fail if assembled to pipe at the limits of the dimensional tolerances. To ensure good performance on the full range of pipe dimensions that meet specifications, it may be necessary to procure or to manufacture specimens at the extremities of both wall thickness and outside diameter and to perform verification tests on one or more sizes of such material.

8.2 *Specimen Preparation:*

8.2.1 Cut the required number of thermoplastic pipe specimens to length. Make each pipe specimen a minimum of three pipe diameters long plus the length needed for insertion into the fitting(s).

8.2.2 To obtain dimensions and to verify that pipe used for the test meets ASTM dimensional requirements, perform the following measurements on each specimen, a representative sample from a coil, or 40-ft (12-m) long straight length.

8.2.2.1 Measure the outside diameter (OD) at the center of a specimen, using a circumferential wrap tape, in accordance with Test Method D2122.

8.2.2.2 Using the procedures for wall thickness measurement and calculation of the average wall thickness in Test Method D2122, measure the wall thickness at each end of a specimen and calculate the average wall thickness (AWT).

9. Assembly

9.1 Install the fittings on the pipe specimens in accordance with the manufacturer's instructions.

9.2 With a marking pen or similar device, place an index mark on the pipe directly adjacent to the ends of all mechanical fittings, so that any slippage can be measured and compared to that which may be allowed by the manufacturer's specifications. Some displacement of this mark under load is normal due to the stretching of the material in the joint.

10. Procedure

10.1 The test assembly shall be conditioned to the test temperature for a minimum of 12 h before the load is applied.

10.2 Install the test assembly into the long-term loading device.

10.3 Inspect all parts of the test assembly and the loading mechanism for safety before applying the tensile load.

10.4 After 24 h of loading, examine all joints in the assembly for signs of slippage. If the slippage does not exceed that specified by the manufacturer for the joint under test, slowly introduce the pressurizing fluid into the assembly to the full operating pressure ±1 %.

10.5 Monitor for leaks and record the ambient temperature, the tensile load, the amount of slippage (if any), and the internal pressure for the duration of the test.

11. Calculation

11.1 *Load Calculation Method 1:*

11.1.1 Calculate the cross sectional area, A, of the pipe wall, as follows:

$$A = \pi \times \text{AWT} \times (\text{OD} - \text{AWT}) \quad (1)$$

11.1.2 Calculate the tensile load, P, as follows:

11.1.2.1 Calculate the total load, P_T, as follows:

$$P_T\,(\text{lb}) = \text{stress}\,(\text{psi}) \times A\,(\text{in.}^2) \quad (2)$$

11.1.2.2 Calculate the axial loading generated by the internal pressure, P_1, as follows:

$$P_1 = \pi/4 \times \text{OD}^2\ (\text{in.}^2) \times \text{test pressure}\,(\text{psig}) \quad (3)$$

11.1.2.3 Calculate the load (lb) to be applied by the loading mechanism, P_2, as follows:

$$P_2 = P_T - P_1 \quad (4)$$

11.2 *Load Calculation Method 2:*

11.2.1 This alternative load calculation method has been included to accommodate producers who use this test method for large numbers of developmental tests. The procedure in 11.1 is recommended for referee-type tests because the error in the calculated cross-sectional area of in-specification pipe may exceed 10 % if this alternative method is used.

11.2.2 Calculate the cross-sectional area of the pipe wall, A, as follows:

$$A = \pi \times MW \times (MOD - MW) \quad (5)$$

where:

MW = maximum wall from Table 2 or 3 of Specification D2513, and

MOD = maximum outside diameter from Table 2 or 3 of Specification D2513.

