Non-Destructive Examination of PE Welded Joints

1. INTRODUCTION

Several new and emerging technologies have been developed for non-destructive examination (NDE) of Electrofusion and Butt fusion welded polyethylene (PE) pipe systems. The purpose of this technical note is to provide an update on these technologies, including references to published standard codes, and resources for further structured research in Non-Destructive Testing (NDT) technology development.

Examination and testing of PE pipe welds has traditionally been based on visual and destructive testing procedures, with visual inspection by the unaided eye still one of the most effective and reliable non-destructive techniques for PE welds. PIPA's Technical Guideline POP014 Assessment of Polyethylene welds provides further information on examination techniques.

NDT instruments, procedures and skills developed for steel pipe do not directly translate to plastic pipe systems, therefore NDT inspector qualification and experience in fusion jointed plastic pipe systems is essential for achieving reliable and reproducible test results. Several codes and standards are published which specify NDT Inspector training, qualification, and certification requirements. Refer to Section 6 - Codes and Standards for further details.

Successful welds primarily depend upon correct joint assembly and preparation, and use of appropriate tooling. Most importantly, NDT is not considered a substitute for adhering to correct welding procedures. Information on these processes can be found in PIPA's Technical Guideline POP001 Electrofusion Jointing of PE Pipes and Fittings for Pressure Applications and POP003 Butt Fusion Jointing of PE Pipes and Fittings – Recommended Parameters.

2. NEW NDT ISO TECHNICAL SPECIFICATIONS

The continued development of NDT test methods has led to publication of ISO Technical Specifications. **These Technical Specifications address work still under technical development, or where it's believed there will be a future, however no immediate possibility of agreement for an International Standard.** A Technical Specification is published for immediate use, but it also provides a means to obtain feedback.

ISO/TS 16943 describes phased array ultrasonic testing (PAUT) for electrofusion socket joints and **ISO/TS 22499** for butt fusion joints. It should be noted these technical specifications advise the

techniques are only applicable to pipes and fittings without a barrier to ultrasonic waves. A brief overview of each technical specification is outlined below:

ISO/TS 16943:2019 Thermoplastic pipes for the conveyance of fluids - Inspection of polyethylene electrofusion socket joints using phased array ultrasonic testing (PAUT)

This technical specification describes PAUT of polyethylene (PE) electrofusion (EF) socket joints used for the conveyance of fluids. It also provides a test whereby the presence of imperfections such as voids, wire dislocation, misalignment, pipe under-penetration, particulate contamination, cold fusion, and lack of fusion of electrofusion socket joints can be detected.

Requirements for procedure qualification and guidance for personal qualification are also provided which are essential for the application of this test method.

Note:

(1) At the time of publication, experience only exists on the use of PAUT for PE 80 and PE100 electrofusion socket joint sizes between 90mm and 710mm (SDR11 and 17)
(2) Round robin testing has shown that PAUT is a viable method for enhancing the integrity assessment of electrofusion joints.
(3) This technical specification does not apply to the detection of unpeeled pipe. Such detection is achieved by simple visual inspection and ensuring measurement of minimum pipe peel strip thickness from the pipe surface, provided mechanical peeling tools are employed.

ISO/TS 22499:2019 Thermoplastic pipes for the conveyance of fluids – Inspection of polyethylene butt fusion joints using phased array ultrasonic testing (PAUT)

This technical specification describes PAUT of polyethylene butt fusion (BF) joints, including pipe-to-pipe, pipe-to-fitting and fitting-to-fitting joints used for the conveyance of fluids. In addition, outlines tests to detect the presence of imperfections such as voids, inclusions, lack of fusion, misalignment, and particulate contamination in the BF joints.

Essential for the application of this test method, the specification provides requirements for procedure qualification and guidance for personnel qualifications. Details covering equipment, the preparation and performance of the test, indication assessment and the reporting for PE BF joints are included, however not the assessment of ultrasonic indications and acceptable criteria.

Note:

(1) At the present time, laboratory experiences exist on the use of PAUT for polyethylene BF joints and/or reference blocks of wall thickness between 8mm to 100mm. Recently, field experience on BF joints in PE80 and PE100 materials has been reported.
(2) Round robin testing has shown that PAUT is a viable method for enhancing the integrity assessment of BF joints.

(3) PAUT techniques for cold fusion detection are known to be available. However further research, verification and experience are needed to transfer the technique into an ISO Standard. This document does not provide any information regarding the detection of cold fusions.

3. NDT ISO TECHNICAL SPECIFICATIONS UNDER DEVELOPMENT

Technical Specification ISO/WD TS 24399 Thermoplastic pipes for the conveyance of fluids – Inspection of polyethylene butt fusion joints using time of flight diffraction testing is currently under development and expected to be published soon.

4. NDT/NDE CONSIDERATIONS FOR THE USER

The Plastics Pipe Institute's (PPI) Technical Note-60 "Inspection of plastic pipes, fittings and joints using non-destructive test methods and evaluation (NDT/NDE)" outlines NDT/NDE considerations for the user of these emerging technologies, including discussion of the following topics:

- Detection Capabilities and Confidence Levels
- Joint Type Limitations
- NDT Inspector Qualification
- Evaluation Procedures
- Establishing Acceptable Criteria

PPI TN-60 should be read in conjunction with this Technical Note TN16, for a greater understanding of NDT technology capabilities and limitations.

