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PS02-001

DOCKET NO.

In the Matter of IN THE MATTER OF THE FILING BY MONTANA-DAKOTA UTILITIES CO., A DIVISION OF MDU RESOURCES GROUP, INC. FOR APPROVAL OF WAIVER

Public Utilities Commission of the State of South Dakota

DATE		MEMORANDA
6/6	02	Filed and Docketed;
6/13	02	Weekly Filing;
9/4	02	Stipulation;
9/23	02	Order approving stipulation;
9/23	02	Docket Closed
1/26	04	Test Results

STATE PUBLISHING CO., PIERRE, SOUTH DAKOTA—SMEAD 104 SP14130

PS02-001

MONTANA-DAKOTA
UTILITIES CO.
A Division of MDU Resources Group, Inc.

400 North Fourth Street
Bismarck, ND 58501
(701) 222-7900

June 3, 2002

RECEIVED
JUN 06 2002
SOUTH DAKOTA PUBLIC UTILITIES COMMISSION

Executive Director
Deborah Elofson
South Dakota Public Utilities Commission
State Capitol Building
500 East Capitol Avenue
Pierre, SD 57501-5070

Re: Waiver Request; 49 CFR Part 192, Paragraph 192.59(a)(1) (ASTM D2513) Plastic Pipe Materials

Dear Ms. Elofson:

Martin Bettman of your office advised Montana-Dakota Utilities Co. (Montana-Dakota) with an April 23, 2002 letter confirming the need to request a waiver for UPONOR pipe received in July 2000. The following letter is Montana-Dakota Utilities Co.'s request for that waiver.

In July 2000, a shipping error made by Chevron Phillips Chemical Company resulted in UPONOR receiving non-standard polyethylene raw materials, i.e. TR-130 resin, that they subsequently converted into pipe. Montana-Dakota received several thousand feet of this pipe that had not been properly qualified to ensure compliance with ASTM D2513 as required by the referenced code for use in its natural gas system. Montana-Dakota did install that pipe near Rapid City, South Dakota. Since its installation, Chevron Phillips Chemical Company performed extensive testing and demonstrated the pipe does in fact meet the minimum requirements of ASTM D 2513. Please see the attached copy of their report.

Based on the Chevron Phillips testing, Montana-Dakota proposes to allow this pipe to remain in service. Accordingly, Montana-Dakota is requesting a waiver from the South Dakota Public Utility Commission and the Federal Department of Transportation regulations to allow the pipe to remain in service.

In accordance with Mr. Bettmann's April 23, 2002 letter, Montana-Dakota is providing the following information for your consideration:

1. Montana-Dakota Contact:

   Bruce Nelson, P.E.
   Gas Distribution Manager
   400 North Fourth Street
   Bismarck, ND 58501
   701/222-7784

2. Waiver requested for:

   49 CFR Part 192, Paragraph 192.59(a)(1) (ASTM D2513) Plastic Pipe Materials

3. Description of facilities:

   The waiver request is for approximately 38,600 feet of two-inch pipe. See attached.

4. Location of facilities:

   Miscellaneous gas distribution mains scattered throughout the Rapid City and Black Hills Area of South Dakota. Since the pipe installation was part of routine growth for the area and a portion of approximately 75,000 feet of pipe installed in 2000, the exact location of the pipe is unknown.

5. Description of particular operation for which the waiver is requested:

   Montana-Dakota received several thousand feet of the UPONOR pipe made from TR-130 resin that had not been properly qualified to ensure compliance with ASTM D2513 as required by the referenced code for use in its natural gas system.

6. An indication of increased risks that the particular operation would create and additional safety measures that proposed to compensate for the additional risk:

   Based on the attached report, research performed by UPONOR and Chevron Phillips Chemical Corporation, and supported by the Plastic Pipe Institute, Montana-Dakota does not believe there is additional risk to its customers or the public in general. Montana-Dakota expects the pipe in question to perform at least as well as approved polyethylene pipe installed today.

7. Risk Mitigation Measures:

   Based on the above statement and the attached report, Montana-Dakota believes that granting of this waiver is not inconsistent with pipeline safety and the replacement of the pipe would be unnecessarily burdensome on Montana-Dakota's customers since it would involve excavation of streets and yards as well as an interruption of service.

Montana-Dakota strives to remain in compliance with the pipeline safety requirements and considers this issue a significant matter. Accordingly, Montana-Dakota appreciates your support in accepting and processing this waiver request.

Please let me know if you have any questions or concerns.

Sincerely,

Douglas M Lee

Douglas M. Lee, P.E.
Senior Staff Engineer

Attachment - UPONOR and Chevron Phillips Chemical Corporation Report

CC: Bruce Nelson – General Office
Tamie Aberle – General Office
Tom Hopgood – Schuchart Building – Legal Department
Wanda Dewing – General Office
Dan Farmer – Billings

Timothy G. Taylor
Chevron Phillips Chemical Company
1301 McKinney, Suite 1200
Houston, TX 77010

Jimmy Collier
Uponor Aldyl Company
5062 Allred Road
Mariposa, CA 95338

CONFIDENTIAL AND PROPRIETARY
TREATMENT REQUESTED

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SOUTH DAKOTA PUBLIC
UTILITIES COMMISSION

MEMORANDUM CONCERNING UPONOR MEDIUM DENSITY POLYETHYLENE PIPE RECALL

Prepared by:
Chevron Phillips Chemical Company LP

November 12, 2001

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2	Letter Dated March 14, 2001 from Chevron Phillips Chemical Company LP
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4	ASTM D3350 Cell Classification - Samples Remolded from Plastic Pipe
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MEMORANDUM CONCERNING UPONOR MEDIUM DENSITY POLYETHYLENE PIPE RECALL

EXECUTIVE SUMMARY

On March 14, 2001, Chevron Phillips Chemical Company LP ("CPChem") advised customers of Uponor Aldyl Company ("Uponor") that certain Medium Density Polyethylene ("MDPE") pipe manufactured by Uponor from resin supplied by CPChem was being recalled, because the pipe was made from the wrong CPChem resin. In facilitating the March 14 recall announcement, and implementing its Reimbursement Program for costs associated with the recall, CPChem was acting in a proactive manner while an investigation of all relevant facts continued. Since that time, a substantial amount of testing and analysis has occurred. This Memorandum, and exhibits, are intended to bring Uponor's customers up to date on recent developments and to provide a comprehensive overview of the history of this matter, as well as our analysis of the safety of the pipe in question and its compliance with applicable standards.

As set forth in detail in this Memorandum, CPChem believes that the MDPE pipe in question is safe for natural gas pipe applications, and complies with all applicable laws, regulations, and specifications for natural gas pipe applications. Accordingly, it is not necessary to apply with state or federal regulators for a waiver for non-compliance. Nevertheless, should an operator decide to apply for a waiver for its unique reasons, the data set forth in this Memorandum should suffice to establish that the granting of a waiver would not be inconsistent with – and, in fact, would be wholly consistent with – pipeline safety. See 49 U.S.C. §60118(c) (waiver may be granted provided that the waiver "is not inconsistent with pipeline safety").

The present situation arose after CPChem mistakenly delivered to Uponor, in July 2000, a single shipment of CPChem Marlex® HHM TR-130 polyethylene ("TR-130") rather than CPChem Marlex® HHM TR-418N polyethylene ("TR-418N"). Not knowing of the mis-shipment, Uponor extruded the resin into MDPE pipe of various sizes during a three-day period in July 2000.

TR-130 and TR-418N have essentially equivalent physical properties, rendering both appropriate for gas pipe applications. The only significant difference between the two resins is that virgin TR-418N polyethylene contains an UV inhibitor additive to prevent UV degradation after prolonged exposure to UV, whereas virgin TR-130 polyethylene does not contain an UV inhibitor as sold by CPChem. However, all of the pipe made with TR-130 <u>does</u> contain UV inhibitor because UV inhibitor was contained in the yellow color concentrate used in the pipe, and it was a constituent in the regrind material used in making the pipe. Accordingly, as discussed more fully herein, the pipe meets applicable regulations concerning the presence of UV inhibitor. Moreover, the installed pipe in question does not present a safety risk, even though it contains less UV inhibitor than pipe made with TR-418N, because the pipe in question was not stored outside for a significant amount of time.

There has only been one reported instance of field failure of the pipe made with TR-130. In that case, three different segments of six-inch pipe in one installation, and one segment of six-inch pipe in a separate installation, cracked during pre-installation pressure testing by Keyspan Energy Delivery – New England ("Keyspan") in the Boston area. Extensive investigation of this incident shows that the cracking was likely caused by a unique combination of circumstances, including an impact event and installation in extremely cold temperatures. Moreover, it appears that any potential issue is limited in scope to six-inch pipe made on a single production line when Uponor was unknowingly extruding TR-130 resin, all of which was covered by the announced recall program. Finally, other than the pipe that cracked in Boston, all installed pipe manufactured during the period in question passed pre-commission pressure tests and has performed without incident for close to, or in some cases more than, a year.

In sum, we believe that the subject pipe poses no safety or performance risks and meets all applicable standards.[1] In any case, we recognize that certain owners or operators may feel more comfortable seeking affirmation from their regulatory agencies, whether in the form of a waiver request or otherwise. The facts and data contained in this Memorandum outline in detail the basis for such regulatory cooperation.

I. FACTS

A. Discovery Of The Use Of TR-130 In Certain MDPE Pipe Manufactured By Uponor

In July 2000, CPChem mistakenly delivered to Uponor a shipment of TR-130 resin rather than the specified TR-418N resin. Uponor, in turn, manufactured approximately 520,000 feet of MDPE gas pipe in sizes ranging from one-half inch to six-inch using the TR-130 resin on July 21 - 23, 2000. The pipe was then sold to Uponor's customers. CPChem's shipment error was discovered when one of Uponor's customers, Keyspan, experienced cracking of four segments of six-inch pipe, manufactured by Uponor on July 22, 2000. The cracking was discovered during routine pre-commission pressure testing in December 2000 during installation of the pipe in extremely cold weather. Samples of the cracked pipe were sent to CPChem in December. Initial product testing did not reveal anything abnormal (i.e., there was nothing to lead CPChem to believe that the pipe had been made with a resin other than TR-418N). It was

1 Added comfort is derived from the fact that utilities that installed MDPE pipe manufactured with TR-130 presumably will engage in all normal patrolling and leak survey testing of its pipeline as required by 49 C.F.R. Part 192.723.

not until subsequent testing performed in January showed lower levels of UV inhibitor in the cracked pipe that CPChem was able to determine that the pipe had been manufactured with a resin other than TR-418N. Additional testing revealed that the pipe was made from TR-130 rather than TR-418N.

Other than the issues discovered during the Keyspan installation, neither Uponor nor CPChem have been notified of any abnormal installations, problems with pressure testing, or any performance problems whatsoever with any pipe made with TR-130.

B. Actions Taken By CPChem And Uponor Following Discovery Of The Use Of TR-130

Uponor and CPChem immediately informed the U.S. Department of Transportation Office of Pipeline Safety of the discovery of the use of TR-130 in certain MDPE pipe, because TR-130 had not previously been determined to comply with the American Society for Testing and Materials ("ASTM") D2513-96a (one of the applicable regulatory standards). On January 24, 2001, Uponor and CPChem issued a letter to Uponor's customers advising them of the discovery.

The January 24, 2001 letter was sent by CPChem and Uponor as soon as the companies learned of the resin mis-shipment, without waiting for the development of additional facts or analysis. The companies only knew that pipe had cracked in the field and that the pipe contained the wrong resin. They had not yet been able to confirm the pipe's safety, nor had they had time to confirm whether the resin switch was the cause of the cracking incident. Given that it would take time to perform the extensive analysis needed to answer these questions, CPChem and Uponor took what they believed to be the proactive, correct course of action: immediately informing utilities of the facts then known, and stating that details of a product recall would be announced in the near future.

The January 24 letter was sent to all of Uponor's customers that purchased pipe made at Uponor's facilities within a four-day timeframe when it was suspected the TR-130 resin could have been used. The letter advised that Uponor and CPChem were initiating extensive testing to more fully evaluate the situation and to assure that the affected pipe posed no safety hazard. The letter also asked Uponor's customers to immediately refrain from further installation of uninstalled pipe made during the suspect timeframe. A copy of the January 24, 2001 letter is attached as Exhibit 1.

In the immediate aftermath of that letter, analysis of Uponor's pipe production information revealed that TR-130 had been used to manufacture pipe only on part of July 21, 2000, all of July 22, 2000, and part of July 23, 2000. Moreover, analysis confirmed TR-130's likeness to TR-418N, and that pipe made from TR-130 should perform safely in the field. Based on this new information, on March 14, 2001, CPChem sent a letter to customers outlining the specific terms of the Recall and Reimbursement Program. The March 14 letter announced the recall of six-inch pipe produced during the operative time period with TR-130 (only five Uponor customers received the recalled six-inch pipe), and all pipe made during the July 20-23, 2000 time period that had not yet been installed. The March 14 letter also indicated that extensive testing protocols aimed at assuring that TR-130 met applicable safety standards were continuing. A copy of the March 14, 2001 letter is attached as Exhibit 2.

To date, the recall program has been highly successful. A substantial amount of the recalled pipe has been taken out of service and/or returned, and the operators have been fully reimbursed by CPChem. Moreover, other than the original cracking of Keyspan pipe, there have been no reported incidents of cracking or any other field performance problems with the pipe in question.

C. Extensive Testing And Analysis Show That TR-130 And TR-418N Have Essentially Equivalent Physical Characteristics, And That A Unique Confluence Of Several Factors That Have Not Been Replicated Elsewhere In The Field Resulted In The Keyspan Cracking Incident

The initial inference that may have been drawn by some upon first learning that the Keyspan pipe that cracked was made with the wrong resin, was that the resin may have been the cause of the failure and that potentially all pipe made with that resin in the July 21-23 timeframe could pose a risk. Because the companies felt it was important to communicate immediately to Uponor's customers and to move forward with a Recall program as soon as possible, the companies initiated contact with Uponor's customers before a full and complete analysis of the issue could be conducted. Since that time, CPChem has devoted a great deal of effort and resources to determining why, of all the pipe manufactured with TR-130 during the July 2000 time period, only the Keyspan six-inch pipe cracked. This analysis suggests, as explained below, that the Keyspan pipe failed as a result of a unique combination of circumstances, and not because there is something inherent in the TR-130 resin that could cause continued failures.

First, results of extensive testing demonstrate that pipe made with TR-130 has essentially equivalent physical characteristics and performance capabilities as pipe made with TR-418N. Accordingly, pipe extruded from both resins should perform in a similar – and safe – fashion. Documentation of all such test results may be found at Exhibits 25 to 28. Additionally, among other things:

- Exhibits 3 and 7 are summary charts that show that TR-130 meets all specifications of the two ASTM standards that apply to the pipe in question: ASTM D2513 and ASTM D3350. The ASTM standards are illuminated in greater detail at pages 10-12 of this Memorandum.
- Pipe made with TR-130 and TR-418N (including pipe manufactured by Uponor as well as six and eight-inch pipe recently extruded by CPChem from TR-130) shows similar results in impact testing. See Exhibit 14 - 17.

- The only exception is that samples of six-inch pipe made by Uponor on the same date and production line as the Keyspan cracked pipe, exhibited low cold temperature impact resistance in recent laboratory testing. See Exhibits 14 and 15. Six-inch pipe made from the same material on the same day on Uponor's other production line had excellent cold temperature impact strength. See Exhibit 14. (CPChem has also tested samples from July 21 and 23 from the same production line that produced the Keyspan pipe. These samples were made from TR-418N, not TR-130, and exhibited good cold temperature impact resistance thus isolating the production window at issue. See Exhibit 14.)

- Testing of pipe made with TR-130 shows excellent resistance to slow crack growth, which is an indication that long-term performance characteristics should be excellent. See Exhibits 3, 4, 5. Specifically the Polyethylene Notch Tests ("PENT") and sustained pressure testing at elevated temperatures show similar results for TR-130 and TR-418N. See Exhibits 12 and 32.

- Rapid Crack Propagation ("RCP") was tested on six-inch Uponor pipe using the Small-Scale Steady State ("S4") laboratory testing equipment, and results were similar for pipe made from TR-130 and TR-418N. Actual pipe from the Keyspan site was tested and confirmed to have good resistance to RCP. See Exhibit 33. Dr. Walter Bradley's work (see the following text for a description of Dr. Bradley and his work) also showed similar RCP results for pipe made with TR-130 and TR-418N; his report states: "Izod testing of razor notched specimens indicates that the resistance to rapid crack propagation of pipe made from TR-418N resin and TR-130 resin is essentially the same."

- Standard MDPE molded fittings were tested for compatibility with pipe made from TR-130 per the Department of Transportation's regulations for polyethylene fittings for gas applications. This included butt fusion, socket fusion, saddle fusion and electrofusion fittings which were fused to TR-130 pipe and then tested according to the DOT standards with excellent results. See Exhibits 10, 11, 18, 19, 20.

In addition to comparative testing of TR-130 pipe and TR-418N pipe, CPChem retained a highly respected plastics expert, Dr. Walter Bradley, a retired member of the Texas A&M University faculty, to examine and analyze the actual cracked Keyspan pipe and to compare performance capabilities of TR-130 pipe with TR-418N pipe. Dr. Bradley's report is attached to this Memorandum as Exhibit 34 (his report is referred to in the remainder of this Memorandum as the "Bradley Report"). Dr. Bradley's analysis led him to conclude that pipe made with TR-130 should perform as well as pipe made with TR-418N, and that the cold installation temperatures on the day of the failure and impact of some type in the handling of the pipe undoubtedly contributed to cause the cracking of the six-inch Keyspan pipe. See Bradley Report at p. 10.

Taken together, the available data conclusively demonstrate that the Keyspan pipe did not crack as a result of any inherent unsuitability of TR-130 for gas pipe applications. To the contrary, it appears that the Keyspan pipe cracked due to a combination of several factors:

- First, information provided by Keyspan indicates, and Dr. Bradley's analysis confirms, that the cracked pipe was likely subjected to impact at some point following production. It is unlikely that pressure alone would have been sufficient to cause the cracking.

- Second, the installation occurred in extremely cold (sub-freezing) weather in Boston. Laboratory testing subsequently revealed that the only abnormality of the pipe that cracked was its lower than normal impact strength at very low temperatures.[2]

- Third, it appears that only six-inch pipe made during a narrow production window, on a single production line when TR-130 was being used, is susceptible to cracking when faced with the unique conditions identified above. The absence of any problem in the laboratory or in the field with any other size pipe, together with the data demonstrating the essential equivalence of the resins, strongly suggests that any conceivable issue was limited to a narrow production window of six-inch pipe.[3]

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[2] As the data attached in Exhibit 6 confirms, the pipe Keyspan received had slightly lower thermal stability readings than tested samples of pipe manufactured on other production lines and pipe made prior to the mistaken delivery. However, thermal stability tests performed on all sizes of pipe manufactured with TR-130 and on TR-130 resin confirm that all the pipe and the resin comply with ASTM standards for both pipe and resin (i.e., > 220°C).

[3] As we have stated in this Memorandum, the only pipe that has cracked at cold temperatures – whether in the field or in laboratory testing – is six-inch pipe made on a single production line. By contrast, six-inch pipe made with TR-130 on other production lines withstood cold temperature impact. Uponor reports that there were no abnormal operating issues associated with production on that line at the time. Uponor therefore believes that the explanation may lie in the fact that TR-130 and TR-418N have somewhat different stabilization systems, in terms of specific grade of antioxidant and additive level. Both formulations provide a high level of thermal stability which exceeds the applicable requirements of thermal stability set out for both the resin (ASTM D3350) and the pipe (ASTM D2513), i.e. >220°C. Both resins contain a high performance primary antioxidant (hindered phenolic additive) and a secondary stabilizer (phosphite additive). Nonetheless, Uponor reports that the production line from which the pipe that cracked originated, while optimized for TR-418N, may not have been optimized for extruding TR-130 into thick-walled (i.e., six-inch) pipe given the different stabilization package. This, together with extreme cold temperature installation and impact, could have played a contributing role in the cracking of the six-inch

D. TR-130 Has Received A Hydrostatic Design Basis Rating From The Plastic Pipe Institute

When the resin mis-shipment was discovered, CPChem initiated the required steps to obtain what is known as a Hydrostatic Design Basis, or "HDB," rating from the Plastics Pipe Institute ("PPI") for TR-130 resin. As explained more fully below, one of the regulatory standards applicable to gas pipe, ASTM D2513-96a, requires that the resin used to make such pipe has a "PPI recommended long term hydrostatic stress rating." TR-130 was not offered for sale by CPChem for gas pipeline applications, and thus CPChem had not previously sought a PPI rating for TR-130. Nonetheless, because of the essentially equivalent physical characteristics of TR-130 and TR-418N resins, CPChem was confident that TR-130 would qualify for the required PPI rating.

On May 4, 2001, PPI did in fact grant an E-2 Hydrostatic Design Basis ("HDB") rating for TR-130 resin.[4] See Exhibit 35.

II. PIPE MANUFACTURED WITH TR-130 COMPLIES WITH APPLICABLE LAWS AND SAFETY STANDARDS IN ALL RESPECTS, AND DOES NOT REQUIRE A WAIVER

At the time of the January 24, 2001 and March 14, 2001 customer communications, CPChem was not in a position to state that the pipe complied with all applicable regulations for two reasons. First, at that time PPI had not granted the HDB rating to TR-130. Second, CPChem had been unable to confirm that the pipe manufactured with TR-130 contained UV stabilizer – an ingredient required by the regulations. See discussion at pp. 12-14

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pipe in question. Without taking a position as to Uponor's explanation, CPChem can confirm that its TR-130 resin contains a different stabilization system, and that the only incidents of abnormal laboratory or field performance appear isolated to the six-inch pipe produced by Uponor on this single line – when Uponor was unwittingly extruding TR-130 rather than TR-418N. In any event, the issue should not concern Uponor's customers because all six-inch pipe has been recalled.

4 On October 25, 2001, PPI extended the E-2 HDB rating to an E-6 HDB rating based on additional data submitted by CPChem.

of this Memorandum. However, after extensive analysis and fact development, and now that PPI has granted the HDB rating, we are confident that in fact the pipe does comply with applicable regulations. Accordingly, owners/operators do not need to obtain a waiver to lawfully operate gas pipeline facilities made with TR-130 pipe.

The U.S. Department of Transportation's Office of Pipeline Safety is charged with regulating gas pipeline safety. 49 U.S.C. §60102. The Office of Pipeline Safety has, in turn, promulgated extensive regulations carrying out this mandate. See generally 40 C.F.R. Part 192. The regulations require that materials used to manufacture plastic pipe for natural gas transport meet a "listed specification." 49 C.F.R. Part 192.59. In this case, ASTM D2513-96a, "Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings," is the relevant listed specification. A copy of ASTM D2513-96a is attached as Exhibit 36.

- Section 4 of ASTM D2513-96a requires that the plastic used to make gas pipe "shall have a PPI recommended long-term hydrostatic stress rating." As stated previously, "PPI" refers to the Plastic Pipe Institute. TR-130 recently received the required rating. See p. 9, above.

- Annex A1 to ASTM D2513-96a contains many different materials, testing, and performance requirements for polyethylene gas pipe such as the pipe at issue. Section A1.3.1 requires that polyethylene ("PE") material be classified in accordance with ASTM D3350 "Cell Classifications of Polyethylene Pipe Tubing and Fittings Materials." ASTM D3350 classifies PE pipe and fitting compounds according to: density, melt index, flexural modulus, tensile strength at yield, environmental stress crack resistance, and HDB at 23°C. These categories describe the physical properties of materials that fall within certain cell classifications. Exhibits 3, 4, and 5 to this Memorandum demonstrate that TR-130 pipe satisfies these requirements.

- ASTM D2513-96a section A1.3.4 requires either Class C (carbon black) or Class E (colored with UV stabilizer), with Class E the appropriate requirement for yellow pipe. See Section 6.2 of ASTM D3350, Exhibit 37 hereto. Neither ASTM D3350 nor ASTM D2513-96a requires a particular amount of UV stabilizer for qualified PE materials. The pipe in question meets this requirement, even though TR-130 resin does not contain UV inhibitor, because:

- The yellow color concentrate used by Uponor is made with TR-418N, which contains UV inhibitor.[5]

- Furthermore, the pipe made by Uponor with TR-130 would have gained additional UV inhibitor from the introduction of regrind material containing pipe made on previous production runs from TR-418N resin.

- Therefore, *all* pipe manufactured with TR-130 contains some amount of UV inhibitor. While the amount of UV inhibitor in the pipe made with TR-130 is lower than that in Uponor's TR-418N pipe, the pipe is "colored with UV stabilizer" and therefore complies with the applicable ASTM standard.[6]

In sum, the pipe in question complies with the applicable regulations and does not require a waiver.

III. ANY PERCEIVED NON-COMPLIANCE WITH APPLICABLE REGULATIONS SHOULD BE WAIVED

The foregoing discussion and accompanying data demonstrates the likeness of TR-130 and TR-418N resins. Even more significantly, the data confirm that the pipe made with TR-130 should perform in an equivalent manner to pipe made from TR-418N and poses no threat to health and safety. CPChem believes that pipe manufactured with TR-130 complies with all applicable laws, regulations and specifications and therefore does not require a waiver. Nonetheless, if – presumably because of the lower level of UV inhibitor in the pipe in question – any of Uponor's customers prefer to seek a waiver or other affirmation from the appropriate regulators, this Memorandum may be used to demonstrate that granting such a waiver is wholly consistent with pipeline safety.

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5 The yellow color concentrate contains approximately 91% TR-418N and 9% pigment.

6 UV stabilizer is also the subject of section A.1.5.7. of ASTM D2513-96a. That section states:

> PE pipe stored outdoors and unprotected for *at least two years* from the date of manufacture shall meet all the requirements of this specification. PE pipe stored outdoors for over two years from date of manufacture may be used if it meets the requirements of this specification (emphasis added).

The pipe at issue in connection with the waiver applications was only stored outdoors for a short period of time, well less than two years, and thus the foregoing provision would not appear to apply.

At the outset, it is important to note that the Recall program addressed all uninstalled pipe (i.e., pipe that might have been exposed to the sun for longer periods of time) as well as all installed six-inch pipe. Thus, the issue of obtaining a waiver for any arguable non-compliance should properly only focus on the remaining installed pipe (the pipe that was not covered by the Recall program), none of which is six-inch pipe.

