Assessment of Squeeze-off Location for Small Diameter Polyethylene (PE) Pipe and Tubing

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Abstract

INTRODUCTION: Squeeze-off of PE pipe (Figure 1) is a common method that is used to stop gas flow to enable downstream repairs or perform emergency shutoff.
Current ASTM standard F1041-02(2008) details how to perform squeeze-offs for this material. Article 7.3 of this standard states squeeze-off must be performed "at least three (3) pipe diameters or twelve (12)-inches (305 mm), whichever is greater, from any fusion joint (1.5 diameters for butt-fusion joint) or mechanical fitting". This standard is widely adhered to within the gas industry.
Several natural gas utilities have expressed interest in examining the potential for reducing current minimum squeeze-off distances for small pipe diameters (<=3" IPS), where the current minimum of 12-inches is larger than three (3) pipe diameters. Reducing the minimum allowable distance from a fitting will help facilitate routine operations and maintenance (O&M) tasks.
A project was set up at GTI1 to study the impact of a reduction in minimum squeeze-off distance, sponsored by OTD2. Finite Element Analysis (FEA) and accelerated testing were performed to provide a solid standing for any proposed changes to the best-practices outlined in ASTM F1041-02(2008).

USE OF COMSOL MULTIPHYSICS® software: GTI developed a fully parametric PE, time-dependent squeeze-off model (Figure 2) in COMSOL Mulitphysics, utilizing the Nonlinear Structural Materials Module and a custom viscoelastic-plastic constitutive model developed specifically for PE by Veryst Engineering3.
To calibrate the constitutive model, GTI carried out a comprehensive material testing program covering mechanical responses up to very large strains in tension and compression, at various strain-rates, and at various temperatures.
The model utilizes a contact pair to simulate the internal pipe-to-pipe contact, and a contact pair between the squeeze bar and pipe to get correct deformation of the pipe.
Special attention was given to the meshing of the pipe which, together with the custom constitutive model, enabled the simulation of the very large deformations encountered in pipe squeeze-off.

RESULTS: A table of the simulation results is shown in (Figure 3). The results showed that squeeze-offs of small diameter pipe performed at distances of three (3) pipe diameters from a fused coupling, do not induce strains larger than the acceptable strains for bent pipe. Based on these findings, accelerated lifetime tests were initiated for small diameter pipes squeezed off at

a distance of three (3) pipe diameters. The tests are still ongoing.

CONCLUSION: The simulations results indicated that squeeze-off of small diameter pipe at distances of three (3) pipe diameters from a fused joint are viable and empirical testing is ongoing to verify this indication.
Future work is planned to further calibrate and verify the PE constitutive model by carefully measuring and datalogging pipe deformation and compression loads during squeeze-offs and installation of pipe reinforcement clamps.

Reference

1. Gas Technology Institute (GTI). http://www.gastechnology.org

2. Operations Technology Development (OTD). http://www.otd-co.org

3. Elabbasi N, Bergstrom J, Constitutive Modeling of Polyethylene in COMSOL Multiphysics, COMSOL Conference 2015, Newton MA.

Figures used in the abstract

Figure 1: Squeeze-off of PE pipe

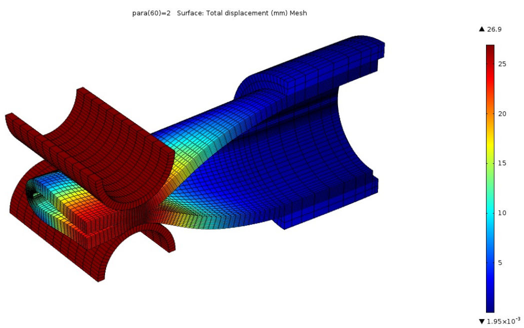

Figure 2: COMSOL simulation of PE pipe squeeze-off

Pipe Configuration	1/2" IPS 11	1/2" IPS 11	1/2" IPS 11	2" IPS 11	2" IPS 11	4" IPS 11	6" IPS 11
Offset from Coupling	12-inch	3xOD	2.5xOD	12-inch	3xOD	3xOD	3xOD
Offset Distance [in]	12.000	2.520	2.100	12.000	7.125	13.500	19.875
FEA Pipe Strain [%]	0.38	0.92	1.06	1.19	1.26	2.17	3.12
FEA Coupling Strain [%]	0.4	1.26	1.47	0.61	0.66	1.23	1.18

Figure 3: Maximum First Principal strain at vicinity of coupling edge, per geometric configuration

Figure 4