Ethiopian TVET-System

Water Supply and Sanitation Work

Level-III

Based on Feb, 2017G.C. Occupational Standard

Module Title: Installing Polyethylene Pipe lying

TTLM Code: EIS WSO3 TTLM 0920v1

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This module includes the following Learning Guides

LG28: Identify PE pipe materials

LG Code: EIS WSO3 M09 LO1-LG-28

LG29: Identify applications for alternative jointing technologies

LG Code: EIS WSO3 M09 LO2-LG-29

LG30: Identify compatibility of commercial electro fusion control systems

LG Code: EIS WSO3 M09 LO3-LG-30

LG31: Maintain and calibrate electro fusion control unit equipment

LG Code: EIS WSO3 M09 LO4-LG-31

LG32: Determine methods for handling, storage, transport and installation of PE pipeline components.

LG Code: EIS WSW3 M09 LO4-LG-32

LG33: Identify appropriate service connection and repair techniques.

LG Code: EIS WSW3 M09 LO4-LG-33

LG34: Perform electro fusion welding

LG Code: EIS WSW3 M09 LO4-LG-34

LG35: Assess quality of completed installation, electro fusion joints.

LG Code: EIS WSW3 M09 LO4-LG-35

Instruction Sheet	Learning Guide 28: Identify PE pipe materials

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Identifying PE grade, National standard, Job specification and worksite instruction
- Determining PE materials properties
- Identifying job needs from worksite instructions and specifications
- Identifying PE materials and pipes compatible for welding

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Identify materials as PE grades from national standards, job specifications and work site instructions.
- Determine PE materials properties from national standards and material data sheets.
- Identify job needs from worksite instructions and specifications.
- Identify PE materials and pipes supplied as being compatible for welding from specifications

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 4”.on page 5,9,12&15 Try to understand what are being discussed.
4. Accomplish the “Self-checks 1, 2, 3and 4” in each information sheets on pages 8, 11, 14 and 16.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “next learning guide.However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After you accomplish LG, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Identifying PE grade materials

1.1. Introduction to polyethylene pipe

Since its discovery in 1933, polyethylene (PE) has grown to become one of the world's most widely used and recognized thermoplastic materials. Today's modern PE resins are highly engineered for rigorous applications such as pressure-rated gas, recycled water, sanitary and drinking water systems, sustainable energy systems, landfill membranes, automotive fuel tanks and other demanding applications.Polyethylene (PE) is a thermoplastic material produced from the polymerization of ethylene. PE plastic pipe is manufactured by extrusion in sizes ranging from ½" to 63". PE is available in rolled coils of various lengths or in straight lengths up to 40 feet.

Some of the specific benefits of PE pipe are:

- Life Cycle and Construction Cost Savings – For municipal applications, the life cycle and construction cost of PE pipe can be significantly less than other pipe materials.
- Leak-Free, Fully Restrained Joints - PE heat fusion joining forms leak-free joints that are as strong as, or stronger than, the pipe itself. For municipal applications, fused joints eliminate the potential leak points.
- Construction Advantages – PE pipe's combination of light weight, flexibility and leak-free, fully restrained joints permits unique and cost-effective installation methods that are not practical with alternate materials.
- Durability – PE pipe installations are cost-effective and have long-term cost advantages due to the pipe's physical properties, leak-free joints and reduced maintenance costs.
- Design flexibility – easily shaped;
- Integrated design – multifunction, ready assembled components – couplers and fittings;
- Light-weight design – ease of transport and handling;
- Flexibility – ease of transport and handling, use in conjunction with trenchless technologies and resistance to seismic activity;
- Relative ease of jointing (compared to metallic pipe systems);
- Corrosion and good chemical resistance;
- Biologically inert capabilities;
- Toughness, impact resistance, abrasion resistance and long term durability – technical lifetime of >50 years;
- Low temperature performance;
- Low friction bore - no scale build-up and efficient flow of transfer medium; and

- Environmental benefits - recyclable

1.2 Polyethylene - PE - pipes and pressure classes

High density polyethylene - HDPE - is a very popular material for water pipes. It is

- resistant to chemicals
- easy and light weighted
- long living
- low friction
- relatively cheap
- flexible
- tough
- ductile
- sun resistant
- ability to dampen water shock

PE pipes can be used in range of temperatures *-40^{o}C to 60^{o}C* considering the change of operating pressure. Typically the standard specification identifies class of a HDPE pipe is by the nominal pressure class - PN - up to PN 20 or *20 bars*. HDPE pipe can also be classified by the material used - PE 100, PE 80, PE63, PE 40 or PE 32.

1.3 Pressure Nominal - PN

PE pipes are produced in different pressure grades (PN grades), which indicates the pressure in bars the pipe can support with water at *20^{o}C*.

The pressure grades available according to European standards are

- PN 2.5 - max pressure *2.5 bar*
- PN 4 - max pressure *4 bar*
- PN 6 - max pressure *6 bar*
- PN 10 - max pressure *10 bar*
- PN 16 - max pressure *16 bar*
- 1 bar = 10^5 Pa (N/m^2) = 0.1 N/mm^2 = 10,197 kp/m^2 = 10.20 m H_2O = 0.9869 atm = 14.50 psi (lb$_f$/in^2) = 10^6dyn/cm^2 = 750 mmHg

1.4 Color Codes and Pressure Grades

Color codes used to indicate the pressure grades on the pipes are

Color Code	PE Pressure Grade
Yellow	PN 4

Red	PN 6
Blue	PN 10
Green	PN 16

1.5 Classed by Materials

Polyethylene pipes are also classified by the type of material used:

- PE 32 - low pressure piping systems
- PE 40 - low pressure piping systems
- PE 63 - medium pressure piping systems - irrigation system - drinking water connections
- PE 80 - gas pipe for natural gas distribution network with pressure rate up to *4 bars* - drinking water pipe with pressure rate up to 16 bar - sewers, outfall pipes, industrial pipes
- PE 100 - high demands piping applications.

The Minimum Required Strength - MRS - according ISO 4427 for the different materials are:

Designation of material	MRS at *50 years* and *20°C* *MPa (bar)*
PE 100	10 (100)
PE 80	8 (80)
PE 63	6.3 (63)
PE 40	4 (40)
PE 32	3.2 (32)

1.6 Color Codes and Materials Classifications

Common colors used to classify the pipes

- completely black for industrial applications
- completely blue, or black with blue stripes, fro potable water
- completely yellow, or black with yellow stripes, for gas conduits

Self-Check -1	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth twopoint

1. One of the following is a benefit of PE pipe
   A. Life Cycle and Construction Cost Savings
   B. Leak-Free, Fully Restrained Joints
   C. Durability
   D. All
2. Completely black PE pipe used for
   A. Potable water
   B. Industry application
   C. Gas conduit
   D. Gas conduit and potable water
3. One of the following is used for a medium pressure piping system
   A. PE 32
   B. PE 40
   C. PE 63
   D. PE 100
4. One of the following is **not** a properties of HDPE pipe
   A. resistant to chemicals
   B. easy and light weighted
   C. High friction
   D. sun resistant

Note: **Satisfactory rating - 4 points and above** **Unsatisfactory - below 4points**

Answer Sheet-1

Name: _____ Date: _____

Choice Questions

Score = _____

1_____ 4._____

2._____

3_____

Information Sheet-2	Determining PE materials properties

2.1 Introduction to PE materials

Polyethylene (PE) is a thermoplastic material produced from the polymerization of ethylene. PE plastic pipe is manufactured by extrusion in sizes ranging from ½" to 63". PE is available in rolled coils of various lengths or in straight lengths up to 40 feet.

The PE pipe properties are to a large extent determined by the PE resin of which the pipeis manufactured. The pipe manufacturers normally use compounded PE materials fromthe resin suppliers, and do not add on any additives at the manufacture of the pipes.

PE materials for pipe manufacture are available in different material designations (PE 40,PE 63, PE 80 and PE 100). A PE material of lower density like PE 40 is softer and has lowerstrength properties than a PE material of higher density.

The expected lifetime of a PE pipe is determined by:

- The PE material properties
- The stress level
- The loading time
- The temperature
- The environment

2.2 PE pipe properties

- **Hydraulic losses**

PE pipes have a smooth internal surface and a low hydraulic roughness coefficient, k. For PE pipes < 200 mm the k-value is 0, 01 mm. For pipes > 200 mm a k-value of 0, 05 mmcan be used. Butt welded PE pipes get small weld beads at each joint, see photo.

The beads, which are usually left on the pipes, have normally a height corresponding toapproximately 2 % of the pipe diameter and will only give a minor increase of the headloss in the pipe system. In thick-walled PE pipes the internal bead will be cooled slowly andwill then show a tendency to stand out more from the pipe wall, which thus could give aslightly increased head loss. It is possible to remove weld beads, but this ought to be doneat the welding operation when the bead still is hot.

Special equipment is required to remove internal beads. To assess the total head loss in a PE pipe system a roughness coefficient of 0.1-0.2 mm can be used. When using the latterroughness coefficient all additional losses from weld beads, bends, etc can be neglected, and the estimated head loss will normally be on the safe side. When pumping untreatedsewage

water, a thin surface growth may appear on the inside of the pipe which sometimescould give a somewhat increased hydraulic roughness.

- **Resistance against water hammer**

When designing PE pressure pipe systems, pressure surge needs normally not to be considered.The reason is that a PE pipe has a relatively high short-term strength compared toits long-term strength, Frequent pressure surge up to 1.5 times the PN-rating of thepipe has been found not to influence on the long-term strength of the pipes.Furthermore, the low E-modulus of the PE material results in a much lower pressure wavevelocity in the system, and thus a lower surge, than in pipe systems made of other materials,for further information see /ref.1/. For thin-walled PE pipes (SDR >26) the risk forbuckling due to under pressure at pressure surge, ought to be taken account of.

