GTI Energy – Plastic Piping Systems

Dennis Jarnecke – Sr. Director of R&D

2026 Nebraska Pipeline Safety Seminar | February 4, 2026

Agenda

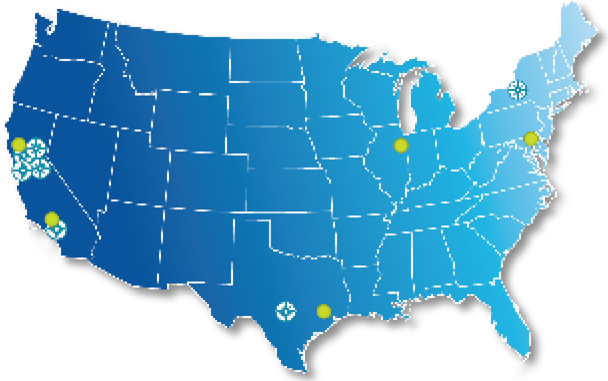
GTI ENERGY

- Plastic Piping Systems
- Vintage Plastic Pipes
- Impacts of Elevated Temperatures
- PE Fusion Failures & Guidelines
- Qualification of Fusion Procedures

GTI Energy Overview

Serving the Energy Industry Since 1941

- Independent, not-for-profit research, technology development and deployment organization
- Areas of research include energy production and conversion, energy delivery, and end-use
- Technology development focus on safety, improving efficiency, and reducing emissions
- Research Facilities
  - 18-acre campus near Chicago
  - Laboratories in Agoura Hills, CA and Davis, CA
  - Pilot and demo facilities worldwide



Our Capabilities

GTI is addressing global energy and environmental challenges across the energy value chain

Supply

Expanding the supply of natural gas and renewable energy

Conversion

Transforming natural resources into clean fuels, power, and chemicals

Delivery

Ensuring a safe and reliable energy delivery infrastructure

End Use

Promoting the clean and efficient use of energy resources

GTI's Energy Delivery R&D Program

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- GTI has an expanding R&D portfolio focused on industry priorities:
  - **Safety, Integrity, Reliability, Operational Efficiency, and the Environment**
- Collaborative R&D efforts:
  - Highly cost effective
  - Leverages collective intelligence and experience of funders to develop the best possible solutions

- SAFETY & RISK MANAGEMENT
- DIGITALIZATION & DATA UTILIZATION
- MINIMIZING METHANE EMISSIONS
- EXPANDING ROLE FOR RENEWABLE GAS & H2

U.S. DEPARTMENT OF ENERGY

PHMSA

OTD Operations Technology Development

CALIFORNIA ENERGY COMMISSION

OTD Members

Serving more than 70 million gas consumers in the U.S., Canada & France

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Ameren ILLINOIS	APGA RESEARCH FOUNDATION	ATMOS energy	AVISTA Corp.	Black Hills Energy Ready	
CenterPoint. Energy	People. Power. Possibilities. Central Hudson A FORTIS COMPANY	conEdison	Delta Utilities	DTE	
DUKE ENERGY.	ENBRIDGE	exelon	GRDF	Liberty	
MDU RESOURCES GROUP, INC.	National Fuel	nationalgrid	Nicor Gas	NiSource	
NW Natural	NYSEG An Avangrid company	ONE Gas	PEOPLES GAS We Keep Life Moving	PG&E	
SoCalGas	SOUTHWEST GAS	spire	TECO PEOPLES GAS AN EMERA COMPANY	UGI Energy to do more	Washington Gas A WGL Company

PE Piping Systems for Natural Gas

- PE has revolutionized natural gas piping systems.
- PE piping systems have an excellent performance track record, reduced installation and operational costs, and have led to a reduction in leaks.

PE Piping Systems in the US

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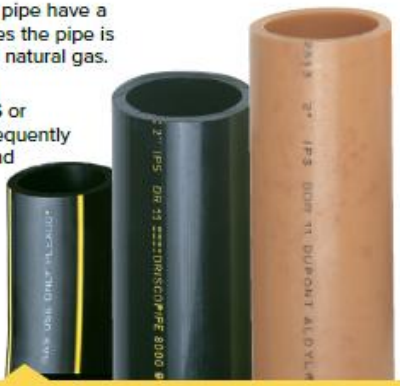
- Polyethylene (PE) pipe accounts for approximately 62% of the total natural gas distribution mains in the United States, representing a massive shift from traditional materials over the past few decades.
- Key statistics regarding PE pipe in U.S. natural gas distribution:
  - **Total Usage:** PE is the dominant material, accounting for roughly 62% of the roughly 1.37 million miles of distribution mains in operation.
  - **New Installations:** Polyethylene pipes account for 90–95% of new gas distribution pipelines in the United States.
  - **Historical Growth:** The percentage of plastic mains has grown significantly from just 27% in 1990 to over 60% today.
  - **Service Lines:** The usage of PE is even higher for service lines (connecting mains to customers), where it is the overwhelming material of choice.

PE Piping – System Integrity

- PE piping systems have an excellent performance track record.
- However, there are various threats to system integrity (other than 3rd party damage).
- Some integrity threats include:
  - Slow crack growth (SCG), especially with vintage plastics
  - Joint integrity issues
  - Static electricity
  - Unlocatable pipes
  - Elevated temperature issues, and
  - Heavy hydrocarbon contamination

Most types of plastic pipe have a print line that indicates the pipe is used for transporting natural gas.

