Special Precautions for Fusing Saddle Fittings to Live PE Fuel Gas Mains Pressurized on the Basis of a 0.40 Design Factor

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SPECIAL PRECAUTIONS FOR FUSING SADDLE FITTINGS TO LIVE PE FUEL GAS MAINS PRESSURIZED ON THE BASIS OF A 0.40 DESIGN FACTOR

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Foreword

SPECIAL PRECAUTIONS FOR FUSING SADDLE FITTINGS TO LIVE PE FUEL GAS MAINS PRESSURIZED ON THE BASIS OF A 0.40 DESIGN FACTOR

This report was developed and published with the technical help and financial support of the members of the PPI (Plastic Pipe Institute). The members have shown their interest in quality products by assisting independent standards-making and user organizations in the development of standards, and also by developing reports on an industry-wide basis to help engineers, code officials, and users.

Recent changes to the gas system codes in Canada have increased the maximum operating pressure (MOP) for gas service. In the United States, substantial investigation has been undertaken to explore the installation and operations considerations of moving to a higher design factor. Six special permits (waivers) allowing for systems to be installed and operated with a 0.40 design factor (DF) have been granted. Based on these installations, the American Gas Association Plastic Materials Committee (AGA-PMC) has submitted a petition to the US Department of Transportation (DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA) to increase the design factor for high performance PE materials to 0.40.

The internal pressure capability of polyethylene gas piping products is not at issue because the increased MOP is well within the long-term internal pressure design capabilities of materials used for polyethylene gas piping today with a 0.40 design factor. However, higher internal pressure signifies the need for more careful attention to the process of fusing service and branch saddles and self-tapping tees to the live PE mains. This PPI Technical Note addresses precautions that should be considered relative to this issue.

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PPI intends to revise this report from time to time, in response to comments and suggestions from users of this note. Please send suggestions for improvements to PPI. Information on other publications can be obtained by contacting PPI directly or visiting the web site.

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1.0 BACKGROUND

Polyethylene piping has long been used to transport liquid and gaseous fluids including water, wastewater, water slurries, industrial process liquids, benign chemicals and wastes, gaseous and liquid fuels, and oilfield gases and liquids under pressure. Most polyethylene pressure piping systems operate at service pressures that are based on material design strengths. However, governmentally regulated gas distribution systems in the U.S. and Canada are required to operate at lower service pressures to provide added assurance of public safety; that is, permissible internal pressures are more conservative in gas distribution systems compared to typical service pressures for the same pipe in a comparable non-regulated service. For the purposes of this technical note the ability of polyethylene pipe to provide long term service under internal pressure is not an issue and is not a concern.

When adopted by Canadian Provincial Governments, the Canadian Standards Association (CSA) document CSA Z662-15 ***Oil and Gas Pipeline Systems*** standard serves as part of the design and safety regulations for gas piping systems. In the United States, the Department of Transportation (DOT) administers minimum safety standards in CFR 49, Part 192 “Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards.”

Polyethylene gas piping systems are rated for internal pressure using a design factor (DF) to determine a maximum operating working stress. In CSA Z662, a maximum 0.40 DF is used for standard PE 2708 and PE 4710. CSA Z662 was revised to include a 0.45 DF for use with PE 2708 PLUS and PE 4710 PLUS compounds, with no additional gauge pressure design limitation. The PLUS designation confirms that the PE compound has higher slow crack growth (SCG) resistance - a PENT value over 2000 hours, and minimum rapid crack propagation (RCP) of 10 bar in the ISO S4 RCP test. These SCG and RCP requirements justify the 0.45 design factor and the PLUS designation.

In the U.S., the American Gas Association (AGA), Plastic Materials Committee (PMC) petitioned DOT to raise the maximum allowable operating pressure in PE gas piping to 125 psig, and DOT approved this request for pipeline 12-inch IPS and smaller with an effective date July 14, 2004. Like the change already effected in Canada, for a given dimension ratio (DR) or standard dimension ratio (SDR) of polyethylene gas pipe, a DF increase to 0.40 would increase the MOP by 25%.

The economic advantages of higher allowable main pressures in compressible gas systems include transporting a greater volume of gas in the same pipeline, or using thinner wall piping than heretofore for the same pressures. Just as CSA – Z662-2011 does not allow regulatory authorities to consider applying the higher design factor retroactively to existing systems, any petition to the US DOT or change to the CFR 49 Part 192 will specifically exclude retroactive application of the proposed design factor change to 0.40.