- **Diffusion**

PE pipes are not completely diffusion tight against low molecular organic substances. The permeability differs for different types of PE materials, and increases with increasing temperatures. On rare occasions, a taste and odour effect on the water has been found for small-sized PE pipes in heavily contaminated ground.

Reported problems are almost exclusively related to house connections of LDPE (low density polyethylene). PE80 and PE100 materials have a significantly higher diffusion resistance compared to earlier LDPE materials. The penetration time for a substance to pass the wall of PE pipes of same SDR-ratio is directly proportional to the square of the pipe wall thickness. It thus takes 100 times longer to notice taste and odour influence in a 250 mm pipe than in a 25 mm pipe of the same PE material and pressure rating.

- **Notch sensitivity**

PE pipes are relatively soft and can be scratched if carelessly handled. Normal handling will only result in the occurrence of minor scratches, which however will not influence the strength properties of the pipes. Scratches on PE pipes may appear visually worse than they are in reality. The real depth of a scratch can be measured by using a measuring device, see photo.

Scratches up to a depth of 10 % of the pipe wall thickness have been found not to affect the strength properties of a PE pipe. Therefore, in most cases it is of little consequence which type of PE pipe is used (a co-extruded pipe or just a standard one).

In most cases standard solid wall PE pipes can be used for most applications without any disadvantages.

Figure 2.1Measuring devices for scratches

Self-Check -2	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two points

1. One of the following is not properties of PE pipe
   A. Resistance against water hammer
   B. Notch sensitivity
   C. completely diffusion
   D. Hydraulic losses
2. The expected lifetime of a PE pipe is determined by
   A. The stress level
   B. The loading time
   C. The temperature
   D. All

Note: **Satisfactory rating – 2and above points** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-2

Name: _____ Date: _____

Choice answer sheet

Score = _____

1_____

2._____

Information Sheet-3	Identifying job needs from worksite instructions and specifications

3.1 Introductions to Work requirement

Determining work requirement includes knowing how much work to do, what materials are required, how the work to be executed. Work requirements for construction and installation of PE pipe for water distribution should be determining from plans, specifications and instructions. So to determine the required work, drawings and specifications like water distribution pipe installation and different water distribution asset drawings such as valve chambers drawings, crossing structure drawings, manhole drawings, water meter pit drawings, wastewater collection pipe drawings are required.

The specifications should include all construction and installation information not shown on the drawings and required to inform the contractor of all project requirements.

Job needs for Installation of Pipe

- Handling and storage of pipe and fittings shall be
  - ✓ with care to avoid damage to pipe and lining,
  - ✓ So that pipe units are kept from contact with adjacent units by means of wooden blocks.
  - ✓ In a manner to keep interior of pipe free from dirt, foreign material and ground water.
- Laying of pipe shall be
  - ✓ Be in manner that the pipe is uniformly supported throughout its entire length on the bottom Quadrant.
  - ✓ Be subject to the approval of the Inspectors as pertains to the method of laying and Inspection of pipe for damage.
  - ✓ Not be on blocks.
  - ✓ Include the interior cleaning by use of a ram brush or other approved methods immediately prior to installation.
  - ✓ Be at least 10' horizontally from any sanitary sewer, storm sewer, or sewer manhole where conditions allow.
  - ✓ Provide 18" vertical separation between water and sewer lines in the event of crossing where
  - ✓ Conditions allow.

- ✓ Be so that when conditions prevent a 10 foot horizontal separation the bottom of the water main must be at least 18 inches above the top of the sewer. Water and sewer pipes cannot be in the same trench.
- ✓ be so that if water mains must cross under sewers there must be at least 18 inches separation andthe length of water pipe shall be cantered so that the joints are equidistant and as far as possible from the sewer.

- Pipe shall be cut using
  - ✓ Hydraulic cutters - cast iron only.
  - ✓ A Carborundum saw - ductile.
  - ✓ Other approved methods for 12" and larger in diameter.
- Pipe shall be protected at the end of each work day by
  - ✓ A plug of the same diameter placed in the pipe and secured by at least two bolts or set screws.
  - ✓ A test plug of the cone-lock or wedge locks variety,
  - ✓ Other methods as approved by the Inspector.
- All dead end mains will be provided with a fire hydrant or blow-off.

Self-Check -3	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two points

1. One of the following is used to cut the pipe
   A. Hydraulic cutters
   B. plug
   C. fire hydrant
   D. blow off

2. Work requirement is determine from

A. plan

B. specification

C. instruction

D. All

Note: **Satisfactory rating – 2 points and above** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-3

Name: _____ Date: _____

Choice answer sheet

Score = _____

1_____

2._____

Information Sheet-4	Identifying PE materials and pipes compatible for welding

4.1. Pipe Compatibility

Plasson (manufacture name) Fittings are weldable to PE80, PE100 and PEX* pipes. Check that the pipe SDR (standard dimension ratio) is compatible with the Plasson fittings. For pipe SDR compatibility refer to Plasson literature or contact your local Plasson representative. SDR is a method of rating a pipe's durability against pressure. It describes the correlation between the pipe dimension and the thickness of the pipe wall. Common nominations are SDR11, SDR17 and SDR35. Pipes with a lower SDR can withstand higher pressure. The different between SDR11 and SDR17 is for a specific outside diameter pipe the thicker the wall thickness, the lower the SDR value, which means a SDR11 pipe, has a higher wall thickness than a SDR17 pipe of than a similar outside diameters. The allowable ring deflection value varies from one SDR to on other and is generally reported by pipe manufacturers.

Pipe compatibility guidelines:

Plasson's Electro Fusion Fittings:

- Up to 75mm (inclusive) are Weldable to Pipes SDR ≤ 11
- Elbows and Tees of main diameter 40mm-75mm ≤ 17
- 90mm & Up are Weldable to Pipes SDR ≤ 17
- 63-75mm Tapping Saddles and Valves are suitable for SDR11

Note: for tapping SDR ≤ 11 pipes (size 63 and up), please consult your Plasson representative.

Light Fit:

- 90mm are Weld able to Pipes SDR ≤ 26
- 110mm - 800mm are weld able to Pipes SDR ≤ 33

Wastewater Saddle:

- 200 mm & Up are weld able to Pipes SDR ≤ 26

Wastewater Adjustable Elbow:

- 160 mm is weld able to Pipes SDR ≤ 17

Measure the pipe external diameter toward the pipe end using a Pi tape. The pipe external diameter must be within the tolerances defined in International standards such as ISO 4437-2.

Check the pipe outer diameter at a distance equal to 5% of the pipe outer diameter from the pipe end using a Pi tape. If the outer diameter is smaller than the standard definition (this can occur due to pipe reversion or necking) cut back the measured section of the pipe and re-measure as described above.

Self-Check -4	Written Test

Directions: **Direction I:** Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two points.

1. A method of rating a pipe's durability against pressure is
   A. MDPE
   B. HDPE
   C. SDR
   D. PE100
2. One of the following can withstand higher pressure
   A. Pipes with a higher SDR
   B. Pipes with a lower SDR
   C. Pipes with a lower outside diameter
   D. Pipes with higher wall thickness

Note: **Satisfactory rating – 2 points and above** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-4

Name: _____ Date: _____

Choice answer sheet

Score = _____

1_____

2._____

Instruction Sheet	Learning Guide 29: Identify applications for alternative jointing technologies.

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Identifying properties and limitations of mechanical jointing systems.
- Identifying properties and limitations of thermal welding jointing systems.
- Identifying, rectifying and reporting Nonconformance jointing.
- Assessing quality against specification requirements.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Identify properties and limitations of mechanical jointing systems.
- Identify properties and limitations of thermal welding jointing systems.
- Perform trial jointing for all methods, identify nonconformance, report, and rectify.
- Assess quality against specification requirements.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 4” on page 18, 23, 27 and 30. Try to understand what are being discussed.
4. Accomplish the “Self-checks 1, 2, 3, &4” in each information sheets on pages 22, 26, 29, & 31.
5. If you earned a satisfactory evaluation proceed to “Operation sheets 1, on pages 32. And do the LAP Test on page 33”.
6. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. Afteryou accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Identifying properties and limitations of mechanical jointing systems

1.1. Introduction mechanical jointing

Mechanical connections are required for transitions, terminations, or joining, use fittings and procedures in accordance with the following section.

1.2 Mechanical Connection of PE Water Service Lines

Terminology

- Mechanical coupling- a device for joining pipe or tubing that does not require heat fusion or welding and utilizes a gripper ring for restraint and seal/gasket for a leak-free connection. Types of mechanical couplings commonly used on HDPE service tubing include Insertion (stab) and Compression.
- Stiffener/Insert- a flanged cylinder of NSF approved material that is inserted into plastic tubing to reinforce the gripping and sealing regions.
- Seal/O-Ring/Gasket- a ring, usually made of an elastomer/rubber, that, when compressed, creates a leak-tight seal on the HDPE tubing preventing leakage of water from the fitting. Gripper Ring-is the plastic component of a coupling that grips or restrains the HDPE tubing preventing pullout from the mechanical fitting.
- Coupling Body- the pressure bearing vessel that can contain the stiffener, gripper ring and seal/gasket into which the HDPE tubing is inserted.
- Chamfer– A bevel or angle put onto the HDPE tubing (required in some coupling products) that aids the insertion of the tubing into the coupling or fitting body.
- Compression Coupling- a type of mechanical coupling that requires an outside force to actuate the sealing and gripping mechanisms. This is often accomplished by tightening a nut or retainer.
- Insertion (stab) Coupling- a type of mechanical coupling in which the sealing and gripping mechanisms are actuated when PE tubing is inserted

General Considerations

Mechanical fittings are designed to seal and restrain (grip). HDPE service line connections and joints using mechanical means. When mechanical couplings are used to join HDPE pipes the coupling must provide full restraint and seal on the HDPE tubing or pipe. Water flow thrust forces that develop at bends or at end closures can push an unrestrained mechanical coupling off the pipe end. HDPE pipes have exceptional resistance to surge pressures. Mechanical couplings must also accommodate repeated surges.