A print line reading **GAS USE ONLY, GAS** or **FOR GAS ONLY** is frequently found on underground gas pipe.



1/2"-2" Pipe Diameter

POLY VINYL CHLORIDE (PVC) PLASTIC PIPE

1/2"-2" Pipe Diameter

ACRYLONITRILE BUTADIENE STYRENE (ABS) PLASTIC PIPE

PVC Sleeve / PE Sleeve

SLEEVING MATERIALS

Chevron Plexco Yellowpipe 1/2"-4" Pipe Diameter

Chevron Plexco Yellowstripe 1/2"-4" Pipe Diameter

POLYETHYLENE (PE) PLASTIC PIPE

Driscoplex 2406 3/4"-4" Pipe Diameter

Driscoplex 8400 1/2"-6" Pipe Diameter

Dupont Aldyl HD 1/2"-4" Pipe Diameter

POLYETHYLENE (PE) PLASTIC PIPE

Performance Pipe Yellowstripe 8300 1"-6" Pipe Diameter

Dupont Aldyl A 1/2"-4" Pipe Diameter

POLYETHYLENE (PE) PLASTIC PIPE

Plastic Tape 3/8"-36" Pipe Diameter

Tar Wrap Coating 3/8"-36" Pipe Diameter

STEEL PIPE PROTECTIVE COATINGS

Swanson 3306 1/2"-3/4" Pipe Diameter

Chevron Plexco 2306 1/2"-2" Pipe Diameter

Chevron Plexco Black 1/2"-4" Pipe Diameter

POLYETHYLENE (PE) PLASTIC PIPE

Phillips Driscopipe M-8000 Black 1/2"-6" Pipe Diameter

Phillips Driscopipe 8100 Yellow 1/2"-6" Pipe Diameter

Dura-line Polypipe® GDB50 GAS- PE4710 1/2"-6" Pipe Diameter

POLYETHYLENE (PE) PLASTIC PIPE

1/2"-2" Pipe Diameter

TENITE PLASTIC PIPE

Plastic Coating 3/8"-36" Pipe Diameter

Epoxy Coating 3/8"-36" Pipe Diameter

STEEL PIPE PROTECTIVE COATINGS

Vintage Plastic Piping Systems

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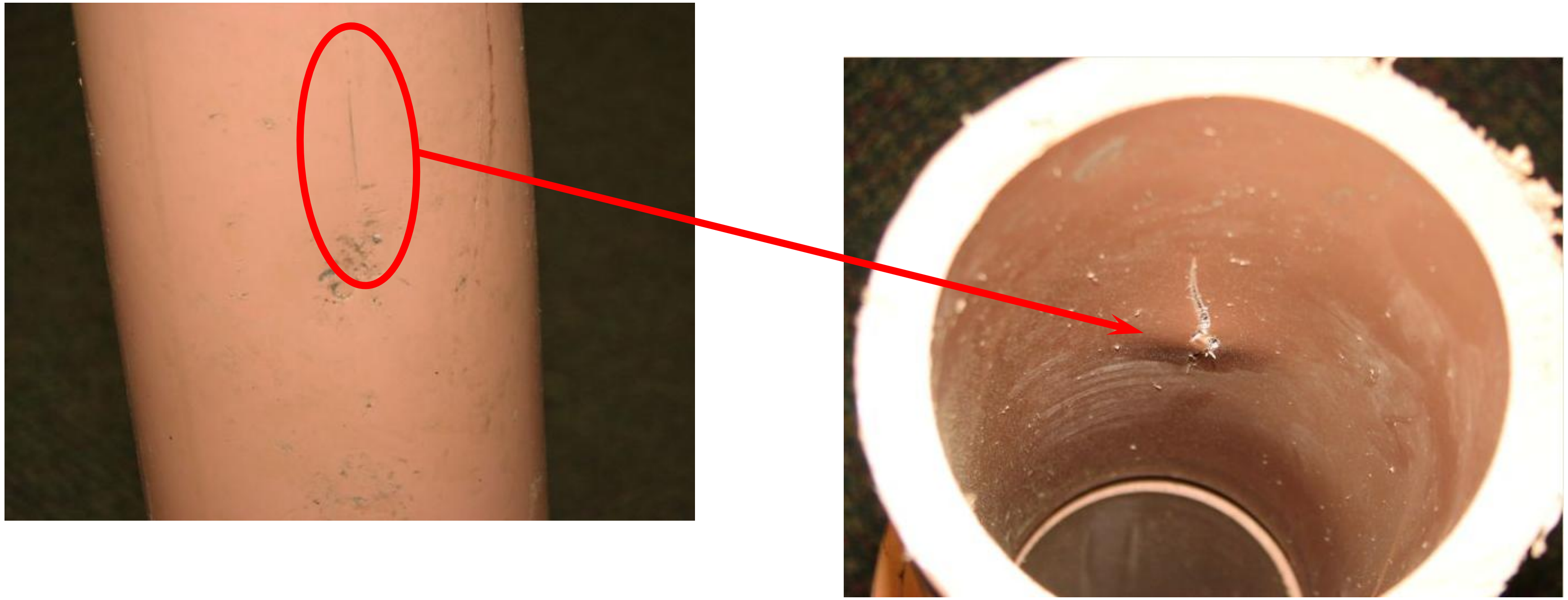
- Plastic pipes started to be used for natural gas distribution in the 1960s.
- Dupont was successful in introducing Aldyl-A pipe and fittings, and installation by operators accelerated in the early 1970s.
- A few examples of vintage plastic pipe include:
  - Aldyl-A (Tan)
  - Aldyl-AAAA (Green)
  - Aldyl-A (Black)
  - Drisco 7000
  - Drisco 8000
  - Plexco Orange 2306

Slow Crack Growth (SCG)

- Brittle-like failures result when stress concentrations are present in early vintage Aldyl-A and other vintage plastic pipe.