Here, the pipe not covered by the Recall program would have been installed within a relatively short period after manufacture. Specifically, MDPE pipe manufactured by Uponor with TR-130 was installed, at the latest, in January 2001. After that date, Uponor's customers received the January 24 letter and were instructed to stop installation of the Uponor pipe. Therefore, given the manufacture dates of July 21 - 23, 2000, the maximum amount of time the affected pipe could have been exposed to UV prior to installation was six months. In reality, much of the pipe was installed within a few months of delivery (before the onset of cold weather), and in any event common sense would suggest that each section of pipe was not fully exposed to the sun for the entire time period between shipment by Uponor and installation. Thus, the reference in the ASTM standards aimed at protecting the structural integrity of pipe that is stored outside for at least two years prior to installation is not implicated.[7]

In fact, given the presence of UV inhibitor in the pipe and given the fact that the yellow pigment itself contributes to prevent UV degradation, any such pipe should withstand any modest outdoor exposure that might have occurred. See Bradley Report at p. 1 (the reduced amount of UV stabilizer "would only be significant if the gas pipe was exposed for some extended time to radiation from the sun, which was not the case for this pipe"). This is confirmed by weathering tests performed by CPChem. Yellow pipe extruded by CPChem with

7 See ASTM D2513-96a Section A1.5.7.

TR-130 was subjected to extreme outdoor exposure at a special facility in the Arizona desert. Analysis of those pipe samples exposed for four months – including the intense UV summer months – revealed no notable change in tensile strength or elongation of the pipe as a consequence of the outdoor exposure. See Exhibits 21 and 22.

Furthermore, in addition to the Arizona testing – in which pipe samples were exposed to actual sunlight, albeit in an extreme "worst case" environment – CPChem also conducted artificial accelerated weathering tests. See Exhibit 23 and 24. Not surprisingly, those test results did show differences in the tensile yield strength and ductility at higher numbers of hours of accelerated weathering. However, such results are not by themselves meaningful, because they do not correlate to actual periods of outdoor exposure. In fact, based on the relative performance in accelerated weathering tests of pipe made with TR-418N and pipe made with TR-130, pipe made with TR-130 is safe for use even after exposure for six months.[8] Test data received to date confirm this conclusion.

IV. OPERATIONAL CHANGES TO PREVENT FUTURE MISTAKES

For the reasons set out previously in this Memorandum, we do not believe that the Keyspan pipe cracked due to any inherent difference between TR-130 and TR-418N. In any case, the resin mis-shipment should not have happened, and CPChem has taken steps to insure that such a mistake does not happen again.

The mistaken delivery of TR-130 to Uponor occurred when the hopper car containing TR-130 was shipped to Uponor rather than the hopper car containing TR-418N. CPChem has subsequently implemented three major changes in the operation of its Houston

8 As shown in Exhibits 23 and 24, the TR-130 samples showed a drop in elongation to under 100% at 500 - 1121 hours compared to 3065 hours for TR-418N. CPChem generally quotes 3-5 year outdoor life for TR-418N. Thus, if one assumes 4 years of outdoor life for TR-418N and a ratio of 500 to 3065 for the relative comparison of TR-130 to TR-418N, that yields a relative outdoor life of 7-8 months for TR-130.

Chemical Complex ("HCC") aimed at preventing another delivery of the wrong resin to Uponor. First, an additional person is now responsible for monitoring the loadout of the hopper cars used to deliver the resin. The operations shift supervisors now go to the loadout spots associated with each of their plants and record which railcars are on a particular spot and which resin is loaded into each hopper car. This information is then cross-checked with the paperwork that the hopper car loaders (distribution attendants) have previously filled out in order to verify that the information is correct. The Certificate of Analysis that accompanies the shipment is based on the information in the cross-checked paperwork, so the cross-checking procedure insures that the Certificate of Analysis has the proper railcar and resin recorded on it.

Second, when the loaded hopper car arrives at the CPChem scales, the scale attendant removes one aluminized tag off one car at a time and verifies that the car number on the tag matches the railcar number. Previously, the attendant pulled tags off all the cars in the string and then matched them with numbers in the computer; this procedure did not provide a cross-check against two switched railcars since both would probably be in the string. Third, HCC no longer schedules the production of pipe resins and similar resins on sister reactors at the same time. Thus, any differences would be very obvious and caught before pipe could be made. These operational changes aim to insure that the labels for a hopper car are properly matched with the contents therein, and to confirm that Uponor receives the proper resin.

Although Uponor could not have prevented CPChem's mis-shipment of resin, Uponor has informed us that it has implemented new quality control procedures to supplement its procedures in place in July 2000. In particular, Uponor advises that it now samples resin from every compartment of every rail car delivered to its Tulsa facility, and that each sample is then subjected to Fourier Transform Infrared Analysis ("FTIR") testing for UV level as well as density and melt index[9] testing.

V. CONCLUSION

CPChem believes that MDPE pipe manufactured with TR-130 complies with all applicable laws and regulations and does not require a waiver. Furthermore, the foregoing discussion establishes that MDPE pipe made with TR-130 still in service should perform in the same manner as MDPE pipe made with TR-418N. The two resins possess essentially equivalent physical characteristics, and pipe manufactured using the two resins should perform in an identical manner in field use. Moreover, even if a utility were concerned by the lower level of UV stabilizer in pipe made with TR-130, that condition – as established above – is immaterial to the durability, performance, and safety of the installed pipe in question. Under these circumstances, we respectfully submit that the pipe at issue poses no safety hazard and is wholly appropriate for use in natural gas transport.

9 Density and melt index testing alone are inconclusive for differentiating between TR-130 and TR-418N because both the density and the melt indexes specification ranges of the two resins overlap.

Dated: November 12, 2001

CHEVRON PHILLIPS CHEMICAL COMPANY, LP

BY:

T. G. Taylor

Timothy G. Taylor
Senior Vice President, Olefins and Polyolefins
Chevron Phillips Chemical Company, LP
Chevron Tower
1301 McKinney
Houston, Texas 77010-3030

Peter Winik

Peter L. Winik
Heather M. McPhee
Latham & Watkins
555 Eleventh Street, NW
Suite 1000
Washington, D.C. 20004

Chevron Phillips Chemical Company LP

Uponor

January 24, 2001

Company Name
Attn: Mr. Customer
123 Main Street
City, State Zip

Dear Mr. Customer:

Uponor Aldyl Company and Chevron Phillips Chemical Company LP want to tell you what we know about a matter that affects you involving some Medium Density Polyethylene ("MDPE") pipe that Uponor manufactured using Chevron Phillips polyethylene resin. You were previously notified of this problem on January 10, 2001.

In July 2000, Chevron Phillips delivered to Uponor's Tulsa, Oklahoma plant a railroad carload of resin that was identified as Chevron Phillips Marlex® HHM TR-418N resin ("TR-418N"). Laboratory analysis indicates that this resin was not TR-418N resin. Uponor, not knowing of the discrepancy, processed this resin into pipe and tubing and sold some of it to you. The date code print line on the affected pipe will state Txx072000, Txx072100, Txx072200, Txx072300 ("xx" can be any two numbers). The affected pipe was manufactured during the July 20 through 23, 2000 period.

All of Uponor's quality control records verify that the pipe made with this different resin passed all dimensional and required tests specified by ASTM D-2513. However, during installation, one Uponor customer found that some of the affected pipe did not pass pressure testing in temperature conditions around 30 degrees Fahrenheit. Specifically, cracking was discovered in certain places on the pipe. The exact cause of the cracking is not known. We have not determined that the failure was related to the type of resin used in the pipe. Other samples of the affected pipe delivered to the customer passed all standard pressure testing.

Chevron Phillips has been provided samples of the failed pipe along with control samples and has conducted significant testing. So far, the analysis by Chevron Phillips indicates that the resin used was probably HHM TR-130 resin, MDPE ("TR-130"). The density and melt index of TR-130 are very close to those of TR-418N, and Chevron Phillips believes the nominal performance characteristics of TR-130 after extrusion should be substantially similar to those of TR-418N. We are at a loss to explain the reported failure of the pipe. The analysis to date has been based on small rings of pipe, and Chevron Phillips is conducting more thorough evaluations to include selected impact and pressure testing.

TR-130 does not contain an ultraviolet stabilizer and does not have a listed Hydrostatic Design Basis with the Plastic Pipe Institute. However, the typical physical characteristics of TR-130 and TR-418N are relatively similar. Chevron Phillips believes that because of these similarities, a pipe manufacturer would not experience noticeable differences during extrusion of the pipe or during typical quality control testing of the pipe.

We have discussed commenting upon the relative seriousness of this problem and making a recommendation to Uponor's customers. Although Chevron Phillips is a resin manufacturer and Uponor is well versed on extrusion of polyethylene resins, we are not experts on natural gas pipe system installation and operation. Moreover, the conditions of installation and operation of pipelines vary from geographical location to location as well as from utility to utility. Therefore, we do not believe it is possible to formulate a comment or recommendation that would be applicable to all customers and all locations. As experienced users of polyethylene as well as many other types of gas piping systems, you will have specific knowledge as to the installation procedures and operating conditions for your systems. Your company is the best judge of the seriousness of this situation as it applies to you.

Chevron Phillips has recalled the resin and committed to reimbursing Uponor and its customers for the reasonable and necessary expenses incurred in the recall of the pipe made with this resin. In the next few days, we will provide you with details of the requirements and process for this reimbursement.

We are actively investigating this matter and will provide additional technical information as it becomes available. In the meantime, if you have any questions at all, please feel free to contact your account representative.

Yours very truly,

UPONOR ALDYL COMPANY

By *Thomas W. Sheridan*
Thomas W. Sheridan, President

CHEVRON PHILLIPS CHEMICAL COMPANY L.P.

By *T. G. Taylor*
T. G. Taylor, Senior Vice President

Chevron Phillips Chemical Company LP

T. G. Taylor
Senior Vice President
Olefins & Polyolefins

Reimbursement Office Address:
1301 McKinney
Suite 1299
Houston, TX 77010-3030

Reimbursement Office Phone: (866)274-6799
Reimbursement Office Fax: (713)289-4979

March 14, 2001

Via Facsimile and CRMM#

Re: Chevron Phillips' Reimbursement Program for Uponor Pipe

Dear Mr. :

On January 24, 2001, Chevron Phillips Chemical Company LP (CPC) and Uponor Aldyl Company (Uponor) sent you a letter explaining events that led to the discovery that some medium density polyethylene pipe manufactured by Uponor during the period July 20 through July 23, 2000 may have contained Chevron Phillips' Marlex® HHM TR-130 resin (TR-130) rather than Chevron Phillips' Marlex® HHM TR-418N resin (TR-418N). That letter stated that further details concerning appropriate customer response to this situation would be supplied. This letter updates and supercedes the January 24 letter.

CPC is prepared to reimburse you, on behalf of Uponor, for the reasonable and necessary costs of abandoning or removing and replacing **six-inch** pipe made on July 21 and 22, 2000. At this time, we are not recommending replacement of pipe made on July 20 or July 23 that has been installed and CPC will not reimburse you for such costs. Nevertheless, CPC will repurchase, at your invoiced cost, any Uponor pipe made between July 20 and July 23, 2000 that has been paid for but not yet installed. CPC will also pay the freight charges necessary to return the inventoried pipe. Additionally, to verify the parameters of the reimbursement program, we are requesting Uponor customers with six-inch pipe manufactured on July 20 and 23, 2000 to send product samples to CPC (see Sampling Procedures Attachment).

The reasons for limiting our reimbursement program to six-inch pipe made on July 21 and 22 are straightforward. First, we have only been notified of a problem by a single customer with six-inch pipe made with TR-130. This customer experienced cracking while pressure testing during cold winter installation. Second, current information indicates that TR-130 was primarily used to produce virgin six-inch pipe on only July 21 and 22, 2000. Third, extensive technical information concerning the TR-418N and TR-130 resins shows that both resins possess essentially equivalent physical characteristics. See Technical Attachment. Although TR-130 does not contain UV inhibitor, this does not present a concern with installed pipe because such pipe was not exposed to sunlight for more than a few months.

With respect to installed pipe other than six-inch pipe, CPC has commenced a program of testing to obtain a Hydrostatic Design Basis (HDB) rating for TR-130 resin. We are keeping the DOT informed of our testing program and are confident that TR-130 will obtain an HDB rating. Once the HDB rating is granted, CPC will request that you file an application for a waiver covering the installed pipe.

Records show that your company received the following pipe manufactured by Uponor: 1 ¼" pipe lot nos. T04-072100, T04-072200 and T04-072300, manufactured on July 21, 22 and 23, 2000, respectively; two-inch pipe lot no. T03-072200, manufactured on July 22, 2000; four-inch pipe lot no. T11-072300, manufactured on July 23, 2000; six-inch pipe lot nos. T08-072000 and T08-072100, manufactured on July 20 and 21, 2000, respectively; and ½" pipe lot no. T09-072100, manufactured on July 21, 2000. Accordingly, your company is eligible to participate in the reimbursement program as to six-inch lot no. T08-072100. CPC asks that your company participate in the pipe sampling program with respect to any installed pipe from lot no. T08-072000. Pipe from any of the above lots that has not been installed is also eligible for repurchase. Furthermore, to the extent you incurred reasonable and necessary removal, storage, or shipping costs with respect to any of this Uponor pipe before the date of this letter, we will consider your application for reimbursement.

Adherence to CPC's Reimbursement Program Guidelines (attached) is a condition to payment. As an administrative convenience CPC will, in certain circumstances, make payment directly to you, on behalf of Uponor. In order to clarify the reasonableness or necessity of expenses incurred, we ask you to submit all removal/abandonment plans to CPC ***before the work is undertaken***. The attached Reimbursement Pre-Approval Form should be used for this purpose.

We have established a reimbursement office and engaged experts to assist with evaluation of proposed replacement programs. A toll-free hotline has been set-up in order to respond to any questions that you may have. Please feel free to contact us at (866) 274-6799. We appreciate your patience with respect to this matter. We hope the foregoing and attached information is of assistance. We stand ready to cooperate with you.

Very truly yours,

T. G. Taylor

Timothy G. Taylor
Senior Vice President
Chevron Phillips Chemical Company LP

Cc: Tom Sheridan, President Uponor Aldyl Co.

Attachments:
Reimbursement Program Guidelines
Sampling Procedures Attachment
Technical Attachment

SAMPLING PROCEDURES

Pipe Sampling and Transmittal Instructions for Six-Inch Pipe Manufactured on July 20 and 23, 2000

1) Locate pipe and record pipe information. The pipe print line contains sufficient information for documentation purposes and should be recorded. Additionally, if available, provide the coil number and/ or foot number.

2) Using a tool such as a carpenter's plane or other scraping device, scrape or shave off a thin sample from the outside diameter surface of the pipe. Approximately 0.01—0.02 inch thickness on 2" Outside Diameter (OD) or larger pipe is sufficient. CAUTION: **DO NOT EXCEED TEN PERCENT (10%) OF THE WALL THICKNESS WHEN TAKING A SAMPLE. REMOVAL OF MORE THAN 10% OF THE WALL RENDERS THE PIPE UNSERVICABLE, REQUIRING REPAIR.** ALSO NOTE: **THIS METHOD OF SAMPLING IS NOT RECOMMENDED FOR TUBING.** The total amount of the sample needs to be approximately the size of a quarter or a large postage stamp, and can be comprised of several pieces.

3) When transmitting the sample to CPC, please include the print line information together with the pipe size, and SDR pipe location by street location, city, and state. Also include the date of sample collection, the name of the person who collected the sample, and the name of the person transmitting the sample.

4) Please identify your company by name, address, and phone/fax. In addition, please supply the name of a designated contact person with whom we can communicate if we have any questions. We will convey our test results to your designated contact person.

5) Please ship all samples to:

   Chevron Phillips Chemical Company LP
   Houston Chemical Complex
   1400 Jefferson Road
   Pasadena, TX 77501
   Attention: Austin Wuu

6) Please direct any questions about this procedure to:

   Reimbursement Office
   1301 McKinney
   Chevron Tower
   Room 1299
   Houston, TX 77010
   (866)274-6799
   (713)289-4979 (fax)

Technical Attachment

	TR-418N	TR-130 *
Density (g/cc)	0.936-0.940	0.938
Melt Index (g/10 min.)	0.16-0.24 **	0.25
Catalyst	SAME	
Molecular Weight Distribution	SAME	
Tensile Strength, psi	2900	2900
Elongation, %	>800	>800
Flexural Modulus, psi (D3350)	86,000	86,000
PENT, hours	>500	>500
Melting Point (°C)	127	127
Additive Formulation		
Primary	YES	YES
Secondary	YES	YES
UV	YES (0.15 - 0.21)	NO
Pipe		
Quick Burst	Ductile	Ductile
ASTM D3350 Thermal Stability (°C)	>220	>220

* Lot used in pipe Uponor's six-inch pipe
** Historically 0.15 - 0.25

REIMBURSEMENT PROGRAM GUIDELINES

March 14, 2001

ELIGIBLE PIPE: Six (6) inch diameter pipe produced by Uponor Aldyl Company ("Uponor") on July 21, 2000 and on July 22, 2000 ("eligible pipe").

REIMBURSEMENT PROCEDURE: CPC will reimburse you for the reasonable and necessary costs you incur for the replacement of eligible pipe. Following the replacement of the eligible pipe, please send us a letter on your letterhead applying for reimbursement. Please attach to the letter sufficient supporting documentation for CPC to process the application, showing with reasonable detail the various components of the reimbursement application, including: location, identification of the eligible pipe removed, equipment rental, and labor costs. This documentation should take the form of invoices, work orders (for internal costs), or, for example, rental contracts for rented equipment. PLEASE NOTE: corporate overhead, capital cost recovery, supervisor or manager time or legal consultations are not subject to reimbursement under this program. Unless pre-approved in writing, CPC shall have the sole authority under this program to determine the reasonableness and necessity of charges.

PRE-APPROVAL PROCEDURE SUMMARY: CPC encourages applicants to provide advance notice that replacement of eligible pipe is beginning or has begun at your location(s). You can fax the attached Reimbursement Pre-Approval Form to us at our office (fax: 713-289-4979). CPC is using the information to ensure that we have sufficient resources available to provide any support you may need. CPC's written approval of a Reimbursement Plan will also confirm CPC's acceptance of the reasonableness and necessity of the activities reflected in it.

PROGRESS PAYMENTS: CPC recognizes that certain applicants might require advance or "progress" payments. We will entertain requests that CPC provide progress payments for applicants requiring such assistance. In order to facilitate review of such requests, applicants requiring advance or progress payments should make the request using the attached Reimbursement Pre-Approval Form. Please note that prior to issuing an advance or progress payment, CPC will require a certification that the funds will be used only for the replacement of eligible pipe. All other requirements of these guidelines must be met.

RECEIPT AND RELEASE: In order to ensure that any and all funds advanced in this program are used exclusively for the purpose intended, that such disbursed funds have been so used, and that the eligible pipe will not enter any secondary market, CPC will require submission of a receipt, release and warranty sufficient to provide such assurances. In addition, to assure the propriety of all payments hereunder, CPC reserves the right to audit the records of any recipient of advance, progress or reimbursement payments hereunder for a period of two (2) years following the final payment. CPC further reserves the right to request additional information from any applicant at any time concerning the purchase, use, replacement or disposition of any eligible pipe, and applicants agree by participating in this program to provide documentation on request.

REIMBURSEMENT PRE-APPROVAL FORM

CUSTOMER NAME: ______________________________

ADDRESS: ______________________________

CONTACT PERSON(S): ______________________________

PHONE: ______________ FAX: ______________

E-MAIL: ______________________________

____

REPLACEMENT WORK SITE: ______________________________

____

____

DESCRIPTION OF ELIGIBLE PIPE TO BE REPLACED: (Size, Series, Lot #) ______________

____

____

____

____

TOTAL NUMBER OF FEET OF ELIGIBLE PIPE: ______________________________

DESCRIPTION OF FITTINGS REQUIRING REPLACEMENT: ______________________________

____

____

____

TYPE OF INSTALLATION: ______________________________

SPECIAL PROBLEMS: (e.g. paving, landscaping, etc.) ______________________________

____

____

____

____

METHOD OF REPLACEMENT: ______________________________

____

____

ESTIMATED COSTS

MATERIAL: ______________________________

CONSTRUCTION: ______________________________

EQUIPMENT RENTAL: ______________________________

OTHER PROPOSED COSTS: (explain) ______________________________

____

____

TOTAL PROPOSED COST FOR THIS SITE:

____

CONFIDENTIAL

Analysis of Uponor Pipe

Prepared for

Chevron Phillips Chemical Company LP
1301 McKinney Suite 3400
Houston, Texas 77010

Prepared by

Walter L. Bradley, Ph.D., P.E.

October 9, 2001

Introduction

Four sections of six-inch polyethylene natural gas distribution pipe cracked during routine pressure testing after installation in Boston in December 2000 in weather that was below freezing (5F-30F). It was subsequently determined that these four failed sections of pipe had been made from TR130 rather than TR418N, which was the specified medium density gas pipe resin. Further investigation documented that on several days in July 2000, certain gas pipe made at the Uponor plant was made with TR130 resin. I have been asked to compare the impact resistance of pipe made with TR130 resin to pipe made with TR418N and also to do a failure analysis on one section of the pipe that cracked, failing pressure testing after installation but prior to being put into service in Boston. This report summarizes the results of this investigation.

Background Information

Chevron Phillips Chemical Company LP has provided me the following basic information about TR418N and TR130 resins. TR130 and TR418N are very similar polyethylene resins, satisfying D3350 Cell Classification. They both result in medium density extruded polyethylene pipe. The natural TR130 resin at issue had a density of 0.938, compared to a manufacturing specification of 0.936–0.940 for TR418N (D3350 requirement: 0.925-0.940). The melt index of the TR130 at issue was 0.25 compared to a manufacturing specification for TR418N of 0.16–0.24 (D3350 requirement: 0.15-0.40). This indicates that the TR130 and the TR418N are very similar in viscosity, and therefore, should process in a similar manner. The weight average molecular weight for the TR130 was 204,000-208,000 with a ratio of weight to number molecular weight of 11.1-12.8, while the TR418N values were 207,000 and 11.8.

One would expect the mechanical properties for these two resins to be quite similar, and they are. The flexural modulus for each was ~86,000 psi (D3350 requirement: 80,000-110,000 psi). The tensile yield strength for both was ~2800 psi (D3350 requirement: 2600-3000 psi). The thermal stability temperature in degrees C ranged from 238-258 for TR130 and from 243-268 for TR418N (D3350 requirement: 220 minimum). The tensile elongation for both resins was ~870% with a brittleness temperature of less than –75C (D3350 requirements: >500% and less than –60C). Finally, the environmental stress cracking resistance (ESCR) as measured by the PENT test gave values of >3000 hours for both the TR130 and TR418N (D3350 requirement: >100 hours). It is worth noting that the PENT specimen for the TR130 was remolded from a section of pipe that failed the pressure testing and precipitated this investigation.

The only significant difference in the two resins is that the TR418N has oxygen and UV stabilizers whereas TR 130 has only oxygen stabilizers. However, the coloring package used by Uponor contains some UV stabilizer, though less than that in the TR418N resin. This difference would only be significant if the gas pipe was exposed for some extended time to radiation from the sun, which was not the case for this pipe.

Experimental Procedures

Materials Provided by Chevron Phillips Chemical Company LP for this Study – The following materials were provided for this investigation:

- Two pieces of pipe (~18 inches in length) that were cut from the several pipes that failed pressure testing in Boston in December 2000;
- Two-inch and six-inch diameter pipe made from TR130 resin and from TR418N resin;
- Pieces of TR130 pipe that was broken at low temperatures in a Dart test performed at Chevron Phillips.

Fractographic Analysis -- Two portions (~15 inches) of 6-inch pipes that failed during pressure testing were provided for inspection. These were carefully sectioned to open up the cracks and permit inspection of the fractured surfaces. The fractured surfaces were carefully examined using a binocular microscope at magnifications from 10X to 70X. Smaller pieces (~1-inch cubes) were cut from the fracture surfaces of the two pieces of pipe for examination in a scanning electron microscope. These pieces were then sputter coated with a gold-palladium film and examined in the scanning electron microscope. The scanning electron microscopy inspection was performed on a JEOL 6400 SEM in the Electron Microscopy Center at Texas A&M University.

Izod Impact Testing -- Since the failure of the pipe during pressure testing was ostensibly by rapid crack growth (as opposed to bulging and rupture, or stress induced slow crack growth), sharply notched Izod impact specimens cut from 2 inch and 6 inch pipe made from TR418N and TR130 resins were tested. The TR130-TO8-072200 pipe used was made on July 22, 2000. This pipe is from the same line and was made on the same day as the pipe that failed during pressure testing in Boston and the pipe that broke in the Dart testing at Chevron Phillips.

The orientations of the Izod specimens cut from the pipe and tested are indicated in Figure 1. The specimens were 0.5 inches by 0.25 inches, and 5" long. To introduce notches/cracks in the Izod specimens that were as sharp as possible, a machine that used a serrated razor blade as a cutting tool was utilized. The cracks were cut to a depth of 20% of the dimension of the specimen in the direction of the cut. Cracks labeled A were cut across the 0.5-inch dimension to a depth of 0.05 inches, leaving an un-cracked ligament of 0.20 inches. Cracks labeled B were cut to a depth 0.1 inch, leaving un-cracked ligament of 0.4 inches. The test results from the specimens with the cracks in the B orientation were more representative of crack growth in pipes, whereas the specimens with cracks in the A orientation sometimes failed by loading the uncracked ligament beyond its yield strength, giving a very ductile, overload type of failure. Thus, only the comparisons for specimens with B orientation cracks are significant.

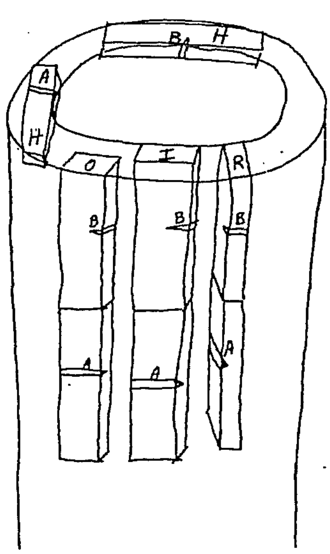

Figure 1. Specimen Nomenclature

Finally, crack growth in the specimens with orientations O (outside diameter), I (inside diameter), and R (radial) is in a plane that cuts through the cross-section of the pipe. Pipe failures for pressurized pipe, however, almost always result from cracks that grow along the axis of the pipe, including the pipe that failed in Boston. Thus, the most relevant test results are comparisons from specimens with the H orientation. Unfortunately, Izod test specimens could not be cut from the 2" pipe. In fact specimens of only one orientation could be cut from the 2" pipe; namely, through-wall specimens, which are labeled O+I in Table 1. All test results are for Izod testing at –40C.

Experimental Results

Izod Testing Results – The test results for the razor notched Izod tests are summarized in Table 1. First, specimens with A-type crack orientation give results that are often very large compared to specimens with cracks with B-type crack orientation. As previously noted, the mode of failure in the A-type specimens sometimes by tensile overload rather than by crack growth. Thus, these results are not significant for our purposes because the four Boston pressure-testing failures were by crack growth, not by tensile overload. Thus, our analysis of the data in Table 1 will focus on only tests for which the crack orientation is B-type (see Figure 1).