1.3 Mechanical Fitting Types

There are multiple types of mechanical fittings commonly used on HDPE water pipe and tubing. For this document, we will review the three primary mechanical fittings or connections used. With all type of mechanical couplings, it is strongly recommended that an insert or stiffener be used to support the inside diameter of the HDPE pipe to ensure long-term seal and restraint.

Figure 1.1HDPE Insert Type Mechanical Coupling

These three different technologies can be classified by the method used for completion. They are:

- Stab or insert type;
- Tightening of compression nut or compression type; and
- Pack style or clamp ring.

1.4 Stab or Insert Type Mechanical Couplings

The “stab” or insertion style coupling requires no tightening of a compression nut. With stab type couplings, the seal and restraint are accomplished independent of each other. Insert type couplings contain either single or multiple elastomeric O-rings that provide a seal on the outside diameter of the HDPE tubing which has been inserted into the fitting. The seal on the HDPE is accomplished because the inside diameter of the sealing O-ring is smaller than that of the outside diameter of the polyethylene tubing. When the tubing is inserted into the coupling or fitting body, the rubber O-ring is compressed or squeezed onto the HDPE tubing surface, thus creating a watertight seal. Figure 1.2 reveals the internal components of a typical HDPE stab or insert type coupling.

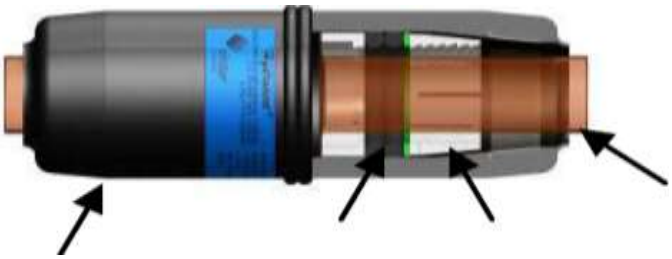


Figure 1.2 HDPE Insert Type Mechanical Coupling

1.5 Compression Couplings

Compression style couplings require an outside force to seal. The outside force is commonly a nut that is tightened down by the installer to a stop or predetermined torque value. As the installer tightens the nut, the sealing gasket and/or internal gripping ring is brought onto the HDPE pipe to provide seal and restraint (grip). The gas seal and restraint (grip) are dependent upon the amount of tightness the operator applies to the compression nut. There are a variety of gripping mechanisms commonly used with compression couplings. One version uses a reinforced gasket – as the nut is tightened, a metal grip ring inside the gasket is driven onto the HDPE tubing as depicted in figure 1.3a. Another version, the split clamp, contains separate sealing and gripping mechanisms. The seal is accomplished via a compression nut tightened down, while the grip is accomplished by a set screw, as seen in figure 13c. In a third version, as the operator tightens down the compression nut a sealing gasket and gripper ring are forced down upon the HDPE tubing to provide seal and restraint on the pipe. Refer to figure 1.3d for a component detail of this type of compression coupling.

Compression couplings were originally designed for metallic pipe connections. As such, many designs do not include an ID insert stiffener, which may reduce the compression fitting pull-out strength on PE tubing. Many manufacturers sell insert stiffeners separately. When using a compression type coupling to join or connect to HDPE, it is recommended that an insert stiffener be used to ensure long term restraint and water tight seal.

Figure 1.3 a compression fitting

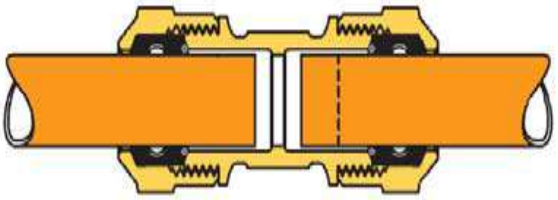


figure 1.3b reinforced gasket style

Figure 1.3c Split Clampfigure 1.3d Compression Nut Style

Figure 1.2 Compression Type Mechanical Couplings

1.6 Mechanical Connections to Meter boxes and Curb Stops

Connecting your HDPE service line to meter boxes and curb stops/valves can also be easily accomplished using mechanical couplings. Please refer to Figures 1.4a-1.4d for examples of such mechanical connections.

Figure 1.4a meter box mechanical coupling **Figure 1.4b Meter Box Connection Using Clamp Ring Connection**

Figure 1.4 cInsert Type Curb Stop **Figure 1.4d Compression End Curb Stop**

Figure 1.4 Meter Box Connection Options

1.7 Limitations of mechanical joints

The major limitation of mechanical joints in Developing Countries is the high purchase cost of the fitting. Despite the negligible cost of tools and equipment for mechanical joints the cost per fitting makes mechanical joints considerably more expensive than butt fusion joining methods. Finally mechanical joints would have to be imported to developing countries, potentially creating supply problems and increasing leakage times when waiting for repair fittings.

Self-Check -1	Written Test

Directions I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two points.

1. A device for joining pipe or tubing that does not require heat fusion
   A. Electro fusion
   B. Mechanical coupling
   C. Butt fusion
   D. Thermal fusion
2. One of the following is limitation of mechanical joint
   A. purchase cost of the fitting
   B. cost of tools and equipment
   C. cost per fitting makes mechanical joints
   D. All
3. A type of mechanical coupling in which the sealing and gripping mechanisms are actuated when PE tubing is inserted
   A. coupling box
   B. Stab coupling
   C. Compression coupling
   D. Coupling body

Answer Sheet-1

Name: _____ Date: _____

Part:-choice question

1._____

2._____

3._____

Note: **Satisfactory rating – 3 and above points** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Information Sheet-2	Identifying properties and limitations of thermal welding jointing systems

2.1 Introductions to Thermal Heat Fusion Methods

There are three types of conventional heat fusion joints currently used in the industry; Butt, Saddle, and Socket Fusion. Additionally, electro fusion (EF) joining is available with special EF couplings and saddle fittings.

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. The following sections of this chapter provide a general procedural guideline for each of these heat fusion methods.

2.1.1 Butt fusion

The most widely used method for joining individual lengths of PE pipe and pipeto PE fittings is by heat fusion of the pipe butt ends as illustrated in Figure 2.1. Thistechnique produces a permanent, economical and flow-efficient connection. Qualitybutt fusion joints are produced by using trained operators and quality butt fusionmachines in good condition

The butt fusion machine should be capable of:

- Aligning the pipe ends
- Clamping the pipes
- Facing the pipe ends parallel and square to the centerline
- Heating the pipe ends
- Applying the proper fusion force

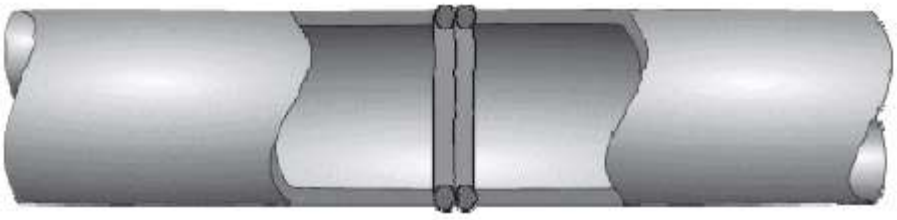


Figure 2. 1 A Standard Butt Fusion Joint

2.1.2 Saddle/Conventional Fusion

The conventional technique to join a saddle to the side of a pipe, illustrated inFigure 2.2, consists of simultaneously heating both the external surface of the pipeand the matching surface of the “saddle” type fitting with concave and convexshaped heating tools until both surfaces reach proper fusion temperature. This maybe accomplished by using a saddle fusion machine that has been designed for thispurpose.

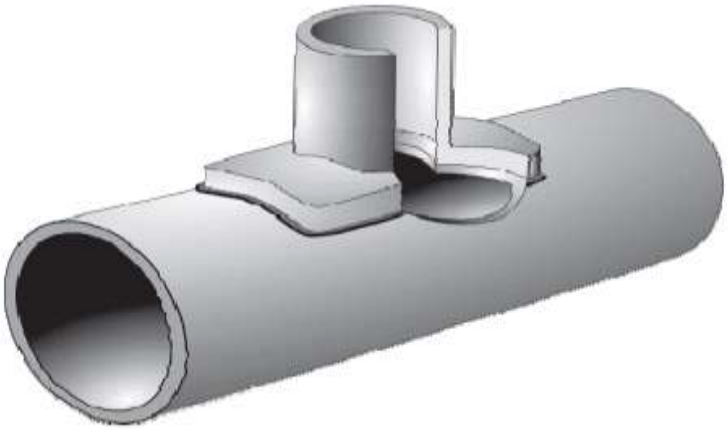


Figure 2.2 Standard Saddle Fusion Joint

Saddle fusion using a properly designed machine, provides the operator betteralignment and force control, which is very important to fusion joint quality. ThePlastics Pipe Institute recommends that saddle fusion joints be made only with amechanical assist tool unless hand fusion is expressly allowed by the pipe and/orfitting manufacturer.

2.1.3 Socket Fusion

This technique consists of simultaneously heating both the external surface of thepipe end and the internal surface of the socket fitting until the material reaches therecommended fusion temperature, inspecting the melt pattern, inserting the pipeend into the socket, and holding it in place until the joint cools. Figure 4 illustrates atypical socket fusion joint. Mechanical equipment is available to hold both the pipeand the fitting and should be used for sizes larger than 2” CTS to help attain theincreased force required and to assist in alignment. Most pipe manufacturer’s havedetailed written procedures to follow. The majority refer to ASTM F 2620.

Figure 2.3 Standard Socket Fusion Joint

2.1.4Electro fusion (EF)

This technique of heat fusion joining is somewhat different from the conventionalfusion joining thus far described. The main difference between conventional heatfusion and electrofusion is the method by which the heat is applied. In conventionalheat fusion joining, a heating tool is used to heat the pipe and fitting surfaces. Theelectrofusion joint is heated internally, either by a conductor at the interface of thejoint or, as in one design, by a conductive polymer. Heat is created as an electriccurrent is applied to the conductive material in the fitting. Figure2.4 illustrates atypical electrofusion joint. PE pipe to pipe connections made using the electrofusionprocess require the use of electro fusion couplings.