Brittle-like Failures

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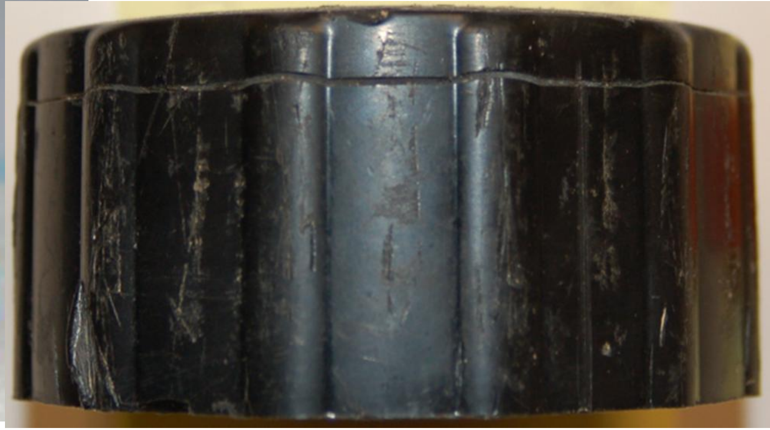
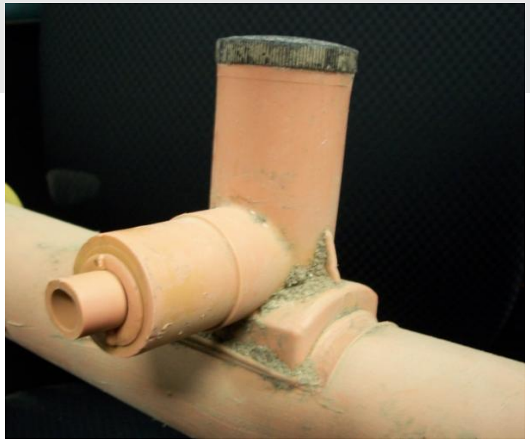
- PHMSA has issued multiple advisories regarding premature brittle-like cracking in older plastic pipes (pre-mid 1980s)
  - ADB-99-02 (14) advised operators of the potential susceptibility of certain plastic pipe installed between 1960 and the early 1980s to premature failure due to brittle-like cracking.
  - ADB-02-07 [15] provided recommendations for identifying and managing brittle-like cracking for certain vintage polyethylene pipe and noted the susceptibility of older plastic pipe to premature failure by brittle-like cracking.
  - ADB-07-01 [16] updated the list of pipe material susceptible to brittle-like cracking to include Delrin insert tap tees and Plexco service tee Celcon (polyacetal) caps.



Failure Types Noted

- Service tee towers & caps
  - Original stress of standard assembly leads to cracking later



- Bending & deflection
  - Ground settlement, stress at service pipe connections to steel main

- Rock impingement
  - Variations in padding & backfill

- Squeezing pipe
  - Occurs through normal operations activities

Potential for Material Degradation

- Additional PHMSA Advisory Bulletins
  - ADB-2012-03, *Notice to Operators of Driscopipe® 8000 High Density Polyethylene Pipe of the Potential for Material Degradation*, 77 FR 13387 (Mar. 6, 2012). This ADB alerted operators using Driscopipe 8000 high-density polyethylene (HDPE) pipe of the potential for material degradation.

	Driscopipe® 7000	**Driscopipe® 8000**
Years Produced	1973-1980	1979-1997
Resin	Marlex® M-7000 - PE 3306/3406	Marlex® M-8000 - PE 3408
Size	¾" – 10"	¼" – 8"
		8000 pipe contains an additive blend that is distinguishable from other polyethylene pipes.

Solid black with burnished gloss surface and a yellow print line

Potential for Material Degradation

- M8000 pipe material – Blistering and Delamination

Findings

- The cause of the degradation is thermal oxidation of the pipes.
- The potential for thermal oxidation increases with increased temperature of the pipe and with increased time at the elevated temperature conditions.
- Laboratory tests replicated the failure mode in pipe that met thermal stability requirements.
- Only Driscopipe 7000 and 8000 HDPE pipes have been affected.

PHMSA’s Latest Advisory Bulletin

GTI ENERGY

- ADB–2026–01- Distribution Integrity Management Program Considerations for Plastic Piping and Components.
- On March 24, 2023, a natural gas distribution incident occurred in West Reading, Pennsylvania, resulting in seven fatalities, 10 injuries, and the destruction of one building and damage to two nearby buildings. (chocolate factory incident)
- Failure of a retired 1982 Aldyl-A polyethylene service tee with a Delrin insert that allowed natural gas to leak and migrate underground into the chocolate factory buildings, where it ignited.
- Contributing to the degradation of the service tee and insert were significantly elevated ground temperatures from steam escaping the Company’s corroded underground steam pipe.