5. STRUCTURED RESEARCH IN NDT TECHNOLOGY DEVELOPMENTS

Structured research has been conducted around the world in NDT technology developments which continues today. The projects and their associated reports listed below are by no means the only activities in the area. This research is primarily based upon inspection by phased array ultrasonic, chord or time of flight diffraction options, and microwave technology.

1. GERG Project *"Suitability of non-destructive techniques for testing polyethylene pipe joints" Peter J. Postma, Rene' J.M. Hermkens, Kiwa Technology, The Netherlands, 2012.*

2. TestPEP Project *"Development of an automated phased array ultrasonic system and flaw acceptance criteria for welding joints in polyethylene pipe" Mike Troughton, Malcom Spicer and Fredrick Hagglund, TWI Ltd, 2012.*

3. TestPEP Report *"Development and validation of an automated non-destructive evaluation approach for testing welded joints in plastic pipes" Project Ref: 243791,2016.*

4. TWI Ltd Report *"Development of flaw acceptance criteria for welding joints in PE pipes" Mike Troughton and Amir Khamsehnezhad, TWI Ltd, 2016.*

5. TWI Ltd Report " *Advanced NDT Techniques for Plastic pipeline inspection" Eurico Assuncao, Luisa Coutinho, Fredrik Hagglund, Mike Troughton, Malcom Spicer, 2013.*

6. TWI Ltd Report "*Detection Capabilities of a Phased array ultrasonic inspection system for plastic pipe butt fusion joints" Fredrik Hagglund, Malcom Spicer, Mike Troughton, 2012.*

7. Pacific Northwest National Laboratory "*Assessment of NDE Methods on Inspection of HDPE Butt Fusion piping joints for lack of fusion with validation from mechanical testing" S. L Crawford, S. R Doctor, A. D Cinson, M. W Watts, .TL Moran, M.T Anderson, 2011.*

8. Faculty of Mechanical Engineering, University of Tabriz, Iran " *Application of Neuro-Wavelet Algorithm in Ultrasonic-Phased Array Non-Destructive Testing of PE Pipeline" Reza Bohlouli, Babak Rostami, Jafar Keighobadi, 2012.*

6. CODES AND STANDARD REFERENCES

1. ISO 5577:2017 Non-destructive testing — Ultrasonic testing — Vocabulary
2. ISO 23243:2020 Non-destructive testing — Ultrasonic testing with arrays — Vocabulary
3. ISO 13588:2019 Non-destructive testing of welds — Ultrasonic testing — Use of automated phased array technology
4. ISO/TS 16829:2017 Non-destructive testing — Automated ultrasonic testing — Selection and application of systems
5. ISO 22232-1:2020 Non-destructive testing — Characterization and verification of ultrasonic test equipment — Part 1: Instruments
6. ISO 22232-2:2020 Non-destructive testing — Characterization and verification of ultrasonic test equipment — Part 2: Probes
7. ISO 18563-1:2015 Non-destructive testing — Characterization and verification of ultrasonic phased array equipment — Part 1: Instruments
8. ISO 18563-2:2017 Non-destructive testing — Characterization and verification of ultrasonic phased array equipment — Part 2: Probes
9. ISO 18563-3:2015 Non-destructive testing — Characterization and verification of ultrasonic phased array equipment — Part 3: Combined systems
10. ISO 9712 Non-Destructive testing – Qualification and certification of NDT personnel
11. ASME B31.3 Process Piping
12. ASNT SNT-TC-1A Recommended Practice for Qualification of Non-destructive Examination (NDE) Personnel
13. ANSI/ANST-CP-189 Standard for qualification and certification of Non-destructive testing personnel

14. NAS 410 Certification and Qualification of Non-Destructive Testing Personnel

15. ASTM E317 Standard Practice for Evaluating the Performance Characteristics of Ultrasonic Pulse-Echo Testing Systems without the Use of Electronic Measurement Instruments

16. ASTM E543 Standard Specification for Agencies Performing Non-destructive Testing

17. ASTM EN 583-6 Non-Destructive Testing - Ultrasonic Examination - Part 6 time of Flight Diffraction Technique as a method for detection and sizing of Discontinuities

18. ASTM E1316 Standard Terminology for Non-destructive Examinations

19. ASTM E3044/E3044M22 Standard Practice for Ultrasonic Testing of Polyethylene Butt Fusion Joints

20. ASTM E3167/E3167M-18 Standard Practice for Conventional Pulse-Echo Ultrasonic Testing of Polyethylene Electrofusion Joints

21. ASTM E3170/E310M-18 Standard Practice for Phased Array Ultrasonic Testing of Polyethylene Electrofusion Joints

22. ASTM E3101-18 Standard Practice for Microwave Examination of Polyethylene Butt Fusion Joints

23. ASTM E3102-18 Standard Practice for Microwave Examination of Polyethylene Electrofusion Joints Used in Piping Application

24. BS 7706 Guide to calibration and setting up of the Ultrasonic time of Flight Diffraction (TOFD) technique for the detection, location, and sizing of Flaws

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