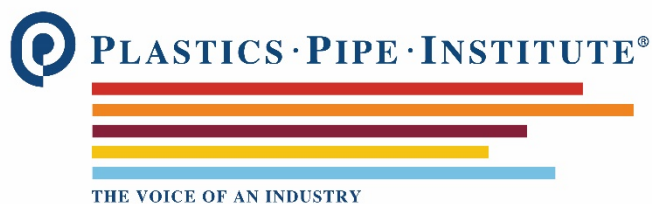


Generic Electrofusion User Guide for Field Joining of Polyethylene Gas Piping

TR-49

2020



FOREWORD

This user guide was developed and published with the technical help of the members of the PPI (Plastics Pipe Institute, Inc.). The members have shown their interest in quality products by assisting independent standards-making and user organizations in the development of standards, and also by developing reports on an industry-wide basis to help engineers, code officials, specifying groups, and users.

The purpose of this user guide is to provide important information available to PPI on a particular aspect of polyethylene pipe electrofusion to engineers, users, contractors, code officials, and other interested parties. More detailed information on its purpose and use is provided in the document itself.

This guide has been prepared by PPI as a service of 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. Consult the manufacturer for more detailed information about the particular joining procedures to be used with its piping products. Any reference to or testing of a particular proprietary product should not be construed as an endorsement by PPI, which does not endorse the proprietary products or processes of any manufacturer. The information in this report is offered for consideration by industry members in fulfilling their own compliance responsibilities. PPI assumes no responsibility for compliance with applicable laws and regulations.

PPI intends to revise this guide from time to time, in response to comments and suggestions from users of the report. Please send suggestions of improvements to the address below. Information on other publications can be obtained by contacting PPI directly or visiting the web site.

The Plastics Pipe Institute, Inc.

www.plasticpipe.org

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Generic Electrofusion User Guide for Field Joining of Polyethylene Gas Piping

1.0 HISTORY

Electrofusion joining of PE pressure pipe has been commonly used in North America for over 30 years. ASTM standard specifications for materials (ASTM D3350), performance (ASTM F1055), and installation practice (ASTM F1290) have been in publication for many years. Since each fitting manufacturer may have slightly varying geometrical designs, and each manufacturer is responsible for establishing safe installation temperature limits, it is also common that installation instructions can vary from one manufacturer to another. Although instructions can vary, all fitting designs share some common requirements for installation and all manufacturer's instructions include these same requirements.

A PPI task group was formed in 2017 to examine the differences among the varying joining procedures, to identify similarities in those procedures, and to determine whether there were a sufficient number of common elements to provide a basis for a more uniform, or "generic" joining procedure that could be implemented by pipeline operators for regulated gas applications as required in §192.283 (Plastic pipe, qualifying joining procedures) of C.F.R (Code of Federal Regulations) Title 49.

The result of the task group work, along with input from utility users and industry expertise, is the following technical report, *TR-49 - Generic Electrofusion User Guide for Field Joining of Polyethylene Gas Piping*.

2.0 SCOPE

The purpose of this document is to provide background and supporting information related to the common installation practices for electrofusion fittings. This information is intended to be used in support of the development of generic joining procedures and practices. The procedures contained herein are in alignment with the manufacturers procedures that have been qualified by subjecting specimen joints made using this procedure to the tests described in C.F.R Title 49, Part 192, §192.283 (1)(iii) and (2).

This document is applicable for electrofusion joining to modern commercially available PE pipe grades of PE2406, PE2708, PE3408, and PE4710. Legacy materials such as PE2306, PE3406, PE3306, Dupont® Aldyl A, Uponor® Aldyl A, and Driscopipe® 7000 or 8000 pipe materials were not included in the development of this document.

PPI hopes that the inherent value of greater uniformity will provide all the incentive necessary for companies to evaluate this procedure as a first option for electrofusion joining of its PE piping products. Use of this procedure is obviously not mandatory, and every electrofusion fitting producer, pipe producer, and pipeline operator retains the option of developing different procedures for its particular products and pipelines. However, PPI believes that its work in developing this procedure as a candidate for

widespread acceptance throughout the industry will lead to greater efficiency, simplicity, and understanding in this area and promote the use of effective, qualified procedures for electrofusion joining of PE gas pipe.