PHMSA's Latest Advisory Bulletin

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Elevated Temperature Impacts on PE Systems

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- The effects of elevated temperature on plastic pipes are well understood.
- Increased temperatures reduce the hoop stress required to make a PE pipe fail.

Heat sources may include:

- Nearby external heat sources, such as welding on steel pipe
- Elevated ground temperatures
- Steam lines and other underground sources of heat.

Effect of elevated temperature on lifetime expectancy in years.

Aldyl A pipe: DR 11 @55psig

Temperature in °F	73	91	109	127
Pipe with no stress risers	662	157	39	10
Pipe with typical stress risers	85	20	5	1
Pipe with moderate stress risers e.g. squeeze-off	26	6	2	0
Pipe with significant stress risers e.g. impingement	11	3	1	0
Pipe with extreme displacements or impingements	6	1	0	0

Note: the relative effect will be similar for any polyethylene material

Elevated Temperature Impacts on PE Systems

GTI ENERGY

- Recently completed a project studying the impacts of heat on plastic pipe
- The project was in response to an incident at a gas utility where the wall of a polyethylene pipe experienced extreme damage due to heat generated by a welding operation on a connected steel pipe.
  - Replicated the applied heat incident in the lab and measured heat transfer
  - Developed a finite element method (FEM) model to simulate the heat impact

Elevated Temperature Impacts on PE Systems

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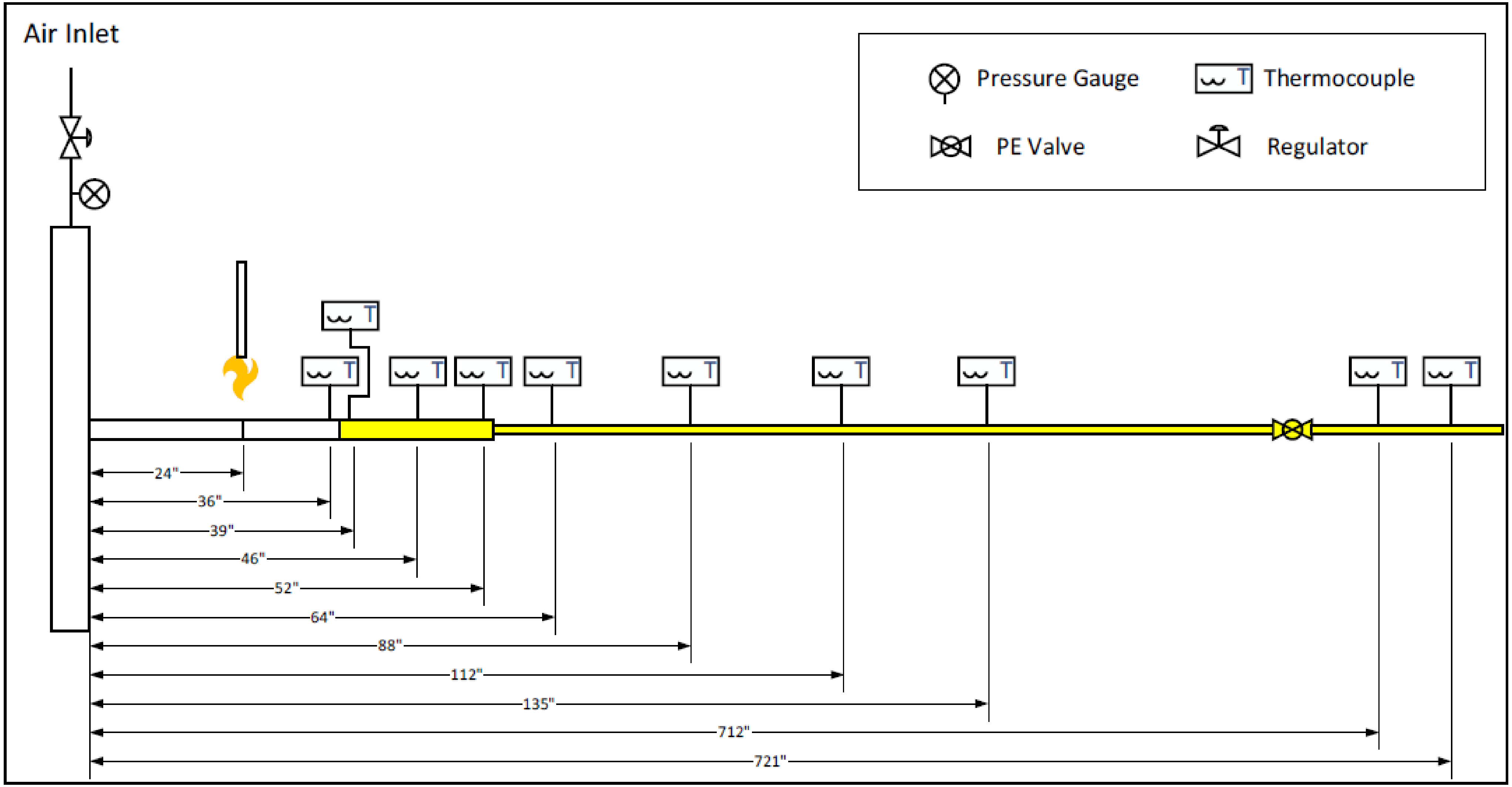

