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TESTS RELATING TO A PLASTIC GAS PIPE/METAL COUPLING PULL-OUT FAILURE IN LAWRENCE, KANSAS

Samuel D. Toner

Product Safety Technology Division
Center for Consumer Product Technology

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U.S. DEPARTMENT OF COMMERCE, Juanita M. Kreps, *Secretary*
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Jordan J. Baruch, *Assistant Secretary for Science and Technology*
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TESTS RELATING TO A PLASTIC GAS PIPE/METAL COUPLING

PULL-OUT FAILURE IN LAWRENCE, KANSAS

The Pipeline Accident Division, National Transportation Safety Board, requested that the Product Safety Technology Division conduct a series of tests on a polyethylene natural gas main. Of particular interest was an evaluation of the axial stress required, under various conditions of tests, to pull sections of the plastic pipe out of a metal transition coupling. The results of these tests would subsequently be analyzed by the Pipeline Accident Division to determine whether current regulations governing installation of gas piping systems should be revised to reduce the accident potential of those systems involving combinations of plastic and metal components.

On December 15, 1977, an explosion and fire occurred near 747 Massachusetts Street, Lawrence, Kansas, resulting in two fatalities. The cause of the explosion was reported to have been due to a gas leak resulting when a section of polyethylene gas main pulled out of a metal coupling. The 2-inch (5-cm) plastic pipe had been installed by the insertion renewal method into a section of an existing 3-inch (7.6-cm) IPS metal gas main. The section of plastic pipe in question, had been attached to an adjacent section of the 3-inch (7.6-cm) metal main by means of a standard Dresser Style 90 compression coupling.

The Pipeline Accident Division had requested the Kansas Public Service Company, Inc., 73 Massachusetts Street, Lawrence, Kansas, to submit for tests, the coupling assembly, the section of plastic pipe that had pulled out of the coupling, and an additional 20 feet (6.1 metres) of plastic pipe from the same installation. These materials, as well as some other items for use in this investigation, were delivered in January 1978 to the Structures, Materials and Safety Division of the National Bureau of Standards, by a representative of the Kansas Public Serice Company, and were subsequently received in this laboratory on February 24, 1978.

Materials

Among the items received from the accident site were the following:

1. The section of 2-inch (5-cm) plastic pipe containing a metal insert in one end, which was identified as having been attached to the metal coupling. The pipe had a Kansas Public Service Company identification tag attached to it. A legend imprinted on the pipe wall, which was partially decipherable, read as follows: "IPS SDR11 DUPONT ALDYL[R] A (..?..) T0307?33".

2. The end of the metal gas main into which the plastic pipe had been inserted. This section was about 11.75 inches (29 cm) in length, and had been attached to the plastic pipe by means of pipe wrap tape

at a point approximately 13-15 inches (33-38 cm) from the pipe end containing the insert.

3. The Dresser coupling into which the plastic pipe had been inserted. The coupling was still attached to a section of the original metal gas main by means of a short length of 2-in (5-cm) metal pipe. The nut on the plastic pipe end of the coupling was loose, and on removal the presence of a metal gasket retainer and a rubber gasket was noted. The rubber gasket bore the following identifying legend: "Dresser 2 ID No. 11D0237 GRADE 27 M-13837 -10- AZ HC". The gasket, which was 0.75 inch (1.9 cm) in length, exhibited evidence of permanent compressive deformation on its outer circumference at approximately 0.19 - 0.25 inch (0.48 - 0.64 cm) from the outer face, i.e., in the area where the gasket appeared to have been in contact with the outer rim of the coupling barrel.

