

**INSPECTION OF PLASTIC PIPES,  
FITTINGS AND JOINTS  
USING  
NON-DESTRUCTIVE TEST METHODS AND  
EVALUATION  
(NDT/ NDE)**

**TN-60**

**2019**



## Foreword

This technical note was developed and published with the technical help and financial support of the members of the Plastics Pipe Institute (PPI). These members have shown their commitment to developing and improving quality products by assisting standards development organizations in the development of standards, and also by developing design aids and reports to help engineers, code officials, specifying groups, contractors and users.

The purpose of this technical note is to provide information regarding the use of non-destructive testing and/or evaluation (NDT/NDE) technologies for the inspection of plastic pipe and fitting fusion joints.

The PPI has prepared this technical note as a service to the industry. The information in this report is offered in good faith and believed to be accurate at the time of its preparation, but is offered “as is” without any express or implied warranty, including WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Additional information may be needed in some areas, especially with regard to unusual or special applications. Consult the manufacturer or material supplier for more detailed information. A list of member manufacturers is available on the PPI website. PPI does not endorse the proprietary products or processes of any manufacturer and assumes no responsibility for compliance with applicable laws and regulations.

PPI intends to revise this technical note within five years or sooner if required, from the date of its publication, in response to comments and suggestions from users of the document. Please send suggestions of improvements to the address below. Information on other publications can be obtained by contacting PPI directly or visiting our website. The Plastics Pipe Institute, Inc.

The Plastics Pipe Institute, Inc.

[www.plasticpipe.org](http://www.plasticpipe.org)

This Technical Note, TN-60, was first issued in September 2019.

© 2019 The Plastics Pipe Institute, Inc.

# Table of Contents

1.0	INTRODUCTION .....	1
2.0	CURRENT NDE METHODS FOR FUSION JOINTS.....	1
2.1.	Visual.....	2
2.2.	Bead Assessment.....	2
2.3.	Data Recording Devices .....	2
2.4.	Hydrostatic Pressure Testing prior to Start-up.....	3
3.0	INDUSTRY RESEARCH .....	3
4.0	NDT/ NDE CONSIDERATIONS for the USER .....	3
4.1.	Detection Capabilities and Confidence Levels.....	4
4.2.	Joint Type Limitations .....	4
4.3.	NDT Inspector Qualification.....	4
4.4.	Evaluation Procedures .....	5
4.5.	Establishing Acceptance Criteria .....	6
5.0	SUMMARY .....	6
6.0	BIBLIOGRAPHY.....	7

# **INSPECTION OF PLASTIC PIPES, FITTINGS AND JOINTS USING NON-DESTRUCTIVE TEST METHODS**

## **1.0 INTRODUCTION**

Historically, inspection of plastic pipes, fittings and joints comprised visual inspection and conformance testing to the applicable standard. These methods are well proven as proactive measures that help ensure a quality plastic pipe system. As with most industries, technology continues to evolve, driving continuous improvements in the knowledge base, methods and measurement techniques. This is now reflected in the growing use of non-destructive test methods and evaluation within the plastic pipe industry.

Over the last 30 years, only a few companies in North America have used non-destructive testing (NDT) for inspection and non-destructive evaluation (NDE) for the volumetric examination of plastic pipes. It is only within the last 2 – 5 years, organizations such as ASTM E07 or F17 and ISO TC138 have worked to introduce standardized inspection methods for polyethylene (PE) heat-fusion and electro-fusion (EF) joints.

Although visual assessment is an NDE technique, as discussed in Section 2.0, this document is primarily intended to address considerations for the existing and emerging instrumented methods as they relate to heat fusion (butt and saddle), electro-fusion (socket and saddle) and socket fusion of plastic pipe. Currently, these current state-of-the-art methods include:

- microwave testing
- ultrasonic testing (UT)
  - phased array ultrasonic testing (PAUT)
  - time-of flight diffraction (TOFD)

## **2.0 CURRENT NDE METHODS FOR FUSION JOINTS**

The plastic piping industries' current NDE practice includes visual, bead inspection and short-term hydrostatic pressure test methods to evaluate the quality of fusions. For heat fusion, electrofusion and socket fusion, practitioners are generally limited to a visual inspection of the final joint with particular attention made to the size, shape and location of the resulting melt bead, where visible. The bead is not visible in all electrofusion fittings.