Preventing Heat Damage to PE Pipe and Fittings

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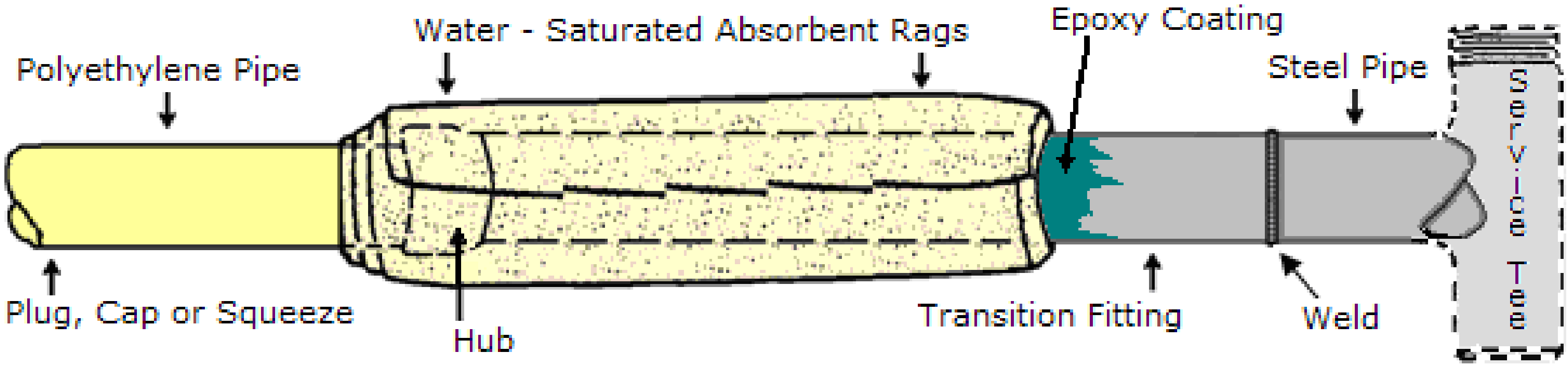
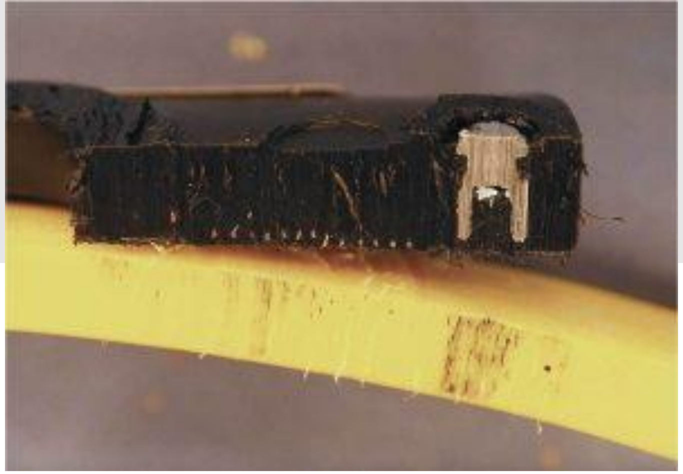
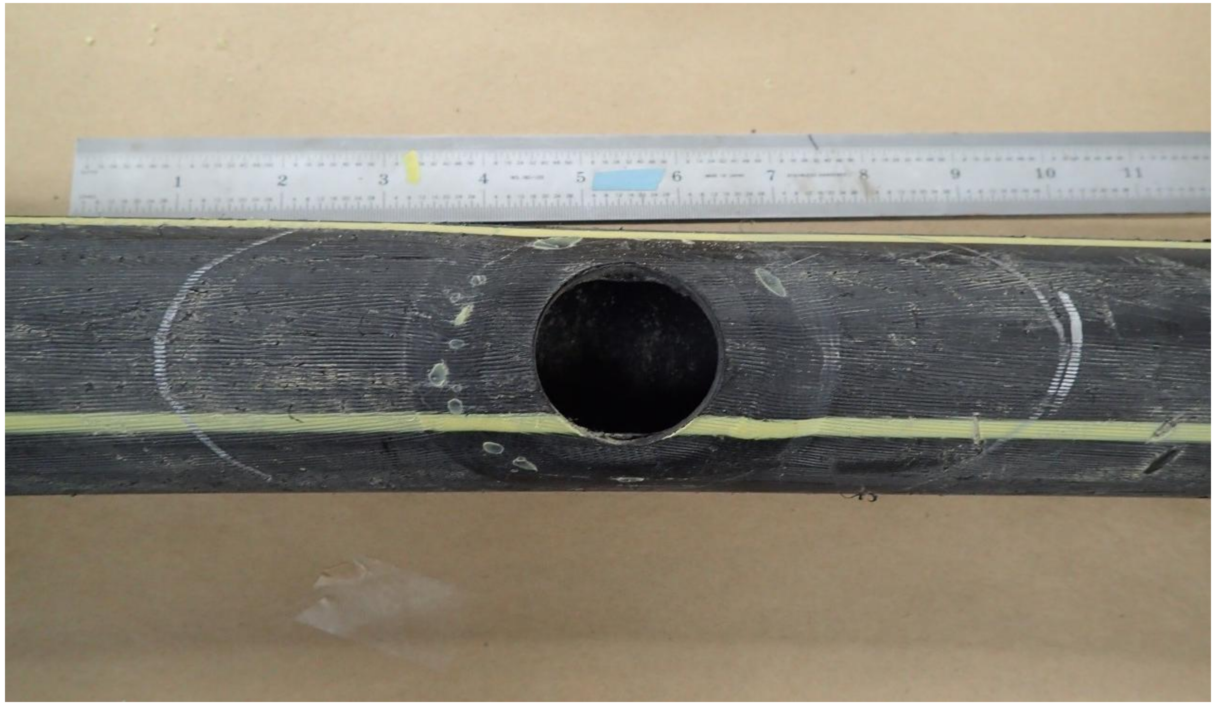
- An industry practice to help prevent heat damage to PE pipe and fittings
  - Exposed PE pipe and fittings can be damaged by heat, hot slag/ debris and must be protected when welding, torch cutting, or heating is being performed in close proximity to the PE pipe and fittings.
  - To eliminate the potential of heat damage to lateral PE pipe from hot gases or air flow during welding, the lateral PE piping shall be shut down and protected by water saturated rags.
  - Wrap several layers of water-saturated rags around the steel portion of the transition fitting
  - Keep rags saturated with water during welding and heating process.