Second, the specimens of TR418N with cracks in the B orientation for specimens O, I, and R had very similar Izod impact energies, implying that the resistance to crack growth (test groups 4,6, and 8) is the same in each direction in the plane perpendicular to the axis of the pipe (radial/circumferential plane).

Third, Izod impact energies for test specimens cut from six inch pipe made from TR418N resin and TR130 resin are both 5.7 KJ/m^2, indicating that the difference in resin did not produce any significant difference in resistance to rapid crack growth in the circumferential direction (test groups 2 and 4). However, the most meaningful comparison of the resistance to rapid crack growth of TR418N and TR130 resin made into six-inch pipe is for H specimens with razor notching in the B orientation (see Figure 1). The results seen in Table 1 for test groups 16 and 18 indicate no difference in resistance to rapid crack propagation. Note that such a comparison for 2-inch pipe could not be made because suitable specimens could not be cut with this orientation in 2-inch pipe.

Fourth, two-inch pipe made of TR130 resin by two different manufacturers (see group numbers 10 and 14 in Table 1) indicated a very similar resistance to rapid crack propagation as measured in a razor notched Izod test to two-inch pipe made of TR418N.

Table 1. Summary of Izod Test Results on Razor Notched Specimens
(See Figure 1 to clarify nomenclature in Table 1.)

Specimen Type	Crack Type	Material Processing	Pipe Dia (in.)	Fracture Energy KJ/m^2	Test Group Number
R	A	TR130-T08-072200	6	24.3*	1
R	B	TR130-T08-072200	6	5.7*	2
R	A	TR418N-T08-071900	6	24.3*	3
R	B	TR418N-T08-071900	6	5.7*	4
I	A	TR418N-T08-020601	6	5.4	5
I	B	TR418N-T08-020601	6	5.4	6
O	A	TR418N-T08-020601	6	4.9	7
O	B	TR418N-T08-020601	6	6.0	8
O+I	A	TR130-Lot 81-9-CPC	2	25.5**	9
O+I	B	TR130-Lot 81-9 CPC	2	6.0*	10
O+I	A	TR418N-T04-012901	2	6.1	11
O+I	B	TR418N-T04-012901	2	5.8	12
O+I	A	TR130-T01-072200	2	34.0	13
O+I	B	TR130-T01-072200	2	5.2*	14
H	A	TR130-T08-072200	6	9.7*	15
H	B	TR130-T08-072200	6	2.8*	16
H	A	TR418N-T08-071900	6	8.7*	17
H	B	TR418N-T08-071900	6	2.8**	18

- *Avg. of 5 tests **Avg. of 3 tests
- Most important comparisons: 16 to 18 for six-inch pipe, and 10 and 14 to12 for two-inch pipe.

Fractography – Boston Pressure Test Failure and Dart Laboratory Failure – Macroscopic View

Only one of the two pieces of six-inch pipe made of TR130 resin that failed pressure testing in Boston that were provided had the actual crack origin site. My purpose was to see if the cracking started at a manufacturing defect, some impurity in the resin, or possibly at a field weld. The results of the fractographic examination at low magnification are seen in Figures 2. Figure 2 (top) is from the surface from the failed pipe, showing that the fracture originated adjacent to the weld, not at or in the weld. The smooth region is the region of crack initiation while the regions with lines (so-called chevrons) point in the direction of local crack growth and also indicate a brittle fracture. For comparison, a specimen of TR130-T08-072200 6-inch pipe that failed by brittle fracture in a Dart test at –40C is also shown in Figure 2 (bottom). The chevron marks characteristic of brittle fracture point back to the origin site.

The absence of any significant reduction in cross-section of either the Dart laboratory test or the pipe that failed the pressure testing in Boston further suggests that both were brittle failures.

Microscopic View -- Using Scanning Electron Microscope

The scanning electron microscopy image of the fractured surface at the origin site for the pipe that cracked during pressure testing in the field is seen in Figure 3. Figure 3A is taken at the origin site at 12X magnification while Figure 3B is the smooth area from the top of Figure 3A, but taken at 1000X. Figure 3C is taken away from the origin site, where the crack is running rapidly and the fracture is even more brittle, as evidenced by the smoother fracture surface.

The scanning electron microscopy image of the fractured surface at the origin of a Dart test specimen cut from a piece of 6-inch pipe, TR130-T08-072200, and tested at minus 18C is seen in Figure 4A at 12X magnification and in Figure 4B at 1000X. The fracture surfaces are similar to the field failure that occurred at a similar temperature and with the same TR130-T08-072200 extruded pipe, as seen in Figure 2A and 2B.

Summary -- The fractographic examination of the TR130-T08-072200 six-inch pipe that failed during field pressure testing in Boston and during Dart tests at –18C in laboratory tests of specimens cut from the same pipe indicates brittle failure in some pipe manufactured from TR 130 on a single production line on July 22, 2000.

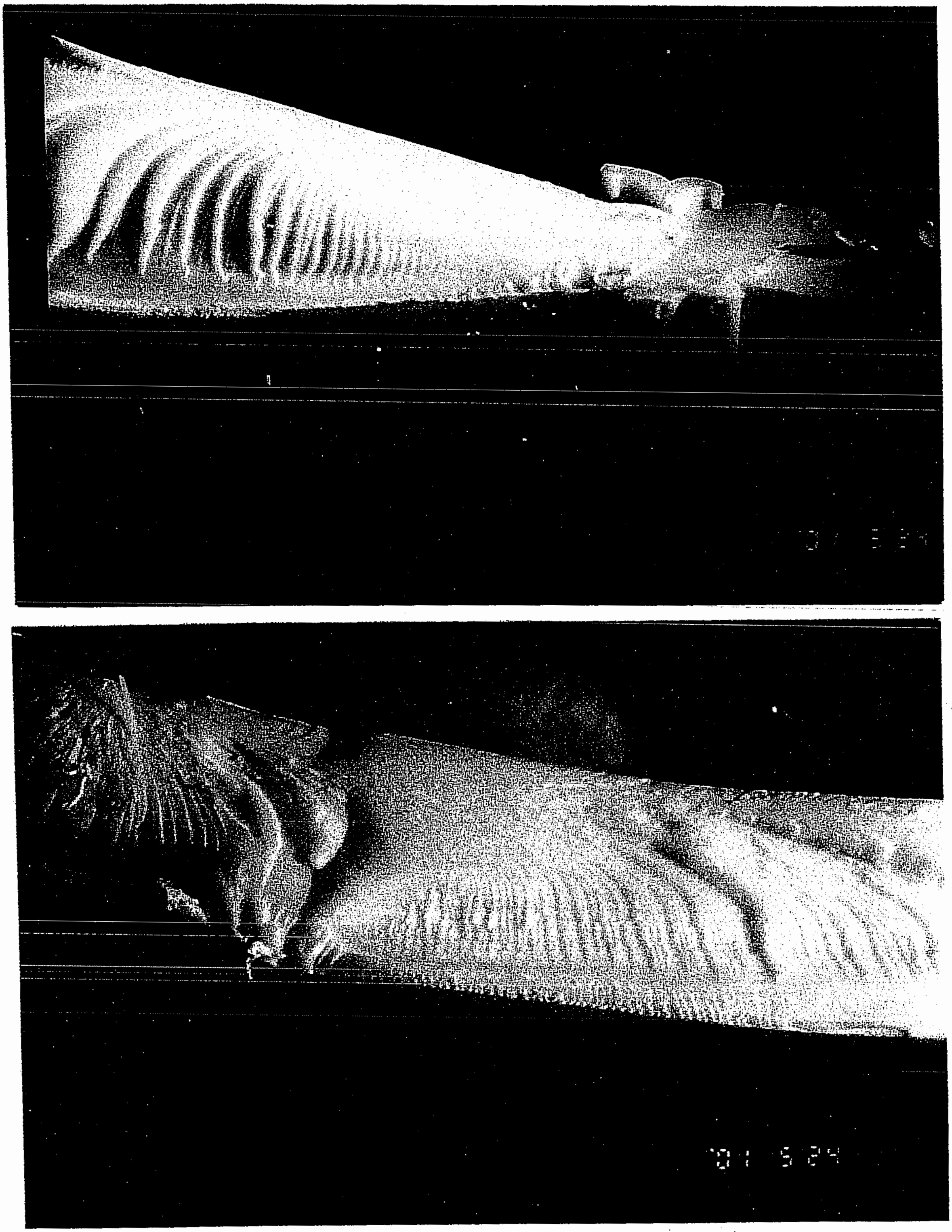

Figure 2. Top – 2A, showing fractured surface of field failure of 6-inch pipe TR130-T08
Bottom – 2B, showing fractured surface of Dart specimens cut from above pipe.

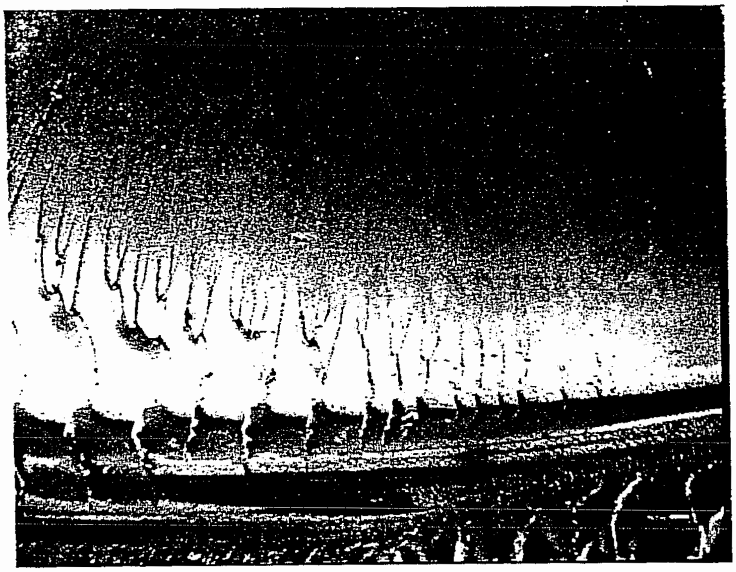

Figure 3A. Scanning electron microscopy image of fractured surface of TR130-T08 6-inch pipe that failed during pressure testing, taken at the origin of the fracture. 12X

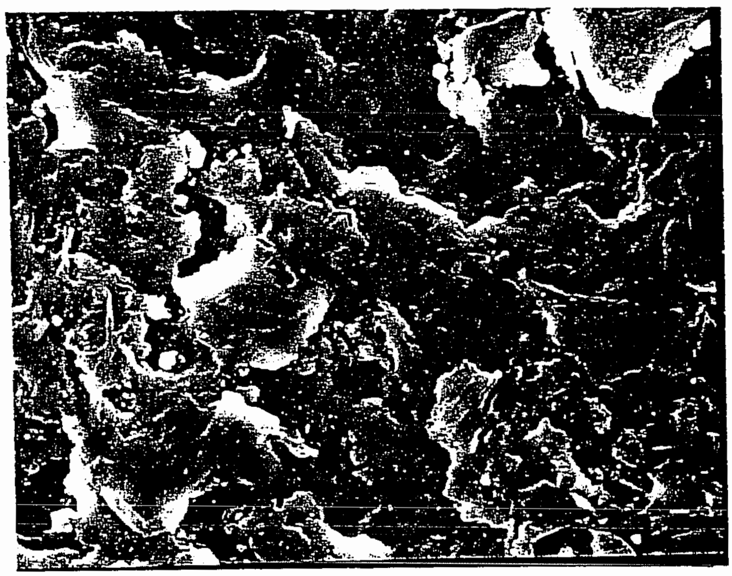

Figure 3B. Scanning electron microscopy image of fractured surface of TR130-T08 6-inch pipe that failed during pressure testing, taken at the origin of the fracture. 1000X

Figure 3C. Scanning electron microscopy image of fractured surface of TR130-T08 6-inch pipe that failed during pressure testing, but taken away from the origin site where crack is "running". 1000X

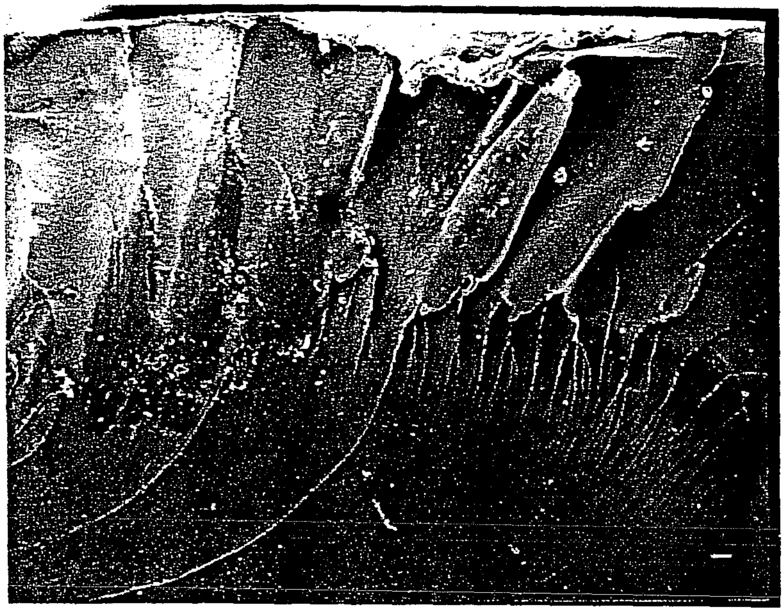

Figure 4A. Fractured surface of Dart specimen of TR130-T08 cut from 6-inch pipe and tested at –18C. 12X

Figure 4B. Fractured surface of Dart specimen TR130-T08 cut from 6-inch pipe and tested at –18C.
1000X

Discussion

Chevron Phillips has conducted Dart tests on specimens cut from 2-inch, 4-inch and 6-inch diameter pipes and tested them from room temperature to –40C. Some six-inch pipe made with TR130 resin on a single production line on July 22, 2000 has been found to give brittle failures at low temperatures for Dart testing. This is consistent with the observed fact that the only pipe to fail pressure testing in Boston was six-inch pipe made from TR130 on the same production line on the same day . Since no incipient notch or flaw was found at the origin site for the pipe that failed pressure testing in Boston and since the Dart specimens were also un-notched, one would expect the Dart testing to correlate well with the field service, and it does.

Only six-inch pipe made with TR130 resin on a single production line on July 22, 2000 has experienced failures, either during pressure testing in Boston or in a brittle fashion during Dart testing at low temperatures in the laboratory.

Izod testing of razor notched specimens indicates that the resistance to rapid crack propagation of pipe made from TR418N resin and TR130 resin is essentially the same.

This result is consistent with the results from PENT test and HSB lifetime predictions, with all three implying that the fracture behavior of TR418N and TR130 are essentially the same.

The absence of field failures for other sizes of pipe made from TR130 resin and the ductile behavior of specimens cut from these pipes during Dart testing indicates that there is nothing inherent in the TR130 resin that can account for the failures that occurred during pressure testing of six-inch TR130 pipe in Boston. The fact that ONLY six-inch pipe of TR130 resin extruded on one production line on a single day failed in a brittle fashion during pressure testing in Boston and Dart testing in the laboratory further supports the proposition that there is nothing inherent in TR130 resin that necessarily leads to the production of pipe that is brittle. This proposition is further supported by the wide range of mechanical properties that were found to be essentially identical for TR418N and TR130 resins.

In sum, a combination of factors including cold weather the day the pressure testing took place, possibly assisted by some field impact somehow caused the failure of the pressure test. However, the detailed explanation of what caused the failure of the pressure test to occur remain obscure.

PPI PLASTICS PIPE INSTITUTE

May 4, 2001

Al Wolfe
Chevron Phillips Chemical Company
Plastics Technical Center
Bartlesville, OK 74004

Al,

As you requested, I have been authorized by the Hydrostatic Stress Board to grant you an experimental grade Hydrostatic Design Basis (HDB) rating for your Marlex TR-130/M358Y2 PE 2406 material. As you requested, we will not publish this listing in TR-4 when it is next revised.

PE Material	Temperature (°C)	HDB (psi)	Grade	Expiration Date	PPI Data Set
Marlex TR-130/M358Y2	23	1250	E-2	11/30/01	2978

To arrive at this HDB listing, I used the ISO TC 138/SC 5 diskette for ISO 9080, which calculates the long-term hydrostatic strength (LTHS) using a two coefficient equation. I have attached the ISO 9080 computer print out and graph for your Marlex PE material. The LTHS value is 1280 psi. The HDB is the categorized value of this LTHS value.

Your experimental (E) grade rating is effective this date. The expiration date is noted above. You need to send PPI additional data in accordance with PPI TR-3 to advance to the standard grade.

chevron phillips

I have copied NSF to notify them of this new listing for Marlex TR-130/M358Y2 PE 2406.

There is an initial listing fee of $350.00 (PPI member fee) for each material at each temperature. Attached is an invoice for $350.00.

Please call me at 202-462-9607 ext. 11 if you need additional assistance.

Sincerely,

Gene Palermo

Dr. Gene Palermo
PPI Technical Director

CC: Rich Gottwald – PPI
James Paschal – NSF
Nasrin Kashefi – NSF

Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings[1]

This standard is issued under the fixed designation D 2513; 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.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This specification covers requirements and test methods for material (see Appendix X1) dimensions and tolerances, hydrostatic burst strength, chemical resistance, and impact resistance of plastic pipe, tubing, and fittings for use in gas mains and services for direct burial and reliner applications. The annexes provide specific requirements and test methods for each of the materials currently approved. If and when additional materials are available, specific annex requirements will be added. The pipe, tubing, and fittings covered by this specification are intended for use in the distribution of natural gas. Use of polyethylene systems with liquefied petroleum gas is covered in Appendix X2.

1.1.1 This specification does not cover threaded pipe. Design considerations are discussed in Appendix X2. In-plant quality control programs are specified in Annexes A3 and A4.

1.2 The text of this specification references notes, footnotes, and appendixes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the specification.

1.3 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are provided for information purposes only.

1.4 The following is an index of the annexes and appendixes in this specification:

Annex	Subject
A1	Polyethylene (PE) Pipe, Tubing, and Fittings
A2	Poly (Vinyl Chloride) (PVC) Pipe, Tubing, and Fittings
A3	In-Plant Quality Control for all materials up to 12 in.
A4	In-Plant Quality Control for PE materials between 14 and 24 in.
A5	Polyamide (PA) Pipe, Tubing and Fittings

Appendixes	Subject
X1	New Materials
X2	Design Consideration

1.5 The following precautionary caveat pertains only to the test method portion, Section 6, of this specification. *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:*

2.1.1 *Terminology:*

D 1600 Terminology for Abbreviated Terms Relating to Plastics[2]

F 412 Terminology Relating to Plastic Piping Systems[3]

2.1.2 *Test Methods for:*

D 543 Resistance of Plastics to Chemical Reagents[2]

D 638 Tensile Properties of Plastics[2]

D 1598 Time-to-Failure of Plastic Pipe Under Constant Internal Pressure[3]

D 1599 Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings[3]

D 2122 Determining Dimensions of Thermoplastic Pipe and Fittings[3]

D 2290 Apparent Tensile Strength of Ring or Tubular Plastics and Reinforced Plastics by Split Disk Method[4]

D 2837 Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials[2]

2.1.4 *Practices for:*

D 618 Conditioning Plastics and Electrical Insulating Materials for Testing[2]

D 1898 Sampling of Plastics[2]

D 2657 Heat-Joining Polyolefin Pipe and Fittings[3]

D 2774 Underground Installation of Thermoplastic Pressure Piping[3]

F 699 Accelerated Conditioning of Polybutylene Pipe and Tubing for Subsequent Quality Control Testing[3]

2.2 *ANSI Standards:*

B16.40 Manually Operated Thermoplastic Gas Shutoffs and Valves in Gas Distribution Systems[5]

B31.8 Gas Transmission and Distribution Piping Systems[5]

2.3 *Federal Specifications:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[6]

OPS Part 192 Title 49, Code of Federal Regulations[6]

2.4 *Military Standards:*

MIL-STD-129 Marking for Shipment and Storage[6]

MIL-STD-1235 (ORD) Single- and Multi-Level Continuous Sampling Procedures and Tables for Inspection by Attributes

2.5 *Other Documents:*

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[1] This specification is under the jurisdiction of ASTM Committee F-17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.60 on Gas.

Current edition approved Sept. 10, 1996. Published November 1996. Originally published as D 2513 – 66. Last previous edition D 2513 – 96.

[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 08.04.

[4] *Annual Book of ASTM Standards*, Vol 15.03.

[5] Available from American National Standards Institute, 1430 Broadway, New York, NY 10018.

[6] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111 – 5094, Attn: NPODS.

TABLE 1 Outside Diameters and Tolerances for Plastic Pipe, in. (mm)

Nominal Pipe Size	Outside Diameter	Tolerance	Tolerances For Maximum and Minimum Out-of-Roundness SDR 32.5	SDR 26	SDR 21	SDR 17, SDR 13.5, SDR 11
½	0.840 (21.3)	±0.004 (±0.102)	...	...	±0.015 (±0.381)	±0.008 (±0.203)
¾	1.050 (26.7)	±0.004 (±0.102)	...	...	±0.015 (±0.381)	±0.010 (±0.254)
1	1.315 (33.4)	±0.005 (±0.127)	...	...	±0.015 (±0.381)	±0.010 (±0.254)
1¼	1.660 (42.1)	±0.005 (±0.127)	...	...	±0.015 (±0.381)	±0.012 (±0.305)
1½	1.900 (48.3)	±0.006 (±0.152)	...	...	±0.030 (±0.762)	±0.012 (±0.305)
2	2.375 (60.3)	±0.006 (±0.152)	...	...	±0.030 (±0.762)	±0.012 (±0.305)
2½	2.875 (73.0)	±0.007 (±0.179)	...	...	±0.030 (±0.762)	±0.015 (±0.381)
3	3.500 (88.9)	±0.008 (±0.203)	...	...	±0.030 (±0.762)	±0.015 (±0.381)
3½	4.000 (101.6)	±0.008 (±0.203)	...	...	±0.050 (±1.25)	±0.015 (±0.381)
4	4.500 (114.3)	±0.009 (±0.229)	...	...	±0.050 (±1.25)	±0.015 (±0.381)
5	5.563 (141.3)	±0.010 (±0.254)	...	...	±0.050 (±1.25)	±0.030 (±0.762)
6	6.625 (168.3)	±0.011 (±0.279)	±0.060 (±1.50)	±0.055 (±1.37)	±0.050 (±1.25)	±0.035 (±0.889)
8	8.625 (219.1)	±0.013 (±0.330)	±0.12 (±3.05)	±0.080 (±2.03)	±0.060 (±1.50)	±0.040 (±1.02)
10	10.750 (273.0)	±0.015 (±0.381)	±0.12 (±3.05)	±0.10 (±2.54)	±0.070 (±1.79)	±0.050 (±1.25)
12	12.750 (323.8)	±0.017 (±0.432)	±0.14 (±3.56)	±0.10 (±2.54)	±0.070 (±1.79)	±0.050 (±1.25)

Plastic Pipe Institute: TR-3, Policies and Procedures for Developing Recommended Hydrostatic Design[7]

National Fire Protection Association: NFPA 58, Storage and Handling Liquefied Petroleum Gases[8]

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology F 412, and abbreviations are in accordance with Terminology D 1600, unless otherwise specified.

3.2 The gas industry terminology used in this specification is in accordance with ANSI B31.8 or 49 CFR Part 192, unless otherwise indicated.

3.3 The term *pipe* used herein refers to both pipe and tubing unless specifically stated otherwise.

3.4 *standard thermoplastic material designated code*—the pipe material designation code shall consist of the abbreviation for the type of plastic (PE, PVC, PB, or PA) followed by Arabic numerals which describe the short term properties in accordance with applicable ASTM standards, the hydrostatic design stress for water at 73.4°F (23°C) in units of 100 psi with any decimal figures dropped. Where the hydrostatic design stress code contains less than two figures, a zero is used before the number. Thus, a complete material designation code shall consist of two or three letters and four figures for plastic pipe materials. For example, PE 2406 is a grade P24 polyethylene with a 630 psi design stress for water at 73.4°F (23°C). It should be noted that the hydrostatic design stresses for gas may be different than those for water and are not used in this designation code.

3.5 *thermoplastic pipe dimension ratio (DR)*—the ratio of pipe diameter to wall thickness. It is calculated by dividing the specified outside diameter of the pipe, in inches, by the minimum specified wall thickness, in inches. The standard dimension ratio (SDR) is a common numbering system which is derived from the ANSI preferred number series R 10.

3.6 *toe-in*—a small reduction of the outside diameter at the cut end of a length of thermoplastic pipe.

4. Materials

4.1 *General*—The plastic used to make pipe, tubing, and fittings shall be virgin plastic or reworked plastic (see 4.2) as specified in the Annexes and shall have a PPI recommended long-term hydrostatic stress rating.

4.2 *Rework Material*—Clean rework material of the same commercial designation generated from the manufacturer's own pipe and fitting production may be used by the same manufacturer as long as the pipe, tubing, and fitting produced meet all the requirements of this specification.

NOTE 1—References and material descriptions for ABS, CAB, PB, PE2306, PE3306 and PE3406 have been removed from D 2513. Elimination of these materials does not affect the pipelines that are in service. They can still be used for gas distribution. The main reason for removing these materials from this standard is to reflect the current state of the art in gas distribution plastic piping.

5. Requirements

5.1 *General*—See the annexes for specific product requirements in addition to the following. Pipe and tubing may be supplied in either coils or straight lengths. Any pipe and tubing supplied in coils must meet the same requirements before and after coiling.

5.2 *Workmanship*—The pipe, tubing, and fittings shall be homogeneous throughout and free of visible cracks, holes, foreign inclusion, blisters, and dents, or other injurious defects. The pipe, tubing, and fittings shall be as uniform as commercially practicable in color, opacity, density, and other physical properties.

5.3 *Pipe and Tubing Dimensions and Tolerances:*

5.3.1 *Dimension*—The dimensions shall be specified by wall thickness and outside diameter.

5.3.1.1 *Diameters*—The outside diameter shall meet the requirements given in Tables 1 or 2 when measured in accordance with 6.5.

5.3.1.2 *Toe-In*—When measured in accordance with 6.5.1.1, the outside diameter at the cut end of the pipe shall not be more than 1.5 % smaller than the undistorted outside diameter. Measurement of the undistorted outside diameter

[7] Plastic Pipe Institute, Division of Society of the Plastic Industry, Inc., 355 Lexington Avenue, New York, NY 10017.

[8] National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210.