Two NDE methods widely used in the plastics pipe industry are listed below. Their use is regional in that, North America employs visual inspection and the United Kingdom utilizes the bead assessment method. These are a couple of the many confirmatory checks performed on the pipe, fittings and joints.

## 2.1. Visual

The visual inspection procedures were introduced as far back as when heat-fusion was originally developed. This method has served the industry well as a quick qualitative inspection method to assess the heat fusion process. The visual inspection method is used in conjunction with fusion procedure and operator qualification to determine whether or not the joint was properly made. Even though technology transitioned the industry to quantitative methods assessing the joining process, e.g. a device recording key fusion parameter data, visual inspection is still used as a quick assessment.

PPI TR-33<sup>1</sup> Section 7.0 provides some guidance on the configuration of and inspection of the fusion bead. At this time, the fusion bead configuration is under discussion within the industry. This is because beads formed from many high density polyethylene resins (HDPE) may differ from those formed from some medium density polyethylene resins (MDPE).

ASTM F2620<sup>2</sup> details the visual inspection procedures for the melt pattern of socket fusion joints (Section 7.2.7), a fusion bead of a butt-fused joint (Section 8.3.7.1) and the fusion bead of a saddle joints (Section 9.5.1).

The reader is referred to the publications referenced above for specifics regarding fusion bead quality.

## 2.2. Bead Assessment

In the United Kingdom (UK), it is common place to remove and assess the external bead from butt-fusion joints for continuity and ductility as an NDE technique<sup>3</sup>. When the external and/or internal fusion beads are removed properly, the integrity of the joint is not damaged. Note, the UK bead assessment technique has not been validated for use with the ISO high force, PPI TR-33 nor ASTM F2620 butt-fusion procedures.

## 2.3. Data Recording Devices

Data recording devices are another method to further ensure that a quality joint was made. These devices record fusion parameters including time and pressure for thermally fused joints. These parameters allow comparison of

---

<sup>1</sup> PPI TR-33. Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe. Irving, TX; PPI.

<sup>2</sup> ASTM F2620. Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings. West Conshohocken, PA; ASTM

<sup>3</sup> Mark, N., Bridgstok, E., Carey, D. 2016. Big Data, Big Difference. Proceedings of the 18th Plastic Pipes Conference PPXVIII, Berlin, Germany.

the actual process used to make the joint to that specified in the joining standard. This in turns allows installers to take corrective actions such as cutting out the joint and replacing if any deviation is identified. ASTM F3124 describes the information and process of data recording <sup>4</sup>.

#### 2.4. Hydrostatic Pressure Testing prior to Start-up

Prior to the commissioning of sections or the entire plastic pipe system, short-term hydrostatic pressure testing is conducted<sup>5,6</sup>. This practice is used to confirm that the system does not leak and pressure can be maintained. In summary, the practice involves filling the pipe system with a calculated volume of water, removal of entrapped air, equalization of the pipe section and test water without pressure and then pressurization of the system for a set amount of time. Pressurization is typically conducted up to 1.5 times the design pressure providing the lower rated components are isolated. The system might experience an initial decrease in pressure due to the Poisson Effect as the pipe expands. In this case, make-up water is introduced to compensate.

### 3.0 INDUSTRY RESEARCH

Numerous organizations (e.g. code bodies, standards bodies, inspection companies and users) are actively developing and evaluating the instrumented NDT techniques for plastic pipe and fusion joints. A selection of recent papers from organizations conducting research, specific to the inspection of plastic pipe, fittings and joints using NDT technology are listed in the bibliography. Other literature and documents are also available in the industry to include the standard of practices for the inspection of polyethylene butt fusion and electrofusion joints under ASTM E07.

