Polyethylene Piping Distribution Systems for Components of Liquid Petroleum Gases

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105 Decker Court, Suite 825, Irving, TX 75063 P: 469-499-1044 F: 469-499-1063 www.plasticpipe.org

Foreword

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COMPONENTS OF LIQUID PETROLEUM GASES

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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. This report has been prepared by PPI as a service of the industry. The information in this report is offered in good faith and believed to be accurate at the time of its preparation, but is offered "as is" without any express or implied warranty, including WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Any reference to or testing of a particular proprietary product should not be construed as an endorsement by PPI, which does not endorse the proprietary products or processes of any manufacturer. The information in this report is offered for consideration by industry members in fulfilling their own compliance responsibilities. PPI assumes no responsibility for compliance with applicable laws and regulations.

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POLYETHYLENE PIPING DISTRIBUTION SYSTEMS FOR COMPONENTS OF LIQUID PETROLEUM GASES

1.0 INTRODUCTION

Polyethylene (PE) gas piping is the most widely used plastic piping material for the distribution of natural gas. PE has a well-documented inertness to both the external soil environment and to natural gas. Extensive testing and over 45 years of successful field experience confirm that the long-term strength of polyethylene is unaffected by natural gas and its common constituents.

Polyethylene (PE) piping systems complying with ASTM D 2513 have been successfully used in all types of fuel gas piping applications since the mid 1960s. These PE piping materials have been continually improved throughout the ensuing three decades assuring the safe, cost effective, transport of fuel gases in residential, commercial and industrial applications.

PE piping is the only approved plastic piping under NFPA 58, *Liquefied Petroleum Gas Code,* and is commonly used in the piping of liquefied petroleum gases (vapor LP-Gas). To be Code-complaint, PE lines must transport gas only in a vapor state, and therefore, must operate at 30 psig or less to avoid LP gas liquefaction. Vapor LP-Gas is one of those fuel gases, which can be safely piped in PE gas piping systems. The use of D 2513 PE piping for the transport of vapor LP-Gas is permitted and codified under US DOT CFR Title 49 Part 192. By reference, Part 192 identifies ANSI/NFPA 58 –as the installation standard for PE vapor LP-Gas piping systems.

NFPA 54 / ANSI Z223.1 – *National Fuel Gas Code* paragraph 2.6.4 also refers the user to ANSI/NFPA 58 by stating "The use of plastic pipe, tubing and fittings in undiluted liquefied petroleum gas piping systems shall be in accordance with *Standard for the Storage and Handling of Liquefied Petroleum Gases [Liquefied Petroleum Gas Code], NFPA 58."*

NFPA 58 places certain restrictions on the use of PE piping for vapor LP-Gas distribution. NFPA limits the size of PE piping to 2" NPS piping with a nominal OD of 2.375". Furthermore, NFPA 58 limits the maximum operating pressure of PE vapor LP-Gas piping systems to 30 psig. The reader should refer to NFPA 58 for the details of these and other installation requirements.

2.0 BACKGROUND

The components of liquid LP-Gas are known to have short-term, reversible effects on PE gas piping. At low temperatures and high pressures, vapor LP-Gas will condense into a liquid state. The effect of liquid LP-gas is to lower the long-term strength capabilities (hydrostatic design basis) of PE gas piping, as summarized in Table I. These data were obtained on a PE 2306 piping material. It is therefore prudent to limit the operating pressure (stress) when using PE gas piping to transport vapor LP-Gas. In addition, vapor LP-Gas systems operating within particular temperature and pressure guidelines are less likely to produce condensation. Many PE gas-piping materials have been evaluated to determine their long-term strength using vapor LP-Gas as the pressurizing medium. A design factor of 0.25 (chemical design factor of 0.5 times service design factor of 0.5) has thus been established for PE piping in vapor LP-Gas service. As stated above, NFPA 58 prescribes the established pressure and design limitations.