4. Six pieces of 2-inch (5-cm) plastic pipe, each about 3 feet (0.9 m) in length, which had been removed from inside the metal gas main. These sections bore the following legend: "ASTM D2513 2" IPS SDR11 DUPONT ALDYL^R A PE2306 T0307J33". This indicated that the pipe conformed to the requirements of the American Society for Testing and Materials (ASTM) Method D2513, Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings for outside diameter controlled, nominal 2-inch (5-cm) diameter iron pipe size, and had a Standard Dimension Ratio of 11 (the quotient of the nominal O.D. divided by the minimum wall thickness). The legend also indicated it was manufactured from E.I. DuPont de Nemours and Company Aldyl^{R}A medium density polyethylene pipe compound conforming to ASTM Grade PE; and was rated at a hydrostatic design stress of 600 psi (414×10^4 Pascals).

In addition to the above items from the accident site the following were also received for use in the individual tests: a new Dresser Style 90 coupling complete with gaskets, gasket retainers and nuts; a 5-inch-long (13-cm) straight metal pipe insert; and several additional rubber gaskets. All of the rubber gaskets contained a metal bead which had been partially embedded around the circumference of the inner end of the gasket prior to vulcanization. The metal bead consisted of four pieces, each approximately 1.75 - 1.88 inches (4.4 - 4.8 cm) in length, of tightly spiraled, 0.125-inch-diameter (0.3-cm) coils of metal wire. All of the new gaskets, including the two in the coupling, were marked as follows: "Dresser 2 I.D. GASKET No. 11D0237 GRADE 27 OLD No. 7164-27 HF".

The Pipeline Accident Division provided, in addition, a slip-proof pipe grip assembly for use in attaching one end of the plastic pipe specimen to the load cell of the Universal Testing Machine to be used in the pull tests; a special wrench for torquing the compression nut on the coupling; and a special locking-type Dresser Style 90 coupling for use in sealing off one end of a pipe specimen when being pressure tested to failure.

Description of Failed Section of Pipe

This section of pipe had been identified as that which was attached to the coupling at the accident site. Figure 1 is a photograph of the pipe section. The overall length was of the order of 21.5 inches (0.55 m). The pipe was permanently bowed to the extent that when a straight edge was laid across the ends of the pipe, on the inside of the bow, there was a gap of about 0.3 inch (0.76 cm) between the straight edge and the outer pipe wall, at the midpoint of the length. Similar bowing was observed in the other sections of pipe that had been received for tests, and was consistent with the fact that the pipe had been coiled after its manufacture.

Approximately 8 inches (20 cm) of the left end of the pipe, as viewed in the figure, had been inserted into the original metal gas main. Some of the pipe wrap tape used to attach it to the metal pipe is visible. The right end of the pipe had been inserted into the coupling. This end contained a 5-inch long (12.7 cm) straight metal pipe stiffener. The end of the pipe had not been cut square, and gave the appearance of having been cut with a carpenter saw or hacksaw. As a result, when the metal stiffener had been inserted until the outer end was flush with the end of the pipe on the inside of the bow, the opposite side of the stiffener protruded about 0.19 - 0.25 inch (0.48 - 0.64 cm) beyond the end of the plastic pipe. Visual examination indicated that at the time of installation about 2.8 inches (7.3 cm) of the pipe had been inserted into the gasket and coupling barrel.

The original plastic pipe was tan in color; however, that portion between the original metal gas main and a point near the end that had been inserted into the coupling, was discolored. The discoloration was perceptibly darker in the region between the metal main and the apparent initial coupling point, roughly defined by the location of the pieces of tape adhering to the pipe, as shown in figure 1. The discoloration was not particularly uniform, appeared to be greater on what was believed to be the top of the pipe in its installed configuration, and did not appear to occur in areas protected by the pipe tape and/or its adhesive. The other sections of pipe submitted for tests had been installed in the metal gas main and exhibited no evidence of discoloration. The discoloration appeared to be strictly a surface phenomenum, and probably was caused by the presence of some unknown constituent in the surrounding soil.