PE Fusion Failures



- <u>Improper scraping / peeling</u> of the pipe surface
- <u>Contamination</u> in the joint interface
  - Common ingredient in drilling mud could lead to ineffective bonding of electrofusion joints.



PE Fusion Procedures – Industry Differences

- Different types and condition of scrapers can lead to mixed results.




PE Fusion Procedures – Pipe Cleaning

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- When should the pipe be cleaned?
  - Before scraping?
  - After Scraping?
  - Other?
- Do you clean the pipe and fittings with solvents?
- What type of solvents? - isopropyl alcohol, acetone, others
- If isopropyl alcohol is used –
  - What is the minimum concentration?
  - How is it applied? - wipes, sprays, others

PE Fusion Procedures – Cleaning

Cleaning (continued)

- Pipe Preparation is essential, and the removal of surface contamination and oxidized layers requires proper cleaning and scraping.
- A clean and uncontaminated surface is the single most important factor in achieving a good fusion bond.
- Types of contamination that will reduce PE joint integrity:
  - Dirt
  - Drilling mud
  - Grease or oily deposits
  - Oxidation due to air and/or UV
  - Soap
  - Water / cleaning solvents

Developed fusion joining preparation best practices

GTI ENERGY

Completed a series of fusion joining preparation projects

- Summary of GTI/OTD Work to Date:
  - Various scrapers tested with respect to scrape depth, scrape uniformity, and contamination (bentonite powder) removal, at different temperatures.
  - Three solvents (99% & 91% isopropyl alcohol, acetone) were tested with respect to contamination removal (talc, bentonite powder, silicone grease), with three different cleaning tools (polyester fiber wipe, paper towel, cotton rag).
- The three critical steps of pipe preparation for fusion are:

1. Removal of all loose and spreadable contaminants (dirt, oil, grease, sweat).
2. Proper scraping of the pipe promptly after cleaning.
3. Assembly of the fitting and performing the fusion promptly after scraping.