This technical note addresses precautions and recommendations related to short term mechanical effects on polyethylene gas mains during saddle fusion joining of branch and service saddles and tapping tees to pressurized gas mains. This technical note complements PPI TR-41 and ASTM F2620, which provide generic procedures for saddle fusion. Saddle fusion requires simultaneously melting a surface area of the main pipe and the mating fitting base for joining. Because thermoplastic materials such as polyethylene have reduced mechanical strength at higher temperatures, appropriate precautions and recommendations to minimize the effect of temporarily reduced mechanical effects on pressurized gas mains during saddle fusion joining of branch and service saddles and tapping tees.

2.0 PRECAUTIONS AND RECOMMENDATIONS

2.1 Precautions

Polyethylene service/branch saddles and self-tapping tees are fused to live (pressurized) PE mains in order to establish a branch connection. Under a 0.40 DF, the allowable hoop stress in the pipe wall is 25% greater compared to the hoop stress permitted with a 0.32 DF. While long-term pressure rating is not a concern, PPI and its member companies are concerned that higher hoop stress in the pipe wall will increase the potential for gas main blowout during the process of fusing these branch connection type fittings to the pipe.

Using existing procedures, fusion of service/branch saddles and self-tapping tees to the main involves simultaneously heating the mating surfaces of the pipe and fitting until the proper melt consistency is achieved then joining the melted surfaces together (these steps are concurrent in the electrofusion process). As the melted surfaces cool, they fuse and bond together. When properly performed, heating of the matching surfaces is controlled so that the mechanical strength of the heated main remains high enough to contain the internal pressure in the main. If the heating phase is not properly controlled, the main may be over heated, weakened, and may blow out.

***WARNING* – BLOWING GAS CAN IGNITE CAUSING EXPLOSION, FIRE, DEATH, PERSONAL INJURY, AND PROPERTY DAMAGE.**

Under U.S. and Canadian regulations, gas pipeline system operators are required to have qualified fusion procedures and to qualify persons who work on and inspect their pipelines in those procedures. Many gas system operators may be using procedures for fusing service/branch saddles and self-tapping tees to PE mains similar to manufacturer's recommendations that may be based on gas piping stresses determined using a 0.32 DF. But, the hoop stress in the pipe wall at 0.40 DF is 25% higher.

To evaluate the risk of blowout, several PPI member companies made saddle fusions on pressurized polyethylene gas pipes using a saddle fusion joining procedure which had been developed and qualified for MOP on 0.32 DF polyethylene gas pipe. When these procedures were used at a 0.40 DF MOP, the risk of main blowout during saddle fusion was:

- greater for smaller diameter pipes,
- greater when pipe surface temperature was elevated (above 100ºF/38ºC), and
- greater with higher DR (thinner wall) pipes.

These tests suggest that procedures that were suitable for saddle fusion at 0.32 DF stresses may be unsuitable at higher stresses such as at 0.40 DF. PPI established a Task Group and retained an independent consultant to establish saddle fusion parameters and procedures to accommodate the design factor change.

Therefore, for hot-plate saddle fusion, a different saddle fusion procedure may be required when hot tapping a 0.40 DF gas main. Additionally, service/branch saddles and self-tapping tee connections made with some electrofusion processes may also result in blowout of the main in some cases if the appropriate joining procedures are not followed.

2.2 Recommendations

PPI and its member companies strongly recommend that U.S. and Canadian gas system operators fully evaluate their procedures for attaching service/branch saddles and self-tapping tees to live PE mains, and take appropriate measures to ensure that persons and property are not exposed to greater hazards from higher gas main pressures or from increased operating wall stresses in higher DR (thinner wall) pipes.

PPI recommends using Plastics Pipe Institutes Technical Report TR-41 and ASTM F2620 for the fusion of service and branch saddles and self-tapping tees with the following limitations:

- For fusing these fittings to pressurized mains 2” IPS and smaller, the maximum DR (thinnest wall) for the main shall be DR 11.

- For larger main sizes, the maximum DR is:
  3” – DR 13.5
  4” – DR 17
  6” – DR 21
  >6” – DR 21