Of particular interest were a series of scratch-like marks in the outer wall of the pipe that were essentially parallel to one another, perpendicular to the length of the pipe, and located in the area along the inside of the bow in the pipe. These marks can be seen in figure 2. The mark indicated by the arrow on the left was about 2.8 inches (7.3 cm), and that on the right, about 1.25 inches (3.2 cm) from the end of the pipe, as measured along the inside of the bow to the point where the metal stiffener was flush with the end of the pipe. The actual orientation of this section of pipe with respect to the installed configuration had not been indicated, however, a considerable amount of debris was adhering to a portion of the inner wall of the metal insert and the adjoining inner wall of the plastic pipe, approximately opposite the descriptive legend imprinted on the pipe. Assuming that this debris collected in the bottom of the pipe while it was still in the ground, then the markings shown in figure 2 would have been along the side of the pipe. There were ten visible marks on the pipe, separated from each other by an average distance of about 0.19 inch (0.48 cm). The two outer marks indicated by the arrows were approximately 1.25 inches (3.2 cm) in length, while the eight intermediate marks were of the order of 0.75 inch (1.9 cm) in length. Microscopic examination of these marks indicated that in proceeding from left to right in figure 2, the first five and the last three marks were due to gouging of the plastic and cold flow of the plastic toward the end of the pipe. It is believed that these eight marks were caused by the pipe being thrust against a metal component of the coupling, either the inner edge of the nut, or, more probably, the metal gasket retainer. The sixth mark showed evidence of having been caused by indentation of the plastic by the metal bead on the gasket, while the seventh mark consisted only of a slight depression of the surface, with no unusual features. No similar marking was observed anywhere else on the outer circumference of the pipe wall on that portion believed to have been originally inserted into the coupling. The surface of the plastic within the first five scratches, from the left, was definitely discolored in the same manner as the surrounding areas of the pipe wall. The remaining marks were in an area in which the surface discoloration was somewhat mottled in appearance, and it could not be determined whether the surface within these marks was also discolored.

The previously noted discoloration of the outer pipe wall may also be observed in figure 2. Discoloration extended about 0.4 in (1.0 cm) to the right of the last parallel mark. The edge of the discolored area was sharply defined. Since there was no evidence to indicate that the discoloration of the pipe was due to the gasket, this suggests that the outer face of the gasket would have been at this location. The distance from the edge of the discolored area to the end of the pipe ranged from 0.6 - 0.8 inch (1.6 -2.1 cm), as a result of the angle at which the pipe had been cut. It could be further assumed that approximately 2 in (5 cm) of the pipe originally inserted into the coupling, had pulled out and been exposed to the conditions causing the discoloring, for some time prior to the accident.

The deep, slightly curved scratch located in the area containing the parallel marks appears to be due to some type of mechanical damage unrelated to that which caused these marks.

Physical Measurements

The wall thickness of the pipe averaged about 0.23 inch (0.58 cm), was found to be consistently uniform, and well within the allowable dimensional tolerances of 0.216 to 0.242 inch (0.549 to 0.615 cm) specified in ASTM D2513.

All of the sections of pipe were somewhat flattened and out-of-round. Outside diameter measurements made with a vernier caliper from the inside to the outside of the bow in the pipe were consistently smaller than those made perpendicular to this dimension. However, the average values were sufficient to indicate that the pipe probably met the required nominal dimension of 2.375 inches (6.032 cm) at the time of manufacture. It should be noted that for roundable plastic pipe, the specified tolerances for out-of-round are required to be met only at the point of manufacture. This variation in the pipe diameter was attributable in part to the fact that it had been coiled. Outside diameter measurements were made on the section of pipe that had pulled out of the coupling at the accident site, in the area where the gasket and compression nut appeared to have been originally located. These measurements did not exhibit as great a difference between the observed minimum and maximum values as occurred in other sections of the pipe. Therefore, it appeared that the compressive forces exerted on the pipe when first installed had had the effect of partially rounding the pipe. However, it could not be determined whether these forces had resulted in any permanent compressive set in the plastic, primarily because of the tendency for the pipe to be out-of-round.