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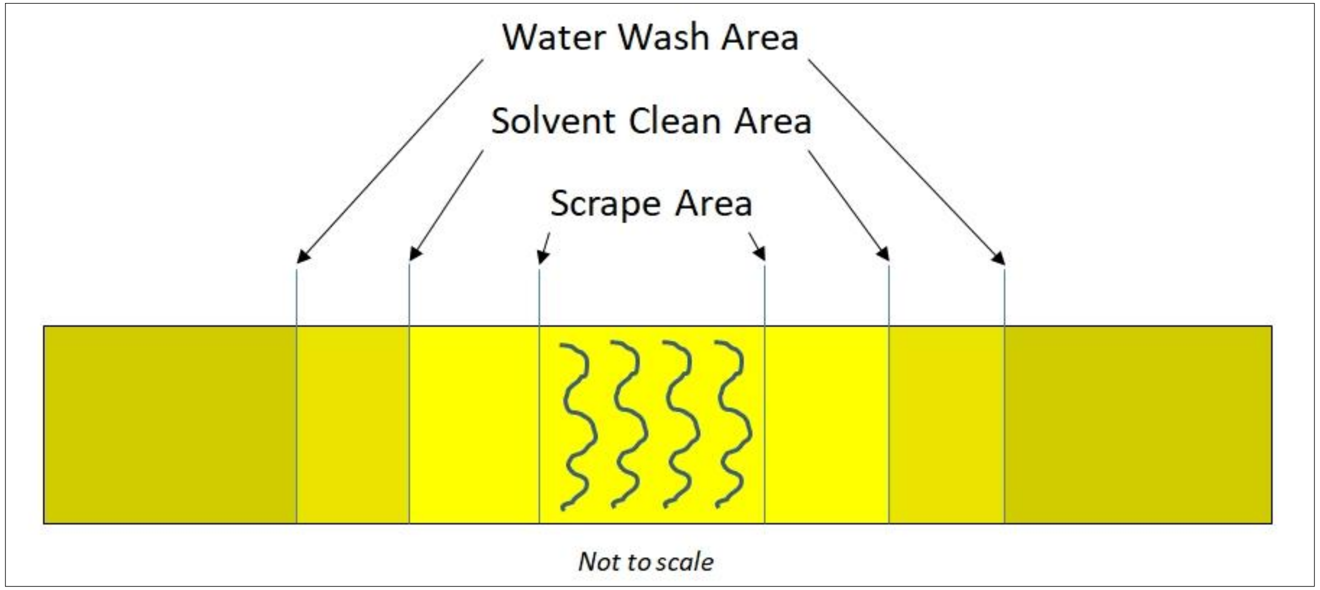
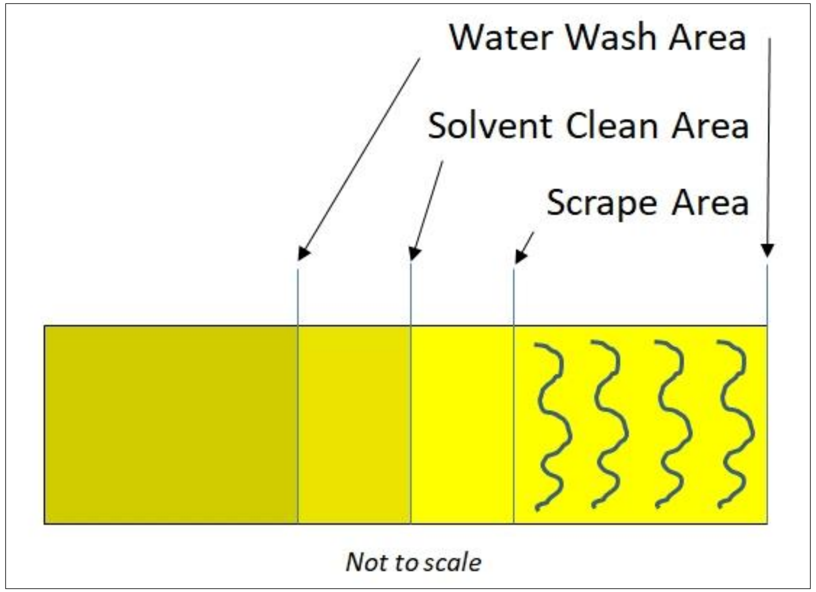
	Yellow MDPE Pipe	Black HDPE Pipe
Minimum Scrape Depth	0.007 inches (0.014 inches of pipe OD)	0.004 inches (0.008 inches of pipe OD)
Maximum Scrape Depth for EF fittings	Dependent on EF fitting	
Absolute Maximum Scrape Depth	10% of pipe wall thickness	



Pipe Preparation for a Saddle



Pipe Preparation for a Coupling

Develop fusion joining preparation best practices

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- New PPI Generic electrofusion installation guideline document:
  - New TR49 titled "Generic Electrofusion User Guide for Field Joining of Polyethylene Gas Piping"
  - Includes more robust cleaning and pipe preparation:
  - Provides for a more consistent, manufacturer agnostic, gas industry guideline
- In addition, a new ASTM was created for PE electrofusion installation on pressure piping systems including gas distribution.
  - ASTM F3565 – "Standard Practice for Electrofusion Joining Polyethylene (PE) Pipe and Fittings for Pressure Pipe Service".

§192.283 Plastic pipe: Qualifying joining procedures

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(a)Heat fusion, solvent cement, and adhesive joints. Before any written procedure established under 192.273(b) is used for making plastic pipe joints by a heat fusion, solvent cement, or adhesive method, the procedure must be qualified by subjecting specimen joints made according to the procedure to the following tests, as applicable:

(1) The test requirements of -

(i) In the case of thermoplastic pipe, based on the pipe material, the Sustained Pressure Test or the Minimum Hydrostatic Burst Test per the listed specification requirements. Additionally, for electrofusion joints, based on the pipe material, the Tensile Strength Test or the Joint Integrity Test per the listed specification.

(ii) In the case of thermosetting plastic pipe, paragraph 8.5 (Minimum Hydrostatic Burst Pressure) or paragraph 8.9 (Sustained Static Pressure Test) of ASTM D2517-00 (incorporated by reference, see§ 192.7).

(iii) In the case of electrofusion fittings for polyethylene (PE) pipe and tubing, paragraph 9.1 (Minimum Hydraulic Burst Pressure Test), paragraph 9.2 (Sustained Pressure Test), paragraph 9.3 (Tensile Strength Test), or paragraph 9.4 (Joint Integrity Tests) of ASTM F1055-98 (incorporated by reference, see § 192.7).

(2) For procedures intended for lateral pipe connections, subject a specimen joint made from pipe sections joined at right angles according to the procedure to a force on the lateral pipe until failure occurs in the specimen. If failure initiates outside the joint area, the procedure qualifies for use.

(3) For procedures intended for non-lateral pipe connections, perform tensile testing in accordance with a listed specification. If the test specimen elongates no less than 25% or failure initiates outside the joint area, the procedure qualifies for use.

Qualification Letters from Manufacturers

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CENTRAL +GF+ GEORG FISCHER PIPING SYSTEMS

Product Management
Georg Fischer Central Plastics LLC
P.O. Box 3129
39605 Independence St.
Shawnee, OK 74801
USA
Phone (800) 654-3872 (Toll free)
+1 (405) 273-6302
www.centralplastics.com

Jeff Wright
Phone +1 (405) 878-3923
Fax +1 (405) 878-5923
Mobile +1 (405) 878-6010
jeff.wright@georgfischer.com

Shawnee, September 22, 2023

Subject : ASTM F3565 - Standard Practice for Electrofusion Joining Polyethylene (PE) Pipe and Fittings for Pressure Pipe Service

Georg Fischer Central Plastics, LLC has qualified the electrofusion joining procedures contained in ASTM F3565 *Standard Practice for Electrofusion Joining Polyethylene (PE) Pipe and Fittings for Pressure Pipe Service* for use in joining its electrofusion piping products.

