



Standard Practice for Heat Fusion Equipment (HFE) Operator Qualification on Polyethylene (PE) and Polyamide (PA) Pipe and Fittings¹

This standard is issued under the fixed designation F3190; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This practice describes criteria for the training, assessment and qualification of heat fusion equipment (HFE) operators in, but not limited to, a field environment in order to establish and maintain competency in the joining of Polyethylene (PE) and Polyamide (PA) piping systems.

1.2 This HFE operator training and qualification is applicable to heat fusion joining of PE pipe and fittings to other PE pipe and fittings of related polymer chemistry specified in the heat fusion procedures or standards used. It is also applicable to heat fusion joining of PA pipe and fittings to other PA pipe and fittings of the same polymer chemistry specified in the heat fusion procedures or standards used. The heat fusion between PE pipe and fittings to PA pipe and fittings is NOT allowed.

1.3 The HFE operator training and qualification shall be for butt fusion for either PE or PA piping products, using the specific brand and size range of fusion machine to be used by the HFE operator and the heat fusion procedures or standards specified. If the HFE operator trainee requests, the training shall also include saddle and/or socket fusion of PE pipe and fittings of related polymer chemistry specified in the heat fusion procedures or standards used. This standard does not include training on the electro-fusion of these piping products.

1.4 The HFE operator qualification shall be for one specific manufacturer's fusion machine or a size range of that manufacturer's hydraulic fusion machines or equipment that all operate in the same manner with the same hydraulic design and controls and the same heater and facer design. For smaller pipe sizes (6 in. and smaller), the qualification can be on a specific fusion machine or a combination of butt, saddle and/or socket fusion machines or equipment.

1.5 The HFE operator qualification shall be on specific heat fusion procedures or standards specified for PE and PA pipes. For PE pipe and fittings, this shall include Practice F2620 or other company or pipe manufacturer's procedures, or a combination thereof. For PA-11 pipe and fittings, this shall include

Plastics Pipe Institute (PPI) Technical Report TR-45 or other company or pipe manufacturer's procedures. For PA-12 pipe and fittings, this shall include Practice F3372 or other company or pipe manufacturer's procedures, or a combination thereof. For other PA pipe materials, use other company or pipe manufacturer's procedures.

1.6 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

F2620 Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings

F2634 Test Method for Laboratory Testing of Polyethylene (PE) Butt Fusion Joints using Tensile-Impact Method

F3124 Practice for Data Recording the Procedure used to Produce Heat Butt Fusion Joints in Plastic Piping Systems or Fittings

F3372 Practice for Butt Fusion Joining of PA12 Pipe and Fittings

2.2 PPI Standards:³

TR-45 Butt Fusion Joining Procedure For Field Joining of Polyamide-11 (PA-11) Pipe

¹ This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.20 on Joining.

Current edition approved May 1, 2021. Published May 2021. Originally approved in 2016. Last previous edition approved in 2016 as F3190-16. DOI: 10.1520/F3190-21

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062, http://www.plasticpipe.org.

*A Summary of Changes section appears at the end of this standard

3. Terminology

3.1 Definitions:

3.1.1 *heat fusion equipment operator (HFE)*—an operator who has been trained to use specified heat fusion equipment to join specific thermoplastic pipe in accordance with a specified standard or procedure and has passed the tests outlined in this practice.

3.1.2 *heat fusion equipment (HFE) operator training organization*—a training organization dedicated to providing quality heat fusion training for HFE operators and instructors in accordance with Annex A1 of this practice.

3.1.3 *qualified (HFE) Operator Training Instructor*—an instructor who has been trained in the operation of the heat fusion equipment and the heat fusion procedure or standard being specified and has satisfied the requirements in A1.3 of this practice.

4. Summary of Practice

4.1 In order to obtain a HFE operators qualification card, the operator shall complete a training course from a Heat Fusion Equipment Operator Training Organization (see Annex A1) and pass a written examination and a performance examination.

4.2 The HFE operator trainee shall obtain training for the written examination from the Heat Fusion Equipment Operator Training Organization. This training can be in a training class or through an internet based training course or a combination of both and the written examination shall be given at the end of the training. The HFE operator trainee shall be trained in the areas outlined in Table 1 and Table 2 for the written and performance examination. The HFE operator trainee shall be given a minimum of 50 multiple choice questions and the HFE operator trainee is required answer 80 % or more of the questions correctly to pass. The HFE operator trainee shall be allowed to use all course material provided, standard proce-

