	FABRICATION PROCESS AND PROCEDURE	**FUSION-Butt and Saddle**

1.0 INTRODUCTION

This document provides guidelines and general practices and procedures implemented at Rahn Plastics Inc. for our fabricated products.

Rahn Plastics Inc. is certified to ISO 9000-2015 Quality Management System that ensures all operations are to be performed in accordance with Production Process Instructions, Workmanship, Standards, Inspections and Test Instructions.

These procedures include all control conditions that must be maintained during operations including:

- Equipment specifications and environmental working conditions
- Process parameters and product characteristics that must be monitored and controlled
- Operator qualifications
- Acceptance criteria for workmanship

2.0 STANDARDS

This document makes reference, directly or implied from the identified Standards and Guidelines. Compliance requirements identified by relevant standards and/or codes:

- **ASTM D3350**
  PE Plastics Pipe and Fittings Materials
  This specification covers the identification of polyethylene plastic pipe and fittings materials in accordance with a cell classification system.

- **ASTM D3035**
  PE Pipe based on Controlled Outside Diameter
  This specification covers polyethylene (PE) pipe made in thermoplastic pipe dimension ratios based on outside diameter and pressure rated for water.

- **ASTM F714**
  PE Pipe based on OD NSF 14 & 61
  This specification covers polyethylene (PE) pipe made in dimensions based on outside diameters of 90 mm (3.500 in.) and larger.

- **ASTM 2620**
  Heat Fusion Joining of PE pipe and Fittings
  This practice describes procedures for making joints with polyethylene (PE) pipe and fittings by means of heat fusion joining in, but not limited to, a field environment.

This procedure is also intended for butt fusion joining of PE fuel gas pipe produced in accordance with (ASTM D2513). It applies to butt fusion joining of PE potable water, sewer and industrial pipe manufactured in accordance with ASTM F714, ASTM and AWWA C-906.

3.0 REFERENCE DOCUMENTS

This procedure is to be used in conjunction with PPI Handbook of Polyethylene Pipe, Chapter 9: Polyethylene Joining Procedures and the following PPI Technical Report.

- **PPI TR-33-Butt Fusion**
  This procedure is designed for widespread acceptance throughout the industry, leading to greater efficiency, simplicity and understanding in this area and promotes the use of effective, qualified procedures for butt fusion joining of PE pipe.

- **PPI TR-41-Saddle Fusion**
  This procedure is designed for widespread acceptance throughout the industry by providing consistency, simplicity and understanding for saddle fusion of PE pipe.

4.0 Work Instruction and Procedures

- **Work Instruction WI-158 Butt Fusion Procedure:** This work instruction provides detailed information, parameters and instructions on how to complete the butt fusion process. Fabrication personnel are trained to this procedure and its specific requirements.
- **Work Instruction WI-180 Saddle Fusion Procedure:** This work instruction provides detailed information, parameters and instructions on how to complete the saddle fusion process. Fabrication personnel are trained to this procedure and its specific requirements.

5.0 THERMAL HEAT FUSION METHODS

There are three types of conventional heat fusion joints currently used in the industry; Butt, Saddle, and Socket Fusion. Additionally, electrofusion (EF) joining is available with special EF couplings and saddle fusion. The principle of heat fusion is to heat two surfaces to a designated temperature, and then fuse them together by application of a sufficient force. This force causes the melted materials to flow and mix, thereby resulting in fusion. When fused according to the pipe and/or fitting manufacturers' procedures, the joint area becomes as strong as, or stronger than, the pipe itself in both tensile and pressure properties and properly fused joints are absolutely leak proof. As soon as the joint cools to near ambient temperature, it is ready for handling.

5.0 BUTT FUSION

The most widely used method for joining individual lengths of PE pipe and pipe to PE fittings is by heat fusion of the pipe butt ends. This technique produces a permanent, economical and flow-efficient connection. Quality butt fusion joints are produced by using trained operators and quality butt fusion machines in good condition. The butt fusion machine should be capable of:

- Aligning the pipe ends to various miter angles as required
- Clamping the pipes
- Facing the pipe to various angles as required
- Heating the pipe ends
- Applying the proper fusion force

