PLASTIC PIPING FOR DISTRIBUTION OF LIQUID PETROLEUM GASES (LPG)

TR-22

2024

Plastics Pipe Institute
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Foreword

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The purpose of this technical report is to provide important information available to PPI on a particular aspect of polyethylene piping systems for distribution of liquid petroleum gases.

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This Technical Report, TR-22, was issued in July 1974, and was revised October 1988, August 1998, June 2006, May 2013, and October 30, 2024.

Table of Contents

Foreword....2
Table of Contents....3
List of Tables....3
1.0 Introduction....4
2.0 LPG Properties....4
3.0 Codes & Standards....5
4.0 Effects of Liquid Petroleum on PE....5
5.0 Joining & Installation....7
References....9
Codes & Standards....9

List of Tables

Table 1: Vapor Pressure of Propane & Butane....4
Table 2: Summary of Stress Rupture Data for PE 2406 Pipe (early vintage Aldyl "A" pipe)....6
Table 3: 73°F Pressure Ratings using 630psi HDB....7

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1.0 INTRODUCTION

This document discusses the codes, standards, and requirements for distributing liquid petroleum gas (LPG or LP gas) in polyethylene (PE) and polyamide (PA11) piping systems. These piping systems offer safe and cost-effective means to transport fuel gases in residential, commercial, and industrial applications.

2.0 LPG PROPERTIES

LPG consists mostly of mixtures of propane (C_3H_8), butane (C_4H_{10}), butylene (C_4H_8), propylene (C_3H_6), and isobutane (C_4H_{10}). The percentage of propane in an LPG gas mixture can range from 100% propane to 20% propane/ 80 % butane depending on the climate where it will be used. Higher propane concentrations are used in colder climates, and higher butane concentrations may be used in warmer climates. ASTM D1835 and the Gas Processors Association LPG specification provide standards for different grades of LPG. Propane boils at lower temperatures than butane (see **Table 1**), making it more suitable for cold climates. Butane will not vaporize at temperatures below 33°F. Liquid petroleum in a storage tank will boil to gas until its vapor pressure corresponding to the temperature of the tank and gas is reached. As liquid petroleum boils, it draws heat through tank walls causing them to cool and even frost if enough moisture is present outside the tank. The vapor pressure of LPG increases as the temperature of the tank and gas increases (see **Table 1**).

Table 1: Vapor Pressure of Propane & Butane

Gas Temperature, °F (°C)	Vapor Pressure, psig (kPa)	
	Propane	Butane
0 (-17.8)	24.5 (168)	
10 (-12.2)	34 (234)	
20 (-6.7)	42 (290)	
30 (-1.1)	53 (365)	
40 (4.4)	65 (448)	3.1 (21)
50 (10.0)	78 (538)	6.9 (48)
60 (15.6)	93 (641)	11.5 (79)
70 (21.1)	110 (758)	17 (117)

3.0 CODES & STANDARDS

Federal Code (§ 192.11) regulating the transportation of petroleum gas by pipeline incorporates by reference NFPA 58 (2004), “Liquefied Petroleum Gas Code” and NFPA 59 (2004), “Utility LP-Gas Plant Code”.

§ 192.11 Petroleum gas systems.

(a) Each plant that supplies petroleum gas by pipeline to a natural gas distribution system must meet the requirements of this part and NFPA 58 and NFPA 59 (incorporated by reference, *see* § 192.7).

(b) Each pipeline system subject to this part that transports only petroleum gas or petroleum gas/air mixtures must meet the requirements of this part and of ANSI/NFPA 58 and 59.

(c) In the event of a conflict between this part and NFPA 58 and NFPA 59 (incorporated by reference, *see* § 192.7), NFPA 58 and NFPA 59 prevail.

[Amdt. 192-78, 61 FR 28783, June 6, 1996, as amended by Amdt. 192-119, 80 FR 180, Jan. 5, 2015; 80 FR 46847, Aug. 6, 2015]

NFPA 58 covers LPG piping up to the second stage regulator of a service. NFPA 54 covers LPG piping downstream of the second-stage regulator. NFPA 58 allows the use of polyamide (PA11) and PE pipe meeting the requirements of ASTM F2945 and ASTM D2513, respectively. Prior to the 1992 edition of NFPA 58, the use of PE and PA piping in LP-Gas service was not allowed except by approval from the “authority having jurisdiction” (AHJ). The use of PE piping was restricted because compression-type mechanical fittings were prohibited until the publication of the 1992 edition, and transition fittings were considered to be compression-type; therefore, there was no way to transition from PE pipe to steel pipe and be in compliance with NFPA 58. With the use of compression-type mechanical fittings allowed in 1992, the use of PE tubing underground in LP-Gas piping systems has grown at a very rapid rate. PA11 was added to NFPA 58 in the 2004 edition of the code.