TABLE 1 Theoretical and General Information

Health and Safety
Pipe Handling
General personal protective equipment (PPE)
Electrical shock
Equipment is not explosion proof
Hydraulic pressure safety topics
Heater temperature issues
Pipe handling, installation and removal from the fusion machine
Operating the fusion machine carriage off of the chassis for in-ditch fusion
Safe lifting practices
How to fuse in adverse weather conditions
Pinch point to be aware of
Fuel, oil, etc. handling
Exhaust emission issues
Facer blades are sharp
Operating on an incline (fore and aft and side to side)
Pipe Information
ASTM standards for PE or PA pipes for different markets
Markings on the pipes and what they mean
Size and DR designations
Standard lengths of straight pipes
How to deal with coiled pipes
Standard fittings available for PE or PA pipes
General
Working in a trench and lifting the equipment
Power requirements for all fusion equipment

TABLE 2 Practical Information

Procedure Information
ASTM standard heat fusion procedures for butt, saddle and socket fusion as required or other joining procedure as required, or manufacturer's qualified procedures as required
Discuss the heat fusion joining procedures in detail
Discuss interfacial pressure, heater temperature, heater removal time and cooling time in detail
Go through the calculation details to obtain the fusion pressure and cooling time for a specific pipe OD and DR on a specific fusion hydraulic machine
On manual butt fusion machines, discuss the application of the fusion force in detail
Discuss data recording of the fusion process on hydraulic butt fusion machines and what it records.
Common causes of failures that is, insufficient soak, improper alignment/gap, heating under pressure, contamination
Equipment Information and Operation
Range of equipment and pipe sizes that the training will cover
Safety training on the equipment to be trained on
Basic operation information on the equipment to be trained on
Maintenance on the equipment and how to make sure the machine meets the manufacturer's specifications
Performance training on equipment to be trained on using the specified fusion procedure
On hydraulic machines, train each operator on using a Data Recording device on the equipment – how to use it and how to review the joint after the fusion. Remove the carriage from the chassis on the hydraulic fusion machines being trained on and show how to connect them together and operate them for in-ditch fusion applications, if applicable.
Show how to butt fuse fittings to the pipe
Teach how to detect and avoid typical fusion defects
Visual Inspection
How to evaluate the Data Recording Device information in accordance with the ASTM standard
How to evaluate the fusion bead in accordance with the trained procedure
Recording Device information in accordance with the ASTM standard
Destructive Test Methods to check ductility in the butt fusion joints
Guided Side Bend Test
High Speed, Tensile Impact Test
In Field Tensile Test
Standard bend test for small diameter, thin wall pipe

dures provided and any notes the trainee has made during the training, while taking the written examination. The maximum time allowed for completing the examination shall be two (2) minutes times the number of questions on the examination.

4.3 The HFE operator trainee shall obtain performance training on the proper and safe operation of the specific brand and size range of fusion equipment the HFE operator trainee will be using. The training shall cover the heat fusion procedure or standard specified and how to use the fusion equipment to satisfy the heat fusion procedure or standard. At the end of the training, the HFE operator trainee shall be given an operator's performance examination which will include making a heat fusion joint to the heat fusion procedure or standard specified under the supervision of a qualified HFE operator training instructor and be able to do a visual inspection of the joint.

4.4 A destructive test or non-destructive test shall be performed on the heat fusion joint, made by the HFE operator trainee during the performance examination. The HFE operator trainee must pass 100 % of the performance examination criteria, which includes following the specified heat fusion procedure or standard to make the heat fusion joint, passing the visual inspection of the joint made, accompanied by a passing result of the destructive joint tests or non-destructive tests (if approved by national codes or standards). The HFE operator

trainee shall obtain the Heat Fusion Equipment Operators Qualification card if he or she passes the written examination and passes the performance examination outlined in this standard. This card shall outline the training organization, the name of the qualified operator, the specific manufacturer of the fusion equipment and the size range of the fusion equipment the operator is qualified to operate, and the specific heat fusion procedure or standard the operator was qualified on. The card may also have a mechanism to access the specific equipment the operator is qualified to operate on line, such as a web URL, scannable barcode or QR code. The operator shall be qualified to heat fuse all the pipe sizes the qualified equipment is designed to heat fuse. The qualification card can include several different heat fusion machines or equipment if the HFE operator trainee passes the tests for all the equipment.

5. Significance and Use

5.1 This standard practice is designed to specify the minimum training and testing required of HFE operators trainees before they obtain a Heat Fusion Equipment Operator Qualification card. It will allow the industry to require the “HFE” operators be trained and qualified to an approved procedure before they can heat fuse PE or PA pipe in the field. The standard practice will bring more competency in the operators and more consistency in the training they receive.

