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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[1]

This standard is issued under the fixed designation F1734; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers qualifying a combination of a squeeze tool, a polyethylene gas pipe, and a squeeze-off procedure to avoid long-term damage in polyethylene gas pipe. Qualifying is conducted by examining the inside and outside surfaces of pipe specimens at and near the squeeze to determine the existence of features indicative of long-term damage. If indicative features are absent, sustained pressure testing in accordance with Specification D2513 is conducted to confirm the viability of the squeeze-off process. For assistance with specimen examination, an Adjunct, ADJF1734[2], is available from ASTM.

1.2 This practice is appropriate for any combination of squeeze tool, PE gas pipe and squeeze-off procedure, and is particularly appropriate for pre-1975 Polyethylene (PE) pipe, and for pipe sizes of 8 in. or above, because of a greater possibility of long-term damage.

1.3 This practice is for use by squeeze-tool manufacturers, pipe manufacturers and gas utilities to qualify squeeze tools made in accordance with Specification F1563; and squeeze-off procedures in accordance with Guide F1041 with pipe manufactured in accordance with Specification D2513.

1.4 Governing codes and project specifications should be consulted. Nothing in this practice should be construed as recommending practices or systems at variance with governing codes and project specifications.

1.5 Where applicable in this guide, "pipe" shall mean "pipe and tubing."

1.6 *Units*—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.

1.7 *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:*[3]

D2513 Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings

D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials

F1041 Guide for Squeeze-Off of Polyolefin Gas Pressure Pipe and Tubing

F1563 Specification for Tools to Squeeze-off Polyethylene (PE) Gas Pipe or Tubing

2.2 *ASTM Adjuncts:*

Interpretation Aid for Squeeze-Off Damage[2]

3. Terminology

3.1 *Definitions:*

3.1.1 *squeeze-off, n*—a technique used to temporarily control the flow of gas in a polyethylene gas pipe by flattening the pipe with a mechanical or hydraulic device.

3.1.2 *squeeze process, n*—the combination of the squeeze tool, the pipe being squeezed, and the squeeze-off procedure being used.

3.1.3 *wall compression (WC), n*—the percentage extent to which the pipe walls are compressed when the pipe is squeezed. (See Fig. 1.) It is defined as:

$$WC, \% = \left(1 - \frac{L}{2t}\right) \times 100 \quad (1)$$

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.60 on Gas.

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[2] Available from ASTM International Headquarters. Order Adjunct No. ADJF1734. Original adjunct produced in 1995.

[3] 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.

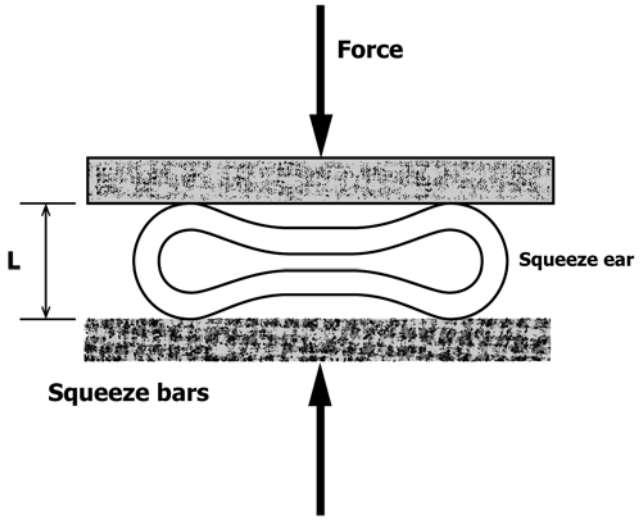

FIG. 1 Definition of Wall Compression

where:

L = distance between the squeeze tool bars as shown in Fig. 1, and

t = uncompressed pipe wall thickness, expressed in the same units as L.