TABLE 2 Plastic Tubing-Diameters, Wall Thicknesses, and Tolerances, in. (mm)

Nominal Tubing Size (CTS)	Outside Diameter	Tolerance	Minimum Wall Thickness	Wall Thickness Tolerance
1/4	0.375 (9.52)	±0.004 (±0.10)	0.062 (1.58)	+0.006 (+0.15)
3/8	0.500 (12.7)	±0.004 (±0.10)	0.062 (1.58)	+0.006 (+0.15)
1/2	0.625 (15.9)	±0.004 (±0.10)	0.062 (1.58)	+0.006 (+0.15)
1/2	0.625 (15.9)	±0.004 (±0.10)	0.090 (2.27)	+0.009 (+0.23)
1/2	0.625 (15.9)	±0.004 (±0.10)	0.104 (2.64)	+0.010 (+0.25)
3/4	0.875 (22.2)	±0.004 (±0.10)	0.062 (1.58)	+0.006 (+0.15)
3/4	0.875 (22.2)	±0.004 (±0.10)	0.077 (1.95)	+0.008 (+0.20)
3/4	0.875 (22.2)	±0.004 (±0.10)	0.090 (2.27)	+0.009 (+0.23)
1	1.125 (28.6)	±0.005 (±0.13)	0.062 (1.58)	+0.007 (+0.18)
1	1.125 (28.6)	±0.005 (±0.13)	0.090 (2.27)	+0.011 (+0.28)
1	1.125 (28.6)	±0.005 (±0.13)	0.099 (2.51)	+0.012 (+0.31)
1	1.125 (28.6)	±0.005 (±0.13)	0.101 (2.56)	+0.012 (+0.31)
1	1.125 (28.6)	±0.005 (±0.13)	0.121 (3.07)	+0.015 (+0.38)
1 1/4	1.375 (34.9)	±0.005 (±0.13)	0.062 (1.58)	+0.007 (+0.18)
1 1/4	1.375 (34.9)	±0.005 (±0.13)	0.090 (2.27)	+0.011 (+0.28)
1 1/4	1.375 (34.9)	±0.005 (±0.13)	0.121 (3.07)	+0.015 (+0.38)
1 3/4	1.875 (47.6)	±0.006 (±0.15)	0.062 (1.58)	+0.007 (+0.18)

shall be made no closer than 1.5 pipe diameters or 11.8 in. (300 mm), whichever distance is less, from the cut end of the pipe. Undistorted outside diameter shall meet specifications on Table 1 or 2.

5.3.1.3 *Wall Thickness*—The wall thickness shall be as specified in Tables 2 or 3 when measured in accordance with 6.5.1.2. The minimum wall thickness at any point of measurement shall be not less than the minimum wall thickness specified in Tables 2 or 3.

5.3.1.4 *Wall Thickness Eccentricity Range*—The wall thickness eccentricity range shall be within 12 % when measured in accordance with 6.5.1.3.

5.3.1.5 *Ovality*—The ovality (cross section) of the pipe shall not exceed 5 % when measured in accordance with 6.5.3. Measurements on coiled pipe shall be made on a sample cut from the coil.

NOTE 2—Other factors, that is, installation compaction, static soil loading, and dynamic vehicular loads may increase the ovality; therefore, 5 % was chosen as the limit for the amount contributed by manufacturing, packing, in-plant storage, and shipping. For further information, see the literature.[9]

5.3.1.6 *Length*—The pipe and tubing may be supplied in straight lengths or coils as agreed upon between the manufacturer and the purchaser. The length shall not be less than the minimum length agreed upon when corrected to 73°F (23°C).

5.3.1.7 When sizes other than those listed in Tables 1, 2, or 3 are used, tolerances shall be: for outside diameter, use same tolerance of next smaller size; for wall thickness, use same tolerance percentage as shown in the tables.

5.3.2 *Fittings*—Fittings shall meet the requirements given in the applicable Annex.

5.4 *Chemical Resistance*—The pipe, tubing, and fittings shall not increase in weight more than 0.5 % (1.0 % for toluene in methanol). Where the test specimen is a pipe ring, the material shall not change more than ±12 % in apparent

TABLE 3 Wall Thicknesses and Tolerances for Plastic Pipe, in. (mm)[A, B]

Nominal Pipe Size (IPS)	DR[C]	Minimum	Tolerance
1/2	D	0.062 (1.58)	+0.007 (+0.178)
	11.0	0.076 (1.93)	+0.009 (+0.229)
	9.33	0.090 (2.29)	+0.011 (+0.279)
3/4	D	0.090 (2.29)	+0.011 (+0.279)
	11.0	0.095 (2.41)	+0.011 (+0.279)
	Sch 40	0.113 (2.87)	+0.014 (+0.356)
1	D	0.090 (2.29)	+0.011 (+0.279)
	13.5	0.097 (2.46)	+0.012 (+0.305)
	11.0	0.119 (3.02)	+0.014 (+0.356)
	9.9	0.133 (3.38)	+0.016 (+0.406)
	9.33	0.140 (3.56)	+0.017 (+0.432)
1 1/4	D	0.090 (2.29)	+0.011 (+0.279)
	17.0	0.098 (2.49)	+0.012 (+0.305)
	13.5	0.123 (3.12)	+0.015 (+0.381)
	Sch 40	0.140 (3.56)	+0.017 (+0.432)
	11.0	0.151 (3.84)	+0.018 (+0.457)
	10.0	0.166 (4.22)	+0.020 (+0.508)
	9.33	0.178 (4.52)	+0.021 (+0.533)
	6.0	0.277 (7.04)	+0.033 (+0.838)
1 1/2	D	0.090 (2.29)	+0.011 (+0.279)
	17	0.112 (2.85)	+0.013 (+0.330)
	13.5	0.141 (3.58)	+0.017 (+0.432)
	Sch 40	0.145 (3.68)	+0.017 (+0.432)
	11	0.173 (4.39)	+0.021 (+0.533)
2	21	0.113 (2.87)	+0.014 (+0.356)
	17	0.140 (3.56)	+0.017 (+0.432)
	Sch 40	0.154 (3.91)	+0.018 (+0.457)
	13.5	0.176 (4.47)	+0.021 (+0.533)
	11	0.216 (5.49)	+0.026 (+0.660)
	9.33	0.255 (6.48)	+0.031 (+0.787)
2 1/2	21	0.137 (3.48)	+0.016 (+0.406)
	17	0.169 (4.29)	+0.020 (+0.508)
	13.5	0.213 (5.41)	+0.026 (+0.660)
	11	0.261 (6.63)	+0.031 (+0.787)
3	21	0.167 (4.24)	+0.020 (+0.508)
	17	0.206 (5.23)	+0.025 (+0.635)
	Sch 40	0.216 (5.49)	+0.026 (+0.660)
	13.5	0.259 (6.58)	+0.031 (+0.787)
	11.5	0.304 (7.72)	+0.036 (+0.914)
	11	0.318 (8.08)	+0.038 (+0.965)
	9.33	0.375 (9.53)	+0.045 (+1.143)
3 1/2	21	0.190 (4.83)	+0.023 (+0.584)
	17	0.236 (5.99)	+0.028 (+0.711)
	13.5	0.296 (7.52)	+0.036 (+0.914)
	11	0.363 (9.22)	+0.044 (+1.118)

Table 3 is continued

tensile yield strength when measured in accordance with 6.9. Where the test specimen is a plaque, the material shall not change more than ±12 % in tensile strength at yield when measured in accordance with Test Method D 638. See Annex A5 for specific requirements for polyamide pipe.

NOTE 3—This pipe/tubing test is only an indication of what will happen as a result of short term exposure to these chemicals. For long-term results, additional testing is required.

5.5 *Sustained Pressure*—The pipe, tubing, fittings, or systems shall not fail as defined in Test Method D 1598, when tested in accordance with 6.6.

5.6 *Elevated Temperature Service*—Plastic piping mate-

[9] Allman, W. B., "Earthloading Design Considerations for Polyethylene Gas Distribution Systems," *Proceedings of the Fifth Plastic Pipe Symposium*, Nov. 13–15, 1974, Houston, TX, A.G.A., 1515 Wilson Blvd., Arlington, VA 22209, p. 55–71.

TABLE 3 *Continued*

Nominal Pipe Size (IPS)	DR[C]	Minimum	Tolerance
4	21	0.214 (5.44)	+0.026 (+0.660)
	19	0.237 (6.02)	+0.028 (+0.711)
	17	0.264 (6.71)	+0.032 (+0.813)
	13.5	0.333 (8.46)	+0.040 (+1.016)
	11.5	0.391 (9.93)	+0.047 (+1.194)
	11.0	0.409 (10.39)	+0.049 (+1.246)
	9.33	0.482 (12.24)	+0.058 (+1.473)
5	21.6	0.258 (6.55)	+0.031 (+0.787)
	21	0.265 (6.73)	+0.032 (+0.813)
	17	0.328 (8.33)	+0.039 (+0.991)
	13.5	0.413 (10.49)	+0.050 (+1.270)
	11	0.506 (12.85)	+0.061 (+1.549)
6	32.5	0.204 (5.18)	+0.024 (+0.610)
	26	0.255 (6.48)	+0.031 (+0.787)
	23.7	0.280 (7.11)	+0.034 (+0.864)
	21	0.316 (8.03)	+0.038 (+0.965)
	17	0.390 (9.91)	+0.047 (+1.194)
	13.5	0.491 (12.47)	+0.059 (+1.499)
	11.5	0.576 (14.63)	+0.069 (+1.753)
	11.0	0.602 (15.29)	+0.072 (+1.829)
8	32.5	0.265 (6.73)	+0.032 (+0.813)
	26	0.332 (8.43)	+0.040 (+1.016)
	21	0.410 (10.41)	+0.049 (+1.245)
	17	0.508 (12.90)	+0.061 (+1.549)
	13.5	0.639 (16.23)	+0.077 (+1.956)
	11.5	0.750 (19.05)	+0.090 (+2.286)
	11	0.785 (19.94)	+0.094 (+2.388)
10	32.5	0.331 (8.41)	+0.040 (+1.016)
	26	0.413 (10.49)	+0.050 (+1.270)
	21	0.511 (12.98)	+0.061 (+1.549)
	17	0.633 (16.08)	+0.076 (+1.930)
	13.5	0.797 (20.24)	+0.096 (+2.438)
	11.5	0.935 (23.75)	+0.112 (+2.845)
	11	0.978 (24.84)	+0.117 (+2.972)
12	32.5	0.392 (9.96)	+0.047 (+1.194)
	26	0.490 (12.45)	+0.059 (+1.499)
	21	0.608 (15.44)	+0.073 (+1.854)
	17	0.750 (19.05)	+0.090 (+2.286)
	13.5	0.945 (24.00)	+0.113 (+2.870)
	11.5	1.109 (28.17)	+0.133 (+3.378)
	11	1.160 (29.46)	+0.139 (+3.531)

[A] The sizes listed in Table 3 are those commercially available sizes used by the gas industry.

[B] The minimum is the lowest wall thickness of the pipe at any cross section. The maximum permitted wall thickness, at any cross section, is the minimum wall thickness plus the stated tolerance. All tolerances are on the plus side of the minimum requirement.

[C] The DR shown are designations commonly accepted by the gas industry and do not calculate exactly.

[D] These wall thicknesses are minimum and are not a function of the dimension ratios.

rials intended for use at temperatures above 100°F (38°C) shall have the PPI recommended hydrostatic design basis (HDB) determined at the specific temperature in accordance with Test Method D 2837. The 100 000-h intercept (long-term strength) shall be categorized in accordance with Table 4 and be listed as the "hydrostatic design basis of XXX psi at XXX °F (C°) for (compound name)."

NOTE 4—Many design factors for elevated temperature service cannot be covered in this specification. Users should consult applicable codes for limitations on pertinent maximum temperatures.

NOTE 5—In the absence of a HDB established at the specified temperature, the HDB of a higher temperature may be used in determining a design pressure rating at the specified temperature by arithmetic interpolation.

5.7 *Minimum Hydrostatic Burst Pressure*—The burst requirements for plastic pipe and tubing shall be as given in the appropriate annexes.

~~5.8~~ *~~Apparent Tensile~~ Strength At Yield*—The minimum apparent tensile strengths at yield for plastic pipe and tubing are given in the annexes when determined in accordance with ~~6.8~~.

5.9 *Joints:*

5.9.1 *Solvent Cemented*—Joints of solvent cementable pipe and fittings shall be made in accordance with the user's written procedure.

5.9.2 *Heat Fusion:*

5.9.2.1 Heat fusion joints of thermoplastic pipe and fittings shall be made in accordance with Practice D 2657 and the user's written procedure.

5.9.2.2 PE butt fusion joining shall be between components (pipes, fittings, or valves) having the same SDR or DR. Butt fusion between unlike SDR or DR components shall be allowed only if it has been demonstrated that long term performance is not adversely affected. The minimum requirement to demonstrate long term performance shall be the validation procedure for PE in Test Method D 2837. The Hydrostatic Design Basis Category (HDBC) of the PE material shall be validated using specimens containing butt fusion joints resulting from different SDR's or DR's (pipe/pipe joints of the given PE material that pass shall validate pipe/pipe, pipe/fitting, or fitting/fitting joints of the same SDR ratio for that PE material).

5.9.3 *Mechanical*—Mechanical fittings shall be installed in accordance with the user's written procedures and the fitting manufacturer's recommended installation instructions. The joint shall be tested in accordance with the specific design category as outlined in 6.10.

5.10 *Plastic Valves*—All plastic gas valves shall meet the requirements of ANSI Standard B16.40.

6. Test Methods

6.1 *General*—The test methods in this specification cover plastic pipe, tubing, and fittings to be used for gas distribution. Test methods that are applicable from other specifications will be referenced in the paragraph pertaining to that particular test.

6.2 *Sampling*—Take a sample of the pipe, tubing, and fittings sufficient to determine conformance with this specification. About 40 ft (12 m) of pipe or tubing is required to make all the tests prescribed. The number of fittings required varies, depending upon the size and type of fitting. It is suggested that a sampling plan be agreed upon by the purchaser and the manufacturer (see Practice D 1898).

6.2.1 *Pipe Test Specimens*—Not less than 50 % of the test specimens required for any pressure test shall have at least a part of the marking in their central sections. The central section is that portion of pipe which is at least one pipe diameter away from an end closure.

6.3 *Conditioning*—Unless otherwise specified, condition the specimens prior to test at 73.4 ± 3.6°F (23 ± 2°C) and 50 ± 5 % relative humidity for not less than 40 h, in accordance with Procedure A of Practice D 618 for those tests where conditioning is required and in all cases of disagreement.

6.4 *Test Conditions*—Conduct the test in the standard laboratory atmosphere of 73.4 ± 3.6°F (23 ± 2°C) and 50 ± 5 % relative humidity, unless otherwise specified.

6.5 *Dimensions and Tolerances:*

6.5.1 *Pipe and Tubing*—Any length of pipe or tubing may be used to determine the dimensions. Coiled pipe shall be measured in the natural springback condition, unless specified otherwise.

6.5.1.1 *Diameter*—Measure the diameter of the pipe or tubing in accordance with Test Method D 2122. The average outside diameter for nonroundable pipe is the arithmetic average of the maximum and minimum diameters at any cross section on the length of the pipe. For roundable pipe the tolerances for out-of-roundness shall apply to measurements made after the pipe is rounded with the manufacturer's recommended equipment. See Test Method D 2122 for definitions of nonroundable and roundable pipe.

6.5.1.2 *Wall Thickness*—Make a minimum of six measurements at each cross section in accordance with Test Method D 2122.

6.5.1.3 *Wall Thickness Eccentricity Range*—Measure in a manner such that the maximum, *A*, and the minimum, *B*, wall thickness at single points of each cross section measured are obtained. Calculate the wall thickness eccentricity range, *E*, in percent for each cross section as follows:

$$E = [(A - B)/A] \times 100 \quad (1)$$

6.5.1.4 *Length*—Measure pipe or tubing length and other linear dimensions with a steel tape or other device, accurate to ±1/32 in. (±1 mm) in 10 ft (3 m).

6.5.2 *Fittings*—Measure the dimensions of fittings in accordance with Test Method D 2122.

6.5.3 *Ovality:*

6.5.3.1 *Apparatus*—A micrometer or vernier caliper accurate to within ±0.001 in. (±0.02 mm).

6.5.3.2 *Procedure*—Take a series of outside diameter (OD) measurements at closely spaced intervals around the circumference to ensure that the minimum and maximum diameters have been determined.

6.5.3.3 *Calculation*—Calculate the percent ovality as follows:

$$\% \text{ ovality} = \frac{\text{maximum OD} - \text{minimum OD}}{\text{minimum OD} + \text{maximum OD}} \times 200 \quad (2)$$

6.6 *Sustained Pressure Test:*

6.6.1 Select six test specimens of pipe, tubing, or fittings at random, condition at the standard laboratory test temperature and humidity, and pressure test in accordance with Test Method D 1598.

6.6.1.1 Test specimens shall be prepared so that the minimum length of pipe on each side of the fitting is equal to 5 times the diameter of the pipe but in no case less than 12 in. (304 mm) for sizes less than 6 in. For sizes 6 in. and larger, the minimum length shall be equal to 3 times the diameter or 30 in. (762 mm), whichever is shorter.

6.6.1.2 Pressures used shall be as shown in the annexes or as calculated (using the pipe or tubing's actual measured minimum wall thickness, outside diameter, and the applicable fiber stress shown in the annexes), whichever is greater. Piping intended for use at temperatures of 100°F (38°C) and higher shall be tested at both 73°F (23°C) and the maximum design temperature. The test fiber stress shall be the hydrostatic design basis (HDB) or 80 % of the 100 000-h intercept of the material, whichever is greater.

NOTE 6—Air, methane, or nitrogen may be substituted for water as the test medium.

6.6.2 Maintain the specimens at the pressures required, held to ±10 psi (0.07 MPa), for a period of 1000 h at the test temperature ±3.6°F (±2°C) as specified in 6.6.1.

6.6.3 Failure of two of the six specimens tested shall constitute failure in the test. Failure of one of the six specimens tested is cause for retest of six additional specimens. Failure of one of the six specimens in retest shall constitute failure in the test. Evidence of failure of the pipe shall be as defined in Test Method D 1598.

6.7 *Minimum Hydrostatic Burst Pressure (Quick Burst)*—The test equipment, procedures, and failure definitions shall be as specified in Test Method D 1599 and the annexes. Pressures shall be as shown in the Annexes or as calculated (using the pipe or tubing's actual measured minimum wall thickness, outside diameter, and the applicable fiber stress), whichever is greater.

6.8 *Apparent Tensile Properties*—The procedure and test equipment shall be as specified in Test Method D 2290, Procedure B. The speed of testing shall be 0.5 in. (12.7 mm)/min. Cut "ring" specimens from pipe or tubing. They shall be ½ in. (12.7 mm) wide with a ¼-in. (6.3-mm) wide reduced section. Test a minimum of five specimens. This method is applicable to all pipe and tubing of nominal ¾-in. (19.0-mm) outside diameter and larger.

6.9 *Chemical Resistance*—Determine the resistance to the following chemicals in accordance with Test Method D 543. Where available, the test specimen shall be a ring 2 in. SDR 11 pipe cut to the ring dimensions specified in 6.8. For materials that are not readily available as 2 in. SDR 11 pipe, the test specimen shall be a plaque of material ¼ by 2 by 4 in. (6.3 by 50.8 by 101.6 mm) with a 1 in. (25.4 mm) wide reduced section.

Chemicals	Concentration (% by volume)
Mineral oil (USP)	100
Tertiary-butyl mercaptan	5 in mineral oil
Antifreeze agents (at least one shall be used):	
Methanol, or	100
Ethylene glycol	100
Toluene	15 in methanol

Test five specimens with each chemical. Weigh the specimens to the nearest 0.005 g and completely immerse them in the chemicals for 72 h. On removal from the chemicals, wipe the specimens with a clean dry cloth. Condition in air for 2 to 2¼ h and reweigh. Calculate the increase in weight to the nearest 0.01 % on the basis of initial weight. Test the specimen in tension in accordance with 6.8 within ½ h after weighing. Examine the weight and apparent tensile strength of each specimen for conformance to the requirement in 5.4.

NOTE 7—**Caution:** Because of the possible toxicity of these reagents, refer to the Material Safety Data Sheet on each of these reagents before using or handling them.

6.10 *Categorization of Mechanical Joints*—The following test methods provide a uniform procedure for qualification or categorization of mechanical joints using short term pullout resistance tests and burst tests. The mechanical joint categories and test methods are as follows:

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

6.10.1.1 The apparatus and report shall be as specified in Test Method D 638. The test shall be conducted at ambient temperatures, that is, 67 ± 10°F (19.4 ± 5.6°C). The speed of the testing shall be 0.2 in. (5 mm)/min ± 25 %. Five specimens shall be prepared following the manufacturer's published installation instructions. Length of the specimens shall be such that the unreinforced distance between the grip of the apparatus and the end of the stiffener is at least five times the nominal outside diameter of the pipe size being tested. Apply a load until permanent deformation (yield) occurs in the unreinforced area of the piping or tubing.

6.10.1.2 Results obtained from the above method pertain only to the specific outside diameter, wall thickness, and compound of the piping or tubing used in the test and specific fitting design tested.

NOTE 8—The ability to restrain pipe or tubing to its yield as specified above does not guarantee that a properly installed joint will prevent pullout under actual long-term field conditions. Joints that cannot pass this test would be expected to pullout under actual long term field conditions. To date, this test is the best available for disqualifying unsound joints.

6.10.2 *Category 2*—A mechanical joint design that provides a seal only (see Appendix X2.5.5). A mechanical joint designed for this category excludes any provisions in the design or installation of the joint to resist any axial pullout forces; therefore, tensile tests are not required.

6.10.2.1 The test assembly shall meet the burst test requirements of 5.7 when tested in accordance with Test Method D 1599 with end closures designed in accordance with Test Method D 1599.

6.10.3 *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 (see Appendix X2.4). This category has a manufacturer's rated pipe end restraint less than the value required to yield the pipe as outlined in 6.10.1 (Category 1).

6.10.3.1 The procedures and testing shall be the same as outlined in 6.10.1 (Category 1) except the test tensile values shall meet the rated values published by the mechanical fitting manufacturer.

7. Marking

7.1 *Pipe*—All required marking shall be legible, visible, and permanent. To ensure permanence, marking shall be applied so it can only be removed by physically removing part of the pipe wall. The marking shall (1) not reduce the wall thickness to less than the minimum value for the pipe, (2) not have any effect on the long-term strength of the pipe, and (3) not provide leakage channels when elastomeric gasket compression fittings are used to make the joints. These marking shall consist of the word GAS, the designation ASTM D 2513, the manufacturer's name or trademark, the normal pipe size including the sizing system used (IPS, CTS, or OD), DR or minimum wall thickness, material designation, and date of manufacture.

7.1.1 In addition to 7.1, the pipe marking shall include a coding that will enable the manufacturer to determine the location of manufacture, pipe production and resin lots, and any additional information which may be agreed upon between the manufacturer and purchaser. The manufacturer shall maintain such records for fifty years or for the design service life of the pipe, whichever is longer.

7.1.2 All the markings in 7.1 and 7.1.1 shall be repeated at intervals not exceeding 5 ft (1.5 m). For indented printing, either the indented print line shall be in a color that contrasts with that of the pipe, or a separate print line (that may be non-permanent) shall be in a color that contrasts with the pipe. See Annexes A1 and A2 for possible additional specific marking requirements.

7.2 Pipe intended for natural gas service at elevated temperatures greater than 73°F (23°C) shall be marked with additional code letters from Table 4 (the first code letter to identify the temperature of pressure rating, the second code letter to identify HDB at highest recommended temperature, and the third code letter to identify the melt index).

7.3 *Fittings*—Fittings shall be marked with the applicable Fitting Specification if those specifications require fittings used for gas service to meet this specification. Otherwise they shall be marked ASTM D 2513.

8. Quality Assurance

8.1 When the product is marked with this designation, D 2513, the manufacturer affirms that the product was manufactured, inspected, sampled, and tested in accordance with this specification and has been found to meet the requirements of this specification.

TABLE 4 Pipe Category

Property	Test Method	Category						
		A	B	C	D	E	F	G
Temperature, °F (°C)	...	100(38)	120(49)	140(60)	160(71)	180(82)	...	...
Hydrostatic design basis, psi (MPa)	D 2837	400(2.8)	500(3.4)	630(4.3)	800(5.5)	1000(6.9)	1250(8.6)	1600(11.0)
Melt index	D 1238	>0.5	0.2-0.5	0.01–0.3	<0.01[A]	...	...	...

[A] Typically melt flow measured under condition 190/21.6 is less than 4.01 g/10 min.

Examples: CDB – At 140°F (60°C) the HDB is 800 psi (5.5 MPa) The approximate melt index range is 0.2 to 0.5 g/10 min for this PE pipe.
DF – At 160°F (71°C) the HDB is 1250 psi (8.6 MPa). A melt index range is not given for non-PE materials.

SUPPLEMENTARY REQUIREMENT

GOVERNMENT/MILITARY PROCUREMENT

These requirements apply only to federal/military procurement, not domestic sales or transfers.

S1. *Responsibility for Inspection*—Unless otherwise specified in the contract or purchase order, the producer is responsible for performance of all inspection and test requirements specified herein. The producer may use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless the purchaser disapproves. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to ensure that material conforms to prescribed requirements.

NOTE S1—In U.S. federal contracts, the contractor is responsible for inspection.

S2. *Packaging and Marking for U.S. Government Procurement:*

S2.1 *Packaging*—Unless otherwise specified in the contract, the materials shall be packaged in accordance with the supplier's standard practices in a manner ensuring arrival at destination in satisfactory condition and which will be acceptable to the carrier at lowest rates. Containers and packing shall comply with Uniform Freight Classification rules or National Motor Freight Classification rules.

S2.2 *Marking*—Marking for shipment shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD 129 for military agencies.

NOTE S2—The inclusion of U.S. Government procurement requirements should not be construed as an indication that the U.S. Government uses or endorses the products described in this specification.

ANNEXES

(Mandatory Information)

A1. SUPPLEMENTAL REQUIREMENTS FOR GAS PRESSURE PIPE, TUBING, AND FITTINGS PRODUCED FROM POLYETHYLENE (PE) MATERIAL

A1.1 Scope

A1.1.1 This annex covers requirements for PE pipe, tubing, and fittings. These requirements are in addition to those in the main body of this specification.

NOTE A1.1—Because Table 1, which covers nominal pipe sizes up to 12 in. is in the body of this specification, and Table A1.3 is in Annex A1, the user should be aware of the larger tolerance allowed the larger pipe.

A1.2 Referenced Documents

A1.2.1 *ASTM Standards:*

A1.2.1.1 *Test Methods for:*

D 1238 Flow Rate of Thermoplastics by Extrusion Plastometers[3]

A1.2.1.2 *Specification for:*

D 1248 Polyethylene Plastics Molding and Extrusion Materials[3]

D 2683 Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing[2]

D 3261 Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing[2]

D 3350 Polyethylene Plastic Pipe and Fittings Materials[3]

F 1055 Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing[3]

TABLE A1.1 Specification D 3350 Cell Classifications of Polyethylene Pipe Tubing and Fittings Materials

PE Material Designation Code:	PE2406	PE3408
Physical Properties:		
Density	2	3
Melt index	1, 2, or 3	3, 4, or 5
Flexural modulus	3 or 4	4 or 5
Tensile strength	3 or 4	4 or 5
Environmental stress crack resistance	3	3
Hydrostatic design basis	3	4

A1.3 Materials

A1.3.1 *Classification*—Polyethylene materials suitable for use in the manufacture of pipe, tubing, and fittings under this specification shall be classified in accordance with Specification D 3350 and as shown in Table A1.1. *Example:* for a polyethylene material having an HDB of 1250 psi (8.6 MPa), Cell Class 3, the base resin density must have a cell classification of 2 or 3; the melt index classification must be 1, 2, 3, 4, 5, or 6; etc.