A user should recognize and consider that not all companies offering NDT inspection services have conducted research on plastic pipe, fittings or joints. As discussed in the next section of this document, technology developed for the inspection of metal pipe systems does not necessarily translate to plastic pipe systems.

### 4.0 NDT/ NDE CONSIDERATIONS for the USER

As an emerging technology, instrumented NDT techniques for inspection of plastic fusion joints, show promise in detecting some flaws in the joints. As the maturity and capabilities of the technologies and service provided differ, users of these technologies should be aware of the following considerations:

---

<sup>4</sup> ASTM F3124. Standard Practice for Data Recording the Procedure used to Produce Heat Butt Fusion Joints in Plastic Piping Systems or Fittings. West Conshohocken, PA; ASTM

<sup>5</sup> ASTM F2164. Standard Practice for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure. West Conshohocken, PA; ASTM

<sup>6</sup> PPI TN Guidance for Field Hydrostatic Testing Of High Density Polyethylene Pressure Pipelines: Owner's Considerations, Planning, Procedures, and Checklists TN-46/2013a. Irving, TX; PPI

#### 4.1. Detection Capabilities and Confidence Levels

At this time, only a limited number of NDT technologies and inspection companies exist that demonstrate high detectability of some known flaws or irregularities that may be detrimental to the joint integrity of a plastic pipe joint. Further, much work is needed to ensure a quality inspection is conducted and conclusions are accurate. As such, improvements are needed to increase the probability of detection (POD) and reduce the false call rates (FCR).

Users should consider the needed detection capabilities and reliability in the selection of an NDT technology or service provider. Further, to also confirm if the NDT technology is capable of detecting the specific flaw of interest.

#### 4.2. Joint Type Limitations

For fittings, the geometry of the joint and fitting is of importance. These can affect the placement of instruments obscuring portions the fusion interface thus impeding full NDT inspection of the area or volume. Examples include protrusions on the surface of socket or saddle fitting that impede placement, or the compound curvatures seen in fabricated fittings which can move the transmitted inspection 'beam' from the desired field of fusion-joint examination, thus impeding NDT inspection of the area or volume.

Users should be aware of the limits of the chosen technology and practices in the selection an NDT technology or service provider.

#### 4.3. NDT Inspector Qualification

NDT inspector qualification and experience in plastic pipe and fusion NDT is critical in ensuring high quality results. NDT techniques, procedures and skills developed for steel pipe do not directly translate to plastic pipe systems. This is analogous to an experienced driver of a regular passenger car. Although the skill set is well practiced, it would not translate directly to a Formula One racing car. Baseline knowledge exists but new skills and expertise are required to drive a Formula One racing car as designed. The same can be said of those inspecting metal pipe now conducting inspection on plastic pipe, fittings and joints.

Differences in equipment, materials, joint configurations, and flaw types requires distinct practices, procedures, training and experience to reliably interpret the resulting scans. This is similar to heat fusion of plastic pipe systems – only those with the right knowledge, expertise and skills are able to

utilize the correct equipment and proper procedures to form a quality joint as well as inspect the joint.

Users should ensure that NDT Inspectors have adequate training and experience with plastic fusion joint inspection procedures when selecting an NDT service provider.

#### 4.4. Evaluation Procedures

Qualification of the inspection procedure, the inspection agency and the NDT operator are equally important. Inspection procedures should follow the applicable ASTM Standard of Practice or ISO NDT Inspection technical specifications. Over the past few years, a limited number of companies have introduced their inspection procedures into two key standards organizations: ASTM and/or ISO, meaning, these are the only inspection procedures vetted by both the NDT and plastic pipe industry.

As a minimum, inspection agencies should comply with ASTM E543 Standard Specification for Agencies Performing Nondestructive Testing or equivalent specification. Per ASTM E543, "Criteria are provided for evaluating the capability of an agency to properly perform designated examinations and establishes essential characteristics pertaining to the organization, personnel, facilities, and quality systems of the agency."