Testing was conducted on both medium density (MDPE) and high density (HDPE) polyethylene pipe and fittings (coupling and saddle fittings) and those fusion joints satisfactorily passed all tests. Those tests satisfy the requirements of 49 CFR Part §192.283 (a)(1)(iii) and inlcuded minimum hydraulic burst tests, sustained pressure tests, tensile strength tests (couplings only), impact tests (lateral connections only), and joint integrity tests as described in ASTM F1055.

Based on these tests Georg Fischer Central Plastics has qualified the use of ASTM F3565 as an acceptable procedure for use to join its polyethylene products to commercial grade polyethylene piping materials produced for pressure pipe service, including ASTM D2513 piping for regulated natural gas service.

Yours sincerely

Georg Fischer Central Plastics LLC

Jeff Wright
Technical Director

IPEX by aliaxis

September 10th, 2024

Dennis Jarnecke
Senior Director
GTI Energy

SUBJECT: ASTM F3565 ELECTROFUSION JOINING PROCEDURES

Dear Mr. Jarnecke;

IPEX USA LLC. (IPEX) endorses the electrofusion joining procedure specified in *ASTM F3565-23 - Standard Practice for Electrofusion Joining Polyethylene (PE) Pipe and Fittings for Pressure Pipe Service.*

IPEX has reviewed the procedure and its fitting products can safely join PE Pipes via electrofusion when this procedure is correctly followed. IPEX has installed its fittings using procedures from our Installation Guides which are comparable to the procedures laid out in the new standard.

The procedure matches IPEX's prescribed installation method except that it allows for the use of a lower concentration alcohol cleaning solution (90% vs 96%) than we specify, however we do not expect this to make a significant difference in the quality of the installation. However, in order to have the required documentation on hand we will be conducting tests to verify this over the next few months.

Should you need any additional information please do not hesitate to contact me at (416) 315-5700

Sincerely,
IPEX USA LLC.

Richard St-Aubin, P.Eng.
General Sales Manager – Municipal Systems

IPEX USA LLC.
10100 Rodney Street, Pineville NC 28134

WL PLASTICS The Ideal Piping Solution

WL Plastics Corp
3575 Lone Star Circle
Fort Worth, TX 76177

August 23, 2023

Re: Fusion Qualification of WL Plastics ASTM D2513 products

The ability to fuse PE components, i.e., pipe or fittings, made from the same stress-rated PE compound is primarily a function of the PE compound. Manufacturers of stress-rated PE compounds used by WL Plastics have demonstrated their compound's intrinsic ability to fuse. TR-33 confirmed commercial stress-rated PE compounds in the form of pipe can be fused to itself (self-fusions) and also to each other (cross-fusions). The stress-rated PE compounds (MDPE, HDPE) evaluated in TR-33 had the melt index cell classification values (per ASTM D3350) of '3' (<0.40 to 0.15 g/10 min.) or '4' 151 (<0.15 g/10 min. or a high load melt index 190°C/21.6 kg of 4 – 20 g/10 min). TR-33 showed that stress rated compounds with melt index within the range of cell class '3' and '4' can be fused, whether HDPE or MDPE. WL Plastics manufacturers MDPE and HDPE using stress rated compounds with melt index within the range of cell class '3' and '4'.

WL Plastics has performed fusion qualification testing per 49CFR192.283 to validate that its pipe products are fusible. ASTM D2513-NR pipe manufactured by WL Plastics and other manufacturers pipe made from melt index cell classes '3'and '4' were fused in accordance with ASTM F2620 which was created from PPI TR-33 (Generic Butt Fusion Joining Procedure). The history of TR-33 and ASTM F2620 is explained in Appendix A. All butt fusions were made using a McElroy Pitbull 14 machine. Pipe ends were heated to approximately 425ºF until the appropriate melt bead sizes were formed. The Pitbull is a manual fusion machine so fusion pressures could not be recorded but it should have been in the range of 60 to 90 psi to create the proper fusion bead size and geometry. All fusions were visually inspected and tested in accordance with ASTM D-1599 (quick burst), ASTM D-638 (tensile), and ASTM D-1598 (sustained pressure at 176°F (80°C)). All testing of the fused pipe joints produced passing results. Based on these tests and previous testing performed by a PPI task group to validate TR-33, WL Plastics pipe is fusible and can be fused to any polyethylene pipe manufactures MDPE or HDPE product that meets ASTM D2513 requirements. These other manufactures include JM Eagle, Performance Pipe, KWH/Infra, Duraline/PolyPipe, Pipeline Plastics, Charter Plastics (now a WL Plastics company), Endot, and others.

If you need additional information, please feel free to contact me.

Sincerely,

Christopher W. Ampfer, P.E.
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Cold Spring, KY 41076
Work: 682-831-2734 Cell: 513-509-0391
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Web: www.wlplastics.com

GTI ENERGY

solutions that transform

Questions / Comments

GTI Energy develops innovative solutions that transform lives, economies, and the environment

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