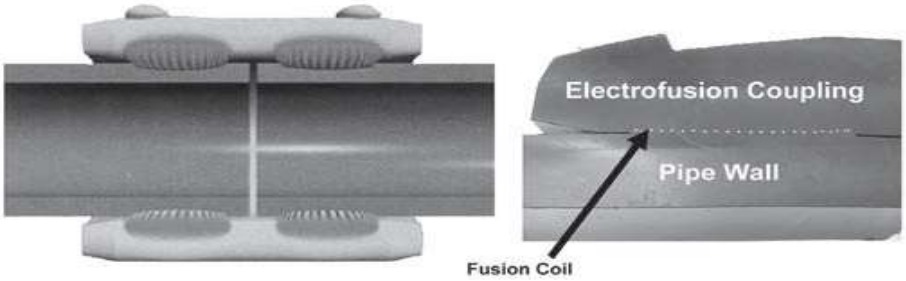


Figure 2.4 Typical Electro fusions Joint

2.2 Limitations of thermal welding jointing

One of major limitations of butt fusion jointing in developing country is that the manual thermal welding (butt fusion) procedure is highly complex and requires skilled personnel. The quality of the final joint is highly dependent of the manual pipe joining crews experience and competency. As there are no pipe alignment tools used in the jointing operation, pipe misalignment is a potential problem that can cause premature joint failure. Additionally developing countries may experience difficulties in obtaining the Teflon coated paper and thermo chrome crayons.

Butt fusion jointing is commonly used in developing countries for repairs, where sections of existing pipe are cut out. In this process two butt fusion joints will be required, one joint at each end of the section being replaced. This will require the second joint to be completed inside the excavation, which will increase the likelihood of joint contamination and pipe misalignment. Additionally the excavation required will have to be larger to increase the amount of movement in the existing pipeline and allow the new section of pipe to be “sprung in”. Finally, successful butt fusion jointing requires the system being worked on to be fully isolated (i.e. no water flowing through repair section) and the pipe to be dryinside. This will require effective flow stop equipment (squeeze offs). Compression joints may be carried out with small quantities of water still flowing through the isolated pipe section.

Self-Check -2	Written Test

Directions I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two points.

1. One of the following is a thermal welding jointing system
   A. electro fusion
   B. butt fusion
   C. saddle fusion
   D. all
2. One of the following is The most widely used method for joining of PE pipe
   A. Electro fusion
   B. Butt fusion
   C. Saddle fusion
   D. Socket fusion
3. One of the following is the main difference between EF and conventional joint
   A. Method of heat apply
   B. Types of PE pipe use
   C. Types power source use
   D. all

Answer Sheet-2

Name: _____ Date: _____

Part I:-choice question

1._____

2._____

3._____

Note: **Satisfactory rating – 3 and above points** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Information Sheet-3	Performing trial jointing for all methods and identify Nonconformance jointing

3.1. Pipe jointing trials

- Trials shall be carried out to demonstrate that the pipes, joints and fittings for water supply pipework are fit correctly.
- The trials shall be carried out at least 6 weeks, or such shorter period agreed by the Engineer, before the materials are to be incorporated in the permanent work.
- The Contractor shall inform the Engineer 24 hours, or such shorter period agreed by Engineer, before carrying out trials.
- The Contractor shall immediately inform the Engineer of any pipes, joints or fittings which do not fit correctly. Modifications shall be made to pipes, joints and fittings that do not fit correctly or replacements shall be provided as instructed by the Engineer. On days butt fusions are to be made, the first fusion shall be a trial fusion in the presence of an Inspector. The following shall apply:
  - ✓ Heating plate surfaces shall be inspected for cuts and scrapes and shall be free of dirt and residue. Heater surfaces should be between 400OF (minimum) to 450O F (maximum). Measure the temperature @ 12:00, 3:00, 6:00 and 9:00 o'clock positions using a pyrometer of infraredThermometer at locations where the heating plate will contact the pipe/fitting ends. The maximum temperature difference between any two points on a single heating surface must not exceed 24OF. If this ASG Housing Distribution Lines Replacement Project 6 temperature is exceeded; the heating plate shall be cleaned per the manufacturer's recommendations.
  - ✓ The fusion or test section shall be cut out after cooling completely for inspection.
  - ✓ The test section shall be 12" or 30 times (minimum) the wall thickness in length and 1" or 1.5 times the wall thickness in width (minimum).
  - ✓ The joint shall be visually inspected as to continuity of "beads" from the melted material, and for assurance of "cold joint" prevention (i.e. –joint shall have visible molded material between walls of pipe). Jointspacing between the walls of the two ends shall be a minimum of1/16" to a maximum 3/16".

3.2 Nonconformity

A non-conformance means that something went wrong. ... The non-conformance could be in a service, a product, a process, goods from a supplier, or in the management system itself. It occurs when something does not meet the specifications or requirements in some way. When nonconformity occurs, the organization shall:

- identify the nonconformity;
- React to the nonconformity and,
- as applicable, take action to control and correct it,

How to Handle Non-Conformances

- Document the nonconformance and give the nonconformance a unique number.
- Issue the documented nonconformance to relevant department.
- Department (responsible person) to investigate root cause.
- Implement corrective action.
- Verification of implemented corrective action.
- Close out the nonconformance and file.

Corrective Action – in order for your response to be fully accepted it must include: A statement that the nonconformity has been corrected. (Your response needs to be written in the past tense. i.e. the missing record was found, not will be found).

3.3 Non-Conformances report

The report helps define the problem in a clear, logical and concise way so that management can take steps to implement changes. ISO 9001:2015 no longer requires a documented procedure, but one must still keep records of the nonconformity and what was done to correct it.A non-conformance report documents the details of a non-conformance identified in a quality audit or other process review. The objective of the report is to make an unambiguous, defensible, clear and concise definition of the problem so that corrective action can and will be initiated by management.

Self-Check -3	Written Test

Directions I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two points.

2. One of the following is method of handling nonconformity
   A. Implement corrective action
   B. Close out the nonconformance
   C. investigate root cause
   D. all
3. When nonconformity occurs, the organization shall
   A. identify the nonconformity
   B. React to the nonconformity
   C. take action to control and correct
   D. all

Answer Sheet-3

Name: _____ Date: _____

Choice item Questions

1._____**2.**_____

Score = _____

Rating: _____

Note: **Satisfactory rating – 2 and above points** **Unsatisfactory - below 2 points**

4.1 Methods of Assessing Weld Quality

One of the great things about butt fusion welding of a polyethylene pipe is that there are a range of techniques that can be used to assess the quality of welds. This includes simple on site tests that the weldercan perform, none destructive examination (NDE) and destructive testing in laboratories under reference conditions.

During the formation of a butt fusion joint, an internal and an external weld bead is formed at the location of the joint. The bead formed on the outside of the pipe can be removed easily with simple mechanical tools and provides a quick and easy means of checking for common problems in welding.

- Before removing it from the pipe, the external weld bead can be visually checked. It should be uniform both in terms of its width and of each side of the bead when viewed around the circumference of the weld. If not, then it would indicate that there most likely is a problem with the heater plate (distorted, or heater elements broken)
- The width of the bead can be measured to check it falls between a minimum and maximum width. A bead too small might indicate insufficient heat in the weld, a bead too large may be too much heat or too much pressure during the welding process
- Once removed, the bead can be subjected to bending and twisting along its length. If the bead splits in a brittle fashion then it is likely that the pipe joint also has brittle areas (the bead is representative of the weld quality in the pipe wall). If the bead has brittle like defects then the pipe joint should be remade.

Non destructive examination (NDE) of butt fusion welds can be performed and tools are usually very good at detecting voids, or contamination, which may exist in the weld and need to be addressed. NDE techniques are not routinely used as the industry has very good experience of combining assessment of weld beads, together with sampling of joints by destructive testing, as the means by which it demonstrates the suitability of the technique.

Definitive tests on weld quality can be made by conducting destructive testing. Such tests can be made on construction sites in a simplified form but in case of reference, are conducted in a laboratory. The purpose of such testing is usually to check that the butt fusion machine that is taken onto the construction site is working properly and that the welds it makes are of the expected quality, so often it is the first weld made on the site that is tested as a minimum. In section 6 we talk about the standards that can be specified for this work, usually the test is

one where tensile specimens are cut from the weld and pulled to force failure which can be assessed both quantitatively and qualitatively.

Self-Check -4	Written Test

Directions I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two points.