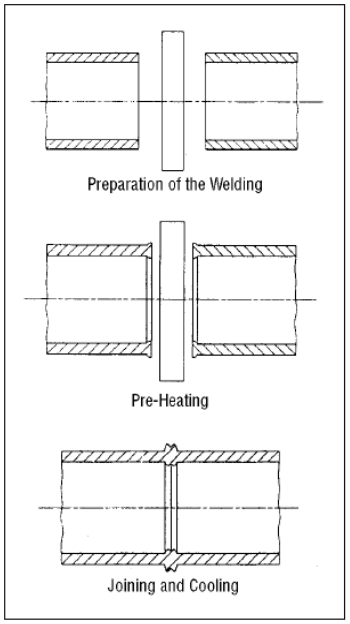
5.1 WORK INSTRUCTION-Butt Fusion

Butt Fusion Procedure Parameters Generic Fusion Interface Pressure Range is 60-90 psi (4.14-6.21 bar) Generic Heater Surface Temperature Range is 400 - 450°F (204-232ºC). Field-site butt fusions may be made readily by trained operators using butt fusion machines that secure and precisely align the pipe ends for the fusion process. The five basic sequential steps involved in making a butt fusion joint;

1-PREPARATION: Clean, clamp and align the pipe ends to be joined. The pipes must be installed in the fusion machine, and the ends cleaned with non- depositing alcohol to remove all dirt, dust, moisture, and greasy films, on both inside and outside diameter faces.

2-FACING: The pipe ends are faced to establish clean, parallel surfaces to fit mitered angles. The ends of the pipes are faced using a rotating cutter to remove all rough ends and oxidation layers. The trimmed end faces must be clean and parallel surfaces to fit mitered angles.

3-PRE-HEATING: The ends of the PE pipes are heated by contact under pressure against a heater plate. The heater plates must be clean and free from contamination, and maintained within a surface temperature depending on the size of the pipe. Contact is maintained until even heating is established around the pipe ends, and the contact pressure then reduced to a lower value called the heat soak pressure. Contact is then maintained until the appropriate heat soak time elapses.



4-JOINING: The heated pipe ends are then retracted and the heater plate removed. The heated PE pipe ends are then brought together and pressurised evenly to the welding pressure value. The pressure adopted in this phase depends on the pipe size. Bead sizes are to be monitored as identified in table 1.

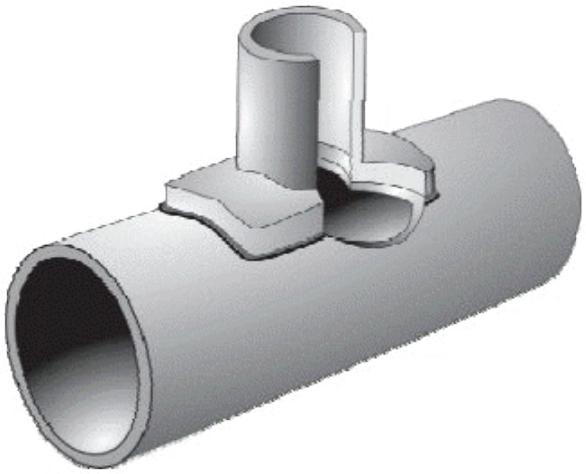
Table 1-Minimum Bead sizes

Pipe (OD) Outside Diameter, in. (mm)	"A" Minimum Bead Size, in. (mm)
< 2.375" 1⁄32 (1)	1/32" (1)
≥ 2.375" (60) ≤ 3.5 (89) 1⁄16 (1.5)	1/16" (1.5)
> 3.500" (89) ≤ 8.62 (219) 3⁄16 (5)	3/16" (5)
> 8.625" (219) ≤ 12.75 (324) 1⁄4 (6)	¼" (6)
> 12.750" (324) ≤ 24 (610) 3⁄8 (10)	3/8" (10)
> 24.000" (610) ≤ 36 (900) 7⁄16 (11)	7/16" (11)
> 36.000" (900) ≤ 65 (1625) 9⁄16 (14)	9/16" (14)

5-COOLING: The pressure is then maintained for a period to allow the fusion process to take place, and the fused joint to cool down to ambient temperature, and hence develop full joint strength. During this cooling period the joints must remain undisturbed and under compression. Under no circumstances should the joints be sprayed with cold water. Finished fitting is removed from fusion tools once sufficient cooling time has elapsed.