3.1.3.1 *Discussion*—When the distance between the squeeze tool bars is greater than twice the wall thickness, the pipe walls are not compressed, which yields a negative value for the wall compression percentage. The value becomes positive when the L value is less than the $2t$ value. Typical squeeze tool stops are set for 30 % or less wall compression based on maximum wall thickness (a distance that is 70 % of twice maximum wall thickness when the squeeze tool is closed to the stops). Maximum wall thickness is the minimum wall thickness plus the wall thickness tolerance.

4. Summary of Practice

4.1 Pipe of the size and material of interest is cut into specimens at least 1 ft long or 3 diameters long whichever is greater, and attached to a supply of pressurized gas. With pressurized gas flowing through the specimen, the specimens are squeezed with the tool of interest, using the procedure of interest, until the desired level of flow control is achieved. Using Eq 1, the wall compression percentage at the desired level of flow control is determined. Let this level of wall compression be called *WCnom*. Additional specimens are squeezed to obtain squeeze levels that are 5 % greater, 10 % greater, 5 % less and 10 % less than *WCnom*. This squeeze range brackets levels of wall compression for flow control.

NOTE 1—For example, if the desired level of flow control were achieved at 25 % wall compression, additional specimens would be prepared at 35 %, 30 %, 20 % and 15 % wall compression. In research tests, a flow of 0.1 ft^3/h was considered equivalent to stopping the flow.[4,5]

4.2 The squeezed samples are split along their length at 90 degrees to the squeeze "ears" (See Fig. 1). The area containing the ears is examined visually using the unaided eye, then magnification. Features such as crazing, small voids, or cracks indicate permanent damage and disqualify the squeeze-off process.

4.3 Where the results of the visual screening do not indicate permanent damage, additional specimens are squeezed at the *WC* level where damage is not indicated, and sustained pressure tests in accordance with Specification D2513 are performed. When sustained pressure test specimens meet the requirements of Specification D2513, the squeeze-off process has been verified.

4.3.1 When damage is identified at *WCnom* less 5 % or *WCnom* less 10 % levels, a wall compression percentage where damage does not occur should be identified. Prepare additional specimens by lessening wall compression in 5 % increments, and then examine the specimens to identify a wall compression percentage that does not indicate damage.

NOTE 2—This practice uses flow through the squeezed-off pipe as a parameter. For some combinations of tool, pipe and procedure, it is not possible to stop flow completely without causing permanent damage to the pipe, particularly for pipes greater than 2 in, nominal size.

4.4 Using a desired squeeze-off procedure, tests conducted at different pipe temperatures with various sizes of tools and pipes can be used to verify a range of temperatures, tool sizes, and pipe sizes for which the squeeze-off process is applicable.

5. Significance and Use

5.1 Squeeze-off is widely used to temporarily control the flow of gas in PE pipe. Squeeze tools vary depending on the size of the pipe and the design of the tool. Squeeze-off procedures vary depending on the tool design, pipe material, and environmental conditions.

5.2 Experience indicates that some combinations of polyethylene material, temperature, tool design, wall compression percentage and procedure can cause damage leading to failure.

5.3 Studies of polyethylene pipe extruded in the late 1980s and thereafter show that damage typically does not develop when the wall compression percentage is 30 % or less, when temperatures are above 50°F (10°C), and when closure and release rates are typical of field conditions for screw-driven tools.[4] With tools meeting Specification F1563, acceptable flow control at typical gas service pressures is achieved at wall compression percentages between 10 and 20 % for pipe diameters less than 6 in.[4,5] Because damage does not develop in these materials at such squeeze levels, the references cited indicate that squeeze-off flow control practices using tools meeting Specification F1563 and qualified procedures meeting Practice F1041 are effective for smaller pipe sizes.[4,5]

NOTE 3—Specification F1563 provides a procedure for evaluating tool flow control performance.

[4] Stephens, D. R., Leis, B. N., Francini, R. B., and Cassady, M. J., *Volume 1: Users' Guide on Squeeze-Off of Polyethylene Gas Pipes*, Topical Report GRI-92/0147.1, NTIS PB93-161032, Battelle Columbus for Gas Research Institute, February 1992.