1. One of the following is used to assess quality joint

A. destructive test

B. Nondestructive examination

C. water quality test

D. A&B

Score = _____

Rating: _____

Note: **Satisfactory rating – 1 points and above** **Unsatisfactory - below 1 point**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-4

Name: _____ Date: _____

Choice Questions

1._____

2._____

Score = _____

Rating: _____

Operation Sheet 1	Technique of inserting mechanical coupling

OPERATIONTITLE: Inserting mechanical coupling

PURPOSE: to inserting mechanical coupling

EQUIPMENT TOOLS AND MATERIALS: pen, chamfering, clean cloth

Procedure

Step 1- Cut the pipe and make the end square

Step 2- Wipe the pipe with clean cloth. Inspect the last several inch of pipe for damage. If any cut again to remove damage

Step 3- Prepare the out diameter of pipe for proper OD chamfer

Step 4- Mark the stab depth

Step 5- Stab the pipe into hydroset fitting

Can you develop operation sheet at

LAP Test 1	Practical Demonstration

Name: _____ **Date:** _____

Time started: _____ **Time finished:** _____

Instructions: Given necessary reagents, tools and materials you are required to perform the following tasks within 1 hour

Task.1. Insert mechanical coupling

Instruction Sheet	Learning Guide 30:Identify compatibility of commercial electro fusion control systems

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Identifying electro fusion welding control unit type and operating data.
- Identifying pipe material and dimension compatibility with electro fusion fittings.
- Identifying control unit compatibility with electro fusion fitting control

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Identify electro fusion welding control unit type and operating data.
- Identify pipe material and dimension compatibility with electro fusion fittings.
- Identify control unit compatibility with electro fusion fitting control

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 3”. On pages 35, 38 and 42.Try to understand what are being discussed.
4. Accomplish the “Self-checks 1, 2,& 3” in each information sheets on pages 37,41&44.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “next LG However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After you accomplish LG, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Identifying electro fusion welding control unit type and operating data

1.1. Introduction to Electrofusion Control Unit

The control unit input supply should be from a nominal 240V generator suitable to drive inductive loads and phase cut systems, commonly of about 5kVA capacity. Some fitting suppliers may consider smaller capacity generators acceptable for small diameter fittings. The nominal output of the generator shall be compatible with the requirements of the control unit. It should be noted that electro fusion control units may generate considerable heat. Refer to the supplier of the controller to ensure the unit has an integrated cooling system. Control units should operate with barcode marked fittings according to ISO 13950, with a maximum output of 48 Volts. Control units should include safety devices to prevent voltages greater than recommended by the manufacturer. The safety device should operate in less than 0.5 sec. Check the suitability of the control unit for use with the fitting supplier.

Figure 1.1 control unit

Electro fusion control units, sometimes referred to as processors, perform vital functions during the fusion process. The unit provides carefully regulated voltage for the required fusion cycle time resulting in the designed energy required for fusion.

During the fusion process, the control box also monitors the power being supplied to the fitting and can detect certain assembly or fitting errors such as shorted heating coils or short-stabbed pipe ends. When using the fitting barcode, the control box checks the ambient air temperature and automatically adjusts the fusion time for that temperature if the fitting barcode requires it.

Adjustment of the fusion time for higher or lower ambient temperature is referred to as “temperature compensation”. Not all fittings require temperature compensation, but all barcodes contain two characters that define whether the feature is used or not. If in doubt,

use the barcode. The control box needs to acclimate to the job site weather conditions for minimum period of 15 minutes to ensure that it accurately measures ambient temperatures before beginning the fusion process.

Figure 1.2 Electro fusions Welder

The control box will terminate a fusion process when any defined protocol is out of range and will display an error message. Control boxes have a list of error message definitions affixed to the unit for reference if an error occurs. A record of each fusion, as well as the result of the fusion cycle, are stored and are downloadable via a USB connection. Displayed error codes are unique to each manufacturer- refer to manufacturer's user manual for interpretation. The control box manufacturer recommends regular calibration intervals, typically every 12 months, to ensure that all monitored parameters are measured accurately and the control box is functioning normally. Units that are past their calibration interval will normally alert the operator at power-up, but will continue to function when acknowledged.

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page. Each question worth two points

1. One of the following is use control unit
   A. regulated voltage for the required fusion cycle
   B. terminate a fusion process when any defined protocol is out of range
   C. monitors the power being supplied to the fitting
   D. all
2. One is referred to as processors, perform vital functions during the fusion process.
   A. electro control unit
   B. electro fusion joint
   C. temperature compensation
   D. Mechanical joint
3. Adjustment of the fusion time for higher or lower ambient temperature is referred to as temperature compensation
   A. True B. false

Note: **Satisfactory rating – 3 points and above** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet -1

Name: _____ **Date:** _____

Score = _____

Rating: _____

Choice question

1_____

2_____

3_____

Information Sheet-2	Identifying pipe material and dimension compatibility with electro fusion fittings

2.1 Introductions to electro fusion

Electro fusion is one of the methods of jointing for Socket and saddle typefittings where, heat is generated by inducing electric current into a wire coil which is apart of the fitting. With electro-fusion jointing, an electrical resistance element isincorporated in the socket of the fitting which, when connected to an appropriatepower supply, melts and fuses the materials of the pipe and fitting together.The effectiveness of this technique depends on attention to preparation of thejointing surfaces and ensuring the surfaces to be welded have satisfactory contactduring the welding and cooling cycles. This can be effectively done by Pipe holdingclamps or other approved methods of restraining, aligning and re-rounding the pipesduring the fusion cycle.

2.2 Preparing the fusion joint

Protect the fusion area and the control box against moisture and contamination.

The necessary generator output depends heavily on the ambient conditions as well as the electro fusion fittings being jointed. The generator must produce at least 22 A current & 40 V voltages 5 KVA for the full performance range of the fusion jointing devices to be utilized.

2.3 Material Properties & Compatibility

GPS manufactures polyethylene systems in both PE80 and Excel (PE100). The numbers relate to the MRS (Minimum Required Strength) values of the material

PE80 – This is the term used to denote the polyethylene material which has been widely used for gas, water and industrial applications for many years. The terms MDPE and HDPE were commonly used to describe this material, although MDPE PE80, as historically supplied by GPS, has a much higher long term stress crack resistance than traditional HDPE PE80.

PE100 – This is a term used to denote high performance polyethylene, and PE100 pipes are sold by GPS under the brand name of Excel. PE100 is a higher performance material than PE80 and demonstrates exceptional resistance to rapid crack propagation as well as to long term stress cracking.

Moreover, the higher strength of PE100 permits thinner pipe walls than PE80 for the same operating pressure. PE100 uses less polymer and provides for a larger bore and increased flow capacity for a given nominal pipe size. This can result in significant cost savings at certain sizes and pressure ratings.

2.4 Standard Dimensional Ratio (SDR)

One of the items of information stated on both pipe and fittings is the standard dimensional ratio. In all but the smallest sizes of PE pipe (< 25mm) the ratio between wall thickness and outside diameter remains constant for a given pressure rating of the pipe. This relationship, called the standard dimensional ratio or SDR, can be expressed as an equation:

$$SDR = \frac{\text{nominal (minimum) outside diameter}}{\text{minimum wall thickness}}$$

Example:

SDR 11 = $\frac{180}{16.4}$

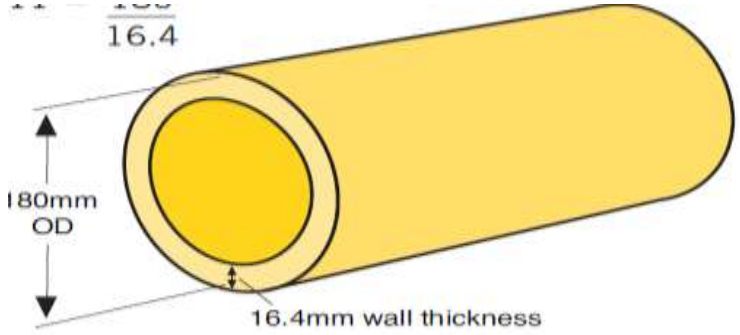
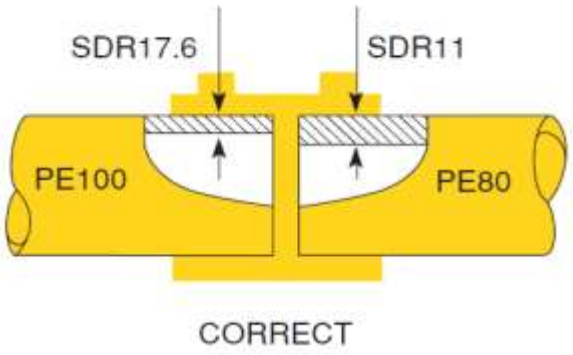


Figure 2.1 Relationship between wall thickness and outside diameter (OD)

2.4.1 Material and SDR Compatibility

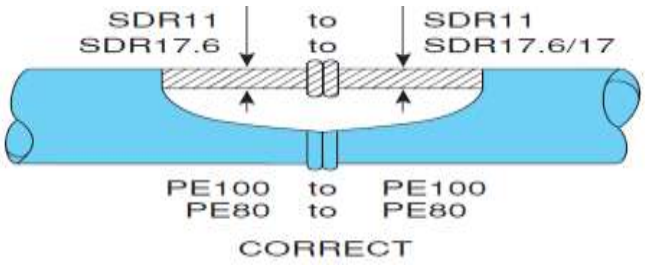
- Dissimilar materials and dissimilar wall thicknesses can be jointed by electro fusion.

NB. The maximum working pressure should not exceed the lower value for the two pipes.



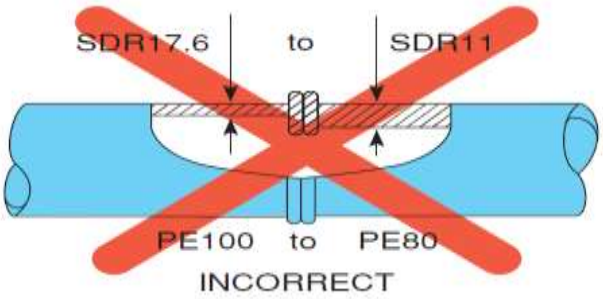
- Similar materials and/or wall thicknesses may be jointed by butt fusion or electro fusion.

Note: SDR17 may be butt fused to SDR17.6.



- Dissimilar wall thicknesses must notbe jointed on siteusing butt-fusion.

  Note: PE80 should only be buttfused to PE100 under closely controlled factoryconditions.



Self-Check -2	Written Test

Directions I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two points.