3.0 USE RECOMMENDATIONS

a) Any plastic material to qualify for use as a vapor LP-Gas piping system should be recommended by the manufacturer for such use, should be qualified using vapor LP-Gas as the medium, and have a hydrostatic design basis (HDB) category of at least 1250 psi (8.6 MPa) at 73°F (23°C) as determined by test method ASTM D2837. All PE piping systems complying with ASTM D 2513 meet these criteria.

b) The vapor LP-Gas PE piping system shall be made from PE materials specified in and manufactured in accordance with ASTM D 2513.

c) To determine the maximum use pressure in vapor LP-Gas distribution, a design factor of 0.25 is recommended (see also PPI TR-9 on recommended design factors) to derate the PE material's hydrostatic design basis (HDB) as listed in PPI TR4 and determined in accordance with ASTM D 2837. This design factor is more conservative than the 0.32 design factor used for PE piping used in natural gas (methane) distribution systems. ASTM D2513 states the following,
"X1.7.2.1 However, it has also been shown by the above referenced studies that propane, propylene and butane, when in the liquid phase, can cause a greater reduction in long-term strength, up to 40 %. Accordingly, the use of PE piping to convey LPG gaseous fuels should recognize this effect and the design and operation of such piping should consider the possibility for the occurrence of condensates. Extensive experience has shown that the NFPA maximum recommended operating pressure of 30 psig for LPG systems (see X1.3.4) 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."

d) With the exception of PE piping in anodeless risers, PE gas piping and fittings should only be used in underground distribution systems designed to operate at internal pressures and temperatures such that condensation will not occur. Condensation is unlikely at the temperature and pressure combinations shown in Table 2.

e) It has been reported (1, 2 and 3)) that during the heat fusion joining of PE piping that has been in service conveying fuel gases that consist of, or that include heavier liquid hydrocarbons, the PE surfaces being heated in preparation for fusion sometimes exhibit a “bubbly” appearance. 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. Pimputkar et al (8) conclude that for a system operating at 50 psi and conveying a mixture of as high as 16 volume percent in methane the liquid propane concentration in PE will be under 0.2 percent, sufficient to sometimes show some bubbling, but not high enough to effect any significant degradation in fusion strength. However, if the concentration of propane in PE exceeds 0.2 percent, there is the risk of a rapid and large drop in fusion strength. Field tests to verify the level of contamination and subsequent degradation of joint strength are not currently available. Therefore, in the case of PE pipe that has previously been installed in these types of services, one should use mechanical fittings to join or repair the pipe.

(1) Sudheer M. Pimputkar, Barbara Belew, Michael L. Mamoun, Joseph A. Stets, “Strength of Fusion Joints Made From Polyethylene Pipe Exposed to Heavy Hydrocarbons”, Fifteenth International Plastics Pipe Symposium, Lake Buena Vista, Florida, October 1997.
(2) S.M. Pimputkar, J.A. Stets, and M.L. Mamoun, “Examination of Field Failures”, Sixteenth International Plastics Pipe Symposium, New Orleans, Louisiana, November 1999.
(3) Gas Research Institute Topical Report GRI-96/0194, “Service Effects of Hydrocarbons on Fusion and Mechanical Performance of Polyethylene Gas Distribution Piping”, May 1997.

Table 1

Summary of Stress Rupture Data for PE 2306 Pipe
(This testing was conducted on early vintage Aldyl "A" pipe that was designated PE 2306)

Test Medium	NPS, Pipe Sizing	Wall Thickness	LTHS, psi	HDB, psi
Methane Vapor	2	0.070", (DR 34)	1390	1250 (LTHS 1200 to 1530)
Propane Vapor	2	0.070", (DR 34)	1140	1000 (LTHS 960 to 1200)
Propane Liquid	1	0.119", (SDR 11)	800	800 (LTHS 760 to 960)
Propylene Vapor	2	0.070", (DR 34)	1210	1250 (LTHS 1200 to 1520)
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 2

Temperature and pressure Combinations Where Condensation Will Not Occur

Temperature °F (°C)	Maximum Pressure, psig (kPa)	Maximum Pressure, psig (kPa)
	Propane	**Butane**
10 (-12.2)	30 (207)	
20 (-6.7)	40 (276)	
30 (-1.1)	50 (345)	
40 (4.4)	60 (414)	2.5 (17)
50 (10.0)	75 (517)	5 (35)
60 (15.6)	90 (621)	10 (67)
>65 (>18.3)	100 (690)	14 (97)

Note: Varieties of LPG bought and sold include mixes that are primarily propane (C_3H_8), primarily butane (C_4H_{10}) and, most commonly, mixes including both propane and butane, depending on the season — in winter more propane, in summer more butane.

APPLICABLE CODES AND STANDARDS

ASTM D 2513, *Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings.*

ASTM D2837, *Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products*

NFPA 58, *Liquefied Petroleum Gas Code*