3.0 INTRODUCTION

Electrofusion is widely used in the installation of polyethylene (PE) piping for gas pressure applications. Electrofusion fitting designs vary between manufacturers and historically each manufacturer had developed and qualified its own installation procedure. Slight differences in procedures between manufacturers made it difficult for pipeline operators to qualify persons through appropriate training and experience. Creating a more uniform electrofusion joining guideline for natural gas distribution systems would bring greater consistency to this aspect of the gas pipeline installation, facilitate the pipeline owner's efforts to qualify the procedure, increase efficiencies, and simplify DOT enforcement duties.

Pipe preparation is perhaps the most important and least understood aspect of making a sound electrofusion joint. Improper pipe preparation is overwhelmingly the leading cause of unsuccessful electrofusion joint attempts because the installer may not completely understand the goal of pipe scraping, which is to remove a thin layer of the outer pipe surface (see trouble-shooting section for more details) to expose clean virgin material beneath. Additionally, contamination is the second leading cause of failures. Installers must appreciate the vital need to keep all surfaces of the pipe and the electrofusion absolutely clean and free of contamination or other foreign matter.

Proper installation techniques, installer understanding of and training to these techniques, and effective examination before installation are key to a successful installation. This document provides detailed instructions for each key step to a successful installation, why each step is important, and how to tell if the requirements of each step have been accomplished.

3.1. **Other Acceptable Fusion Procedures**

It must be recognized that there are many different procedures used both currently and historically throughout the world that have been proven to make effective, reliable electrofusion joints. The pipeline operator and every fitting producer retain the option of developing different fusion procedures for its particular products and pipelines. In certain cases, due to operating conditions, weather, or the characteristics of the joining equipment, it may be necessary or even advisable to use another procedure.

4.0 SAFETY NOTES AND WARNING SYMBOLS

Safety notes are included in this manual where appropriate, however this manual does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this manual to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

Symbols are used throughout this manual to indicate the potential for danger, injury, and/or material damage, and to alert the user of important information related to the fusion process. Symbols indicate that particular attention should be given and that an action is necessary.

Symbol	Meaning
	Attention! – Important Information! Possible danger, damage, risk of unsuccessful fusion or poor fusion quality.
	Best Practice – This symbol is used to indicate an instruction that is considered to be a “best practice”. This practice is recommended and potentially vital to success.
	Prohibited! – This symbol is used to indicate a practice, material, tool, or action that is specifically prohibited in conjunction with instructions in this manual.

-  **Follow company guidelines and safety procedures for grounding/static discharge.**
-  **Electrofusion fittings and equipment are not to be considered “explosion proof”.**
-  **Caution should be exercised when working with generators and other electrical power sources.**
-  **Scraping/peeling tools can have sharp edges. Use with care to avoid injury.**
-  **Tools should be in good working order and inspected before use for wear and/or damage. Damaged or worn tools should not be used until repaired.**
-  **The electrofusion processor and generator should be located out of the excavation, when in a gaseous atmosphere, during the electrofusion operation.**

5.0 JOBSITE PREPARATION

All heat fusion joining methods require that there is no water or any other foreign liquids flowing or standing in the pipe that can reach the fusion surfaces. Dewatering of the site or excavation may be required to prevent ground water or other liquids from reaching the fusion and contaminating the surfaces to be joined. Dewatering can be accomplished using portable pumps (Fig.1) in moderate conditions.



Figure 1: Submersible pump

Electrofusion fittings can be installed in ambient temperatures as recommended by the manufacturer. A typical qualified temperature range for installation is 14°F minimum to 113°F maximum. Some manufacturers have lower and/or higher temperature limits and will state their qualified range in their technical specifications, contact the fitting manufacturer to verify.

6.0 FITTING STORAGE AND HANDLING

Electrofusion fittings are packaged in sealed plastic bags as protection against accumulation of dust, dirt, and contamination. The bag should remain in place during normal handling and should only be removed immediately prior to installation. Fittings are typically boxed to protect against sources of degradation, such as oxidation due to UV exposure over long periods of storage. Surface oxidation can still occur, therefore electrofusion fittings should not be exposed for long periods to direct sunlight. Fittings should always be stored indoors in their original packaging until installation. For transportation until installation, enclosed utility truck storage bins are suitable.

