

Butt Fusion Joint Integrity and NDE Evaluation

Description: Comprehensive testing to validate butt fusion process for safe long-term performance

Status: Butt fusion samples produced at extreme fusion parameters are being non-destructively (NDE) and destructively tested to determine integrity and overall performance. NDE methods were evaluated prior to destructive testing to determine effective interpretation and detection capabilities.

BENEFITS

Ideal butt fusion parameters are a desirable part of any PE pipe user's procedures and installation practice. Tolerances of prescribed butt fusion parameters are important to define as variables, in both controlled and uncontrolled conditions. Also, it is important to know how butt fusion parameters affect the integrity and long-term performance of a PE pipeline. Testing fabricated butt fusion joints made at the extremes of these parameters will reveal the optimal and less optimal fusion conditions and tolerances. Extremes that were tested affected fusion temperatures, ambient temperatures, fusion interfacial pressures and cooling times.

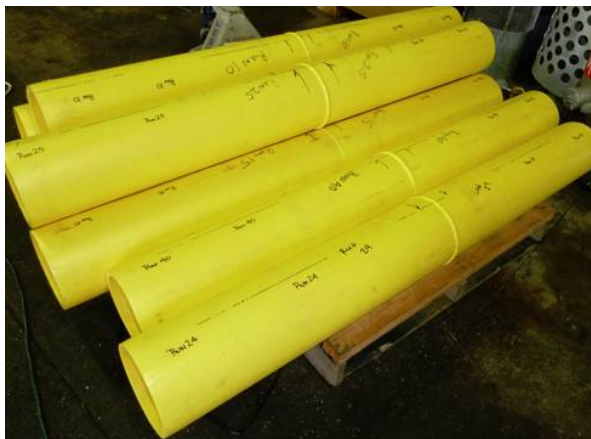


Figure 1: Butt Fusion Joint Samples Fabricated at Extremes of Acceptable Fabrication Parameters

BACKGROUND

In over 40 years of in-service use, the gas industry has developed a high confidence in the performance of PE pipe. Failures of PE pipes, fittings and joints are rare, but investigations reveal that typical failures come from combined effects of internal pressure and secondary stresses, including bending strain, earth loading and thermal expansion / contraction stresses. Properly designed and fabricated butt fusion joints are essential to the overall integrity of the PE pipeline. There is a need to validate the overall butt fusion process parameters using test methods that simulate the combined stresses and resulting failure mechanisms. At a minimum, validation results should be consistent with the 50-year theoretical intended design life.

In the 1990s, the Plastic Pipe Institute (PPI) and its member companies performed comprehensive tensile testing on 2-inch and 8-inch pipes from various pipe manufacturers which led to the butt fusion guidelines prescribed in PPI's technical report and standard TR-33. These results were based on quick burst tests which were the industry standard. ASTM and industry-accepted test requirements describe characteristics for long-term performance of butt fusion joints. The tests are essentially quality control points prescribed for particular pipe specimens. These test requirements only examine effects of circumferential stresses due to internal pressure and not combined, long-term effects on the overall integrity of the pipe.

As PE pipelines age and the use of new PE or other non-metallic materials at higher pressures (100 psi and greater) increases, there will be a need to determine optimized joint fusion quality on a routine or periodic basis. Continuous destructive examination is too costly and visual surface examination of the butt fusion joint does not always offer an optimal method of examination.

TECHNICAL APPROACH

There are multiple levels of interactions with industry representatives in this project. This was necessary as the test results are to be the basis for revising the ASTM standards. Technical formulation of PE butt fusion joint sample design, fabrication and testing was considered for its influence on joint integrity. An analytical model was developed to quantify the impact of both the fusion parameters and combined in-service stresses, as well as appropriate test methods to characterize long-term joint performance. This includes the identifying and adaptation of NDE technologies.

Consideration was given to testing medium density polyethylene pipe (MDPE) and high density polyethylene pipe (HDPE) across the range of fusion parameters. Statistical models of the test were developed using Design of Experiment (DOE) to optimize parameter relationships. After evaluating many sets of parametric combinations, comprehensive testing

was performed by short term and long-term testing to simulate performance over the intended design life of the joints. (See Figures 1 and 2 for test specimen images.) Based on results of the combined analytical modeling and testing, a more proven / validated butt fusion process will be developed.

The results of this testing will be the basis for industry incorporation into future revisions of PPI Guidelines and ASTM standards.

Review the all testing with the preliminary NDE results to determine if certain characteristics are revealed that could be used for predictive methods of butt fusion joint interpretation.

PROGRAM STATUS

Whole Pipe Creep Rupture (WPCR) testing is currently being performed. Results and comparisons will be examined to determine the most influential butt fusion parameters and optimize the process procedure. NDE technique will be reviewed to determine to what degree various methods detect effectiveness.

Highlights

Benefits

- Optimization of butt fusion parameters
- Increased confidence of long-term PE butt fusion joint performance
- Overall PE pipeline integrity



Figure 2: MDPE Specimen Prepared for WPCR Test (left), Failed HDPE Specimen Post WPCR Test (right).

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