6. Training and Testing Procedures

6.1 Butt Fusion with hydraulically operated fusion machines for PE or PA pipe and fittings.

6.1.1 *Training Curriculum:*

6.1.1.1 The training shall be provided by a qualified “HFE” operator training instructor having the skill/experience described in **Annex A1**. The heat fusion course shall be comprised of any combination of fusion machines based on the requirements of the pipeline operators. This training shall be given as individual modules or combined to suit requirements.

6.1.1.2 The training shall be comprised of general information in the areas outlined in **Table 1**. It shall also cover the practical information in the areas outlined in **Table 2**. This includes training on the proper and safe operation of the heat fusion equipment the operator is being qualified on and how to use the equipment to make a heat fusion joint that satisfies the specified heat fusion procedure or standard. This also includes making a minimum of two joints on the training equipment. The general training shall be taken in a class, in an internet course, or a combination of both.

6.1.2 *HFE Operator Testing Requirements:*

6.1.2.1 The testing will be conducted by the Heat Fusion Equipment Operator Training Organization after the general and practical training is completed.

6.1.2.2 After the completion of the general and practical training, the HFE operator trainee shall be given a minimum of 50 multiple choice questions related to the training specified in **Table 1** and **Table 2**. The HFE operator trainee is required to answer at least 80 % of the questions correctly in order to pass the written test. The HFE operator trainee shall be allowed to use all course material provided, standard procedures provided and any notes the trainee has made during the training, while taking the written examination. The maximum time allowed

for completing the examination shall be two (2) minutes times the number of questions on the examination.

6.1.2.3 For training on hydraulically operated fusion machines, the performance examination requires the HFE operator trainee to make a butt fusion joint with a pipe size specified by the Heat Fusion Equipment Operator Training Organization, unless otherwise specified by the project code(s), regulation(s), standard(s) or specification(s). A data recording device, conforming to Practice **F3124**, shall be attached to the fusion machine, if available, and the data concerning the joint entered. If used, the data recording device shall be used to record the joint made by the trainee. The qualified HFE operator training instructor shall observe the butt fusion joint being made and manually record if the specified procedure or standard was followed. After the joint is completed, the data from the data recording device, if used, shall be reviewed by the instructor and the HFE operator trainee to ensure the specified procedure or standard was followed in making the joint. The instructor shall observe the HFE operator trainee in the visual inspection of the joint to make sure the trainee can determine if the joint meets the heat fusion procedure or standard specified.

6.1.2.4 If a data recording device is not available, the instructor shall manually record the butt fusion parameters used in making the test joint. These shall be compared to the heat fusion procedure or standard specified to ensure they meet the requirements.

6.1.2.5 The HFE operator trainee’s test joint shall be tested in accordance with an approved destructive test such as outlined in Practice **F2620** or an approved destructive test such as Test Method **F2634** or an approved non-destructive test (if approved by national codes or standards). The HFE operator trainee shall receive his or her Heat Fusion Equipment Operator Qualification card if the written test was passed, the performance test was passed and the destructive or non-destructive test of the joint passed the proper joint failure criteria.

6.2 Butt Fusion with manually operated fusion machines for PE or PA pipe and fittings

6.2.1 *Training Curriculum*—The training curriculum shall be the same as **6.1.1.1** and **6.1.1.2**.

6.2.2 *HFE Operator Testing Requirements:*

6.2.2.1 The test will be conducted by the Heat Fusion Equipment Operator Training Organization after the general and practical training is completed.

6.2.2.2 After the completion of the general and practical training, the HFE operator trainee shall be given a minimum of 50 multiple choice questions related to the training specified in **Table 1** and **Table 2**. The HFE operator trainee is required to answer at least 80 % of the questions correctly in order to pass the written test. The HFE operator trainee shall be allowed to use all course material provided, standard procedures provided and any notes the trainee has made during the training, while taking the written examination. The maximum time allowed for completing the examination shall be two (2) minutes times the number of questions on the examination.

6.2.2.3 For training on manually operated butt fusion equipment, the performance examination shall require the HFE

operator trainee to make a butt fusion joint on a pipe size specified by the Heat Fusion Equipment Operator Training Organization, unless otherwise specified by the project code(s), regulation(s), standard(s) or specification(s). The qualified HFE operator training instructor shall observe the butt fusion joint being made and manually record if the specified procedure or standard was followed. The instructor shall observe the “HFE” operator trainee in the visual inspection of the joint to make sure the trainee can determine if the joint meets the heat fusion procedure or standard specified.

6.2.2.4 The HFE operator trainee’s test joint shall be tested in accordance with an approved destructive test such as outlined in Practice **F2620** or in accordance with an approved destructive test such as Test Method **F2634** or a non-destructive test (if approved by National codes or standards). The HFE operator trainee shall receive his or her Heat Fusion Equipment Operator Qualification card if the written test was passed, the performance test was passed and the destructive or non-destructive test of the joint passed the proper joint failure criteria.