Both PE and PA11 materials can be used outdoors and underground. Neither material is permitted to be used indoors or above ground (except for PE piping in anodeless risers). PA11 materials can handle LPG in its liquid or gaseous form. NFPA 58 permits PA11 pipe to operate at its full design pressure. NFPA 58 limits the operating pressure of PE piping systems to 30psi or less. The operating pressure restriction on PE piping is intended to prevent LP gas from liquifying in the line. The presence of liquid propane can weaken PE lines; however, the minimum wall thicknesses required by § 192.121 are sufficient to handle 30psig pressure if liquid propane was present in the line. The minimum wall thicknesses for PE and PA pipe and tubing should follow the code requirements § 192.121.

4.0 EFFECTS OF LIQUID PETROLEUM ON PE

Operators using PE piping to convey LPG gaseous fuels should recognize the possibility for the occurrence of condensates. Experience has shown that the NFPA maximum recommended operating pressure of 30psig for LPG systems both minimizes the possible occurrence of condensates and gives adequate consideration of the effect of LPG fuels on the long-term strength of PE piping.

Liquid petroleum can be absorbed into PE piping materials causing them to swell, change color, and reduce their strength. In the absence of liquid petroleum, the absorbed liquid will eventually desorb from the pipe walls. The rate of absorption and desorption from the pipe walls varies based on hydrocarbon mixture and line pressure. PE pipes with absorbed liquid petroleum or any other liquid hydrocarbon should not be joined by heat fusion. Mechanical fittings are recommended for joining when liquid hydrocarbon absorption is suspected. Bubbles or pock marks forming at the heated surface of a pipe face are a possible indication of the presence of absorbed hydrocarbons (Ref. 1, 2, 3). This bubbling is the result of the rapid expansion (by heat) and passage of absorbed heavier liquid hydrocarbons through the molten material. Heat fusion (butt, socket, saddle, or electrofusion) joint strength may be reduced by the presence of the heavier liquid hydrocarbons. A smell of fuel during the fusion face heating is also an indication.

In the 1970's, Dupont performed long-term hydrostatic testing in accordance with ASTM D1598 on early vintage Aldyl "A" (PE2406) piping material using LP-Gas as the pressurizing medium. The results were analyzed in accordance with ASTM D2837 to determine LTHS and HDB values. **Table 2** summarizes these test results. The HDB at 73°F for pipes tested with methane gas and propylene gas as the test mediums were the same as those tested with water (1250psi). Methane gas did not affect the HDB. However, propane vapor reduced the HDB from 1250psi to 1,000psi, and liquid propane and liquid butane reduced the HDB to 800psi. Liquid hydrocarbon condensate reduced the 73°F HDB to 630psi, which is approximately 50% of its water rated HDB. (Ref. 4)

Table 2: Summary of Stress Rupture Data for PE 2406 Pipe (early vintage Aldyl "A" pipe)

Test Medium	IPS Size	Wall Thickness	LTHS at 73°F, psi	HDB at 73°F, psi
Methane Gas	2	0.070", (DR 34)	1390	1250 (LTHS 1200 to 1530)
Methane Gas	1	0.119", (SDR 11)	1250 to 1380	1250 (LTHS 1200 to 1530)
Propylene Gas	2	0.070", (DR 34)	1210	1250 (LTHS 1200 to 1520)
Propane Gas	2	0.070", (DR 34)	1140	1000 (LTHS 960 to 1200)
Propane Liquid	1	0.119", (SDR 11)	800	800 (LTHS 760 to 960)
Butane Liquid	1	0.119", (SDR 11)	850	800 (LTHS 760 to 960)
Liquid Condensate	1	0.119", (SDR 11)	650	630 (LTHS 600 to 760)

Table 3 lists the pressure ratings for PE pipe using an HDB at 73°F of 630psi and design factors of 0.32 and 0.40 required by code (§ 192.121). **Table 3** shows that the maximum allowable operating pressure of 30psig for PE LPG lines is conservative for most DR's.