Test Procedures and Results

Initially, the Pipeline Accident Division had requested that a series of nine tests be conducted to determine what effects differences in installation procedures, subsequent environmental exposure conditions, and testing speeds used in laboratory pull-out tests might have on the amount of axial stress required to pull the plastic pipe out of a standard Dresser coupling. These tests, A through H below, were prescribed in a Notice of Inspection obtained through the United States District Court for the District of Kansas, on January 5, 1978. The tests were to be conducted using pipe specimens taken from the three-foot (0.9 m) sections of the plastic gas main, using the new Dresser coupling and new gaskets, supplied to this laboratory. In addition, Test A was to be repeated using the failed pipe specimen (shown in figure 2) and the original coupling from the accident site. This test was designated as test A-2. Subsequently, after these tests were completed and a preliminary analysis of the data completed, two additional tests, following the procedures of test A, were conducted as requested by the Pipeline Accident Division after their receiving concurrence from the Kansas Public Service Company. These tests were designated as A-3 and A-4.

In accordance with the ASTM recommended practices (ASTM Standard Method D618) for conditioning of plastic test specimens, the plastic pipe was conditioned for a minimum of 40 hours at $73.4^{\circ} \pm 3.6^{\circ}$F ($23^{\circ} \pm 2^{\circ}$C) prior to testing. In those cases where the test procedures required additional conditioning at lower temperature prior to the initiation of a test, the same minimum conditioning time was also used as a criterion for the establishment of thermal equilibrium.

The pipe test specimens were approximately eighteen inches (46 cm) long. One end of each specimen was cut with a hacksaw, providing a bias cut in which the length of the specimen was about 0.25 inch (0.64 cm) shorter on the outer curved surface than on the inner curved surface, to simulate the type of installation procedure that had been used at the accident site. When the straight metal insert was placed into this end of the pipe until its outer end was flush with the end of the plastic pipe along the inner curved surface, the edge of the insert protruded about 0.25 inch (0.64 cm) beyond the end of the plastic pipe along the outer curved surface.

A special test fixture was fabricated as a means of attaching the nut on one end of the Dresser coupling to the crosshead of the testing machine. This fixture was also designed to allow the complete test assembly to be internally pressurized when conducting tests A and B. In conducting the pull tests, the bias-cut end of the specimen was inserted into the coupling in such a manner that the outer face of the rubber gasket was at the desired insert length of the pipe. The gasket retainer and nut were then attached to the upper end of the coupling and the nut torqued to 150 foot-pounds (204 Newton-meter) just prior to initiation of the test. A grooved metal insert was placed in the other end of the pipe specimen, and a circular clamp attached to the outside of the pipe to prevent the specimen from slipping. A fitting on the outer end of the metal insert was used to attach the specimen to the load cell of the testing machine.

In the results described below the torque relaxation, TR in ft-lb (N-m), is given in terms of a decrease in the initially applied torque of 150 ft-lb (204 N-m). The percent TR was computed as follows: % = 100(150 - TR)/150.

In all cases, the maximum pull-out force occurred just prior to failure.

Test A

The pipe specimen was inserted three inches (7.6 cm) into the coupling and the nut was torqued. The specimen was immediately pressurized with nitrogen to 50 psig (3.4×10^5 Pascals), held at that pressure for fifteen minutes, the amount of torque relaxation measured, and the specimen immediately tested to pull-out failure, while still pressurized, at a crosshead speed of 2 inches per minute (5 cm/min). This test was performed four times as follows:

A-1 Using a pipe specimen with the new coupling and new rubber gasket.

A-2 Using the pipe section that had failed (shown in figure 2) and the associated coupling barrel, gasket, gasket retainer, and nut into which it had been inserted at the accident site. The coupling barrel was removed from the nut and gasket by which it had been attached to the metal pipe, and was attached to the testing machine crosshead using a gasket, gasket retainer and nut from the new Dresser coupling.

A-3 Using a pipe specimen with the same coupling assembly used in Test A-2.