⚠ Fittings with an unknown storage history or that have been exposed to questionable storage conditions should be evaluated through destructive testing of sample fusions. If fusion quality is shown to be affected, the fittings in question should not be installed.

Fittings should be inspected for damage before installing to ensure that connection points such as terminal pins have not been damaged from handling, that there is no visible damage to fusion surfaces or heating wires, and that no foreign materials are present on or near the fusion surfaces.

Fittings can be cleaned if incidental contact is made with the fusion surface. A suitable cleaning agent that contains no additives to hinder the fusion process must be used. A 90% or greater concentration of Isopropyl alcohol, with no additional additives except water, is universally accepted as a good cleaning agent. Ensure that wipes are clean before use and do not use wipes on multiple surfaces to avoid picking up and spreading contaminants.

Other cleaning agents, such as acetone, have been evaluated¹ and may be acceptable alternates to Isopropyl alcohol. The fitting manufacturer or local regulations should be consulted in case of questions.

⚠ DO NOT USE DENATURED ALCOHOL – Denatured alcohols may contain additives that can prevent fusion and should not be used.

7.0 REQUIRED TOOLS

Proper tools are essential to a successful electrofusion installation. Tools include devices for measuring, marking, cutting, scraping, peeling, cleaning, clamping (which includes aligning and securing), re-rounding, and power delivery. At minimum, the following items should be accessible during installation

- **Measuring:** A tape measure, rule, or fitting can be used for measurement of insertion (stab) depth of pipe ends inside a coupling. A circumferential wrap Pi tape for measurement of pipe diameter is also recommended to determine that the pipe diameter is within specified tolerance.



Figure 2: Tape Measure and Pi Tape

¹ GTI-OTD FINAL REPORT 5.16.a-Project Number 21948 *Solvent Cleaning and PE Joining Procedures*.

- **Marking:** A fast-drying permanent visible marker of contrasting color to the pipe is used to mark the pipe surface. The marker must not contain oils or other ingredients that could accidentally contaminate a prepared pipe surface. Marks are needed to locate insertion depths and to use as a guide for pipe scraping effectiveness.

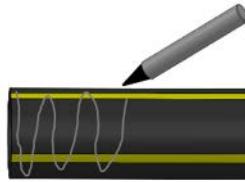


Figure 3: Pipe Marking

⚠ Markers that are slow-drying or contain oils that could be spread onto fusion surfaces should not be used.

- **Cutting:** Devices that deliver a relatively clean and square cut (± 3 degrees) on the pipe ends are recommended. Square cut pipe ends are important when inserting into electrofusion couplings because a pipe end that is cut with a severe enough angle may not completely extend into the center cold zone or may not cover the heating wires.

Many suitable types of pipe cutters are commercially available that can be used for diameters of 12 inch and smaller (see Figure 4).

- ⚠ Use only those devices that are allowed/approved by the pipeline operator in a manner that complies with all safety requirements.**
- ⚠ Use caution when cutting pipe that has carried natural gas. Follow company safety guidance for proper tools, grounding, or anti-static discharge measures.**



Figure 4: Pipe cutters (rotational, ratcheting, and guillotine style)

- ✓ For larger diameter pipe, a suitable saw (without lubricants that can be detrimental to the joint) and a guide or guide marks can be used; reciprocating saws, circular saws with a coarse-tooth blade, hot saws, chop saws, and chain saws are commonly used for larger pipes with appropriate safety precautions and personal protective equipment. Cutting marks can be made around the pipe using a 2 inch or wider strap or

encirclement clamp as a guide so that the pipe can then be cut along the line as shown in Figure 5.



Figure 5: Marking and cutting larger diameter pipes

8.0 MEASURING PIPE

8.1. Diameter

Electrofusion fittings are designed for use on pipe made to standard diameters in dimensions for Iron Pipe Size (IPS) and Copper Tube Size (CTS). Pipe that is outside of the diameter tolerance band of the appropriate pipe standard should not be used. The following tables include diameters and tolerances from ASTM D2513 and ASTM D2737 and can be used for reference when measuring gas distribution pipe diameter to ensure that is within tolerance.