Table 3: 73°F Pressure Ratings using 630psi HDB

DR	DF=0.32	DF=0.40
7	67	84
9	50	63
9.3	49	61
9.7	46	58
11	40	50
13.5	32	40
17	25	32
21	20	25

5.0 JOINING & INSTALLATION

Below is a summary of some of the joining and installation requirements of NFPA 58. This summary is provided only as a reference and is not intended to replace the requirements of NFPA 58.

- Joints of polyamide and polyethylene pipe, tubing, and fittings shall be made by heat fusion, by compression-type mechanical fittings, or by factory-assembled transition fittings. Persons joining polyethylene pipe should be trained under the applicable joining procedure.

- Mechanical fittings for polyethylene gas piping shall comply with Category 1 of ASTM D2513 or ASTM F1948[1]. Compression-type mechanical fittings shall include a rigid internal tubular stiffener, other than a split tubular stiffener, to support the pipe. Gasket material in the fitting shall be resistant to the action of LP-Gas and shall be compatible with the polyamide or polyethylene pipe material.

- Polyethylene and polyamide pipe and tubing shall be buried with a minimum of 12 in. of cover or a minimum of 18 in. of cover if external damage to the pipe or tubing is likely to result. Piping shall be installed in conduit or bridged (shielded) if a minimum of 12 in. of cover cannot be provided.

[1] This current language in NFPA 58 should be updated to reflect that mechanical fittings for polyethylene gas piping shall comply with Category 1 per specifications IBR in CFR Title 49 § 192.7. ASTM D2513 is under ballot to remove the mechanical fitting categories.

- An electrically continuous corrosion-resistant tracer wire (minimum AWG 14) or tape shall be buried with the polyamide or polyethylene pipe to facilitate future locating of the pipe. One end of the tracer wire shall be brought above ground at a building wall or riser. The tracer wire or tape shall not be in direct contact with the polyamide or polyethylene pipe.

- Anodeless risers are used to make a transition between underground PE or PA pipe or tubing and aboveground metallic pipe or tubing. Assembled anodeless risers shall be used to terminate underground polyamide and polyethylene fixed piping systems above ground. The horizontal portion of risers shall be buried at least 12 in. (300 mm) below grade, and the casing material used for the risers shall be protected against corrosion. Either the aboveground portion of the riser casing shall be provided with a plastic sleeve inside the riser casing, or the pipe or tubing shall be centered in the riser casing. Risers shall be sealed, and leak tested by the manufacturer.

- Polyamide and polyethylene piping installed in a vault, underground container, or any other belowground enclosure shall be encased in one of the following:

    - Gastight metal pipe and fittings protected from corrosion
    - An anodeless riser

REFERENCES

1. Pimputkar, S.M., Belew, B., Mamoun, M.L., Stets. J.A., 1997. *Strength of Fusion Joints Made from Polyethylene Pipe Exposed to Heavy **Hydrocarbons***, Fifteenth International Plastics Pipe Symposium, Lake Buena Vista, Florida.
2. Pimputkar, S.M., Stets, J.A., and Mamoun, M.L., 1999. *Examination of Field Failures*, Sixteenth International Plastics Pipe Symposium, New Orleans, Louisiana.
3. Gas Research Institute (GRI), 1997. *Service Effects of Hydrocarbons on Fusion and Mechanical Performance of Polyethylene Gas Distribution Piping*, Topical Report GRI-96/0194.
4. Electronic communication with Dr. Gene Palermo, formerly of Dupont.

CODES & STANDARDS

1. ASME B16.40, *Manually Operated Thermoplastic Gas Shutoffs and Valves in Gas Distribution Systems*.
2. ASTM D1835, *Standard Specification for Liquefied Petroleum (LP) Gases*
3. ASTM F2945, *Standard Specification for Polyamide 11 Gas Pressure Pipe, Tubing, and Fittings, recommended by the manufacturer for use with LP-Gas*
4. ASTM D2513, *Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings*
5. ASTM D2837, *Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products*
6. Gas Processors Association, *Liquefied Petroleum Gas Specifications and Test Methods*
7. NFPA 58, *Liquefied Petroleum Gas Code*