11.2.3 *Calculation of Tensile Load, P:*

11.2.3.1 Calculate the total load as follows:

$$P_T\,(\text{lb}) = \text{stress}\,(\text{psi}) \times A\,(\text{in.}^2) \quad (6)$$

11.2.3.2 Calculate the axial loading generated by the internal pressure, P_1, as follows:

$$P_1 = \pi/4 \times \text{OD}^2\ (\text{in.}^2) \times \text{test pressure}\,(\text{psig}) \quad (7)$$

11.2.3.3 Calculate the load (lb) to be applied by the loading mechanism, P_2, as follows:

$$P_2 = P_T - P_1 \quad (8)$$

12. Report and Documentation

12.1 Report the following information for each product or joint under evaluation:

12.1.1 Test duration (h),

12.1.2 Axial tensile stress (psi) in the pipe wall for the pipe section in that particular joint,

12.1.3 Cross-sectional area (in.^{2}) of pipe wall and the load (lb),

12.1.4 Name the pressurization fluid: air or water,

12.1.5 Leakage,

12.1.6 Ambient temperature range, and

12.1.7 Any slippage detected between pipe and fitting up to and including a pullout. Compare this to the manufacturer's allowable slippage, if any, and to the appropriate standards and specifications. Indicate whether the joint passed or failed.

13. Precision and Bias

13.1 Products subjected to this test either leak, slip beyond the manufacturer's design, or pull out and fail the test. Or products subjected to this test do not pull out, slip within the limits set by the manufacturer, and do not leak and pass the test. Therefore, no precision or bias statement is necessary.

14. Keywords

14.1 constant tensile load; mechanical fitting; mechanical joint; polyethylene gas pipe; pull-out; tensile test

APPENDIX

(Nonmandatory Information)

X1. HISTORICAL PERSPECTIVE OF THE CTLJT

X1.1 *Other Applications for the CTLJT:*

X1.1.1 This test was developed to demonstrate the long-term resistance to pullout of mechanical joints on polyethylene (PE) gas pipe. The CTLJT method was also successfully applied to the evaluation of the bond quality of polyethylene heat fusion joints (butt, socket, and electrofusion), for the evaluation of PE plastic gas valves and for the evaluation of mechanical joints between PE and PVC gas pipe.

X1.1.2 In general, other products such as valves were considered to have passed this test if they maintained their structural integrity, did not leak, and could be operated during and after the test. The actual test conditions, performance requirements, and acceptance criteria for these applications should be listed in the referencing document or included in an agreement between the user and the supplier.

TEST CONDITIONS

X1.2 *Axial Stress:*

X1.2.1 The *total* axial tensile stress used for this test method varied from laboratory to laboratory and ranged from 1320 psi (9100 kPa) to above 1500 psi (10 340 kPa).

X1.2.2 The stress selected shall be less than the yield point (a stress less than that which causes sustained pipe elongation). Experience shows that for PE at 73°F (22.8°C), this point is between 1500 and 1600 psi (10 340 and 11 030 kPa). To avoid rapid yielding accurate determinations of the pipe wall cross section, the internal pressure and the axial force are necessary.

X1.2.3 For polyethylene (PE2306, 2406, 3306, and 3408) pipe, the typical tensile stress from external loading was set at 1320 psi (9100 kPa). In some laboratories, the 60-psi (414-kPa) internal pressure increased the total axial stress in SDR 11 pipe to about 1490 psi (10 270 kPa). In other laboratories, the axial force generated by 60-psi (414-kPa) internal pressure was calculated and subtracted from the axial load, so that the total axial stress equaled 1320 psi (9100 kPa).

X1.2.4 The total axial stress value to be used with this test method will be set by referencing documents. Most users chose a stress value in the range between 1320 and 1490 psi (9100 and 10 270 kPa). For tests in which no referencing document is available, a total stress of 1320 psi (9100 kPa) for PE pipe may be considered.

X1.3 *Quick Tensile Test Correlation*—Some mechanical fittings produce joints that pass the quick tensile test at 0.2 in./min, listed for gas pipe by OPS Part 192, Title 49, but fail a CTLJT. The CTLJT test was designed to identify those fittings so that they could be either redesigned by the manufacturer or removed from consideration by the utility.