A1.3.2 *Short and Long Term Properties*—Polyethylene pipe, tubing, and fittings shall be made from PE materials which also satisfy the combinations of short- and long-term property requirements shown in Table A1.2.

A1.3.3 *Hydrostatic Design Basis Substantiation*—The HDB for PE materials for transport of natural gas or other fuel gas at 73°F (23°C) shall be substantiated by additional long-term stress rupture testing at 140°F (60°C) with natural

TABLE A1.2 Short and Long Term Property Requirements

PE Material Designation Code	Short-Term in Accordance with D 1248	Long-Term in Accordance with D 2837[A]
PE 2406	Grade P 24	HDB of 1250 psi for 73°F
PE 3408	Grade P 34	HDB of 1600 psi for 73°F

[A] The hydrostatic design basis (HDB) shall be established using water or natural gas as the pressurizing fluid.

TABLE A1.3 Outside Diameters and Tolerances, 14 In. and Larger Pipe

Nominal Pipe Size	Actual Outside Diameters, in. (mm)	
	Average	Tolerance
14	14.000 (355.6)	±0.063 (±1.60)
16	16.000 (406.4)	±0.072 (±1.83)
18	18.000 (457.2)	±0.081 (±2.06)
20	20.000 (508.0)	±0.090 (±2.29)
22	22.000 (558.8)	±0.099 (±2.51)
24	24.000 (609.6)	±0.108 (±2.74)

gas or other fuel gas. The data are evaluated in accordance with the requirements of Test Method D 2837 with the 100 000-h intercept not less than 600 psi. Water may be used where previous tests have shown that these requirements can be met.

A1.3.4 *Additive Classes*—PE materials shall be either Class B with antioxidant and UV stabilizer, or C as defined in Specification D 1248, or Class C or E as defined in Specification D 3350.

A1.4 Fittings

A1.4.1 PE fittings intended for use with the corresponding sized outside-diameter PE pipe shall meet the requirements of Specification D 2683 for socket-type fittings, Specification D 3261 for butt-type fittings, or Specification F 1055 for electrofusion-type fittings and the requirements of this specification.

A1.5 Requirements for Pipe and Fittings

A1.5.1 *Conditioning*—For those tests where conditioning is required or unless otherwise specified, condition the specimens prior to testing for a minimum of 1 h in water or 4 h in air at 73.4 ± 3.6°F (23 ± 2°C) or in accordance with 6.3. The conditioning requirements of 6.3 shall be used in all cases of disagreement.

A1.5.2 *Minimum Hydrostatic Burst Pressure/Apparent Tensile Strength (Quick Burst)*—The pipe or system shall fail in a ductile manner when tested in accordance with Test Method D 1599. For pipe sizes above 4-in. nominal diameter, the quick burst test (Test Method D 1599) may be replaced by the apparent ring tensile strength test (Test Method D 2290). The minimum apparent tensile strength at yield when determined in accordance with 6.8 shall be 2520 psi (17.4 MPa).

A1.5.3 *Sustained Pressure 73°F (23°C)*—The pipe or system shall not fail in less than 1000 h when tested in accordance with Test Method D 1598. For PE 2406 material, the stress shall be 1320 psi, for PE 3408 materials, the stress shall be 1600 psi.

A1.5.4 *Melt Index*—Melt index is the flow rate of PE material when measured in accordance with Test Method D 1238, condition 190/2.16 (formerly Condition E). Materials that record zero flow under condition 190/2.16 should be measured in accordance with condition 190/21.6 (formerly condition F). The melt index of pipe/fitting shall meet the designated category in Table 4. The sample shall be representative of the cross section of the pipe or fitting and diced to an appropriate size by a method not producing heat.

A1.5.5 *Squeeze-Off*—This requirement is limited to pipe sizes, wall thicknesses, squeeze procedures, and conditions deemed suitable for squeeze-off in service by the pipe manufacturer. There shall be no leakage or visual evidence of splitting, cracking, breaking or reduction in 1000-h sustained pressure category when pipe is tested as follows:

A1.5.5.1 Prepare six randomly selected pipe specimens in accordance with Test Method D 1598 except they shall be unfilled.

A1.5.5.2 The squeeze-off shall be effected at the midpoint of the test specimen, 90° to the point of the measured minimum wall thickness. Close the squeeze bars to the gap stop recommended by the pipe manufacturer and hold in constraint for four hours. Remove squeeze bars and reround pipe by closing squeeze bars at a point 90° from the squeeze area.

A1.5.5.3 Immediately upon removal of the squeeze-off tool, fill the specimens with room temperature water, condition, and test in accordance with 6.6

A1.5.6 *Thermal Stability*—The PE material shall contain sufficient antioxidant so that the minimum induction temperature shall be 428°F (220°C) when tested in accordance with Specification D 3350. The sample shall be representative of the cross section of the pipe or fittings.

A1.5.7 *Outdoor Storage Stability*—PE pipe stored outdoors and unprotected for at least two years from date of manufacture shall meet all the requirements of this specification. PE pipe stored outdoors for over two years from date of manufacture may be used if it meets the requirements of this specification.

A1.5.8 *Dimensions and Tolerances*—The outside diameter shall meet the requirements in Tables 1 and 2 in the main body for sizes up to 12 in., or in Table A1.3 for larger sizes. The minimum wall thickness shall meet the requirements in Tables 2 and 3 in the main body for sizes up to 12 in., or in Table A1.4 for larger sizes. When sizes other than those listed in these tables are used, the tolerances of the next lower size shall be used.

A1.5.9 *Short Term Pressurization for Sizes Above 12 in.*—Pipe and molded or fabricated fittings shall not fail when tested in accordance with Test Method D 1599 with the hoop stress of 2500 psi for Class 2 density materials or 2900 psi for Class 3 density materials. Hoop stress calcula-

TABLE A1.4 Minimum Wall Thickness and Tolerance, 14 In. and Larger Pipe, In.

Nominal Pipe Size	SDR 32.5	SDR 26	SDR 21	SDR 17	DR 15.5	SDR 13.5	SDR 11	SDR 9	SDR 7.3
14	0.431 +0.052	0.538 +0.065	0.667 +0.080	0.824 +0.099	0.903 +0.108	1.037 +0.124	1.273 +0.153	1.556 +0.187	1.918 +0.230
16	0.492 +0.059	0.615 +0.074	0.762 +0.091	0.941 +0.113	1.032 +0.124	1.185 +0.142	1.455 +0.175	1.778 +0.213	...
18	0.554 +0.066	0.692 +0.083	0.857 +0.103	1.059 +0.127	1.161 +0.139	1.333 +0.160	1.636 +0.196	2.000 +0.240	...
20	0.615 +0.074	0.769 +0.092	0.952 +0.114	1.176 +0.141	1.290 +0.155	1.481 +0.178	1.818 +0.218	...	...
22	0.677 +0.081	0.846 +0.102	1.048 +0.126	1.294 +0.155	1.419 +0.170	1.630 +0.196	2.000 +0.240	...	...
24	0.738 +0.089	0.923 +0.111	1.143 +1.137	1.412 +0.169	1.548 +0.186	1.778 +0.213	2.182 +0.262	...	...

tion shall be based on the DR of the fitting at the point of fusion.

NOTE A1.2—The requirements in A1.5.8 are for laboratory proof testing only and should not be interpreted as applicable to on-site testing for acceptance of installed systems larger than 12 in. See appropriate installation standards or manufacturer's recommendations for field test procedures.

NOTE A1.3—Safety Precaution—Pressurization of pipe specimens above 12 in. nominal diameter being tested in accordance with A1.5.8 should not commence until it is certain that all entrapped air has been bled from the water-filled specimens.

A1.5.10 *HDBC Validation for PE Pipe*—The 73°F (23°C) Hydrostatic Design Basis Category (HDBC) of PE pipe shall be validated by the pipe producer using the PE validation procedure as outlined in Test Method D 2837. For PE 2406 materials, the HDBC of 1250 psi shall be validated; for PE 3408 materials, the HDBC of 1600 psi shall be validated.

A1.6 Marking

A1.6.1 PE pipe and tubing shall be marked with the melt index category in accordance with Table 4 in addition to the marking requirements of 7.1.

A2. SUPPLEMENTAL REQUIREMENTS FOR GAS PRESSURE PIPE, TUBING, AND FITTINGS PRODUCED FROM POLY (VINYL CHLORIDE) (PVC) COMPOUNDS

A2.1 Scope

A2.1.1 This annex covers requirements for PVC pipe, tubing, and fittings. These requirements are in addition to those in the main body of this specification.

A2.2 Referenced Documents

A2.2.1 *ASTM Standards:*

A2.2.1.1 *Specifications for:*

D 1784 Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds[2]

D 2241 Poly (Vinyl Chloride) (PVC) Pressure-Related Pipe (SDR-PR)[2]

D 2466 Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40[2]

D 2467 Socket Type Poly (Vinyl Chloride) (PVC) Plastic Fittings, Schedule 80[2]

D 2564 Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems[2]

D 2672 Joints for IPS PVC Pipe Using Solvent Cement[2]

D 2740 Poly (Vinyl Chloride) (PVC) Plastic Tubing[2]

A2.2.1.2 *Test Methods and Practices:*

D 2152 Degree of Fusion of Extruded Poly (Vinyl Chloride) (PVC) Pipe by Acetone Immersion[2]

D 2412 Determination of External Loading Properties of Plastic Pipe by Parallel Plate Loading[2]

D 2444 Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)[2]

D 2855 Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings[2]

F 402 Safe Handling and Solvent Cements Used for Joining Thermoplastic Pipe and Fittings[2]

A2.3 Materials

A2.3.1 PVC pipe, tubing, and fittings shall be made from the following PVC plastics as defined in Specification D 1784.

Type I, Grade 1, Class 12454B (PVC 11)
Type I, Grade 2, Class 12454C (PVC 12)
Type II, Grade 1, Class 14333D (PVC 21)

A2.4 Requirements

A2.4.1 Requirements for plain end pipe and tubing are specified in Specification D 2241. Belled end pipe requirements are specified in Specification D 2672. Fitting requirements are specified in Specification D 2466 for schedule 40 and Specification D 2467 for schedule 80. These fittings are intended for use with corresponding sized outside diameter pipe made from the same compound. The following additional requirements shall also be met.

A2.4.1.1 *Flattening*—There shall be no evidence of splitting, cracking, or breaking by the specimens subjected to this test and performed in accordance with Test Method D 2412. Flatten three specimens of the pipe, 2 in. (50.8 mm) long, between parallel plates in a suitable press until the distance between the plates is 40 % of the outside diameter of the pipe or the walls of pipe touch. The rate of loading shall be uniform and such that the compression is completed within 2 to 5 min. On removal of the load, examine the specimens for evidence of splitting, cracking, or breaking.

A2.4.1.2 *Impact Resistance*—The impact resistance for PVC pipe shall fall within the range specified by the manufacturer's designated Impact Classification Cell (IC). Table A2.1 lists impact classification cell for SDR 17 and 21 pipe. The impact classification rating for PVC pipe shall be determined in accordance with Test Method D 2444 using a flat plate holder and 20-lb tup B for sizes 2 in. and less and 30-lb tup B for all larger sizes. The specimens shall be conditioned in a mixture of ice and water at 32 to 35°F (0 to

TABLE A2.1 Impact Requirements for PVC Pipe at 32 to 35°F (0 to 2°C) for SDR 17 and 21 Pipe

Impact Classification Cell	ft·lbf (J)		
	IC-1	IC-2	IC-3
Nominal Pipe Size, in.			
1	30 to 50 (41 to 68)	>50 to 65 (68 to 88)	>65 (88)
1¼	30 to 51 (41 to 68)	>50 to 65 (68 to 88)	>65 (88)
1½	40 to 60 (54 to 81)	>60 to 75 (81 to 102)	>75 (102)
2	70 to 90 (95 to 122)	>90 to 100 (122 to 136)	>100 (122)
3	120 to 140 (163 to 190)	>140 to 180 (190 to 244)	>180 (244)
4	160 to 200 (217 to 271)	>200 to 240 (271 to 326)	>240 (326)
6	200 to 260 (271 to 353)	>260 to 300 (353 to 407)	>300 (407)

TABLE A2.2 Minimum Burst Pressure Test Requirements for PVC Pipe at 73°F (23°C)

Standard Dimension Ratio	Minimum Burst Pressure, psi (MPa)	
	PVC 1120 PVC 1220	PVC 2110 PVC 2116
11	1250 (8.6)	1000 (6.9)
13.5	1000 (6.9)	800 (5.5)
17	800 (5.5)	630 (4.3)
21	630 (4.3)	500 (3.4)

2°C) for 1 h (Note A2.1) and tested immediately on removal from this medium.

NOTE A2.1—Other conditioning media such as a refrigerated fluid bath of water and ethylene glycol at 32 to 35°F (0 to 2°C) for 1 h or a refrigerated air chamber at 32 to 35°F (0 to 2°C) for 4 h may be used if it can be demonstrated that equivalent results are obtained. However, in cases of disagreement, the ice water mixture shall be used.

A2.4.1.3 *Impact Quality Assurance*—The impact quality assurance is a GO/NO GO test. Five specimens shall be impacted in accordance with Test Method D 2444 using the tup and holder specified in A2.4.1.2 from a height determined by the lower value of the designated Impact Classification (IC) cell. All five specimens shall pass. If one specimen fails, a second set of five specimens shall be tested. None of the second set shall fail. If nine out of the total ten specimens pass, the lot shall be considered to have met the requirements of this test.

NOTE A2.2—This test is intended only for use as a quality control test, not for use as a simulated service test.

A2.4.1.4 *Extrusion Quality*—PVC pipe shall not flake or disintegrate when tested in accordance with the Test Method D 2152.

A2.4.1.5 *Outdoor Storage Stability*—PVC pipe when stored outdoors unprotected for six months from the date of extrusion shall meet all the requirements of this specification. PVC pipe stored outdoors for over six months from date of manufacture, may be used if it meets the requirements of this specification.

TABLE A2.3 Minimum Fiber Stress, psi (MPa)

	Minimum Hydrostatic Burst Strength and Apparent Tensile Tests	Sustained Pressure Test
PVC 1120	6400 (44.1)	4200 (29.0)
PVC 1220	6400 (44.1)	4200 (29.0)
PVC 2110	5000 (34.5)	2300 (15.9)
PVC 2116	5000 (34.5)	3650 (23.2)

A2.4.1.6 *Solvent Cements for PVC Systems*—Solvent cements for PVC pipe and fittings shall meet the requirements of Specification D 2564.

A2.4.1.7 *Marking*—Impact Classification Cell, as determined by the manufacturer, shall be printed on the pipe in addition to the marking requirements of 7.1.

A2.4.1.8 *Minimum Hydrostatic Burst Strength/Apparent Tensile Strength*—The minimum burst pressure for PVC pipe shall be as given in Table A2.2 or as calculated (using the actural measured minimum wall, the actual measured average outside diameter, and the applicable fiber stress shown in Table A2.3) when determined in accordance with Test Method D 1599. For sizes above 4-in. nominal diameter, the quick burst (Test Method D 1599) may be replaced by the apparent ring tensile strength test (Test Method D 2290). The minimum fiber stress shall be as given in Table A2.3.

A2.4.1.9 *Sustained Pressure 73°F (23°C)*—The pipe or system shall not fail in less than 1000 h when tested in accordance with Test Method D 1598. The stress shall be as given in Table A2.3.

A2.5 Safety Requirements

A2.5.1 Safety requirements for handling solvent cements must be observed. Consult Practice F 402 and the solvent cement manufacturer for appropriate precautions.

A3. IN-PLANT QUALITY CONTROL PROGRAM FOR PLASTIC PIPE, TUBING, AND FITTINGS UP TO AND INCLUDING 12 IN. NOMINAL DIAMETER

A3.1 Quality Control

A3.1.1 The following in-plant quality control program shall be used to assure compliance with this specification. The pipe and fittings producers shall maintain records on all aspects of this program and supply these to the purchaser, if requested.

A3.1.2 *In-Plant Quality Control Test Methods*—Test methods other than those specified in Section 6 may be used as long as they provide equivalent results. In case of disagreement, those test methods in the applicable ASTM standard shall be used.

A3.2 Pipe and Tubing Tests

A3.2.1 *Material and Extrusion Process Qualification*—Sustained pressure tests shall be made on one pipe or tubing size in the range of 2 in., or less, and on one pipe size in the range of 2½ in., or greater. This test shall also be made on pipe and tubing from each particular commercial plastic resin initially, and at least twice a year thereafter for material and extrusion process qualification and not as a quality control on the product. This test shall be made in accordance with 6.6.1, 6.6.1.1 and 6.6.3 using either of the test conditions in Table A3.1.

A3.2.2 *Product Quality Control* (Note A3.1)—The tests in Table A3.2 shall be made per size per extrusion die at the denoted frequencies and the test results recorded and filed for inspection on request.

NOTE A3.1—When the pipe or tubing fails to meet this specification in any test, additional tests shall be made on the pipe or tubing produced back to the previous acceptable result to select the pipe or tubing

TABLE A3.1 Material and Extrusion Process Qualification Test Conditions[A]

Temperature	Stress	Time Requirement
176 ± 3.6°F (80 ± 2°C)	580 ± 10 psi (4.0 ± 0.07 MPa)	1000 h
176 ± 3.6°F (80 ± 2°C)	670 ± 10 psi (4.6 ± 0.07 MPa)	170 h

[A] Methane should not be substituted for water in this 176°F (80°C) test.

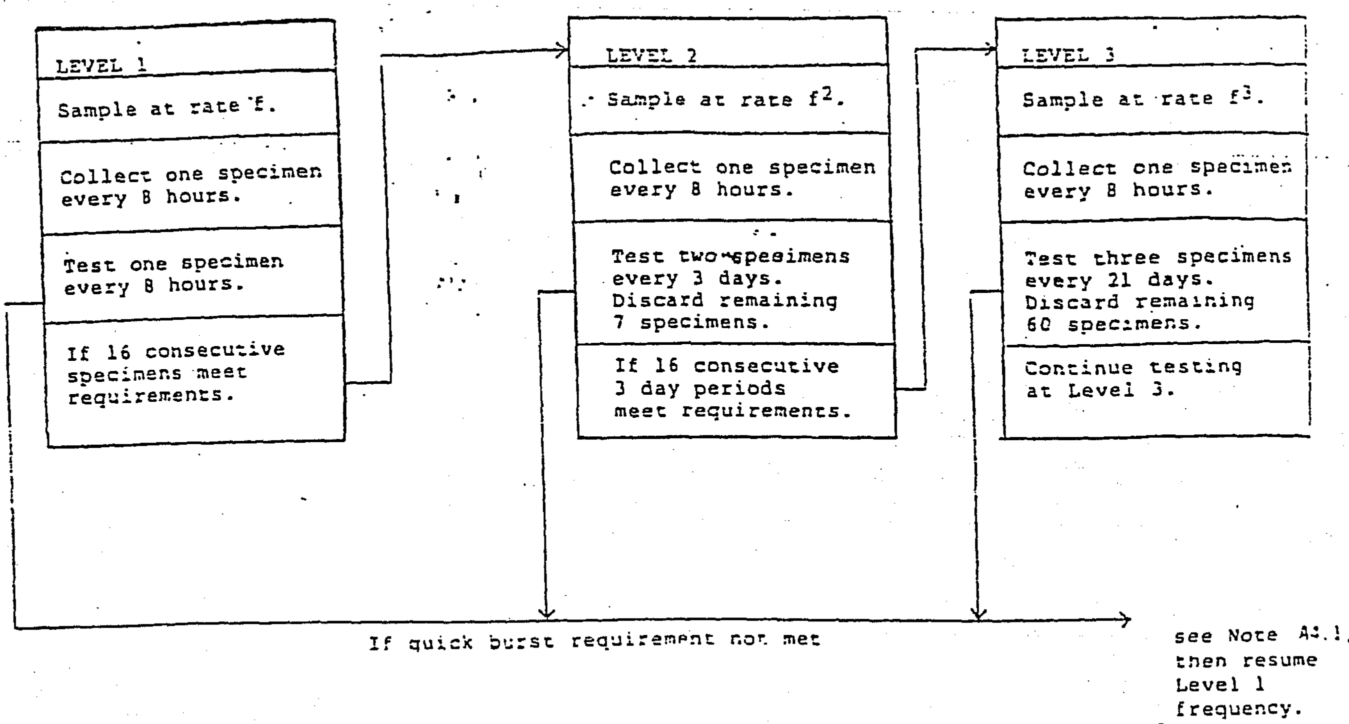

FIG. A3.1 Quick Burst Multilevel Sampling Plan

TABLE A3.2 Product Quality Control Tests

Property	Frequency
Diameter	Once every hour or once every coil, whichever is less frequent.
Wall thickness	Once every hour or once every coil, whichever is less frequent.
Burst pressure (see Note A4.2)	Once every 8 h or once every coil, whichever is less frequent, or multi-level plan described in A4.2.3.
Flattening (PVC Only)	Once every 8 h
Extrusion quality (PVC only)	Once every 2 h
Impact resistance (PVC Only)	Once every hour

produced in the interim that does pass the requirement. Pipe or tubing that does not meet the requirement shall be rejected.

NOTE A3.2—For pipe sizes above 4 in. nominal diameter, the quick burst test (Test Method D 1599) may be replaced by the Apparent Ring Tensile Strength Test (Test Method D 2290) if agreed to between the purchaser and the manufacturer.

A3.2.3 *Burst Pressure Multilevel Plan* (see Fig. A3.1)—This multilevel plan is based on MIL-STD-1235 (ORD), and may be used only when the same product is extruded continuously under the same operating conditions and production is at a steady rate. Before this reduced sampling plan may be considered, steady production conditions must be carefully chosen to ensure a continuous and consistent high quality output. Any interruption (shutdown) or change in resin lot number, percentage rework, or production conditions outside normal operating variations shall cause sampling to revert to Level 1. A sampling level change may be considered only when approved by a production supervisor or authorized quality control personnel.

Level 1 Test one specimen every 8 h. If 16 consecutive specimens have met requirements, proceed to Level 2.

Level 2 Collect one specimen every 8 h. After 72 h (3 days) or portion thereof, test two randomly selected specimens. If both pass, discard the remaining 7 specimens. If any specimen fails to meet requirements, revert to Level 1 (see also Note A2.1). Product for which a specimen has been collected should not be shipped until after the 72-h time period and randomly selected samples have been tested. Continue to test 2 out of 9 specimens for 16 three-day periods (48 days of production), then proceed to Level 3.

Level 3 Collect one specimen every 8 h. After 21 days or portion thereof, test three randomly selected specimens. If all three pass, discard the remaining specimens. If any specimen fails to meet requirements, revert to Level 1 (see also Note A3.1). Product for which a specimen has been collected shall not be shipped until after the 21-day time period. Continue testing at Level 3 until production conditions necessitate reverting to Level 1.

A3.3 Fittings Tests[10]

A3.3.1 The fittings tests listed in the following subparagraphs should be conducted at the frequencies indicated.

NOTE A3.3—When any fitting fails to meet the requirements of this specification, or the applicable referenced fitting specification, additional tests should be made on fittings produced back to previous acceptable result to select the fittings produced in the interim that do meet the requirements. Fittings that do not meet the requirements shall be rejected.

A3.3.1.1 *Dimensions:*

A3.3.1.1(*a*) *Socket Fittings:*

(*1*) *Socket Entrance, Bottom and Minimum Internal Diameters*—Once an hour or one out of ten fittings, whichever is less frequent.

(*2*) *Wall Thickness*—At the beginning of each production setup for each cavity.

[10] Supporting data are available from ASTM Headquarters. Request RR: F17-1018.

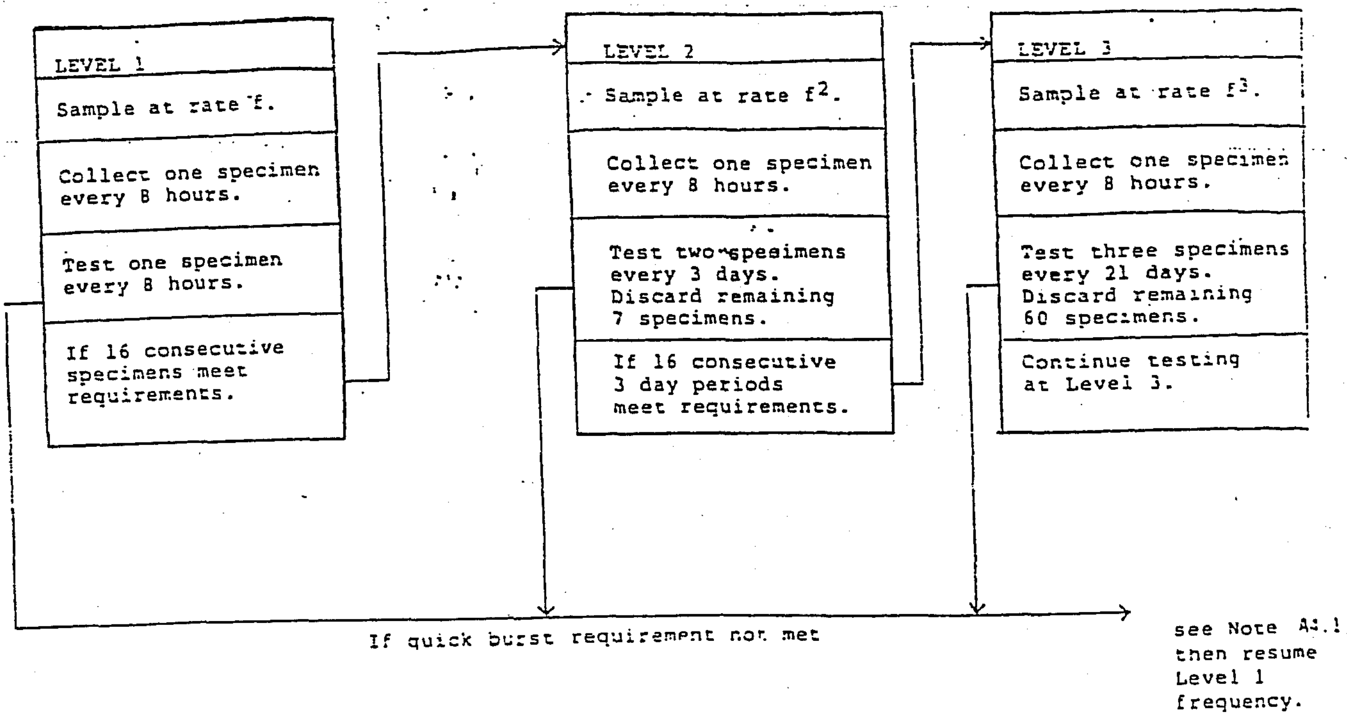

FIG. A3.1 Quick Burst Multilevel Sampling Plan

TABLE A3.2 Product Quality Control Tests

Property	Frequency
Diameter	Once every hour or once every coil, whichever is less frequent.
Wall thickness	Once every hour or once every coil, whichever is less frequent.
Burst pressure (see Note A4.2)	Once every 8 h or once every coil, whichever is less frequent, or multilevel plan described in A4.2.3.
Flattening (PVC Only)	Once every 8 h
Extrusion quality (PVC only)	Once every 2 h
Impact resistance (PVC Only)	Once every hour

produced in the interim that does pass the requirement. Pipe or tubing that does not meet the requirement shall be rejected.