A-4 Same as Test A-2 except that a new rubber gasket was used in the coupling from the accident site.

Results:

A-1 The torque relaxation was 70 ft-lb (95 N-m), or 46.7%. The initial pull-out force was 515 lb (234 kg), which then leveled off at about 700 lb (318 kg), and then increased to a maximum of 825 lb (374 kg).

A-2 The torque relaxation was 0%. The initial pull-out force was 70 lb (32 kg), which then leveled off at about 180 lb (81 kg), and then increased to 300 lb (136 kg).

A-3 The torque relaxation was 0%. The initial pull-out force was 240 lb (109 kg), which then leveled off at an average of about 310 lb (141 kg), and then increased to 390 lb (177 kg).

A-4 The torque relaxation was 0%. The initial pull-out force was 370 lb (168 kg). The force then steadily decreased to 125 lb (57 kg), and then increased to 670 lb (304 kg).

After test A-4 was completed, reexamination of the pipe showed the presence of five new scratch-like marks similar to those shown in figure 2. These marks are shown in figure 3. The mark on the far left appeared to slightly overlap the end of one of the original marks, and was at the approximate original position of the gasket retainer prior to the start of this pull test. The distance between the first and fifth marks was of the order of 0.94 in (2.4 cm). The wall of the pipe was slightly abraded in the area containing five of the original marks closest to the end of the pipe. An area between the two sets of marks, approximately 0.25 in (0.63 cm) in width, and extending for a distance of about 2.5 in (6.4 cm) from the end of the pipe had also been abraded by the metal bead on the gasket.

Test B

The special Dresser Style 90 coupling designed specifically for attaching metal pipe to plastic pipe was hermetically sealed at the metal pipe end, and attached to the pipe specimen into which a flanged lock insert designed for use with this coupling had been placed. The bias-cut end of the specimen was inserted three inches (7.6 cm) into the standard Dresser coupling used in the pipe pull-out tests and the nut torqued to 150 ft-lb (204 N-m). The pipe was pressurized to 50 psig (3.4×10^5 Pa) and maintained at that pressure for a period of 1 hour. The pressure was then increased, initially by 20 psig (13.8 Pa), then slowly at a rate of approximately 5 psig (3.4×10^4 Pa) per minute until the specimen pulled out of the standard coupling.

Results:

Approximately 17 minutes after the increase in pressure was begun, and while the pipe was pressurized at 150 psig (10.3×10^5 Pa), the first perceptible movement of the pipe out of the coupling was observed. The test was continued and about 20 minutes later, or about 37 minutes after the first increase in pressure, the pipe failed by coming out of the coupling under the force created by a pressure of 250 psig (17.2 x 10^5 Pa).

Test C

The pipe specimen was inserted 3 inches (7.6 cm) into the coupling, the nut torqued to 150 ft-lb (204 N-m), the torque relaxation measured after fifteen minutes, the nut retorqued to 150 ft-lb (204 N-m), and the specimen immediately pulled at a crosshead speed of 1 in/min (2.5 cm/min) to failure.

Results:

The torque relaxation was 40 ft-lb (54 N-m), or 26.7%. The initial pull-out force was 590 lb (268 kg), then the force leveled off at about 1120 lb (508 kg), and then increased to 1200 lb (545 kg).

Test D

The pipe specimen was inserted 1 inch (2.5 cm) into the coupling, the nut torqued to 150 ft-lb (204 N-m), the torque relaxation measured after 15 minutes, the nut retorqued, and the test begun.

Two tests were conducted on separate specimens as follows:

D-1 crosshead speed of 0.2 in/min (0.5 cm/min)

D-2 crosshead speed of 1 in/min (2.5 cm/min)

Results:

D-1 The torque relaxation was 28 ft-lb (38 N-m), or 18.7%. The initial pull-out force was 625 lb (284 kg), and the force steadily increased to a maximum of 905 lb (411 kg).