6.3 Saddle Fusion with manually operated saddle fusion machines for PE pipe and fittings only

6.3.1 *Training Curriculum*—The training curriculum shall be the same as **6.1.1.1** and **6.1.1.2**.

6.3.2 *HFE Operator Testing Requirements:*

6.3.2.1 The test will be conducted by the Heat Fusion Equipment Operator Training Organization after the general and practical training is completed.

6.3.2.2 After the completion of the general and practical training, the HFE operator trainee shall be given a minimum of 50 multiple choice questions related to the training specified in **Table 1** and **Table 2**. The HFE operator trainee is required to answer at least 80 % of the questions correctly in order to pass the written test. The HFE operator trainee shall be allowed to use all course material provided, standard procedures provided and any notes the trainee has made during the training, while taking the written examination. The maximum time allowed for completing the examination shall be two (2) minutes times the number of questions on the examination.

6.3.2.3 For training on manually operated saddle fusion equipment, the performance examination requires the operator trainee to make a saddle fusion joint on a minimum pipe size of 2 in. IPS DR11 pipe with a branch or service saddle, unless otherwise specified by the project code(s), regulation(s), standard(s) or specification(s). The qualified HFE operator training instructor shall observe the saddle fusion joint and manually record if the specified procedure or standard was followed. The instructor shall observe the HFE operator trainee in the visual inspection of the joint to make sure the trainee can determine if the joint meets the heat fusion procedure or standard specified.

6.3.2.4 The HFE operator trainee’s test joint shall be tested in accordance with an approved destructive test as outlined in Practice **F2620**. The HFE operator trainee shall receive his or her Heat Fusion Equipment Operator Qualification card if the written test was passed, the performance test was passed and the destructive test of the joint passed the proper joint failure criteria.

6.4 *Socket Fusion for PE pipe and fittings only:*

6.4.1 *Training Curriculum:* The training curriculum shall be the same as **6.1.1.1** and **6.1.1.2**.

6.4.2 *HFE Operator Testing Requirements:*

6.4.2.1 The test will be conducted by the Heat Fusion Equipment Operator Training Organization after the general and practical training is completed.

6.4.2.2 After the completion of the general and practical training, the HFE operator trainee shall be given a minimum of 50 multiple choice questions related to the training specified in **Table 1** and **Table 2**. The HFE operator trainee is required to answer at least 80 % of the questions correctly in order to pass the written test. The HFE operator trainee shall be allowed to use all course material provided, standard procedures provided and any notes the trainee has made during the training, while taking the written examination. The maximum time allowed for completing the examination shall be two (2) minutes times the number of questions on the examination.

6.4.2.3 For training on socket fusion equipment, the performance examination requires the HFE operator trainee to make a socket fusion joint on a minimum pipe size of ½ in. CTS DR11 pipe with a socket fusion coupling, unless otherwise specified by the project code(s), regulation(s), standard(s) or specification(s). The qualified HFE training instructor shall observe the socket fusion joint and manually record if the specified procedure or standard was followed. The instructor shall observe the HFE operator trainee in the visual inspection of the joint to make sure the trainee can determine if the joint meets the heat fusion procedure or standard specified.

6.4.2.4 The HFE operator trainee’s test joint shall be tested in accordance with an approved destructive test as outlined in Practice **F2620**. The HFE operator trainee shall receive his or her Heat Fusion Equipment Operator Qualification card if the written test was passed, the performance test was passed and the destructive test of the joint passed the proper joint failure criteria.

6.5 *HFE Operator Training and Testing on Multiple pieces of Equipment:*

6.5.1 If the HFE operator trainee requests to be qualified on multiple pieces of equipment, he or she shall pass a written test that includes questions covering all different pieces of equipment being qualified on. The HFE operator trainee shall also take the performance test for those pieces of equipment and pass the performance and the destructive or non-destructive tests of the joints made at the examination. If the HFE operator trainee is qualifying on several sizes of hydraulic fusion equipment, that all operate in the same manner with the same hydraulic design, controls and the same heater and facer design, the performance test shall only be on one of the pieces of equipment.

6.6 *Re-assessment:*

6.6.1 If the HFE operator trainee fails the written examination with a score of 59 % or less, the trainee shall not take the performance examination and must repeat the training course.

6.6.2 If the HFE operator trainee fails the written examinations with a score of 60 % - 79 %, the operator trainee may take the performance examination. If the HFE operator trainee passes the performance examination, he or she may take a