1. The ratio of nominal outside diameter to minimum wall thickness is
   A. PE80
   B. SDR
   C. MRS
   D. PE100
2. One of the following is a term used to denote high performance polyethylene
   A. PE100
   B. PE40
   C. PE80
   D. P30
3. One of the following is not is true about Material and SDR Compatibility
   A. Dissimilar materials and dissimilar wall thicknesses jointed by electro fusion
   B. Similar materials and/or wall thicknesses jointed by electro fusion
   C. Dissimilar wall thicknesses must be jointed on siteusing butt-fusion
   D. Dissimilar wall thicknesses must notbe jointed on siteusing butt-fusion
4. The value of the SDR for outside diameter 200mm and wall thickness 18.2mm
   A. SDR17
   B. SDR11
   C. SDR17.6
   D. SDR35

Note: **Satisfactory rating – 4 points and above** **Unsatisfactory - below 4 points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Answer Sheet-2

Name: _____ **Date:** _____

Choice question

1_____ 3._____

2_____ 4._____

Information Sheet-3	Identifying control unit compatibility with electro fusion fitting control

3.1 Introduction to Control unit

Fusion units according to ISO12176-2 should be used to comply with the fusion data recognition and to comply with the necessary health & safety regulations. Preferably data retrieval units should be used allowing the storage of the actual fusion data and permitting a read-out of the data. Ensure that adapter plugs, e.g. 4.7 mm are available, if required. Fusion units shall be calibrated in a regular time.

This part of ISO 12176 specifies performance requirements for electro fusion control units for use with polyethylene (PE) electro fusion fittings for the supply of gaseous fuels or for the conveyance of water for human consumption, including raw water prior to treatment, and for the conveyance of water for general purpose or other fluids.

The control units are divided into three input voltage classes:

- SVLV [safety, very low voltage (up to 50 V)],
- LV [low voltage (50 V to 250 V)] and
- HV [higher voltage (250 V to 400 V)].

This part of ISO 12176 is applicable to electro fusion control units designed for use in the construction of joints between PE pipes and fittings conforming to International Standards for the supply of gaseous fuels or for the conveyance of water, where the normal operating temperature of the control unit is in the range -10 °C to +40 °C. If temperatures outside this range are expected, suitable operating limits are subject to agreement between manufacturer and purchaser. The control box input supply shall be from a nominal 220 volt generator.

No extension leads shall be used on the control box outletconnectors

Example of control unit specification

Technical data:

Operating temperature:

- 14^0F(-10^0C) to 113^0F(45^0C)

Input voltage and frequency:

- 100-130VAC/200-250VAC@50Hz-60Hz

Output voltage and current:

- 0-28.5VAC@ 0-50 Amps

Power consumption:

- 1200 Watt max.

Power cable length:

- 5ft(1.5m)

Fusion cable length:

- 18ft(5.5m)

Remote cable length:

- 20ft(6m)

Weight and dimensions:

- 45lbs(20.5kg),(WXHXD) 22X14X10 inch

Fields of application:

- Gas and water applications
- Industrial applications
- Harsh work site use

Advantages:

- Intuitive user interface
- Multiple joint capability for speedy installations
- Integral carrying case for ease of transportation
- One button repeat fusion cycle for same size joints
- Self-diagnostic error detection system
- Automatic compensation for ambient temperature

Electro plus compatible products

- Fuseal
- Fuseal squared
- Fuseal 25/50
- PPro-Seal

3.2 Couplers jointing guidance and compatible equipment

Radius Systems electro fusion couplers (450 to 710 mm) must be installed using approved compatible equipment which is capable of delivering the 3 stage electro fusion heating cycle: 'warm-up', 'soak' and 'weld' (fuse), followed by the cooling cycle. For successful jointing, a compatible electro fusion control box and matching generator capable of delivering a minimum constant power of 4.8 kW for the duration of the electro fusion cycle, are required (the fitting supply shall be 78 V to 80 V AC rms)

3.3 Minimum equipment requirements

- Compatible 80 V electro fusion control unit
- Generator capable of providing the required power for the full duration of the electro fusion cycle. A 7.5-10 kVA generator will be required depending on the manufacturer
- Compatible re-rounding clamps and alignment bars

- Industry approved pipe surface preparation tool (rotary pipe preparation tool preferred.

5. Welding shelter

- Ground sheet
- Measuring equipment
- Approved marker pen
- Suitable pipe cleaning equipment and disposable paper cleaning towels

Self-Check -3	Written Test

Directions I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two points.

1. One of the following is a very low voltage control unit
   A. Control unit with voltage 50v
   B. Control unit with voltage up to 50v
   C. Control unit with voltage 50v-250v
   D. Control unit with voltage 250v-400v
2. One of the following is stage of electro fusion heating cycle
   A. Warm up
   B. Soak
   C. Weld
   D. all

Note: **Satisfactory rating – 2 points and above** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Answer Sheet-3

Name: _____ **Date:** _____

Choice question

1_____

2._____

Instruction Sheet	Learning Guide 31: Maintain and calibrate electro fusion control unit equipment.

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Setting up electro fusion welding equipment and work area
- Ensuring safety equipment availability and operational
- Identifying, reporting and rectifying nonconformance.
- Determining operational tools and equipments

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Set up electro fusion welding equipment and work area as per enterprise procedures.
- Ensure safety equipment is available and operational as per enterprise procedures.
- Identify non-conformance, report and rectify according to enterprise procedures.
- Determine tools and equipment is operational according to specifications.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 3”. On pages 46, 49&53.Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks1, 2, & 3” in each information sheets on pages 48, 51 and 57.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1 on pages 58 and do the LAP Test on page 59”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After you accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Setting up electro fusion welding equipment and work area

1.1. Introduction Safe and reliable site pre-conditions

The following precautionary measures should be employed to ensure a healthy and safe working environment for operatives in the trench and to generate conditions for secure and reliable jointing, which in turn safeguard a leak-free operation over the life span of the piping system.

1.2Planning

For an efficient and safe execution all necessary equipment (machines and tools) and the corresponding pipe/ fitting components have to be available on site before the fusion process is commenced. The planning stage includes ensuring that the machines, tools and components (fittings) are available, appropriate, fit for purpose and are suitable for interactive use (i.e. adapter pins of the fusion unit and the pin size of the fitting)

1.3 Site surrounding

Excavation pit and retaining walls

The profile of the excavation or retaining walls should prevent soil/ ground movements which could harm the safety of the installer and/or disturb the later fusion process. National safety regulations have to be respected!

Pipe ends have to be excavated in suitable lengthto enable flexibility for ease of alignment.

Figure 1.1: Retaining walls

1.4 Creating the appropriate working conditions

To ensure adequate health and safety conditions for the installers and/ or to guarantee reliable conditions for high quality jointing, sufficient space and dry conditions in the working

pit are important. The application range for Electro fusionis usually -10°C to +45°C. Make sure by checking the installation manual, that installation in the intended temperature range is covered. For deviations or required additional measures, please consult the suppliers of the pipe, fitting, tools and machines.

Protection from rainfall (i.e. by using a tent) and pumping out ground water from the working pit is a necessary preparation measure.

Furthermore protection (e.g. by using an umbrella)from intense sun light especially in very hot ambient conditions shall be guaranteed.

Open pipe ends should be sealed before starting the installation process, to prevent contamination and draft through the pipeline.

1.5 Ensure dry conditions in the working pit

In rehabilitation cases, pipelines often contain residual water, which steadily flows out at the pipe ends. Preventive measures (e.g. closing valves, temporary plungers) shall be taken to stop the flow into the fusion area before the preparation process starts. For special solutions in rehabilitation please consult your suppliers.

Self-Check -1	Written Test

Direction I: write the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two points.

WriteT for true or F for False

1. Before the preparation process of fusion the valve should be close.
2. Open pipe ends should be sealed before starting the installation
3. sufficient space and dry conditions in the working pit are important For high quality jointing

Note: **Satisfactory rating – 3 points and above** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet -1

Name: _____ Date: _____

Multiple choice items

1_____

2_____

3_____

Information Sheet-2	Ensuring safety equipment availability and operational

2.1 Introduction to safety equipment

Personal protective equipment is an important defense against certain types of injury.

Injuries from falling and flying objects, for instance, can be reduced by wearing hard hats and eye protection. Everyone on a construction project or PE pipe installation must wear PPE.

Where it is not possible for emissions to be controlled at their source, or removed or reduced through effective ventilation, extraction or diversion, the use of personal protective equipment (PPE) as a final measure must be considered to ensure safety.

PPE is a lower order control and can only be used where higher order controls are not possible or are not totally effective.

Selection and use of PPE requires careful consideration, as there are many different types that reduce the risk of injury of contact or exposure to a hazard.

Incorrect use of PPE, or purchasing inappropriate PPE, can contribute to serious workplace incidents. PPE that is uncomfortable, restrictive or heavy may create secondary hazards, and, as a result, constant supervision may be necessary to ensure it is used effectively.

Personnel exposed for long periods to noisy equipment should wear hearing protection.

Work in confined spaces such as manholes and valve chambers may require respiratory protection against hazardous atmospheres. Before any PPE is used it should be inspected to ensure:

- A good fit on the user
- Is being used correctly
- Is appropriate and effective to protect the wearer from the hazards it is intended to control
- Does not introduce any new hazards for the task to be performed

The following are types of PPE require in water construction works.

Body & Skin Protection shall be worn when there is remaining risks in the environment.

Overall protects the normal clothes from dust, grease and other spilling materials. Types of body and skin protection include:

- Protective Clothing
- Sunscreen & insect repellent
- High visibility vests working at or near roadways or near moving traffic or moving plant
- Laboratory coats, heat resistant clothing, waterproof jackets.

Head protection shall be worn whenever there is a danger of falling objects, projectile objects or impacts to the head, people striking their heads on objects in the environment or require protection from UV rays. Types of head protection include:

- safety helmets & caps
- hats & hoods

Ear protection

It protects the carrier from damages of the ears.Continuously working in a very noisy Environment harms the eardrums forever.Once the eardrums are damaged there is no Way of restoring the sense of hearing again.A type of hearing protection includes:

- Ear plugs
- Ear muffs
- Ear caps

Hand Protection shall be worn to protect the operator from contact with hazardous substances. Types of hand protection include:

- Special gloves - wrist or elbow length
- Cotton, rubber
- PVC & leather
- Stainless steel mesh

Foot protection shall be worn wear there is a risk of objects dropping onto feet, or slip hazards present. Types of foot protection include:

- Steel capped boots
- Non slip shoes
- Waterproof boots

Respiratory protection shall be used when exposure to the work atmosphere may be injurious to health. Used during working in confined space such as manhole and valve chamber. Types of respiratory protection include:

- Face masks
- Half face respirators
- Air filter units
- Self-contained breathing apparatus

Fall Protection shall be used where a risk of falling is present. Types of fall protection include:

- Helmets
- Belts & harnesses

- Lanyards & pole straps

Ear muffs

Gloves

Particle half face respirator

Welding mask

Safety glasses

Figure 2.1 different types of PPE

Self-Check -2	Written Test

Direction I: Choose the best answer for the following questions. Use the answer sheet provided in the next page: Each question worth two points.