Qualifications of those conducting the inspection could include the requirements listed in the applicable standards of practices or technical specifications. The following recognized documents detail requirements:

- ASNT Practice SNT-TC-1A Personnel Qualification Certification<sup>7</sup>
- ANSI/ASNT-CP-189 Standard for Qualification and Certification of Nondestructive Testing Personnel
- NAS 410 Certification and Qualification of Nondestructive Testing Personnel<sup>8</sup>
- ISO 9712 Non-Destructive Testing—Qualification and Certification of NDT Personnel<sup>9</sup>

All documents, listed above, define different training requirements to comprise work experience and practical and written exams for NDT inspections. The different certification levels achieved indicate the knowledge and skill level. For example, NDT Level I would cover basic inspections whereas NDT Level III includes skills to determine whether or not an indication is a flaw.

---

<sup>7</sup> Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, <http://www.asnt.org>

<sup>8</sup> Available from Aerospace Industries Association (AIA), 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209, <http://www.aia-aerospace.org>

<sup>9</sup> Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <http://www.iso.org>

#### 4.5. Establishing Acceptance Criteria

At this time, neither the NDT nor plastic pipes industry offer a standardized acceptance criterion. Work progresses on this most challenging aspect. Therefore, discussing and determining acceptance criteria prior to inspection is of utmost importance. Minimal guidance on indications, flaws and defects is given in ASTM E1316-18a Standard Terminology for Nondestructive Examinations Section A. Indications or irregularities observed during the NDT process need to be verified as flaws. When usually tolerable flaws create unanticipated detrimental conditions, such as excessive local stress intensities, they qualify as intolerable defects. Defects are quantified by their negative effect on expected service life. The accept-reject criteria from any technology should be based on the quantification of any indication as a tolerable flaw or intolerable defect, using validated, peer reviewed criteria.

#### 5.0 SUMMARY

At this time, the Plastics Pipe Institute (PPI) has not established a position on the use of NDT inspection for plastic pipe, fittings and/or joints as the maturity of the technology and related inspection practices vary significantly.

PPI continues to monitor and actively participate with the NDT industry as it develops these technologies, which show promise for the inspection of plastic pipe, fittings and joints. Due diligence and consideration by users, of the issues raised within this document, are encouraged prior to use of these or other NDT techniques and/or NDE methods.

## 6.0 BIBLIOGRAPHY

- Evisive (United States of America): Stakenborghs, B. and Little, J. 2009. Microwave Based NDE Inspection of HDPE Pipe Welds. In Proceedings of the 17th International Conference on Nuclear Engineering (ICONE17), Brussels, Belgium.
- Georg Fischer (Switzerland): Wermelinger, J. and Hein, O. 2017. *Long term influence of defects in butt fusion joints on PE100 pipes and NDT detection of them*. Plastic Pipes XVIII, Berlin, Germany.
- Jana (Canada): Oliphant, K., Angelo, P. Vibien, P., 2015. White Paper Inspection of Polyethylene Fusions and Electrofusions. AGA Operations Conference. Albuquerque, New Mexico.
- Kiwa Technology (The Netherlands): Postma, P. and Hermkens, R. 2012. *Suitability of Non-Destructive Techniques for Testing Polyethylene Pipe Joints*. Plastic Pipes XVI, Barcelona, Spain.
- Pacific Northwest National Laboratory (United States of America): Denslow, K. M. 2017. Evaluation of Ultrasonic Phased-Array Examination for Fabrication Flaw Detection in High-Density Polyethylene (HDPE) Butt Fusion Joints. Technical Letter Report NRC-ML17123A325.
- TWI (United Kingdom): Troughton M, Spicer M and Hagglund F. 2014. Development and assessment of a phased array ultrasonic inspection system for polyethylene pipe joints. ANTEC, Las Vegas, USA.