NOTE A3.2—For pipe sizes above 4 in. nominal diameter, the quick burst test (Test Method D 1599) may be replaced by the Apparent Ring Tensile Strength Test (Test Method D 2290) if agreed to between the purchaser and the manufacturer.

A3.2.3 *Burst Pressure Multilevel Plan* (see Fig. A3.1)—This multilevel plan is based on MIL-STD-1235 (ORD), and may be used only when the same product is extruded continuously under the same operating conditions and production is at a steady rate. Before this reduced sampling plan may be considered, steady production conditions must be carefully chosen to ensure a continuous and consistent high quality output. Any interruption (shutdown) or change in resin lot number, percentage rework, or production conditions outside normal operating variations shall cause sampling to revert to Level 1. A sampling level change may be considered only when approved by a production supervisor or authorized quality control personnel.

Level 1 Test one specimen every 8 h. If 16 consecutive specimens have met requirements, proceed to Level 2.

Level 2 Collect one specimen every 8 h. After 72 h (3 days) or portion thereof, test two randomly selected specimens. If both pass, discard the remaining 7 specimens. If any specimen fails to meet requirements, revert to Level 1 (see also Note A2.1). Product for which a specimen has been collected should not be shipped until after the 72-h time period and randomly selected samples have been tested. Continue to test 2 out of 9 specimens for 16 three-day periods (48 days of production), then proceed to Level 3.

Level 3 Collect one specimen every 8 h. After 21 days or portion thereof, test three randomly selected specimens. If all three pass, discard the remaining specimens. If any specimen fails to meet requirements, revert to Level 1 (see also Note A3.1). Product for which a specimen has been collected shall not be shipped until after the 21-day time period. Continue testing at Level 3 until production conditions necessitate reverting to Level 1.

A3.3 Fittings Tests[10]

A3.3.1 The fittings tests listed in the following subparagraphs should be conducted at the frequencies indicated.

NOTE A3.3—When any fitting fails to meet the requirements of this specification, or the applicable referenced fitting specification, additional tests should be made on fittings produced back to previous acceptable result to select the fittings produced in the interim that do meet the requirements. Fittings that do not meet the requirements shall be rejected.

A3.3.1.1 *Dimensions:*

A3.3.1.1(*a*) *Socket Fittings:*

(1) *Socket Entrance, Bottom and Minimum Internal Diameters*—Once an hour or one out of ten fittings, whichever is less frequent.

(2) *Wall Thickness*—At the beginning of each production setup for each cavity.

[10] Supporting data are available from ASTM Headquarters. Request RR: F17-1018.

A3.3.1.1(*b*) *Butt Fusion Fittings:*

(1) *Outside Diameter and Wall Thickness*—Once an hour or one out of ten fittings, whichever is less frequent.

A3.3.1.2 *Other Tests:*

A3.3.1.2(*a*) *PVC Fittings*—The burst pressure shall be measured on one fitting per 8-h production.

A3.3.1.2(*b*) *PE and PB Fittings*—At the start of each production run, whenever production conditions have changed, or when the resin lot is changed, but not less frequently than once per 500 fittings thereafter, the following tests should be made:

(1) The knit line strength for at least one fitting from each cavity should be demonstrated by one of the following tests:

(*a*) Crushing a fitting, or a portion of a fitting, in a manner that applies load in the direction normal to the knit line. See Note A3.4.

(*b*) Apparent tensile strength tests of a ring cut from a fitting, with the load oriented normal to the knit line. See Note A3.5.

(*c*) Burst testing of the fitting. See Note A3.5.

(2) The integrity of at least one part from each mold cavity should be verified, using a method selected by the manufacturer as appropriate for his specific product and process.

NOTE A3.4—Separation in the knit constitutes a failure.

NOTE A3.5—In tests 2 and 3 the strength requirements shown in the annexes must be met.

A4. IN-PLANT QUALITY CONTROL PROGRAM FOR 14-IN. AND LARGER DIAMETER POLYETHYLENE PIPE

A4.1 Visual inspection of every length of pipe for workmanship defects shall be carried out at the manufacturer's plant. Measurements of outside diameter and wall thickness shall be made for each hour's production or each length of pipe, whichever is less frequent.

A4.2 Lengths of pipe that are shorter than standard shipping lengths may be butt-fused to produce standard lengths. Such build-up lengths must otherwise meet all of the product requirements of this specification.

A4.3 Manufacturers of pipe shall conduct such other quality control tests as are appropriate to their manufacturing operations that will provide assurance that the product requirements of A1.5 will be met in place of the actual performance of the specified tests.

NOTE A4.1—The pressure tests required under product requirements are tests for performance. These tests are not adaptable to in-plant quality control. Quality control tests have not been standardized because the requirements for such tests vary substantially from one manufacturing plant to another.

A5. SUPPLEMENTAL REQUIREMENTS FOR GAS PRESSURE PIPE, TUBING, AND FITTINGS PRODUCED FROM POLYAMIDE MATERIAL

A5.1 Scope

A5.1.1 This annex covers requirements for PA pipe, tubing, and heat fusion fittings. These requirements are in addition to those in the main body of this specification.

A5.2 Referenced Documents

A5.2.1 *ASTM Standards:*

D 4066 Specification for Nylon Injection and Extrusion Materials (PA)[3]

F 1563 Specification for Tools to Squeeze-Off Gas Pipe and Fittings[3]

A5.3 Materials

A5.3.1 *Classification*—Polyamide materials suitable for use in the manufacturing of pipe, tubing, and fittings under this specification shall be classified in accordance with Specification D 4066, as shown in Table A5.1.

A5.3.2 *Short- and Long-Term Properties*—Polyamide pipe, tubing, and fittings shall be made from a PA material which also satisfies the combinations of short- and long-term property requirements shown in Table A5.2.

TABLE A5.1 Specification D 4066 Classification

Classification	Designation	
PA	Polyamide	
3 (group)	11 nylon	
2 (class)	Heat stabilized	
3 (grade)		
Relative viscosity, min		1.83
Melt point, °C		185–195
Specific gravity		1.03–1.06
Tensile strength, min, MPa		48
Elongation (ultimate), min, %		200
Flexural modulus, min, MPa		900
Izod impact resistance, min, J/M		55
Deflection temperature, min at 1.82 MPa		40
Moisture "as received", %, max		0.08

TABLE A5.2 Short and Long Term Property Requirements

PA Material Designation Code	Short-Term in Accordance with D 4066	Long-Term in Accordance with D 2837
PA32312	PA323	HDB of 2500 psi for 73°F (23°C)

A5.4 Requirements for Pipe and Fittings

A5.4.1 *Conditioning*—For those tests where conditioning is required, or unless otherwise specified, condition the specimens prior to testing for a minimum of 1 h in water or 4 h in air at 73.4 ± 3.6°F (23 ± 2°C) or in accordance with 6.3. The conditioning requirements of 6.3 shall be used in all cases of disagreement.

A5.4.2 *Minimum Hydrostatic Burst Pressure/Apparent Tensile Strength (Quick Burst)*—The pipe or system shall fail in a ductile manner when tested in accordance with Test Method D 1599 at a stress greater than 3900 psi (27 MPa).

For pipe sizes above 4-in. nominal diameter, the quick burst test (Test Method D 1599) may be replaced by the apparent ring tensile strength test (Test method D 2290). The minimum apparent tensile strength at yield when determined in accordance with 6.8 shall be 3900 psi (27 MPa).

A5.4.3 *Sustained Pressure at 73°F (23°C)*—The pipe or system shall not fail in less than 1000 h when tested in accordance with Test Method D 1598. The stress shall be 2800 psi (19 MPa).

A5.4.4 *Squeeze Off*—This requirement is limited to pipe sizes, wall thicknesses, squeeze procedures, and conditions deemed suitable for squeeze-off in service by the pipe manufacturer. There shall be no leakage or visual evidence of splitting, cracking, breaking, or reduction in 1000-h sustained pressure category when pipe is tested as follows:

A5.4.4.1 Prepare six randomly selected pipe specimens in accordance with Test Method D 1598, except they shall be unfilled.

A5.4.4.2 The squeeze-off shall be effected at the midpoint of the test specimen, 90° to the point of the measured minimum wall thickness. Close the squeeze bars to the gap stop recommended by Specification F 1563 and hold in constraint for 4 h. Remove squeeze bars and reround pipe by closing squeeze bars at a point 90° for the squeeze area.

A5.4.4.3 Immediately upon removal of the squeeze-off tool, fill the specimens with ambient temperature water, that is 67 ± 10°F (19.4 ± 5.0°C), condition, and test in accordance with 6.6.

A5.4.5 *Outdoor Storage Stability*—PA pipe stored outdoors and unprotected for at least two years from date of manufacture shall meet all the requirements of this specification. PA pipe stored outdoors for over two years from date of manufacture may be used if it meets the requirements of this specification.

A5.4.6 *Chemical Resistance*—The weight, yield strength, and inherent viscosity requirements for polyamide pipe when measured in accordance with 6.9 are in Table A5.3.

A5.5 Marking

A5.5.1 PA pipe and tubing shall be marked with the elevated temperature code letters EF CG in accordance with Table 4 in addition to the marking requirements of 7.1.

E = maximum temperature of 180°F (82°C),
F = 1250 psi HDB at 180°F (82°C),
C = temperature of 140°F (60°C), and
G = 1600 psi HDB at 140°F (60°C).

TABLE A5.3 Chemical Resistance

Chemical	Weight Change, max %	Yield Strength Change, max %	Inherent Viscosity, %
Mineral oil	+0.5	−12	±3
Tertiary-butyl mercaptan (5 %)	+0.5	−12	±3
Methanol	+5	−35	±3
Ethylene glycol	+0.5	−12	±3
Toluene (5 %)	+7	−40	±3

APPENDIXES

(Nonmandatory Information)

X1. NEW MATERIALS

X1.1 It is the intent of ASTM Committee F-17 on Plastic Piping Systems to consider for inclusion other kinds, types, and grades of thermoplastics in this specification, when evidence is presented to show that they are suitable for underground distribution of natural gas. Minimum requirements, in addition to all the pertinent parts of this specification are: (1) an ASTM material specification, (2) an ASTM product specification, (3) the material's long-term hydrostatic strength, determined in accordance with an appropriate test method such as Test Method D 2837, and (4) at least 3 years of service-related evidence to demonstrate that the material has performed satisfactorily as underground gas pressure piping.

X1.2 Each candidate material is considered individually with respect to its own properties, the intended application, and other pertinent usage experience. Experience with a related approved material may be applicable to a new material provided the germane correlations can be demonstrated.

X1.3 An example of appropriate evidence to meet service related requirements, but not necessarily the only way, would be a minimum of 3 years evaluation of representative piping systems in gas service under representative conditions without significant change in physical or mechanical properties. Such systems should aggregate at least 1000 ft (305 m) of piping to provide an ample basis for statistical evaluation. Piping systems should contain representative pipe sizes and companion pipe fittings such as elbows, tees, couplings, and caps. Recommendations for making individual service connections on both pressured and unpressured systems is also desirable information. If special backfill materials or techniques are necessary for satisfactory performance, they should be so stated and described; otherwise generally accepted industry practices are assumed to be adequate. Publications of the American Gas Association and the Plastic Pipe Institute contain information which may be useful in assessing the suitability or relevancy of candidate materials.

X2. DESIGN CONSIDERATIONS

X2.1 General

X2.1.1 The design of a plastic piping system for natural gas service must include consideration of the combined effects of time, internal and external stress, and environment as an overall basis for selecting a specific kind and size of plastic pipe. The design stress for plastic pipe used for distribution of natural gas and petroleum fuels is regulated by the U.S. Department of Transportation as published in Part 192 Title 49 of the Code of Federal Regulations. The American Gas Association Plastic Materials Committee, the Fuel Gas Division of PPI, and members of ASTM Committee F-17 are cooperating with the ASME Gas Piping Technology Committee to provide assistance in selecting safe design stress levels for the various kinds of plastic pipe.

X2.2 Design Equations

X2.2.1 *Relationship Between Pipe Stress and Pressure*—The following expression is used to relate stress, pressure, pipe size, and wall thickness:

$$P = 2S/(DR - 1) \text{ or } 2S/[(D_o/t) - 1] \quad \text{(X2.1)}$$

where:

S = stress in the circumferential or hoop direction, psi (MPa),
P = internal pressure, psig (MPa),
DR = dimension ratio,
D_o = average outside diameter, in. (mm), and
t = minimum wall thickness, in. (mm).

X2.2.2 The following expression can be used to determine the burst pressure or sustained pressures needed in testing:

$$P_b = 2S_y/(DR - 1) \quad \text{(X2.2)}$$

where:

P_b = burst pressure, psig (MPa),
S_y = yield stress, psi (MPa), and
DR = dimension ratio.

$$P_s = 2S_f/(DR - 1) \quad \text{(X2.3)}$$

where:

P_s = sustained pressure, psig (MPa),
S_f = fiber stress psi (MPa), and
DR = dimension ratio.

X2.2.3 *Relation between Hydrostatic Design Basis (HDB) and Hydrostatic Design Stress (HDS)*—The *HDS* is determined by multiplying the *HDB* by a design factor, *f*. The design factor, *f*, has a value less than 1.0.

$$HDS = (HDB)(f) \quad \text{(X2.4)}$$

NOTE X2.1—The actual choice of design factor for a given installation must be reviewed by the design engineer taking into account federal, state, and local code requirements. For example, the design factor for gas pipelines under the jurisdiction of the Department of Transportation is 0.32.

X2.3 Design Stress and Internal Pressure

X2.3.1 The design stresses for natural gas pipe are based on the hydrostatic design basis categories at 73°F (23°C) obtained in accordance with Test Method D 2837. The test medium should be natural gas or simulated natural gas except that water may be used where previous tests have shown that for the particular type of plastic, water and natural gas give essentially the same test results. The hydrostatic design basis categories of the plastics presently included in the applicable ASTM specifications are as follows:

Plastic Pipe Material Designation	Hydrostatic Design Basis Categories at 73°F (23°C), psi (MPa)
PB 2110	2000 (13.8)
PE 2406	1250 (8.6)
PE 3408	1600 (11.0)
PVC 1120	4000 (27.6)
PVC 1220	4000 (27.6)
PVC 2110	2000 (13.8)
PVC 2116	3150 (24.8)

X2.3.2 The design stresses for natural gas and other fuel gases at service temperatures above 73°F (23°C) should be based on hydrostatic design basis categories of the pipe that are applicable for the particular use temperature.

NOTE X2.2—Water may be used where previous tests have shown that these requirements can be met.

X2.3.3 Strengths for other plastic pipe materials will be added when these materials are included in the applicable ASTM specifications. The design stresses are obtained by multiplying the hydrostatic design basis categories by design factors or service factors according to the class of location as described in Chapter IV of the American National Standard Code for Pressure Piping ANSI B31.8, or, for gas operators in the United States, Subpart C of the Minimum Federal Safety Standards for Transportation of Natural and Other Gas by Pipeline, Title 49, Code of Federal Regulations.

X2.3.4 Any plastic material to qualify for use as pipe for the transportation of liquefied petroleum gas (LPG) must be tested with LPG as the medium, and have a hydrostatic design basis category of 1000 psi (6.9 MPa) at 74°F (23°C), as determined by Test Method D 2837.

X2.3.5 For liquefied petroleum gas applications, a maximum operating pressure of 30 psig (206 kPa) is recommended in NFPA 58 by the members of the National Liquefied Petroleum Gas Association. Liquefied petroleum gas has a higher condensation temperature than does natural gas; this maximum pressure is recommended to ensure that plastic pipe is not subjected to excessive exposure to LPG liquids.

X2.4 Thermal Stress

X2.4.1 Calculate the longitudinal stress (theoretical) induced in a pipe member between fixed points as follows:

$$S = E \times C \times \Delta t \quad \text{(X2.5)}$$

where:

S = stress, psi (MPa),
E = modulus of elasticity, psi (MPa), instantaneous, at 73°F (23°C),
C = coefficient of expansion, in./in./°F, (mm/mm/°C), and
Δt = maximum temperature minus minimum temperature, °F (°C).

X2.4.1.1 The measured stress has been determined to be less than that calculated. This difference is caused by the stress relaxation in viscoelastic materials.

X2.4.2 Calculate the theoretical force sustained at the fixed points (typically joints) in a pipe member as follows:

$$F = S \times A \quad \text{(X2.6)}$$

where:
F = force, lbf (N),
S = stress, psi (MPa), and
A = cross-sectional pipe wall area, in.^{2} (mm^2).

X2.4.3 Calculate pipe contraction in unrestrained pipe caused by a reduction in temperature as follows:

$$\Delta L = k \times L \times C \times \Delta t \quad \text{(X2.7)}$$

where:
ΔL = change in length,
k = 1000 for ΔL (mm), L (m), C (°C^{-1}), Δt (°C), or
k = 12 for ΔL (in.), L (ft), C (°F^{-1}), Δt (°F),
L = original length,
C = coefficient of linear expansion, and
Δt = temperature change.

X2.5 Installation Procedure

X2.5.1 It is recognized that certain minimum requirements exist for the support of earth loads from backfill and other external forces. Proper installation techniques can be used with flexible conduit (as defined by Marston and Spangler[11]) to support relatively large earth loads without excessive deflection by mobilizing lateral passive soil forces. Proper installation technique ensures that the necessary passive soil pressure at the side of the pipe will be developed and maintained. It is also recognized that internal pressures may be valuable in minimizing the deflection caused by earth loads. Installation procedures described in Recommended Practice B 2774, ANSI B31.8, and the AGA Plastic Pipe Manual for Gas Service are recommended.

X2.5.2 Unrestrained plastic pipe expands and contracts from thermal change significantly more than metallic pipe. This ratio may be of the magnitude of ten to one. Typical coefficients of thermal expansion for unrestrained pipe are as follows (see Note X2.3):

PB 7.2×10^{-5} (in./in.)/°F 19.44 (mm/mm)/°C
PE 9.0×10^{-5} (in./in.)/°F 24.30 (mm/mm)/°C
PVC 3.5×10^{-5} (in./in.)/°F 11.45 (mm/mm)/°C

Mains and service lines installed by insertion are considered to approximate unrestrained conditions inside the casing pipe except at end connections. Direct-burial pipe is considered to be partially restrained by passive soil pressures except in the vicinity of joints.

NOTE X2.3—Coefficient of thermal expansion for the specific pipe being considered should be used, if available.

X2.5.3 Internal pressure, earth settlement, ground movement, and thermal contraction impose stresses on the pipe that can be transmitted to joints. These stresses are additive. Installation practices should reflect the need for continuous support and containment of the pipe through suitable bedding and backfilling procedures. Attention should be given to all joints, particularly to transition joints between plastic and metal pipe.

X2.5.4 It is desirable to have pipe joints that are as strong as the pipe itself in the longitudinal (axial) direction. Thermal fusion, solvent cement joints, and mechanical joints outlined in 6.10, Category 1 can provide such joint strength. The joint strength is a function of the assembly procedure, the design of the fitting, and the pipe material and dimensions (see X2.5.5).

X2.5.5 For those mechanical devices that are not designed to restrain the pipe against pullout forces, provisions must be made in the field to prevent pullout, keeping in mind that mechanical joints are vulnerable to the effects of internal pressure, temperature changes, earth settlement, and ground movement. A somewhat limited alternative is to use long sleeve-type fittings that permit limited movement without loss of pressure seal. Otherwise, provisions must be made in the field to prevent pullout through suitable anchoring at the joint.

X2.5.6 Plastic pipe joined with mechanical connectors that utilize a compression-type gasket must be reinforced by means of a tubular stiffener that extends at least under the section of pipe being compressed by the gasket and the gripping device (where used). The stiffener shall be nonsplit-type design to meet the performance requirements recommended by the manufacturer of the fitting in which it is used, and the joint shall meet the test requirements outlined in 6.10.

X2.6 Repair Considerations

X2.6.1 Repairs may be made to plastic pipe under appropriate circumstances. Selection and installation considerations for the use of full encirclement band clamps are available in ASTM Guide F 1025. Additional information on repair of plastic pipe may be found in manufacturers' literature, the A. G. A. Plastic Pipe Manual for Gas Service, ANSI B31.8 Gas Transmission and Distribution Piping Systems, and in the ASME Guide for Gas Transmission and Distribution Piping Systems.

X2.7 Environmental Effects

X2.7.1 The long term effect of natural gas at 73°F (23°C) has been shown[12,13] to be essentially equivalent to that of water at 73°F (23°C) for three kinds of plastic pipe (PVC, PB, and PE). However, the effects of other liquid environments such as antifreeze agents, odorants, and hydrocarbons are known to be deleterious to some plastics, particularly when under service conditions, and therefore, should not be permitted in the gas system unless the plastic pipe has been fully evaluated under the service conditions.

[11] Spangler, M. G., "Secondary Stresses in Buried High Pressure Lines," *Iowa State College Bulletin*, Engineering Report 23 of the Iowa Engineering Experiment Station, 1954, 1955.

[12] Kuhlman, H. W., Leninger, R. L. and Wolter, Fritz, "Investigation of Engineering and Design Concepts for Plastics Pipe for Gas Distribution Application," presented at ANSI B31.8 meeting in St. Charles, IL, Oct. 19, 1965.

[13] Palermo, E. F., and Cassady, M. J., "Comparison of Long-Term Effect of Water and Methane on PE 2306 and PE 3406 Pipe Performance," presented at the American Gas Association Plastic Material Committee Winter Workshop, Feb. 23, 1982.

Designation: D 3350 – 01

Standard Specification for Polyethylene Plastics Pipe and Fittings Materials[1]

This standard is issued under the fixed designation D 3350; 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 specification covers the identification of polyethylene plastic pipe and fittings materials according to a cell classification system. It is not the function of this specification to provide specific engineering data for design purposes, to specify manufacturing tolerances, or to determine suitability for use for a specific application.

1.2 Polyethylene plastic materials, being thermoplastic, are reprocessable and recyclable (Note 2). This specification allows for the use of those polyethylene materials, provided that all specific requirements of this specification are met.

NOTE 1—The notes in this specification are for information only and shall not be considered part of this specification.

NOTE 2—See Guide D 5033 for information and definitions related to recycled plastics.

1.3 The values stated in SI units are to be regarded as the standard.

1.4 *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.*

NOTE 3—There is no similar or equivalent ISO standard.

1.5 For information regarding Molding and Extrusion Materials see D 4976 Specification for Polyethylene Plastics Molding and Extrusion Materials. For information regarding Wire and Cable Materials see D 1248 Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.

2. Referenced Documents

2.1 *ASTM Standards:*

D 618 Practice for Conditioning Plastics for Testing[2]

D 638M Test Method for Tensile Properties of Plastics[3]

D 746 Test Method for Brittleness Temperature of Plastics and Elastomers by Impact[2]

D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials[2]

D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement[2]

D 883 Terminology Relating to Plastics[2]

D 1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer[2]

D 1248 Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable[2]

D 1505 Test Method for Density of Plastics by the Density-Gradient Technique[2]

D 1603 Test Method for Carbon Black in Olefin Plastics[2]

D 1693 Test Method for Environmental Stress-Cracking of Ethylene Plastics[2]

D 1898 Practice for Sampling of Plastics[3]

D 1928 Practice for Preparation of Compression-Molded Polyethylene Test Sheets and Test Specimens[4]

D 2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials[5]

D 3892 Practice for Packaging/Packing of Plastics[6]

D 4976 Specification for Polyethylene Plastics Molding and Extrusion Materials[7]

D 5033 Guide for the Development of ASTM Standards Relating to Recycling and Use of Recycled Plastics[7]

F 1473 Test Method for Notch Tensile Test to Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins[5]

2.2 *ISO Standards*

ISO 9080 Plastics Piping and Ducting Systems Determination of Long-Term Hydrostatic Strength of Thermoplastics Materials in Pipe Form by Extrapolation

ISO 12162 Thermoplastic Materials for Pipes and Fittings for Pressure Applications— Classification and Designation— Overall Service (Design) Coefficient

3. Terminology

3.1 *Definitions*—Terms as described in Terminology D 883 shall apply in this specification.

3.1.1 *polyethylene plastics*—as defined by this specification, plastics or resins prepared by the polymerization of no less than 85 % ethylene and no less than 95 % of total olefins with

[1] This specification is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.15 on Thermoplastic Materials.

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[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] Discontinued; see *1996 Annual Book of ASTM Standards*, Vol 08.01.

[4] Discontinued; see *2001 Annual Book of ASTM Standards*, Vol 08.01.

[5] *Annual Book of ASTM Standards*, Vol 08.04.

[6] *Annual Book of ASTM Standards*, Vol 08.02.

[7] *Annual Book of ASTM Standards*, Vol 08.03.

*A Summary of Changes section appears at the end of this standard.

additional compounding ingredients.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *materials*—polyethylene (PE) resins with the added compounding ingredients.

3.2.2 *PE compounds*—has the same meaning as PE plastics materials, compounds, and plastics.

3.3 Historical usage and user group conventions have resulted in inconsistent terminology used to categorize and describe polyethylene resins and compounds. The following terminology is in use in ASTM specifications pertaining to polyethylene:

3.3.1 *Specification D 1248*:

3.3.1.1 Type (0, I, II, III, IV) = density ranges (same, respectively, as Class in Specification D 4976).

3.3.1.2 Class (A, B, C, D) = composition and use.

3.3.1.3 Category (1, 2, 3, 4, 5) = melt index ranges (same as Grade in Specification D 4976).

3.3.1.4 Grade (E, J, D, or W followed by one or two digits) = specific requirements from tables.

3.3.2 *Specification D 3350*:

3.3.2.1 Type (I, II, III) = density ranges (same as Types I, II, and III in Specification D 1248 and Classes 1, 2, and 3 in Specification D 4976).

3.3.2.2 Class = a line callout system consisting of "PE" followed by six cell numbers from Table 1 plus a letter (A, B, C, D, E) denoting color and UV stabilizer.