1. Before using an item of PPE, you should:
   A. Check the item for signs of wear and tear
   B. Check that the item fits correctly
   C. Ensure you have received training on how to use the item correctly
   D. All of the above

1. Eye protection should be:
   A. Durable
   B. Not interfere with vision.
   C. Kept in good repair.
   D. All of the above

2. Shall be worn whenever there is a danger of falling objects
   A. helmet
   B. goggle
   C. glove
   D. safety boot

Note: **Satisfactory rating – 3 points and above** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet -2

Name: _____ Date: _____

Multiple choice items

1_____
2_____
3_____

Information Sheet-4	Determining operational tools and equipments

4.1 Introduction to tools and equipment

It is important that installers are equipped with the correct tools and measuring equipment to ensure all joints are prepared in accordance with both the manufacturers and industry guidelines. This is to ensure factors including surface preparation, cleaning, permissible joint geometry, control of welding environment and welding parameters are correctly managed. To achieve this, the installers will need to have access to a range of tools, environmental controls and measuring devices for each type of fitting being used at the job site. If the installer plans to use multiple installation crews, then it is important that each crew has all the equipment required for successful welding.Proper tools and equipments are essential to a successful electro fusion installation. Tools include devices for measuring, marking, cutting, scraping, cleaning, clamping (which includes aligning and securing), re-rounding, and power delivery. At minimum, the following items should be accessible during installation:

4.2 Pipe preparation equipment

- Pipe Cutting Tools
- Pipe Scraping Tools
- Pipe Cleaning Material
- Pipe re-rounding tools (on larger pipe sizes)

4.2.1 Pipe Cutting Tools

The pipe ends must be cut square and even. Cutting the pipe square is extremely important. Failure to cut the pipe square may leave the heating wire uncovered. This can lead to short circuit, overheating, uncontrolled melting and even sudden ignition. Remove any burrs or shavings from the pipe ends.

Figure 4.1a Rotational Figure 4.1b pipe cutter Figure 4.1c Rotational pipe cutter (S-type)

Pipe cutter

4.2.2 Pipe Scraping / Peeling Tools

Tools that are approved for scraping pipe for electro fusion joining are those that remove material cleanly. “Peeler” type tools that remove a continuous and measurable ribbon of pipe surface are the preferred scraping tools and should be used whenever possible. The advantages of these tools are:

- The ribbon thickness can be measured to verify that the tool is performing as designed.
- A continuous ribbon ensures that the entire circumference of the pipe is being peeled.
- Any skipped or missed paths between peelers revolutions are easily identified using only lengthwise scribed witness marks.

Figure 4.2 different types of Scraping tools

4.2.3 Re-rounding tools

Polyethylene is a flexible material. Pipe roundness can too be affected by a number of conditions to include manufacturing process conditions, coiling, storage/stacking, and soil load if buried. The condition of pipe roundness can be expressed in two ways,

- out-of roundness or
- Ovalitywhile both are referencing the same basic condition, it can sometimes be confusing.

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.

Ovality is the difference between the maximum and minimum measured outside diameters expressed as a percentage. Ovality is calculated as (d1 – d2) / Average.

If severe enough, pipe out-of-roundness can have a negative effect on electro fusion joint quality. If the pipe is out-of-round, and is not corrected, theamount of gap between the pipe and fitting can be too large for the melt expansion to close and increase the difficulty of sliding the fitting onto the pipe.

Figure 4.3 re-rounding tools

4.2.4 Pipe cleaning materials

Commercially available pre-packaged 96% (or greater) isopropyl alcohol impregnated disposable wipes without additives are recommended to clean pipe surfaces. Denatured alcohol may contain other impurities and is NOT suitable. .

Under no circumstances should a coupling fusion be made with any liquid (water, oil, sewage, etc.) flowing through the fusion area. The fusion zone must be clean and dry before and during fusion.

4.3 Measuring device

The measuring equipment's used for electro fusion or PE installations are

- pressure gauges: to measure the pressure
- watch :- to measure the time
- temperature probes,
- Calliper:-to measure pipe ovality(out-of-roundness)
- Steel rule: to measure insertion depth
- Pi tape– to measure average diameter in the weld zone

Figure 4.4 Pi tape

4.4 Relevant safety equipment

The following may use as safety equipment

- Glove
- Goggle
- Safety shoes
- Safety cloth

4.5 Manual butt fusion jointing equipment

The equipment required for the butt fusion jointing procedure is listed below and shown in Figure 4.5

A. Heat resistant gloves
B .Teflon coated paper sleeve
C .Lighter
D .Tape measure
E. Scraper and blades
F. Alignment clamp
G. PE pipe cutter
H .Thermo chrome crayon
I. Heating plate
J. Blow lamp

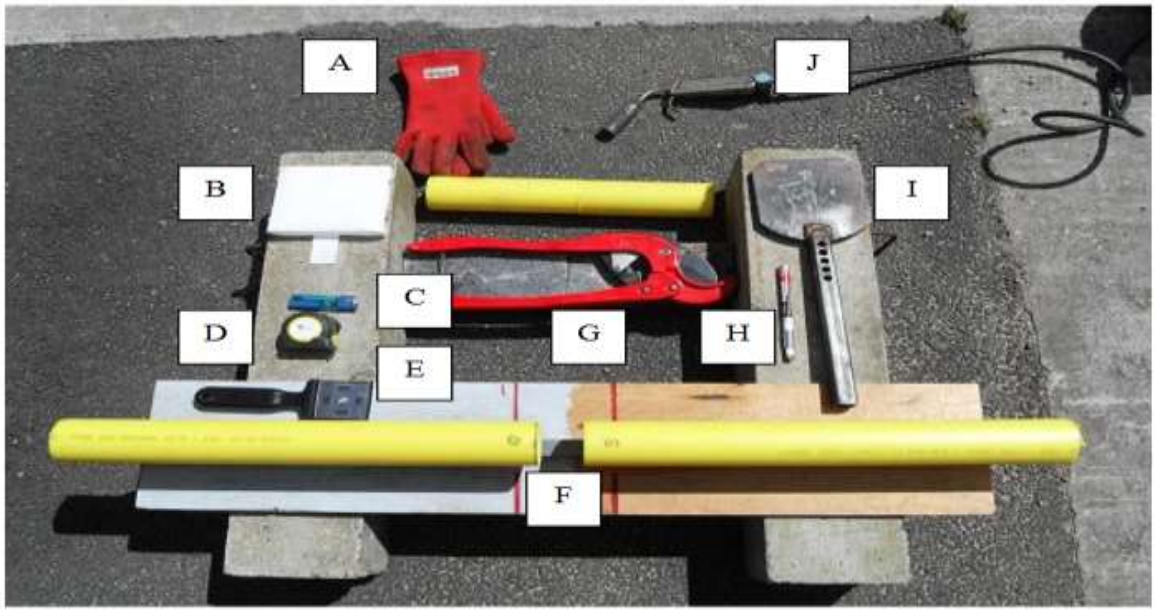


Figure 4.5 Equipment for manual butt fusion of polyethylene pipes

4.6 Fusion equipment

- Power generator the generator should be appropriate for the job and capable of supplying the required power.
- Electro Fusion control box with correct leads, barcode reader (not on manual boxes) and sufficient output power.

Self-Check -4	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two points

1. One of the following is a measuring device
   A. Pressure gauge
   B. Calliper
   C. Pi tape
   D. All
2. One is a safety equipment
   A. temperature probes
   B. glove
   C. Scraper
   D. Pi tape
3. One of the following is not Pipe preparation equipment
   A. Pipe cutter
   B. Scraper
   C. Pressure gauge
   D. 96% isopropyl alcohol

Note: **Satisfactory rating – 3 points and above** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-4

Name: _____ Date: _____

Multiple choice items

1._____
2. _____
3. _____

Operation Sheet -1	Technique of preparing fusion machine

OPERATIONTITLE: Prepare fusion machine

PURPOSE: to prepare fusion machine

EQUIPMENT TOOLS AND MATERIALS: - PPE, fusion machine, grit utility cloth, heating tool

PROCEDURE:

Step1: install the saddle fusion tool on the main according the manufacturer's instruction
Step2: abrade the fusion surface of main with a 50-60 grit utility cloth
Step3: abrade the fusion surface of the fitting with a 50-60 grit utility cloth: remove all dust
Step4: move the fitting base against the main pipe and apply about 100 pound forces to seat the fitting
Step5: place the heating tool on the main centered beneath the fitting base.
Step6: apply the initial heat force until melt is first observed on the crown of the pipe main
Step7: cool the assemble for 30min

LAP Test 1	Practical Demonstration

Name: _____ **Date:** _____

Time started: _____ **Time finished:** _____

Instructions: Given necessary reagents, tools and materials you are required to perform the following tasks within 2 hour.

Task1.prepare fusion machine

Instruction Sheet	Learning Guide 32: Determine methods for handling, storage, transport and installation of PE pipeline components.