D-2 The torque relaxation was 34 ft-lb (46 N-m), or 22.7%. The initial pull-out force was 380 lb (172 kg), and then steadily increased to 1105 lb (502 kg).

Test E

The pipe was inserted 1 inch (2.5 cm) into the coupling, the nut torqued to 150 ft-lb (204 N-m), the torque relaxation measured after 15 minutes, and the nut retorqued. The entire test assembly was cooled to 32°F (0°C) for approximately 65 hours, then tested immediately at a crosshead speed of 0.2 in/min (0.5 cm/min).

Results:

The torque relaxation was 30 ft-lb (41 N-m), or 20.0%. The initial pull-out force was 265 lb (120 kg), and then the force steadily increased to 630 lb (286 kg).

Test F

The pipe specimen was inserted 1 inch (2.5 cm) into the coupling, the nut torqued to 150 ft-lb (204 N-m), the torque relaxation measured after 15 minutes, and the nut retorqued. The entire test assembly was cooled at 32°F (0°C) for about 64 hours, then allowed to warm up at room temperature, 73.4°F (23°C) for 17 hours. The torque relaxation was measured. Then the test was begun using a crosshead speed of 0.2 in/min (0.5 cm/min). When the axial load reached 650 lbs (295 kg), the approximate pull-out force measured for test specimen E, the test was stopped, the entire test assembly removed from the testing machine and recooled at 32°F (0°C) for 24 hours, the torque relaxation remeasured, and the specimen then tested to failure at a crosshead speed of 0.2 in/min (0.5 cm/min) at room temperature.

Results:

The torque relaxation measured 15 minutes after the initial assembly of the test specimen was 20 ft-lb (27 N-m), or 13.3%. After the specimen had been cooled and subsequently allowed to warm at room temperature for 17 hours, the torque relaxation was 0%. The pipe specimen was then stressed to 650 lb (295 kg). After recooling for 24 hours, the measured torque relaxation was 62 ft-lb (84 N-m), or 41.3%. During the final pull test, the initial pull-out force was 760 lb (345 kg), then the force increased steadily to a maximum of 1245 lb (565 kg).

Test G

The pipe specimen was inserted 1 inch (2.5 cm) into the coupling, the nut torqued to 150 ft-lb (204 N-m), the torque relaxation measured after 15 minutes, the nut retorqued, and the entire test assembly cooled at 32°F (0°C) for about 44 hours. The torque relaxation was measured, and the pull test begun at a crosshead speed of 0.2 in/min (0.5 cm/min). The initial intent of this test had been to stop the test when the axial stress reached 50 lb (23 kg) above the initial force required to start pulling the pipe out of the coupling, release the stress, and allow the specimen to relax overnight at room temperature. The test was then to be restarted at a crosshead speed of 0.2 in/min (0.5 cm/min), but the testing speed was to be reduced as necessary to prevent the axial stress from exceeding the initial pull-out force plus 50 lb (23 kg) limit, until failure occurred. Although these procedures were followed, two variants occurred. First the initial axial stress built up so rapidly that the testing machine could not be stopped before the force had reached 80 lb (36 kg) above the initial pull-out force. Secondly, when the test was restarted the following day, the force required to pull the pipe completely out of the coupling did not exceed the original pull-out force, so the crosshead speed was maintained at a constant rate of 0.2 in/min (0.5 cm/min) until the test was completed.

Results:

The initial torque relaxation was 24 ft-lb (33 N-m), or 16%. After the pipe had been cooled the measured torque relaxation was 56 lb (76 N-m), or 37.3%. The initial pull-out force was 1020 lb (463 kg) and the test was stopped when the axial stress reached 1100 lb (499 kg). When the test was restarted the initial pull-out force was 300 lb (136 kg), then the force steadily increased to a maximum of 925 lb (420 kg) over a period of 2 minutes and 40 seconds.

