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Inspection of Fusion Joints in Plastic Pipe

Technology Status Assessment

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Technology Status Assessment

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on

Inspection of Fusion Joints in Plastic Pipe

to

National Energy Technology Laboratory
U.S. Department of Energy
Morgantown, WV

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1.0 Introduction

Butt fusion of PE pipe has been used successfully by the gas and water distribution industries for nearly three decades for applications ranging from city mains to residential service lines. The quality of butt-fused joints is critically important because it affects the overall operational safety of the entire piping system. While failures of PE pipe butt-fusion joints are infrequent, the natural gas industry is continuously looking to maintain this good record. The availability of an accurate and cost-effective non-destructive method of assessing butt-fusion joint quality in the field is important to assure pipe integrity and ultimately deliver long-term benefit to the industry.

The American Gas Association and utility companies are becoming more aware of the need to develop technologies to non-destructive assess PE pipe. As PE materials improve with respect to yield strengths, scratch/gouge resistance and crack growth propagation more distribution companies will be using PE as the pipe material of choice for higher-pressure applications. As this direction continues, the need for NDE testing of pipe and joints in the field will become necessary and federal and state laws will follow requiring operators to perform and document joint integrity.

2.0 Existing NDE Inspection Techniques

Within the gas industry there have been earlier efforts to provide an NDE tool for the inspection of PE butt fusion joints. McElroy, a manufacturer of fusion equipment, developed a tool for the gas industry that used an ultrasonic technique. The product, marketed as “UltraMac”, was purchased by larger utility companies and NDE service providers. McElroy made a number of attempts to improve the product with respect to resolution and user interface. The product was considered by most companies to be high cost and was limited with respect to its assessment capabilities. One major limitation was that the tool could not detect “cold joints” (a weak interface bond between the pipe-ends being joined). This type of defect accounted for the majority of failures that are experienced in the field. In addition, the images produced were difficult to interpret and joints were assessed incorrectly. Operators that used the equipment with some success needed to be highly trained, which made the device only practical for a limited number of service providers and a few gas utilities. As a result, UltraMac sales suffered and the manufacturer is no longer selling or supporting this product.

Recently, another ultrasonic device is being advertised for the gas industry. Flour Corporation developed an NDE inspection tool and RTD Services is the manufacturer and service provider. The tool at this time is not intended for purchase but is being supplied as a service only. Based on literature and gas industry experience the tool was originally designed for large diameter PE butt fusion joint evaluation. It employs Ultrasonic Time of Flight Diffraction (TOFD) technology and claims to have the ability to assess various joint defects, including lack of fusion. The tool requires

a trained technician to interpret joint images and is questionable as to it ability to detect “cold joint” fuses. According to NYSEARCH and ultrasonic experts in this field, this type of joint defect cannot be detected due to ultrasonic technology limitations.

Due to the technical limitations of the technology available for PE butt fusion inspection the majority of gas companies rely on visual inspection and at times destructive examination to determine the integrity of a joint and/or to qualify fusion operators. Visual inspection can be useful at times, but it is not foolproof. There are joint defects that can only be observed by applying some form of technology to it. Visual examination should be considered as a guide or indicator in diagnosing potential problems but does not provide conclusive evidence of future performance. Destructive examination is a foolproof method to determine joint quality but it is quite costly and is of no use when examining joints that are “in service”.

Various technologies are being directed at PE NDE inspection. It should be noted that there is only one technology that is commercially available (Flour Corporation UT-TOFD method) for NDE inspection of PE butt fusion joints. Other applications are either in early stages of development or are not designed for PE butt fusion inspection. At this time, the Weld Zone Inspection Method (WZIM) proposed by EWI is the only method that specifically addresses “cold fusion” defects, which are a major concern for the gas industry.

3.0 WZIM Application

EWI proposed a method to assess the integrity of PE fusion joints. The one major benefit of this methodology, over ultrasonic techniques, is it ability to detect “cold joints”. This method can be applied to NDE of all types of PE butt fusion joints and materials. EWI completed a project for NYSEARCH that demonstrated two innovative ways to evaluate PE pipe butt-fusion joint quality by using a simple and cost-effective method known as WZIM. Phase 1 of this project established proof of concept by applying WZIM as a destructive test. Phase 2 was a non-destructive extension of this method.

The non-destructive WZIM involves removing the external weld bead, polishing the pipe surface in the area underneath the bead, and heating the polished pipe surface for a short time. Provided that the correct amount of heat is applied, a fusion line or “bondline” is revealed if the joint is not sound. The non-destructive method proposed with WZIM is not anticipated to have any detrimental effect on the performance on an in-service pipeline, but this is one of the items that shall be verified experimentally during this project.

Several “blind” tests were conducted on the joints prepared independently by gas companies in the US and the UK. In the largest test, eight joints were fused under standard and non-standard

conditions, and EWI correctly determined the quality of seven of these eight joints. In addition, Con Edison, Keyspan and NYGAS staffs have conducted independent tests to further validate WZIM. To date, these tests have shown a good correlation between joint integrity and the existence of a bondline.

The WZIM method is planned to produce a visual image of the inspected joint. Along with this weld zone image, the software will automatically assign a pass or fail rating to the joint. This assessment will minimize the training required and will lessen the need for a highly skilled technician to interpret the inspection results. Although the cost of the equipment and software is expected to be competitive with other developing technologies; the overall cost of the WZIM system is expected to be lower due to the required technician skill level.

Table I below summarizes the pros and cons of each of the NDE methods previously reviewed.

Table I NDE Methods for Butt Fusion Joint Inspection

TITLE	TECH-TYPE	SPONSOR	PROS	CONS
WZIM – LASER RECOGNITION	Laser – bondline recognition in melt zone	NYSEARCH	• Ease of use • Ability to detect cold fusion joint defects	• Unknown at this time
FLUOR CORP UT INSPECTION	UT-time of flight diffraction (TOFD)	FLUOR CORP	• Currently in use in field • Claims can evaluate lack-of-fusion defects	• No experimental or test results to prove the claim • Available data is related only to thick wall water pipes that are not used for gas distribution • Inability to detect cold fusion joint defects • Product is not available
TWI UT INSPECTION	UT	BRITISH GAS	• Advanced prototype stage	• Inability to detect cold fusion joint defects
ULTRAMAC	UT– pulse echo single point probe	McELROY	• Commercialized	• No longer available on market