3.3.2.3 Grade = simplified line callout system using "PE" followed by density and slow crack growth cell numbers from Table 1.

3.3.3 *Specification D 4976*:

3.3.3.1 Group (1, 2) = branched or linear polyethylene.

3.3.3.2 Class (5, 1, 2, 3, 4) = density ranges (same, respectively, as Type in Specification D 1248).

3.3.3.3 Grade (1, 2, 3, 4, 5) = melt index ranges (same as Category in Specification D 1248).

4. Classification

4.1 Polyethylene plastic pipe and fittings compounds are classified according to density, melt index, flexural modulus tensile strength at yield, environmental stress-crack resistance, and the hydrostatic design basis at 23°C in Table 1.

NOTE 4—It has been a long-standing practice to use the following terms in describing polyethylene plastics:

Type I (0.910 to 0.925) = Low Density
Type II (0.926 to 0.940) = Medium Density
Type III (0.941 to 0.965) = High Density

NOTE 5—The manner in which materials are identified in the cell

TABLE 1 Primary Properties—Cell Classification Limits

Property	Test Method	0	1	2	3	4	5	6	7
1 Density, g/cm³	D 1505	Unspecified	0.925 or lower	>0.925 – 0.940	>0.940 – 0.955	>0.955	...	...	specify value
2 Melt index	D 1238	Unspecified	>1.0	1.0 to 0.4	<0.4 to 0.15	<0.15	[A]		specify value
3 Flexural modulus, MPa (psi)	D 790	Unspecified	<138 (<20 000)	138 – <276 (20 000 to <40 000)	276 – <552 (40 000 to 80 000)	552 – <758 (80 000 to 110 000)	758 – <1103 (110 000) to <160 000)	>1103 (>160 000)	specify value
4 Tensile strength at yield, MPa (psi)	D 638	Unspecified	<15 (<2200)	15 – <18 (2200–<2600)	18 – <21 (2600–<3000)	21 – <24 (3000–<3500)	24 – <28 (3500–<4000)	>28 (>4000)	specify value
5 Slow Crack Growth Resistance									
I. ESCR	D 1693	Unspecified							
a. Test condition (100% Igepal.)			A	B	C	C	...	...	specify value
b. Test duration, h			48	24	192	600			
c. Failure, max, %		Unspecified	50	50	20	20			specify value
II. PENT (hours)	F 1473								
Molded plaque, 80°C, 2.4 MPa			0.1	1	3	10	30	100	
Notch depth, F 1473, Table 1		Unspecified							specify value
6 Hydrostatic Strength Classification									
I. Hydrostatic design basis, MPa (psi), (23°C)	D 2837	NPR[B]	5.52 (800)	6.89 (1000)	8.62 (1250)	11.03 (1600)	...	...	
II. Minimum required strength, MPa (psi), (20°C)	ISO 9080	...	...	...	...	...	8 (1160)	10 (1450)	

[A] Refer to 10.1.4.1.
[B] NPR = Not Pressure Rated.

classification is illustrated for Class PE233424B as follows (refer also to Table 1 and 6.2):

	Class
	2 3 3 4 2 4 B
Density (0.926–0.940 g/cm^3)	2
Melt index (<0.4–0.15)	3
Flexural modulus (276–<758 MPa (40 000–<110 000 psi))	3
Tensile strength at yield (21–<24 MPa (3000–<3500 psi))	4
Slow Crack Growth Resistance I. ESCR D 1693 Condition B, 24 h, 50 % max failure II. PENT F 1473 Average 1 h failure	2
Hydrostatic design basis at 23°C (11.03 MPa (1600 psi))	4
Color and UV stabilizer (colored)	B

4.2 Materials used in polyethylene plastic pipe and fittings shall use a cell-type format for the identification, close characterization, and specification of material properties. The information from the format is to be used alone or in combination.

NOTE 6—This type format, however, is subject to possible misapplication since unobtainable property combinations can be selected if the user is not familiar with commercially available materials. The manufacturer should be consulted. Additionally, the appropriate ASTM standard specification should be reviewed to assure materials utilized will meet all the material and piping requirements as specified in the standard.

4.3 *Grade*—A code for polyethylene pipe and fittings materials that consists of the two letter abbreviation for polyethylene (PE) followed by two numbers that designate the density cell (Property 1) and the slow crack growth resistance cell (Property 5), as defined by either Test Method F 1473 or Test Method D 1693, of the thermoplastic, as specified in Table 1. For the requirements of Property 5 (slow crack growth resistance), consult the materials section of the appropriate ASTM standard specification for the end-use application.

NOTE 7—Grade designations were adapted from Specification D 1248 - 84 prior to the withdrawal of D 1248 - 84. Former Specification D 1248 - 84 grades for PE pipe materials were P14, P23, P24, P33, and P34. Equivalent Specification D 3350 grade designations for these materials are PE11, PE20, PE23, PE30, and PE33, respectively.

5. Materials and Manufacture

5.1 The molding and extrusion material shall be polyethylene plastic in the form of powder, granules, or pellets.

5.2 The molding and extrusion materials shall be as uniform in composition and size and as free of contamination as is achieved by good manufacturing practice. If necessary, the level of contamination may be agreed upon between the manufacturer and the purchaser.

5.3 When specified, the color and translucence of molded or extruded pieces formed, under the conditions specified by the manufacturer of the materials, shall be comparable within commercial match tolerances to the color and translucence of standard samples supplied in advance by the manufacturer of the material.

6. Physical Properties

6.1 *Cell Classification*—Test values for specimens of the PE material prepared as specified in Section 9 and tested in accordance with Section 10 shall conform to the requirements given in Table 1. A typical property value for a PE material is to be the average value from testing numerous lots or batches and determines the cell number. When, due to manufacturing tolerances and testing bias, individual lot or batch values fall into the adjoining cell, the individual value shall not be considered acceptable unless the user, or both the user and the producer, determine that the individual lot or batch is suitable for its intended purpose.

6.2 *Color and Ultraviolet (UV) Stabilizer*—The color and UV stabilization shall be indicated at the end of the cell classification by means of a letter designation in accordance with the following code:

Code Letter	Color and UV Stabilizer
A	Natural
B	Colored
C	Black with 2 % minimum carbon black
D	Natural with UV stabilizer
E	Colored with UV stabilizer

6.3 *Thermal Stability*—The PE material shall contain sufficient antioxidant so that the minimum induction temperature shall be 220°C when tested in accordance with 10.1.9.

6.4 *Brittleness Temperature*—The brittleness temperature shall not be warmer than −60°C when tested in accordance with Test Method D 746.

6.5 *Density*—The density used to classify the material shall be the density of the PE base resin (uncolored PE) determined in accordance with 10.1.3. When the average density of any lot or shipment falls within ±0.002 g/cm^3 of the nominal value, it shall be considered as conforming to the nominal value and to all classifications based on the nominal value.

6.5.1 For black compounds, containing carbon black, determine the density, *Dp*, and calculate the resin density, *Dr*, as follows:

$$Dr = Dp - 0.0044C$$

where:

C = weight percent of carbon black.

6.5.2 For colored compounds, the nominal density of the base resin shall be provided by the manufacturer, on request.

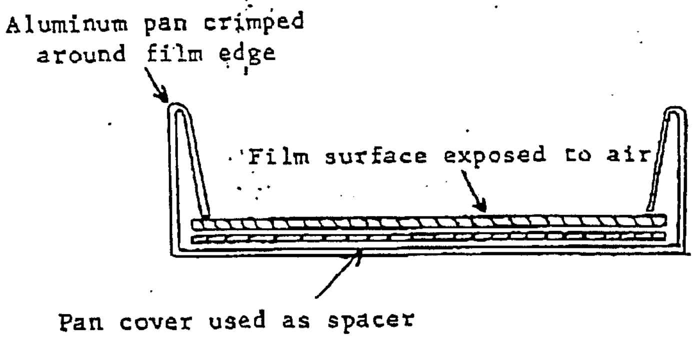
6.6 *Tensile Strength at Yield*—The tensile strength at yield used to classify the material shall be the tensile strength at yield of the PE resin determined in accordance with 10.1.6. When the average tensile strength at yield of any lot or shipment falls within ±3.45 MPa (±500 psi) of the nominal value, it shall be considered as conforming to the nominal value and to all classifications based on the nominal value.

6.7 *Elongation at Break*—As tested per 10.1.6, all pressure rated materials shall have a minimum extension at break of 500 % as determined by grip separation.

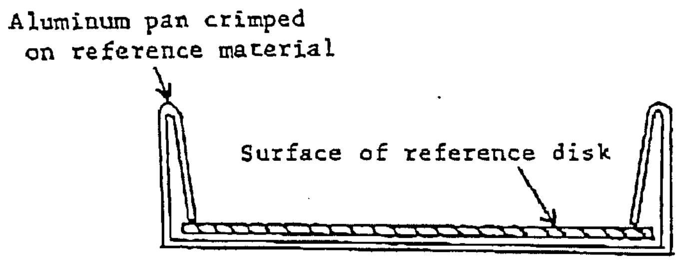
7. Sampling

7.1 A batch or lot shall be considered as a unit of manufacture and shall consist of one production run or as a blend of two or more production runs of material.

7.2 Unless otherwise agreed upon between the manufacturer and the purchaser, the material shall be sampled in accordance with the procedure described in Sections 9 through 12 of



(a) Specimen in pan.



(b) Reference—Temperature standard shall be placed under reference disk in reference pan or alternatively under pan cover (spacer).

FIG. 1 Mounting Film Specimen in Cup

Practice D 1898. Adequate statistical sampling prior to packaging shall be considered an acceptable alternative.

NOTE 8—A sample taken from finished product may not necessarily represent the original batch or lot.

8. Number of Tests

8.1 The requirements identified by the material designation and otherwise specified in the purchase order shall be verified by tests made in accordance with 11.1. For routine inspection, only those tests necessary to identify the material to the satisfaction of the purchaser shall be required. One sample shall be sufficient for testing each batch or lot provided that the average values for all of the tests made on that batch or lot comply with the specified requirements.

9. Specimen Preparation

9.1 Unless otherwise specified in Section 10, the test specimens shall be molded in accordance with Procedure C of Practice D 1928.

9.2 When pipe or fitting test specimens are required, they shall be extruded or molded in accordance with the specifications of the material manufacturer.

10. Test Methods

10.1 The properties enumerated in this specification shall be determined in accordance with the following test methods:

10.1.1 *Conditioning*— Unless otherwise specified in the test methods or in this specification, for those tests where conditioning is required, condition the molded test specimens in accordance with Procedure A of Practice D 618.

10.1.2 *Test Conditions*— Unless otherwise specified in the test methods or in this specification, conduct tests at the Standard Laboratory Temperature of 23 ± 2°C (73.4 ± 3.6°F).

10.1.3 *Density*—Test Method D 1505 or alternative methods providing equivalent accuracy as described in Methods A or B of Test Methods D 792. Make duplicate determinations using two separate portions of the same molding or from two moldings. The molded specimen thickness portions shall be 1.9 ± 0.2 mm (0.075 ± 0.008 in.). Calculate the average value.

10.1.4 *Melt Index*—Test Method D 1238, using Condition 190/2.16. Make duplicate determinations on the material in the form of powder, granules, or pellets, and calculate the average; no conditioning is required.

10.1.4.1 Classify materials having a melt index less than 0.15 (Cell 4) as Cell 5 only if they have a flow rate not greater than 4.0 g/10 min when tested in accordance with Test Method D 1238, Condition 190/21.6.

NOTE 9—Flow rate is the general term used for all results obtained with Test Method D 1238. Although the flow rate of polyethylene plastics may be measured under any of the conditions listed for it under 7.2 of Test Method D 1238, only measurements made at Condition 190/2.16 may be

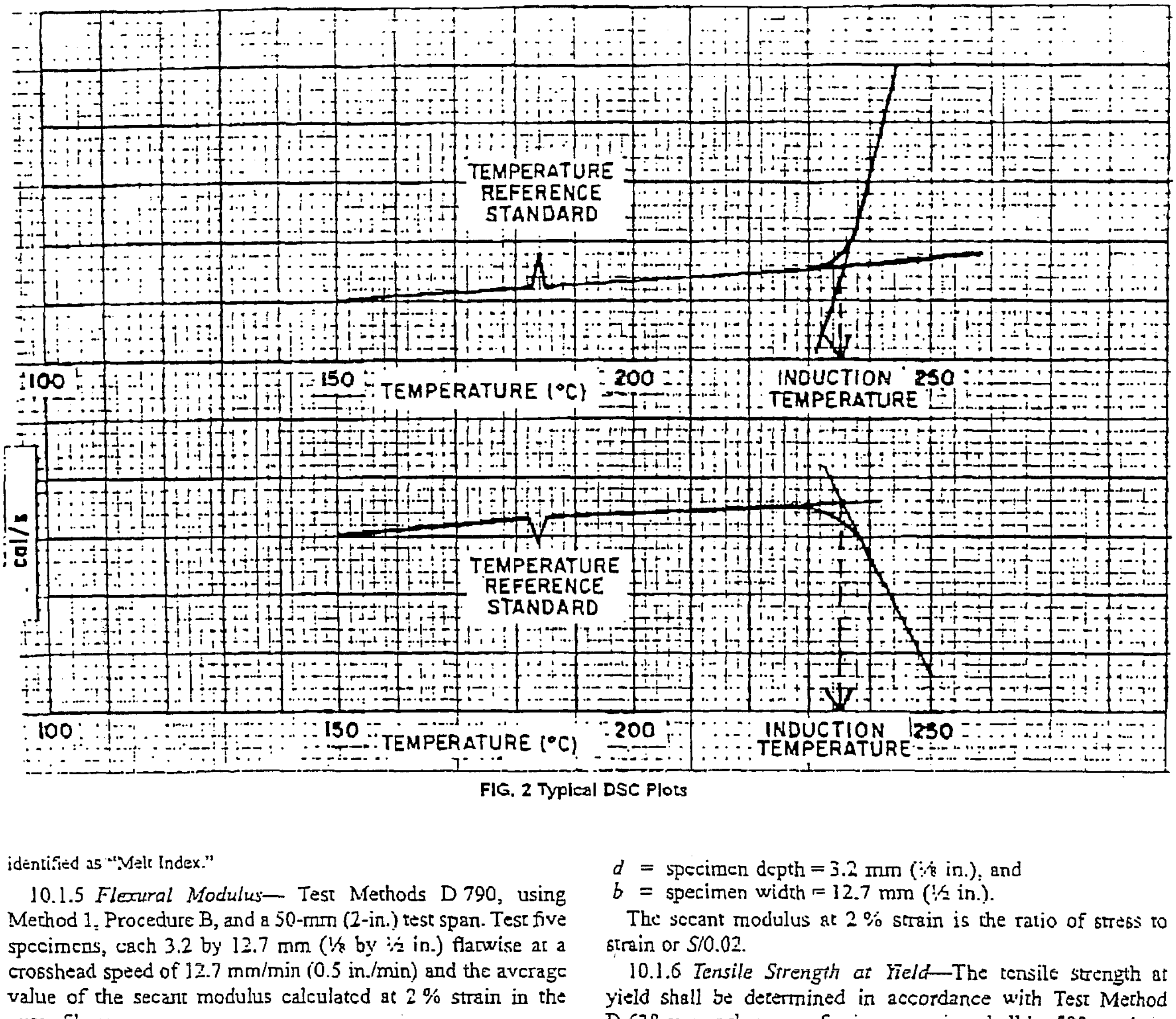


FIG. 2 Typical DSC Plots

identified as "Melt Index."

10.1.5 *Flexural Modulus*— Test Methods D 790, using Method 1, Procedure B, and a 50-mm (2-in.) test span. Test five specimens, each 3.2 by 12.7 mm (⅛ by ½ in.) flatwise at a crosshead speed of 12.7 mm/min (0.5 in./min) and the average value of the secant modulus calculated at 2 % strain in the outer fibers.

10.1.5.1 The deflection of the test specimen corresponding to 2 % strain (0.02 mm/mm or in./in.) is calculated as follows:

$$D = rL^2/6d$$

where:

D = deflection of the center of the beam test specimen at 2 % strain, in.,
r = strain in the outer fibers = 0.02 mm/mm (0.02 in./in.),
L = test span = 50 mm (2 in.), and
d = specimen depth = 3.2 mm (⅛ in.).

10.1.5.2 The stress corresponding to 2 % strain is calculated as follows:

$$S = 3\ PL/2\ bd^2$$

where:

S = stress in the outer fiber at 2 % strain,
P = load corresponding to 2 % strain, N (lbf),
L = test span = 50 mm (2 in.),
d = specimen depth = 3.2 mm (⅛ in.), and
b = specimen width = 12.7 mm (½ in.).

The secant modulus at 2 % strain is the ratio of stress to strain or $S/0.02$.

10.1.6 *Tensile Strength at Yield*—The tensile strength at yield shall be determined in accordance with Test Method D 638 except that rate of grip separation shall be 500 mm/min (20 in./min for materials in the density range from 0.910 to 0.925 g/cm^3) and 50 mm/min (2 in./min for all others). Specimens shall conform to the dimensions given for Type IV in Test Method D 638 with a thickness of 1.9 ± 0.2 mm (0.075 ± 0.008 in.). Specimen shall be either die cut or machined.

10.1.7 *Slow Crack Growth Resistance*—One method shall be used to classify this material property.

10.1.7.1 *Slow Crack Growth Resistance*—The material's resistance shall meet the minimum requirement shown for the appropriate cell classification when tested in accordance with Test Method D 1693.

10.1.7.2 *Slow Crack Growth Resistance*—The average failure time from two test specimens shall meet the minimum requirement shown for the appropriate cell classification when tested in accordance with Test Method F 1473. Test at least four specimens in case of a dispute.

10.1.8 *Hydrostatic Strength Classification*—One method shall be used to classify this material property.

10.1.8.1 *Hydrostatic Design Basis*—Determine the hydrostatic design basis in accordance with Test Method D 2837, on pipe extruded from three different lots of material. Subject specimens from one lot for at least 10 000 h. Terminate the tests on the two additional lots after 2000 h. The results from each of the three lots shall be within the same or next higher cell limits.

NOTE 10—For pressure application at elevated temperatures, the hydrostatic design basis should be determined at that temperature in accordance with Test Method D 2837. The 100 000-h intercept should be categorized in accordance with Table 1 of Test Method D 2837.

10.1.8.2 *Minimum Required Strength*—Determine the minimum required strength in accordance with ISO 9080 and ISO 12162.

10.1.9 *Thermal Stability*—Test specimens taken from pipe or fittings made from the virgin material with a differential scanning calorimeter (DSC).[8] The directions of the instrument manufacturer regarding calibration and operation shall be followed except when in conflict with other parts of this section.

NOTE 11—This test requires accurate temperature and atmosphere control on the DSC specimen compartment. The DSC manufacturers offer choices in cell configuration and temperature control parameters that may affect this required control. For example, in some power compensation DSCs, use of the two-hole platinum specimen holder lids with a special "flow-through" swing-away block cover is required. Therefore, the user may wish to consult equipment-specific literature and with the equipment manufacturer to optimize the operation of individual DSCs for this test.

10.1.9.1 *Specimens*—Press small pieces of the pipe into films 0.127 ± 0.013 mm (0.0050 ± 0.0005 in.) thick. Cut at least three disks 6.35 ± 0.13 mm (0.250 ± 0.005 in.) in diameter from the film.

10.1.9.2 *Procedure*—Place the disk of film in a small aluminum cup used in the DSC in a stretched condition, as shown in Fig. 1(*a*). Place a small piece of indium (melting point 156.6°C) or anisic acid (melting point 183.0°C) for a temperature reference standard contained in a similar cup (see Fig. 1(*b*)) in the reference position. Use an oxidized copper reference disk for black, filled, or dark brown test specimens and an aluminum disk for natural or light pigmented polymers. Place the specimen and reference standard cups in the instrument which is preset at approximately 150°C. The bottoms of the cups shall be pressed and rubbed securely against the flat surface so as to ensure that thermal contact is made. Allow 5 min for the cups to reach thermal equilibrium. Begin the programmed heating at approximately 150°C at a heating rate of 10.0°C/min in static air. Test at least three film specimens from each sample and use the average value for the induction temperature.

NOTE 12—Since the indium standard may change with use, it should not be used more than 30 times without confirming that no significant change in melting point has occurred. This check can be made by comparison with a fresh piece of indium.

10.1.9.3 *Results*—The temperature change (ΔT) or heat absorption rate (J/s) in the specimen plotted against temperature shall produce a line with a clear rise in slope. The induction temperature (degradation onset) is the intersection of the extended base line and a line tangent to the leading slope of the exothermic decomposition peak (see Fig. 2).

10.1.10 *Carbon Black Content*—Test Method D 1603 shall be used. Make duplicate determinations from a sample of the material in the form of powder, granules, or pellets.

11. Inspection

11.1 Inspection of the material shall be made as agreed upon between the purchaser and the manufacturer as part of the purchase contract.

12. Retest and Rejection

12.1 If any failure occurs, and when specified by the manufacturer, the material shall be retested to establish conformity in accordance with the agreement between the purchaser and the manufacturer.

13. Packaging and Marking

13.1 *Packaging*—The material shall be packaged in standard commercial containers, so constructed as to ensure acceptance by common or other carriers for safe transportation at the lowest rate to the point of delivery, unless otherwise specified in the contract or order.

13.2 *Marking*—Unless otherwise agreed upon between the seller and the purchaser, shipping containers shall be marked with the name of the material, identification according to this specification, the lot or batch number and quantity contained therein, as defined by the contract or order under which shipment is made, and the name of the manufacturer.

13.3 All packing, packaging, and marking provisions of Practice D 3892 shall apply to this specification.

[8] Instruments are available from TA Instruments, Perkin-Elmer, and others.

14. Keywords

14.1 cell classification system; pipe and fittings material; polyethylene; recycled

SUMMARY OF CHANGES

This section identifies the location of selected changes to this specification. For the convenience of the user, Committee D20 has highlighted those changes that may impact the use of this specification. This section may also include descriptions of the changes or reasons for the changes, or both.

D 3350–99:
(*1*) Revised Table 1, Property 1, Cells 1, 2, and 3.
D 3350–00:
(*1*) Added 3.3.
D 3350–01:
(*1*) Revised Table 1, Property 6 to add MRS values as cells 5 and 6.
(*2*) Added ISO 9080 and ISO 12162 to the Referenced Documents section.
(*3*) Revised Note 6.
(*4*) Revised subsection 10.1.8.

South Dakota Public Utilities Commission

WEEKLY FILINGS

For the Period of June 6, 2002 through June 12, 2002

If you need a complete copy of a filing faxed, overnight expressed, or mailed to you, please contact Delaine Kolbo within five business days of this report. Phone: 605-773-3705 Fax: 605-773-3809

CONSUMER COMPLAINT

CT02-018 **In the Matter of the Complaint filed by the Loyal Order of Moose, Belle Fourche, South Dakota, against UKI Communications, Inc. Regarding Unauthorized Switching of Services.**

Complainant states that its service was switched without authorization. When UKI was contacted about the charges, UKI indicated that the charges would be refunded, which complainant states never happened. UKI also stated that Complainant's account would be closed. Complainant continued to receive monthly statements with UKI charges. Complainant requests that all charges be removed and/or refunded. Complainant also requests that it receive anything that is available to it under South Dakota law.

Staff Analyst: Mary Healy
Staff Attorney: Karen Cremer
Date Docketed: 06/12/02
Intervention Deadline: N/A

ELECTRIC

EL02-013 **In the Matter of the Filing by Otter Tail Power Company for Approval of a Contract with Deviations with the City of Brandt.**

Application by Otter Tail Power Company for approval of a contract with deviations to serve the City of Brandt. The existing contract to serve the City will expire on July 1, 2002. The new contract does not include any new rates.

Staff Analyst: Dave Jacobson
Staff Attorney: Kelly Frazier
Date Filed: 06/07/02
Intervention Deadline: 07/05/02

PIPELINE SAFETY

PS02-001 **In the Matter of the Filing by Montana-Dakota Utilities Co., a Division of MDU Resources Group, Inc. for Approval of Waiver.**

On June 6, 2002, the Commission received for approval a filing from Montana-Dakota Utilities Company (MDU), requesting a waiver of 49 CFR Part 192, Paragraph 192.59(a)(1) (ASTM D2513) Plastic Pipeline Materials. According to MDU, a shipping error was made in July 2000 by Chevron Phillips Chemical Company (Chevron) resulting in UPONOR receiving non-standard polyethylene raw materials (TR-130 resin) which was subsequently converted into pipe. MDU received several thousand feet of this pipe that had not been properly qualified to ensure compliance with ASTM D2513 as required by the referenced code, for use in its natural gas system. MDU did install that pipe near Rapid City, SD. Since its installation, Chevron performed extensive testing and demonstrated the pipe does in fact meet the minimum requirements of ASTM D2513. MDU proposes to allow the pipe to remain in service and is requesting a waiver from the Commission and the Federal Department of Transportation Regulations to allow the pipe to remain in service. Any party wishing to comment on the filing may do so by filing written comments with the Commission and the parties to the agreement no later than June 26, 2002.

Parties may file written responses to the comments no later than twenty days after the service of the initial comments.

Staff Analyst: Martin Bettmann
Staff Attorney: Kelly Frazier
Date Docketed: 06/06/02
Initial Comments Due: 06/26/02

TELECOMMUNICATIONS

TC02-052 In the Matter of the Establishment of Switched Access Revenue Requirement for West River Cooperative Telephone Company.

On June 10, 2002, West River Cooperative Telephone Company, Bison, South Dakota, filed a switched access cost study developing a revenue requirement and minutes of use that are included in the revenue requirement and minutes of use used to determine the switched access rates for the Local Exchange Carrier Association.

Staff Analyst: Harlan Best
Staff Attorney: Karen Cremer
Date Docketed: 06/10/02
Intervention Deadline: 06/28/02

TC02-053 In the Matter of the Establishment of Switched Access Revenue Requirement for Interstate Telecommunications Cooperative, Inc.

Interstate Telecommunications Cooperative, Inc. (Interstate) filed a switched access cost study developing a revenue requirement and minutes of use. Interstate does not currently have its own access tariff but is seeking membership of the Local Exchange Carrier Association. It is Interstate's desire to be part of the LECA tariff.

Staff Analyst: Heather Forney
Staff Attorney: Karen Cremer
Date Docketed: 06/10/02
Intervention Deadline: 06/28/02

TC02-054 In the Matter of the Establishment of Switched Access Revenue Requirement for Vivian Telephone Company.

Vivian Telephone Company, Wall, South Dakota, filed a switched access cost study developing a revenue requirement and minutes of use that are included in the revenue requirement and minutes of use used to determine the switched access rates for the Local Exchange Carrier Association.

Staff Analyst: Keith Senger
Staff Attorney: Karen Cremer
Date Docketed: 06/10/02
Intervention Deadline: 06/28/02

TC02-055 In the Matter of the Filing for Approval of an Amendment to an Interconnection Agreement between Qwest Corporation and Black Hills FiberCom, Inc.