[5] Stephens, D. R., Leis, B. N., Francini, R. B., and Cassady, M. J., *Volume 2: Technical Reference on Squeeze-Off of Polyethylene Gas Pipes*, Topical Report GRI-92/0147.2, NTIS PB93-161040, Battelle Columbus for Gas Research Institute, October 1992.

5.4 This practice provides a method to qualify a combination of squeeze tool, pipe size and material, and squeeze-off procedure to ensure that long-term damage does not occur. This practice is useful for polyethylene gas pipe manufactured before 1975, for new or revised polyolefin gas pipe materials, for pipe diameters of 8 in. or above, for new or revised squeeze tool designs, and for new or revised squeeze-off procedures.

6. Interpretation of Results

6.1 This practice relies on a screening process using visual inspection followed by sustained pressure testing as described in Specification D2513 to qualify a squeeze-off process.

6.2 The area of wrinkling at the ears on the inside diameter (ID) of the pipe and the area on the outside of the pipe opposite the ears are examined . Evidence of any one or a combination of void formation, cracks or extensive localized stress whitening, or failure during sustained pressure testing disqualifies the squeeze-off process.

6.3 Unacceptable features implying long-term damage are shown in the photographs in adjunct, ADJF1734[2].

7. Apparatus

7.1 *Squeeze-off Tools,* meeting Specification F1563 that are to be covered by the squeeze-off process.

7.2 *Pipe Cutters and Saws,* capable of cutting the PE pipe.

7.3 *Jeweler's Loupe or (Stereo) Optical Microscope,* providing 10× or higher magnification.

7.4 *Vernier Caliper or Ball-End Micrometer,* with an accuracy of at least 0.001 in.

7.5 *Stopwatch,* that can indicate time to at least the nearest second.

8. Materials

8.1 Polyethylene pipe meeting Specification D2513.

9. Safety Precautions

9.1 Care should be taken and appropriate protective equipment for eyes and persons is required when working with hydraulic and power tools that may be used in the squeeze-off process. Personal hearing protection is required when compressed gas is discharged from open-ended specimens.

10. Preparation of the Sample and Equipment

10.1 Select pipe samples at least 3 pipe diameters long but not less than 1 ft long.

10.2 Measure the pipe wall thickness at 15° increments around the pipe, and identify the location of maximum wall thickness.

10.3 Condition samples to the temperature of interest. Studies show that at very low temperatures or on thicker-walled pipe significant hold times are necessary to reach thermal equilibrium. Experience with smaller-diameter, lower SDR pipe (for example, 2 to 6-in. SDR 11 pipe) indicates that a minimum of 24 h is required for the sample to reach equilibrium.

11. Procedure

11.1 Orient the sample in the squeeze tool so that the thickest portion of the pipe wall forms one of the squeeze-off ears. Locate the squeeze tool at the midpoint of the sample length so that the tool is centered on the sample and square to the centerline of the sample.

11.2 The squeeze bar shims or stops, or both, must be within 1 % of the target level.

11.3 Operate the tool in accordance with the procedure of interest, close the bars to the distance required for the desired wall compression, and hold for at least 30 min. Closure stops may need to be removed or smaller stops or shims may be needed to obtain the closure distance required.

11.4 Release the squeeze in accordance with the procedure of interest.

11.5 If re-rounding is included in the procedure of interest, re-round the sample accordingly.

11.6 Allow the sample to sit undisturbed without external force at the desired temperature for 24 h.

11.7 Cut a ring from the pipe sample. The ring is to be at least 2 pipe diameters in length with the squeeze in the middle of the ring. Cut the ring lengthwise with the squeeze-ears oriented 90° to the plane of the cut.

11.8 *Visual Examination*—With the unaided eye, and then with magnification, examine the interior of the sample at each squeeze ear for stress whitening, crazing, or cracking. Examine the exterior of the sample at the squeeze ears for evidence of a dimple centered at the ear. Examine first with the unaided eye. Samples that pass unaided eye visual examination are then visually examined under 10× magnification.