6.0 SADDLE FUSION

The conventional technique to join a saddle to the side of a pipe consists of simultaneously heating both the external surface of the pipe and the matching surface of the "saddle" type fitting with concave and convex shaped heating tools until both surfaces reach proper fusion temperature. This may be accomplished by using a saddle fusion machine that has been designed for this purpose. Saddle fusion using a properly designed machine, provides the operator better alignment and force control, which is very important to fusion joint quality. The Plastics Pipe Institute recommends that saddle fusion joints be made only with a mechanical assist tool unless hand fusion is expressly allowed by the pipe and/or fitting manufacturer.



Standard Saddle Fusion Joint

6.1 WORK INSTRUCTION-Saddle Fusion

There are five basic sequential steps that are commonly used to create a saddle fusion joint;

1-PREPARATION: This procedure requires the use of a Saddle Fusion Tool. This tool must be capable of holding and supporting the main, rounding the main for good alignment between the pipe and fitting, holding the fitting, and applying and indicating the proper force during the fusion process.

2-INSTALL FUSION TOOL: Install the Saddle Fusion Tool on the main according to the manufacturer's instructions. The tool should be centered over a clean, dry location where the fitting will be fused. Secure the tool to the main. Abrade the main, where the fitting will be joined. The abraded area must be larger than the area covered by the fitting base. After abrading, brush residue away with a clean, dry cloth. Abrade the fusion surface of the fitting. Insert the fitting in the Saddle Fusion Tool loosely.

3-PRESSUURE APPLICATION: Using the Saddle Fusion Tool, move the fitting base against the main pipe and apply approximately 100 pounds-force to seat the fitting. Secure the fitting in the Saddle Fusion Tool.

4-HEATING: The heater must be fitted with the correct heater adapters. The temperature of the heater adapter fusion surfaces must be 490°F to 500°F. (Table 2)

Table 2: Heat and soak pressures

Heater Adapter Surface Temperature	490°F to 500°F
Initial Interfacial Pressure	60±6 psi
Heat Soak Interfacial Pressure	0 psi
Fusion Interfacial Pressure	30±3 psi
Total Heating Time on Main—1 _" IPS Pressure Main	15 seconds max
Total Heating Time on Main-- 2" IPS Pressure Main	25-35 seconds max.
Total Heating Time on non-pressure 1 _" IPS, 2" IPS mains, and on pressure or non-pressure 3" IPS and larger mains	Look for a 1/16" bead around the fitting base

Place the heating tool on the main centered beneath the fitting base. Immediately move the fitting against the heater faces, apply the Initial Heat Force (see fitting label), and start the heat time. Apply the Initial Heat Force until melt is first observed on the crown of the pipe main (Initial Heat is the term used to describe the initial heating (bead-up) step to develop a melt bead on the main pipe and usually is 3-5 seconds) and then reduce the force to the Heat Soak Force (Bead-up force) (Table 2). Maintain the Heat Soak Force until the Total Heat Time is complete. At the end of the Total Heat Time, remove the fitting from the heater and the heater from the main with a quick snapping action. Quickly check for an even melt pattern on the pipe main and fitting heated surfaces (no unheated areas).

5-FUSION and COOLING: Whether or not the melt patterns are satisfactory, press the fitting onto the main pipe very quickly (within 3 seconds) after removing the heater and apply the Fusion Force (see the fitting label). Maintain the Fusion Force on the assembly for 5 minutes on 1 _" IPS and for 10 minutes on all larger sizes, after which the saddle fusion equipment may be removed. (Fusion Force adjustment may be required during Cool Time, but never reduce the Fusion Force during cooling.) (Table 2) Cool the assembly for an additional 30 minutes before rough handling or tapping the main.

7.0 MONITORING AND QUALITY

Production processes are to be performed by qualified tradesmen, indentured apprentices and suitably trained workers and in accordance with specified codes, standards, specifications, engineered drawings and Production Process Instructions.

Each first-off part produced by a process must be verified as meeting requirements defined by applicable drawings, Production Process Instructions or Workmanship Standards. A Quality Technician is involved with the verification of first–off pieces to ensure they conform to specifications before a production run proceeds.

When all requirements are found to be acceptable, the process set-up is to be considered acceptable. The Quality Technician will record the results of set-up verification on the set-up sheet and sign off on the results.

In addition to first-off part verification, production processes are to be verified at appropriate intervals/sampling rates (by time or quantity), depending on the product being produced, during operation.

All tested product results are recorded by the operator and the items are provided to Quality Technician to be validated.

These stringent Monitoring and Validation processes ensure the customers are provided with a quality product that meets all their expectations.