On June 10, 2002, the Commission received for approval an Amendment re: DS1 Digital Capable Loops and Provisioning Options to the Wireline Interconnection Agreement between Qwest Corporation (Qwest) and Black Hills FiberCom, Inc. for the State of South Dakota (Black Hills FiberCom). According to the parties, the original Agreement was a negotiated agreement which was approved by the Commission effective January 6, 1999, in Docket TC98-205. The current Amendment is made in order to add to the Agreement the terms, conditions and rates for DS1 Digital Capable Loops and Provisioning Options, as set forth in Attachment 1 and Exhibits A and B, attached to the Amendment. Any party wishing to comment on the agreement may do so by filing written comments with the Commission and the parties to the agreement no later than July 1, 2002. Parties to the agreement may file written responses to the comments no later than twenty days after the service of the initial comments.

Staff Attorney: Kelly Frazier
Date Docketed: 06/10/02
Initial Comments Due: 07/01/02

TC02-056 In the Matter of the Filing for Approval of an Agreement for Terms and Conditions for Interconnection, Unbundled Network Elements, Ancillary Services and Resale of Telecommunications Services between Qwest Corporation and NOW Communications of South Dakota, Inc.

On June 10, 2002, the Commission received for approval an Agreement for terms and conditions for interconnection, unbundled network elements, ancillary services and resale of telecommunications services provided by Qwest Corporation in the State of South Dakota (Qwest) and NOW Communications of South Dakota, Inc. (NOW). According to the parties the Agreement is a negotiated agreement which sets forth the terms, conditions and prices under which Qwest will offer and provide to any requesting CLEC network interconnection, access to unbundled network elements, ancillary services and telecommunication services available for resale within the geographical areas in which Qwest is providing local exchange service at that time and for which Qwest is the incumbent LEC within the State of South Dakota for purposes of providing local telecommunications services. Any party wishing to comment on the agreement may do so by filing written comments with the Commission and the parties to the agreement no later than July 1, 2002. Parties to the agreement may file written responses to the comments no later than twenty days after the service of the initial comments.

Staff Attorney: Kelly Frazier
Date Docketed: 06/10/02
Initial Comments Due: 07/01/02

TC02-057 In the Matter of the Application of ICG Telecom Group, Inc. for a Certificate of Authority to Provide Local Exchange Services in South Dakota.

ICG Telecom Group, Inc. filed an application for a Certificate of Authority to provide facilities-based and resold local exchange telecommunications service in South Dakota. ICG Telecom Group proposes to provide service in the entire service area of Qwest Corporation.

Staff Analyst: Michele Farris
Staff Attorney: Kelly Frazier
Date Filed: 06/10/02
Intervention Deadline: 06/28/02

TC02-058 In the Matter of the Establishment of Switched Access Revenue Requirement for Sioux Valley Telephone Company.

On June 11, 2002, Sioux Valley Telephone Company, Dell Rapids, South Dakota, filed a switched access cost study developing a revenue requirement and minutes of use that are included in the revenue requirement and minutes of use used to determine the switched access rates for the Local Exchange Carrier Association.

Staff Analyst: Harlan Best
Staff Attorney: Karen Cremer
Date Docketed: 06/11/02
Intervention Deadline: 06/28/02

South Dakota
Public Utilities Commission
State Capitol Building, 500 East Capitol Avenue, Pierre, South Dakota 57501-5070

September 3, 2002

RECEIVED
SEP - 4 2002
SOUTH DAKOTA PUBLIC UTILITIES COMMISSION

Debra Elofson
Executive Director
South Dakota Public Utilities Commission

RE: PS02-001

Dear Debra,

Enclosed are five (5) copies of the proposed stipulated agreement between Montana-Dakota Utilities Company (MDU) and the staff of the South Dakota Public Utilities Commission in the above-cited docket. A meeting on this stipulation is scheduled for the Thursday, September 5, 2002 at 1:30 P.M. Staff will be recommending that the Commission at that meeting approve this stipulated agreement. Please contact either Martin Bettmann or myself if you or the Commissioners have any questions regarding this submission.

Sincerely,

Kelly D. Frazier
Staff Attorney

Capitol Office
Telephone (605)773-3201
FAX (605)773-3809

Transportation/
Warehouse Division
Telephone (605)773-5280
FAX (605)773-3225

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Relay South Dakota
1-800-877-1113

Internet Website
www.state.sd.us/puc

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE
STATE OF SOUTH DAKOTA

IN THE MATTER OF THE FILING BY MONTANA-DAKOTA UTILITIES CO., A DIVISION OF MDU RESOURCES GROUP, INC. FOR APPROVAL OF WAIVER	)))))	STIPULATION PS02-001

It is hereby stipulated and agreed by and between Montana-Dakota Utilities Co. ("Montana-Dakota") and Staff of the South Dakota Public Utilities Commission ("Staff"), that the following Findings of Fact and Conclusion of Law, and an appropriate Order consistent with said Findings and Conclusions may be adopted by the South Dakota Public Utilities Commission (the "Commission") in the above captioned matter. In support of the Waiver Request, Montana-Dakota hereby offers this Stipulation, the Waiver Request filed on June 6, 2002 and the responses submitted to Staff's data request. Staff offers no answering testimony or exhibits conditioned upon the Commission accepting the following Findings of Fact and Conclusions of Law.

FINDINGS OF FACT

As the result of a shipping error made by Chevron Phillips Chemical Company LP , UPONOR received non-standard polyethylene raw materials, i.e. TR-130 resin, that they subsequently converted to pipe. Montana-Dakota received approximately 63,000 feet of that pipe from UPONOR in late July and early August 2000. Approximately 38,600 feet of the pipe was installed by Montana-Dakota in the state of South Dakota between July 2000 and November 2000. Montana-Dakota received an alert notice on January 11, 2001, and discontinued installing the pipe. Approximately 4,400 feet was installed in Wyoming and the remaining 20,000 feet of unused pipe was returned to UPONOR.

49 CFR Part 192.59(a) requires that "New plastic pipe is qualified under this part (49 CFR Part 192) if: (1) It is manufactured in accordance with a listed specification: and (2) It is resistant to chemicals with which contact may be anticipated." The specification for all new plastic pipe listed in 49 CFR Part 192 Appendix A, II. C. 10. is ASTM Designation: D2513 "Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings" (D2513-87 edition for §192.59(a)(1), otherwise D2513-96a). D-2513 requires, among other things, that the resin used to make the pipe have a "PPI recommended long term hydrostatic stress rating." At the time the pipe was installed, the resin did not carry such a rating; subsequently, the resin did receive the required rating.

Through subsequent testing of the TR-130 resin and the various sizes of pipe produced from the resin, in particular the two-inch IPS plastic pipe installed by Montana-Dakota, it has been documented that the two-inch pipe made with the TR-130 resin meets the specifications of ASTM D2513. Documentation of the testing conducted on the pipe made with the TR-130 resin was filed as part of the waiver request.

CONCLUSIONS OF LAW

1.

The Commission has jurisdiction over the subject matter and parties to the proceedings pursuant to SDCL Chapter 49-34B-27. Subject to the finding that the waiver of compliance is not inconsistent with gas pipeline safety, the Commission has the authority to waive in whole or in part any standards established pursuant to SDCL Chapter 49-34B-24.

2.

At the time the pipe made with the TR-130 resin was installed, the TR-130 resin did not carry the hydrostatic stress rating required by ASTM D-2513 and 49 CFR Part 192.59(a). Therefore, a waiver request was sought by Montana-Dakota to continue to maintain and operate the approximately 38,600 feet of pipe that has been installed in South Dakota.

3.

The two-inch IPS plastic pipe made with the TR-130 resin and installed by Montana-Dakota in South Dakota has been tested and it has been determined that the pipe meets the qualification requirements found in 49 CFR Part 192.59(a).

4.

A waiver granted by the Commission may not become effective until at least 60 days after the Associate Administrator, Office of Pipeline Safety, Research and Special Programs Administration, United States Department of Transportation, receives a written notice of the waiver from the Commission and has no objection to the waiver and so notifies the Commission.

STIPULATE TO THE FOLLOWING TERMS AND CONDITIONS

1.

Montana-Dakota will continue with its ongoing program to attempt to identify exactly where the 38,600 feet of TR-130 resin pipe has been installed. Montana-Dakota shall make this information reasonably available to the Commission upon request.

2.

After a period of three years following the installation of the aforementioned pipe, three random samples of two-inch size PE pipe containing the TR-130 resin will be taken from the system and tested in accordance with ASTM D2513 Sections A.1.5.2, A.1.5.5, and A.1.5.8 product requirements for pipe and fittings. Specifically, those tests include measurement of pipe diameter, wall thickness, squeeze-off stability, and burst pressure. If the results are within acceptable ranges, no further action or future tests will be taken except for such actions required under DOT 192.617.

If any pipe sample falls outside acceptable ranges, then three additional random samples will be taken and tested in accordance with the above-described procedure. If each of these results are within acceptable ranges, no further action or future tests will be taken except for such actions required under DOT 192.617. Should any one of these samples fall outside acceptable ranges, then Montana-Dakota, in collaboration with the DOT regulatory agencies, will meet to discuss what, if any, further action is appropriate and necessary, and develop a plan of action.

Montana-Dakota shall report the results of any such testing to the Commission.

3.

Montana-Dakota shall report any failures of the TR-130 resin pipe to the Commission and to the American Gas Association Plastic Pipe Database Committee.

Date September 3, 2002

MONTANA-DAKOTA UTILITIES CO.

By: David L. Goodin
David L. Goodin
Vice President – Operations

Kelly Frazier
Kelly Fraizer
Staff Attorney
South Dakota Public Utilities Commission

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE
STATE OF SOUTH DAKOTA

IN THE MATTER OF THE FILING BY MONTANA-DAKOTA UTILITIES CO., A DIVISION OF MDU RESOURCES GROUP, INC. FOR APPROVAL OF WAIVER	)))))	STIPULATION PS02-001

It is hereby stipulated and agreed by and between Montana-Dakota Utilities Co. ("Montana-Dakota") and Staff of the South Dakota Public Utilities Commission ("Staff"), that the following Findings of Fact and Conclusion of Law, and an appropriate Order consistent with said Findings and Conclusions may be adopted by the South Dakota Public Utilities Commission (the "Commission") in the above captioned matter. In support of the Waiver Request, Montana-Dakota hereby offers this Stipulation, the Waiver Request filed on June 6, 2002 and the responses submitted to Staff's data request. Staff offers no answering testimony or exhibits conditioned upon the Commission accepting the following Findings of Fact and Conclusions of Law.

FINDINGS OF FACT

As the result of a shipping error made by Chevron Phillips Chemical Company LP , UPONOR received non-standard polyethylene raw materials, i.e. TR-130 resin, that they subsequently converted to pipe. Montana-Dakota received approximately 63,000 feet of that pipe from UPONOR in late July and early August 2000. Approximately 38,600 feet of the pipe was installed by Montana-Dakota in the state of South Dakota between July 2000 and November 2000. Montana-Dakota received an alert notice on January 11, 2001, and discontinued installing the pipe. Approximately 4,400 feet was installed in Wyoming and the remaining 20,000 feet of unused pipe was returned to UPONOR.

49 CFR Part 192.59(a) requires that "New plastic pipe is qualified under this part (49 CFR Part 192) if: (1) It is manufactured in accordance with a listed specification: and (2) It is resistant to chemicals with which contact may be anticipated." The specification for all new plastic pipe listed in 49 CFR Part 192 Appendix A, II. C. 10. is ASTM Designation: D2513 "Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings" (D2513-87 edition for §192.59(a)(1), otherwise D2513-96a). D-2513 requires, among other things, that the resin used to make the pipe have a "PPI recommended long term hydrostatic stress rating." At the time the pipe was installed, the resin did not carry such a rating; subsequently, the resin did receive the required rating.

Through subsequent testing of the TR-130 resin and the various sizes of pipe produced from the resin, in particular the two-inch IPS plastic pipe installed by Montana-Dakota, it has been documented that the two-inch pipe made with the TR-130 resin meets the specifications of ASTM D2513. Documentation of the testing conducted on the pipe made with the TR-130 resin was filed as part of the waiver request.

CONCLUSIONS OF LAW

1.

The Commission has jurisdiction over the subject matter and parties to the proceedings pursuant to SDCL Chapter 49-34B-27. Subject to the finding that the waiver of compliance is not inconsistent with gas pipeline safety, the Commission has the authority to waive in whole or in part any standards established pursuant to SDCL Chapter 49-34B-24.

2.

At the time the pipe made with the TR-130 resin was installed, the TR-130 resin did not carry the hydrostatic stress rating required by ASTM D-2513 and 49 CFR Part 192.59(a). Therefore, a waiver request was sought by Montana-Dakota to continue to maintain and operate the approximately 38,600 feet of pipe that has been installed in South Dakota.

3.

The two-inch IPS plastic pipe made with the TR-130 resin and installed by Montana-Dakota in South Dakota has been tested and it has been determined that the pipe meets the qualification requirements found in 49 CFR Part 192.59(a).

4.

A waiver granted by the Commission may not become effective until at least 60 days after the Associate Administrator, Office of Pipeline Safety, Research and Special Programs Administration, United States Department of Transportation, receives a written notice of the waiver from the Commission and has no objection to the waiver and so notifies the Commission.

STIPULATE TO THE FOLLOWING TERMS AND CONDITIONS

1.

Montana-Dakota will continue with its ongoing program to attempt to identify exactly where the 38,600 feet of TR-130 resin pipe has been installed. Montana-Dakota shall make this information reasonably available to the Commission upon request.

2.

After a period of three years following the installation of the aforementioned pipe, three random samples of two-inch size PE pipe containing the TR-130 resin will be taken from the system and tested in accordance with ASTM D2513 Sections A.1.5.2, A.1.5.5, and A.1.5.8 product requirements for pipe and fittings. Specifically, those tests include measurement of pipe diameter, wall thickness, squeeze-off stability, and burst pressure. If the results are within acceptable ranges, no further action or future tests will be taken except for such actions required under DOT 192.617.

If any pipe sample falls outside acceptable ranges, then three additional random samples will be taken and tested in accordance with the above-described procedure. If each of these results are within acceptable ranges, no further action or future tests will be taken except for such actions required under DOT 192.617. Should any one of these samples fall outside acceptable ranges, then Montana-Dakota, in collaboration with the DOT regulatory agencies, will meet to discuss what, if any, further action is appropriate and necessary, and develop a plan of action.

Montana-Dakota shall report the results of any such testing to the Commission.

3.

Montana-Dakota shall report any failures of the TR-130 resin pipe to the Commission and to the American Gas Association Plastic Pipe Database Committee.

Date September 3, 2002

MONTANA-DAKOTA UTILITIES CO.

By: David L. Goodin

David L. Goodin
Vice President – Operations

DAG

Kelly Fraizer

Kelly Fraizer
Staff Attorney
South Dakota Public Utilities Commission

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE FILING BY MONTANA-DAKOTA UTILITIES CO., A DIVISION OF MDU RESOURCES GROUP, INC. FOR APPROVAL OF WAIVER	))))	**ORDER APPROVING STIPULATION** **PS02-001**

On June 6, 2002, the South Dakota Public Utilities Commission (Commission) received for approval a filing from Montana-Dakota Utilities Company (MDU), requesting a waiver of 49 CFR Part 192.59(a)(1). According to MDU, a shipping error was made in July 2000 by Chevron Phillips Chemical Company (Chevron) resulting in UPONOR receiving non-standard polyethylene raw materials (TR-130 resin) which was subsequently converted into pipe. MDU received several thousand feet of this pipe that had not been properly qualified to ensure compliance with ASTM D2513 as required by the referenced code, for use in its natural gas system. MDU did install that pipe near Rapid City, South Dakota. Since its installation, Chevron performed extensive testing and demonstrated the pipe does in fact meet the minimum requirements of ASTM D2513. MDU proposes to allow the pipe to remain in service and is requesting a waiver from the Commission and the Federal Department of Transportation Regulations to allow the pipe to remain in service.

On September 3, 2002, the Commission received a Stipulation from Staff and MDU.

At its regularly scheduled meeting of September 5, 2002, the Commission considered whether to approve the Stipulation. Commission Staff recommended its approval.

The Commission has jurisdiction over this matter pursuant to SDCL 49-34B. The Commission unanimously voted to approve the Stipulation. It is therefore

ORDERED, that the Commission approves and adopts the Stipulation, including the Findings of Fact and Conclusions of Law set forth therein; and it is further

ORDERED, that in conformity with the terms and conditions of the Stipulation, MDU shall:

Continue with its ongoing program to attempt to identify exactly where the 38,600 feet of TR-130 resin pipe has been installed. Montana-Dakota shall make this information reasonably available to the Commission upon request.

After a period of three years following the installation of the aforementioned pipe, three random samples of two-inch size PE pipe containing the TR-130 resin will be taken from the system and tested in accordance with ASTM D2513 Sections A.1.5.2, A.1.5.5, and A.1.5.8 product requirements for pipe and fittings. Specifically, those tests include measurement of pipe diameter, wall thickness, squeeze-off stability, and burst pressure.

Montana-Dakota shall report any failures of the TR-130 resin pipe to the Commission and to the American Gas Association Plastic Pipe Database Committee.

If the results are within acceptable ranges, no further action or future tests will be taken except for such actions required under 49 CFR Part 192.617.

If any pipe sample falls outside acceptable ranges, then three additional random samples will be taken and tested in accordance with the above-described procedure. If each of these results are within acceptable ranges, no further action or future tests will be taken except for such actions required under 49 CFR Part 192.617. Should any one of these samples fall outside acceptable ranges, then Montana-Dakota, in collaboration with the DOT regulatory agencies, will meet to discuss what, if any, further action is appropriate and necessary, and develop a plan of action.

Montana-Dakota shall report the results of any such testing to the Commission.

Montana-Dakota shall report any failures of the TR-130 resin pipe to the Commission and to the American Gas Association Plastic Pipe Database Committee.

It is further

ORDERED, that subject to the terms and conditions set forth in the Stipulation and this order, a waiver of the requirements of 49 CFR Part 192.59(a)(1) is hereby granted pursuant to SDCL 49-34B-24, which shall permit Montana-Dakota to continue to maintain and operate the nonconforming pipe; and it is further

ORDERED, that the effective date of this order and waiver shall be the date sixty (60) days after the Associate Administrator, Office of Pipeline Safety, Research and Special Program Administration, United States Department of Transportation has received written notice of this order and waiver and has notified the Commission that it has no objection to the waiver.

Dated at Pierre, South Dakota, this 23rd day of September, 2002.

CERTIFICATE OF SERVICE

The undersigned hereby certifies that this document has been served today upon all parties of record in this docket, as listed on the docket service list, by facsimile or by first class mail, in properly addressed envelopes, with charges prepaid thereon.

By: Delaine Kolbo

Date: 9/23/02

(OFFICIAL SEAL)

BY ORDER OF THE COMMISSION:

James A. Burg

JAMES A. BURG, Chairman

Pam Nelson

PAM NELSON, Commissioner

Robert K. Sahr by RAW

ROBERT K. SAHR, Commissioner

South Dakota Public Utilities Commission

OCT - 3 2002

State Capitol Building, 500 East Capitol Avenue, Pierre, South Dakota 57501-5070

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October 1, 2002

Stacey L. Gerard
Associate Administrator for Pipeline Safety
Office of Pipeline Safety, RSPA
400 7th Street, S.W., Rm. 7128
Washington DC 20590-0001

RE: Notice of Waiver Granted to Montana-Dakota Utilities Company

Dear Ms. Gerard:

Enclosed is a copy of the Waiver Request filed by Montana-Dakota Utilities Company and the Order issued by the South Dakota Public Utilities Commission granting the waiver. We ask your concurrence in the granting of the Waiver.

We would appreciate acknowledgement of receipt of this filing. A duplicate copy of the letter is attached for your convenience. Please date stamp the letter and return it in the enclosed envelope.

Let me know if you have any questions.

Sincerely,

Martin C. Bettmann

Martin C. Bettmann
Pipeline Safety Program Manager

Enclosure.

U.S. Department
of Transportation
**Research and
Special Programs
Administration**

400 Seventh St., S.W.
Washington, D.C. 20590

JAN 7 2003

Mr. Martin C. Bettmann
Pipeline Safety Program Manager
South Dakota Public Utilities Commission
500 East Capitol Avenue
Pierre, South Dakota 57501-5070

Dear Mr. Bettmann:

We have considered your letter of October 1, 2002, notifying us that the Commission granted the Montana-Dakota Utilities Company (MDU) a waiver from compliance with 49 CFR § 192.59(a)(1) for UPONOR plastic pipe that MDU installed between July and November 2000. Section 192.59(a)(1) states that new plastic pipe is qualified for use if it is manufactured in accordance with a listed specification, which includes ASTM D2513.

According to the waiver, after installation, MDU learned from UPONOR that the plastic pipe did not qualify under ASTM D2513 because the pipe resin lacked the PPI long-term hydrostatic stress rating. Subsequently, the resin received the required rating. MDU submitted documentation of extensive testing done by Chevron Phillips Chemical Company on the resin and various sizes of pipe produced from the resin indicating that the pipe installed by MDU does meet the subject ASTM D2513 requirements.

The order granting the waiver indicates the Commission has concluded that the pipe MDU installed meets 49 CFR § 192.59(a)(1). Nonetheless, the order establishes certain additional random sampling, testing, and reporting requirements. We have no objection to the Commission's order.

Sincerely,

Stacey L. Gerard
Associate Administrator
for Pipeline Safety

MONTANA-DAKOTA
UTILITIES CO.
A Division of MDU Resources Group, Inc.

400 North Fourth Street
Bismarck, ND 58501
(701) 222-7900

January 22, 2004

Public Utilities Commission of South Dakota
Capitol Building
500 East Capitol Avenue
Pierre, South Dakota 57501

ATTN: Mr.Kelly Fraizer

RE: UPONOR TR 130 Pipe test results

Dear Mr. Fraizer:

Pursuant to Stipulation PS02-001, dated September 4, 2002 Montana-Dakota Utilities Co. hereby submits the test results from pipe tested in accordance with the stipulation. Testing was conducted by UPONOR at their test facilities in Tulsa, Oklahoma. Tests conducted were: measurement of pipe diameter, wall thickness, squeeze-off stability and burst pressure and were conducted in accordance with ASTM D 2513, ASTM D 1598 and ASTM D 1599. The conclusion of the testing is that "All specimens met or exceeded the listed procedure requirements." A copy of the report and test results is attached.

Based on the results of this testing, and in accordance with the stipulation, Montana-Dakota Utilities Co. considers that the requirements of Stipulation PS02-001 have been met and no further testing, except as required by 49 CFR 192.617, shall be conducted.

Sincerely,

Bruce Nelson, P.E.
Gas Distribution Manager

Attachment

c: Dave Goodin – Executive
Larry Thompson – Rapid City
Tom Hopgood – Legal

1/20/04

TECHNICAL LAB REPORT

For: Bruce Nelson
Montana Dakota Utilities
400 N. Fourth St.
Bismarck, ND 58501

Uponor Aldyl Company
4501 West 49th Street
Tulsa, OK 74107-7315
Tel. (918) 446-4471
Fax (918) 446-9369

Plant Contact: Larry Shelton - Phone 918-445-5643

Job Number: 100302 Lot Numbers: Pipe – 2" SDR 11, T01072200.

Background: Uponor produced UAC 2000 pipe from TR 130 resin in July of 2000. The pipe was quality control checked per standard ASTM D 2513 requirements.

Product Description: Uponor UAC 2000 pipe produced from Chevron Phillips Chemical TR 130 PE 2406 resin. Resin was qualified per PPI TR 3 procedures.

Scope: Testing was performed to satisfy Stipulation PS02-001 issued by the South Dakota Public Utilities Commission, specifically, the requirements of ASTM D 2513, sections A.1.5.2, A.1.5.5, & A.1.5.8.

Preparation: Test Conditions: 23°C & 80° C.

Test Procedures: Per ASTM D 1598, ASTM D 2513, ASTM D 2122 & ASTM D 1599.

ASTM D 1599: 5 specimens were tested, with ductile failure occurring in the pipe wall.
ASTM D 1598 6 specimens were squeezed a minimum of 4 hrs per D 2513 requirements, then tested @ 670 psi for >170 hrs. at 80°C, with no indication of any pipe failures.
ASTM D 1598 6 specimens were squeezed a minimum of 4 hrs per D 2513 requirements, then tested @ 1320 psi for >1000 hrs. at 23°C, with no indication of any pipe failures.
ASTM D 2513 6 specimens measured per ASTM D 2122 procedures.

Conclusion: All specimens met or exceeded the listed procedure requirements. The test results confirm there have been no material changes from when product was produced. See attached data.

Note: "We certify that all portions of each test performed were under continuous, direct supervision of this laboratory."

Bob Creason

Bob Creason
Lab Operator

Larry Shelton

Larry Shelton
Lab Supervisor

Test Data for # 100302
MDU TR 130 2" UAC 2000 Pipe, Lot # T01072200

MDU TR 130 Surveillance Pipe Samples
Lot Number T01072200 / 2" IPS SDR 11 UAC 2000 Pipe
Specimens marked as "Hart Ranch-Mulligan Mile & Meadow Lane"

Sustained Pressure Test per ASTM D 1598

Sample	Test Temp	Stress	Time	Results
1	80° C	670 psi	>170 hrs	Passed
2	80° C	670 psi	>170 hrs	Passed
3	80° C	670 psi	>170 hrs	Passed
4	80° C	670 psi	>170 hrs	Passed
5	80° C	670 psi	>170 hrs	Passed
6	80° C	670 psi	>170 hrs	Passed

Sustained Pressure Test per ASTM D 1598

Sample	Test Temp	Stress	Time	Results
1	23° C	1320 psi	>1000 hrs	Passed
2	23° C	1320 psi	>1000 hrs	Passed
3	23° C	1320 psi	>1000 hrs	Passed
4	23° C	1320 psi	>1000 hrs	Passed
5	23° C	1320 psi	>1000 hrs	Passed
6	23° C	1320 psi	>1000 hrs	Passed

Quick Burst Test per ASTM D 1599

Sample	Test Temp	Stress	Time	Mode	Result
1	23° C	580 psig	63 Sec	Ductile	Passed
2	23° C	580 psig	63 Sec	Ductile	Passed
3	23° C	580 psig	61 Sec	Ductile	Passed
4	23° C	600 psig	60 Sec	Ductile	Passed
5	23° C	600 psig	60 Sec	Ductile	Passed

ASTM D 2513 Dimension Specifications for 2" Pipe
Wall: .216" - .242" / OD: 2.369" - 2.381"

As Measured Dimensions

Sample	Wall	OD
1	.225 - .229	2.376
2	.225 - .229	2.376
3	.224 - .227	2.376
4	.224 - .227	2.376
5	.227 - .228	2.376
6	.227 - .228	2.376