11.8.1 *Unaided-Eye Visual Examination:*

11.8.1.1 Wrinkling of the interior of the squeeze-off ear is expected to occur. Some stress whitening along the ridges and in the valleys of wrinkles is also expected to occur. Stress whitening should be limited to these ridges and valleys in the region where wall thinning occurs in response to the squeeze process. Stress whitening should be diffuse in appearance rather than an intense white band.

11.8.1.2 Cracking or voids on the inside or a dimple on the outside disqualify the squeeze-off process.

11.8.1.3 A dimple on the outside of the pipe, or stress whitening strung out along a severe wrinkle on the inside of the pipe, at *WCnom* plus 5 %, *WCnom*, *WCnom* less 5 % or *WCnom* less 10 % levels disqualify the squeeze-off process.

11.8.2 *Magnified Visual Examination :*

11.8.2.1 At 10× magnification, examine the interior of the squeeze ear of samples that pass the unaided-eye examination, Cracking or voids disqualify the squeeze-off process.

11.8.2.2 At 10× magnification, stress whitening strung out along a wrinkle is evidence of damage that can grow with time. Judgment, depending on the severity of the features, the service conditions, and the utility's service record for that pipe, can disqualify the squeeze procedure if such features are found.

11.8.2.3 General widespread evidence of changes in color, such as intense stress whitening or crazing, is evidence of

damage and indicative of possible subsurface damage. Judgment based on experience related to the service record of the pipe involved should be considered in qualifying procedures that produce such features. Examination of cross sections prepared on a cut through the ear can be used to determine if subsurface damage has occurred in such cases. Indications of small voids in cross sections disqualifies the squeeze-off process.

11.9 *Sustained Pressure Tests:*

11.9.1 If the squeeze-off process is not disqualified by magnified visual examination, prepare additional samples of squeezed pipe at *WCnom* plus 5 % and subject them to sustained pressure tests in accordance with Specification D2513. The number of samples, internal pressure, temperature, and minimum time to failure requirements shall be in accordance with Specification D2513 requirements.

11.9.2 If samples fail to meet Specification D2513 sustained pressure time to failure requirements, the squeeze-off process is disqualified.

12. Report

12.1 The report shall identify the pipe resin in accordance with Specification D3350 (if known), the resin supplier (if known), and the material designation, for example PE 2406 or PE 3408. The report shall identify the pipe manufacturer, the complete printline from the pipe, the pipe size and dimension ratio, and wall thickness measurements. The report shall identify the manufacturer and model of the squeeze-off tool, and shall describe the bar design (bar type (flat, round), bar size (length of flat and transition radius and diameter), number of bars, and so forth), the minimum and maximum pipe diameter for which the tool is designed, stop gap distances for the applicable pipe sizes, and the closure mechanism, for example mechanical screw or hydraulic.

12.2 Report the step-by-step squeeze-off procedure including closure and release rates, and whether or not re-rounding was performed, Report the internal pressure used during the squeeze-off process, the flow control criteria, and wall compression percentages used.

12.3 Include a summary of the visual examination procedures and conditions. Also include test results, sketches, photographs, or other evidence that led to qualification or rejection.

12.4 Report sustained pressure tests in accordance with Specification D2513, including number of specimens, internal pressure, test temperature, time-to-failure requirements from Specification D2513, and the actual time-to-failure test results that led to qualification or rejection.

12.5 If it is determined that the squeeze-off process is qualified, include a statement that identifies any limitations on the use of the squeeze-off process, for example, pipe material, pipe size, pipe wall thickness or dimension ratio, temperature range, or internal pressure.

13. Precision and Bias

13.1 No information is presented about either the precision or bias because this practice results in a pass/fail assessment, which means that the result is non-quantitative.

14. Keywords

14.1 damage; gas flow; pipe; polyethylene; squeeze; squeeze-off; tubing