Table 1: Standard Pipe Dimensions - Iron Pipe Size (IPS) ASTM D2513

IRON PIPE SIZE (IPS) ASTM D2513		
Nominal Pipe Size	Nominal Diameter (inches)	Tolerance (+/-)
1/2 IPS	0.840	0.004
3/4 IPS	1.050	0.004
1 IPS	1.315	0.005
1 1/4 IPS	1.660	0.005
1 1/2 IPS	1.900	0.006
2 IPS	2.375	0.006
3 IPS	3.500	0.008
4 IPS	4.500	0.009
6 IPS	6.625	0.011
8 IPS	8.625	0.013
10 IPS	10.750	0.015
12 IPS	12.750	0.017

Table 2: Standard Pipe Dimensions - Copper Tube Size (CTS) ASTM D2737

COPPER TUBE SIZE (CTS) ASTM D2737		
Nominal Tubing Size	Nominal Diameter (inches)	Tolerance (+/-)
1/2 CTS	0.625	0.004
3/4 CTS	0.875	0.004
1 CTS	1.125	0.005
1 1/4 CTS	1.375	0.005
1 1/2 CTS	1.625	0.006
2 CTS	2.125	0.006

8.2. Pipe Toe-in

A slight reduction in pipe diameter at the end of the pipe is referred to as toe-in. Pipes that are freshly cut and molded fittings generally do not have toe-in. If severe toe-in is present, trimming up to 2 inches off the pipe end will usually remove it.

8.3. Roundness

Polyethylene is a flexible material. Although pipe may be round at the time of manufacture, pipe roundness can be affected by a number of conditions to include coiling, storage/stacking, bending, and soil load if buried. The following information can be used to determine if a pipe is suitable for electrofusion joining without the use of re-rounding devices.

The condition of pipe roundness can be expressed in two ways; “out-of-roundness” and “ovality”. While both are referencing the same basic condition, it can sometimes be confusing.

- 8.3.1. Out-of-roundness is the difference in the maximum measured diameter minus the minimum measured diameter. The pipe can be measured with a tape measure or calipers to find the maximum (d1) and minimum (d2) diameter points. The out-of-roundness is calculated as d1- d2 as measured in the field.

- 8.3.2. Ovality is the difference between the maximum and minimum measured outside diameters expressed as a percentage. Ovality is calculated as $(d1 - d2) / D_{average} \times 100$.

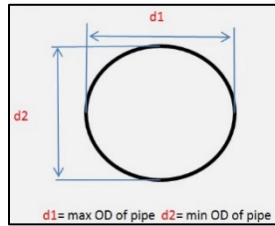


Figure 6: Roundness Measurement

Pipe out-of-roundness can have a negative effect on electrofusion joint quality. If the pipe is out-of-round and is not corrected, the amount of gap between the pipe and fitting can be too large for the melt expansion to close and for proper heat transfer to occur between the fitting and the pipe. An out-of-round pipe can also increase the difficulty of sliding (coupling) or clamping (saddle) the fitting onto the pipe.

Most often, 2 IPS and smaller diameter tubing is flexible enough that the coupling and alignment clamps will provide the necessary rounding forces and no other re-rounding device is needed.

For sizes equal to or larger than 3" IPS, re-rounding clamps may be needed on either side of an electrofusion fitting to ensure that the gap between the pipe and fitting is not too large. The table below can be used for guidance when re-rounding clamps are used.

Table 3: Maximum Out-of-Roundness (IPS/DIPS)

PIPE SIZE	d1 - d2
3"	.0625 or 1/16"
4"	.0625 or 1/16"
6"	.125 or 1/8"
8"	.125 or 1/8"
10"	.125 or 1/8"
12"	.125 or 1/8"

- 8.3.3. **Pipe scratches, gouges, and damage:** Installation of pipe can cause surface scratches or gouges. Smaller scratches from dragging or normal handling are not problematic and will normally be removed during the pipe preparation process by scraping.

⚠ Gouges that are deeper than the scrape depth may also require extra attention when scraping the pipe to ensure that any debris or contaminants embedded in the gouges are removed. If the gouge exceeds 10% of the pipe wall thickness