Test H

The specimen was inserted three inches (7.6 cm) into the coupling, the nut torqued to 150 ft-lb (204 N-m), the torque relaxation measured after 15 minutes, the nut retorqued, and the test begun at a testing speed of 0.2 in/min (0.5 cm/min). The original plan had been to tighten the nut, after the pipe started to pull out, until the axial force reached 625 lb (284 kg). However, retightening was not necessary, since the axial stress built up rapidly to 625 lb (284 kg). At that point, the test was stopped, the axial stress removed from the specimen, and the pipe allowed to relax for 8 hours, prior to testing to failure.

Results:

The torque relaxation was 34 ft-lb (46 N-m), or 22.7%. The initial pull-out force was 350 lb (159 kg), and the test was stopped when the force reached 625 lb (284 kg). After the 8-hour relaxation period, the stress was reapplied. The initial pull-out force was 350 lb (159 kg), then the force continued to increase, leveling off at about 650 lb (295 kg), then increased to a maximum of 775 lb (352 kg).

Thermal Contraction

A request was made to attempt to measure the degree of thermal contraction that the pipe might undergo when exposed to low temperatures, by means of a simple, practical test. A section of the pipe was measured using a vernier caliper, accurate to 0.001 inch (0.025 mm), at 73.4^{o}F (23^{o}C), then cooled for about 53 hours at -13^{o}F (-25^{o}C), and remeasured. The coefficient of thermal expansion computed for the change in gauge length at a ΔT of 86.4^{o}F (48^{o}C) was 8.9 x 10^{-5} in/in/^{o}F (1.60 x 10^{-4} cm/cm/^{o}C). The pipe was allowed to equilibrate to 73.4^{o}F (23^{o}C) and a second test conducted. In this case, the pipe specimen was cooled at -16.6^{o}F (-27^{o}C) for about 52 hours. The coefficient of expansion computed for this test was 9.1 x 10^{-5} in/in/^{o}F (1.64 x 10^{-4} cm/cm^{o}C). These results compared favorably with the manufacturer's reported value of 9 x 10^{-5} in/in/^{o}F, obtained by dilatometric measurements.

Discussion of Pull-Out Tests

A comparative evaluation of laboratory data obtained from single specimens tested under a variety of conditions is a difficult task, since the results may not be a true statistical representation of the sample. However, the data obtained in these tests seem to indicate some trends.

1. The force required to initiate pipe pull-out did not seem to fall into a pattern that could be related to the pre-test procedures used in installing the pipe into the coupling. This variability may have been related to the fact that the pipe specimens were bowed, and that in some cases these forces may have been affected by initial straightening of the pipe due to the applied axial stress. In conducting tests on pipe that has been coiled, the use of shorter test specimens, in which the effect of the bowing would be lessened, might lead to more consistent values.

2. The tests conducted on unpressurized specimens at 0.2 in/min (0.5 cm/min) seemed to provide data more consistent with that obtained using test procedure A, than did those tests conducted at 1 in/min (2.5 cm/min).

3. The variability in torque relaxation after the initial tightening of the coupling nut seems to indicate that retorquing, after an established relaxation period, would be good practice in field installations.

4. In every case, the maximum force achieved in the pull-out tests occurred when less than 1 inch (2.5 cm) of the pipe specimen still remained in the gasket. However, visual examination of each specimen immediately after completion of a test showed no evidence of plastic deformation, or cold flow, that would have resulted in an effective increase in the pipe outside diameter. Neither was there any evidence of deformation of the pipe wall attributable to the metal bead on the gasket.

Figure 1

Figure 2

Figure 3

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A fatal explosion due to a natural gas leak occurred when a polyethylene gas main pulled out of a metal coupling, apparently as a result of thermal contraction of the plastic pipe. This report is based on an evaluation of the axial stresses required, under various conditions of test, to pull sections of plastic pipe, from the accident site, out of metal compression couplings. The objective of these tests was to provide data to assist the Pipeline Accident Division in determining the adequacy of current regulations governing installation of gas piping systems involving combinations of plastic and metal components.

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