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Identifying the requirements for Handling and transporting of PE and hazardous materials
- Determining long term storage requirements.
- Determiningrequirements for installation,

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Identify requirements for handling and transport of PE and hazardous materials.
- Determine requirements for long term storage.
- Determine requirements for installation, including additional materials.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 3”. On page 60, 66&69 try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks 1, 2, &3” in each information sheets on pages 65, 68, and 72.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1 on pages 97 and do the LAP Test on page 99”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After you accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Identifying the requirement for Handling and transporting of PE and hazardous materials

1.1. Introduction to Handling Pipe and Fittings

Use appropriate devices for handling of pipes, e.g. a crane or excavator, tie bar, belts.Deviations from tolerances and defects Maybecause by in-adequate pipe storage ortransportation. Appropriate pipe storage, cautious transportation and handling – also fromstorage to the working pit - shall be executed in away that no excessive ovalisation or damage (flattening, scratches, and cracks) occurs, which could adversely affect the life span of the pipeor thejoint quality. The ends of pipes which are intended for drinkingwater systems shall be closed.Allowable pipe storage times – especially for PE pipes which are not black - have to be confirmed by the pipe supplier. All materials shall be carefully inspected at the time of delivery and any defects shall be notified and reported immediately. Pipe shall be stockpiled adjacent to the site chosen for jointing the pipe. If the pipe is laid directly on the ground, the surface shall be level and free of stones and debris that might damage the pipe or make the pipe stack unstable.

All pipe stacks should be located on firm, flat ground to evenly support the weight of the pipes and lifting equipment. Recommended ground conditions are level gravel, sand, snow or grass. Where such conditions do not exist or when a bed cannot be prepared, the pipe may be placed on planking. This planking shall be evenly spaced along the pipe length. Care must be taken not to load the pipe in such a way that will cause flat spots.

In areas of high temperatures and heavy sunlight pipes shall be covered by a bright tarpaulin. Heat accumulation shall be prevented. Pipes shall be stored so that changes in temperature will not cause the pipes to move.

Figure 1.1 Protection of pipe against direct sunlight

When several different wall thicknesses of pipeare received, it is recommended that the pipe be segregated into piles, each pile containing a single size and pressure rating to minimize sorting of the pipe at a later date. When pipe of different wall thicknesses or pressure ratings have to be stored in the same pile, the pipe with the thickest wall shall be placed at the bottom of the pile with pipe of progressively decreasing wall thicknesses stacked on top, providing this matches the welding sequence. The pile shall be constructed in a pyramidal, freestanding manner, with each successive layer having one less pipe than the layer below. The bottom layer shall be braced to prevent movement under the weight of the pipes above. The maximum allowable stacking height for pipe stored in open yards, in stacks of one nominal size, shall not exceed those given in Table 1.1. For safety and convenience of handling, the stacking height for pipes shall be limited to six units or not more than 2.5m, and they shall be adequately wedged to prevent movement.

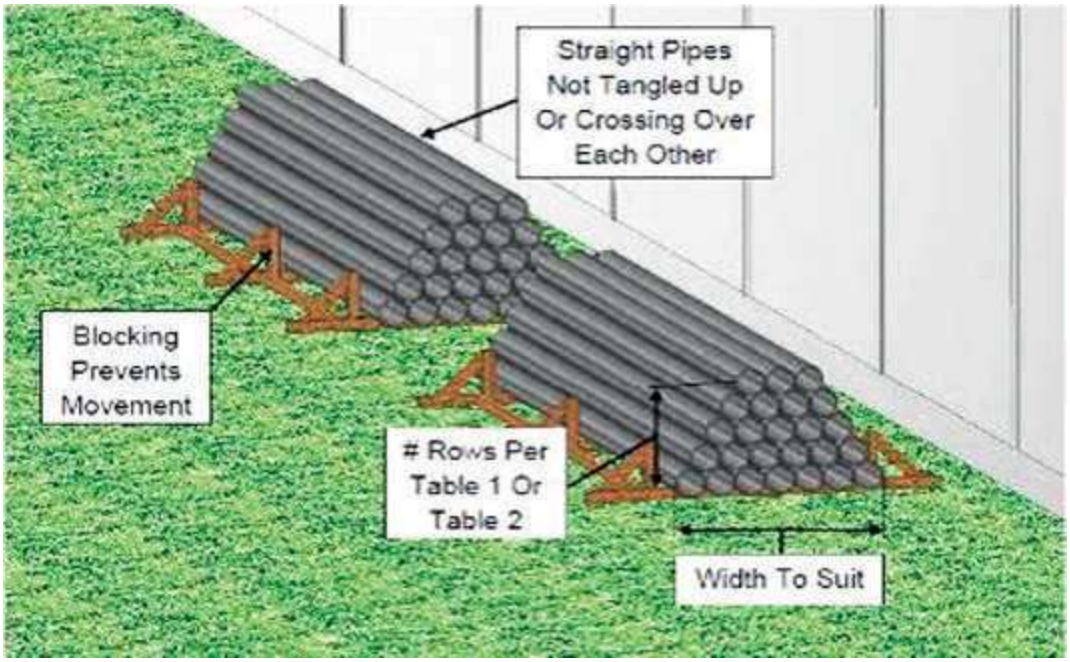


Figure 1.2 shows the maximum level of PE pipespermitted for each DN/OD size on flat ground or on recommended planking for loose pipe storage

Table 1.1 Number of Permitted Layers of PEPipe for Stacking and Storage

NominalPipe Size	On Flat Ground	On Recommended Planking
315	6	5
355	6	5
400	6	4
450	5	4
500	4	3
560	4	3
630	3	2
710	3	2
800	2	1

Each level of pipes must be supported by timberwhen stored as shown in the example in Figure 1.3

Figure 1.3 Example of good on-site PE Pipe Packingand Storage

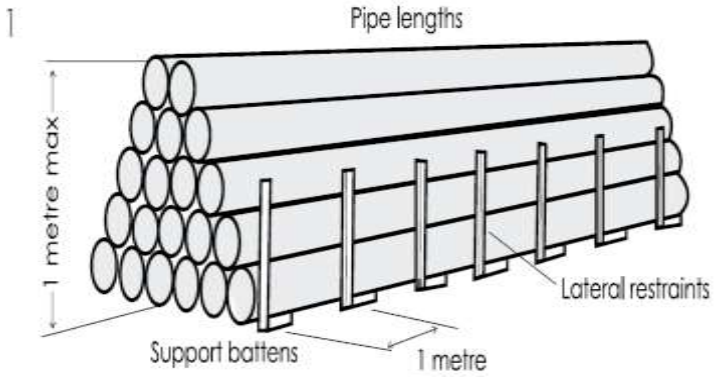


Figure 1.4a Storage of loose pipes

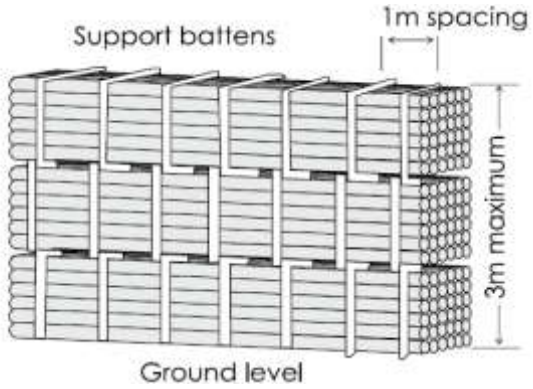


Figure 1.4b Storage of pipe bundles

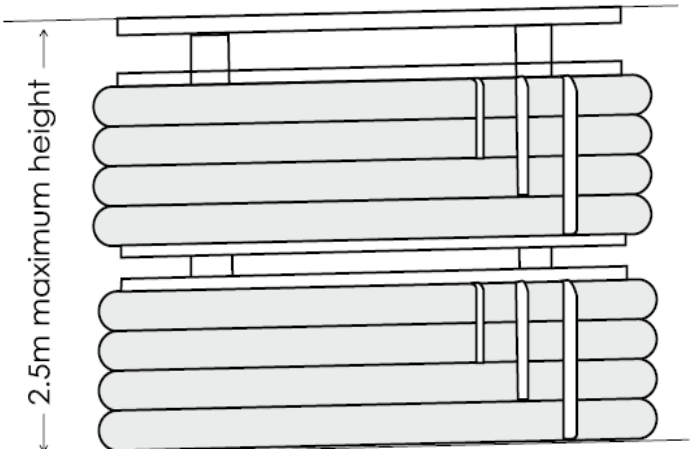


Figure 1.4cStorage of coiled pipes

1.2 Appropriate storage of the EF Fittings

Inadequate transportation and storage can harm the fusion quality; therefore the fitting should be stored in its original packaging (i.e. on pallet, in carton box and PE bag) and handled in accordance with the manufacturer's storage and transportation instructions (e.g. storage in an up-right orientation as elevated ambient temperature can create fitting ovality).

Store electro fusion fittings in closed rooms orcontainers not exposed to UV radiation and effects of weather. The Allowable storage temperature range is 0°C to +50°C. Only remove the fitting from packaging directly before insertion.

Figure 1.4: Transport of EF couplers, packedon individual pallets in horizontal position

Self-Check -1	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth one point

1. One of the following is devices use for appropriate handling of pipes
   A. Crane
   B. Excavator
   C. Tie bar
   D. all
2. Appropriate pipe storage means
   A. cautious transportation and handling pipe
   B. increase excessive ovalisation of pipe
   C. affect the life span of the pipe
   D. removing the pipe from packaging

Note: **Satisfactory rating – 2 points and above** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet -1

Name: _____ Date: _____

Multiple choice items

1_____

2_____

Information Sheet-2	Determining long term storage requirements

2.1 Introductions to Storing

Before pipe and/or fittings are placed into storage, they should be visually inspected for scratches, gouges, discoloration and other defects. Damaged or questionable materials should not be put into storage. Cuts and gouges that reduce the wall thickness by more than 10% may impair long-term service life and should be discarded.

2.1.1 Off-Site Storage Guidelines

Store small pipe in racks according to the length and size of the pipe. Block or strap the pipe to prevent it from rolling or falling off the rack. Pipe larger than two inches in diameter should be stacked with spacing strips between each row. Arrange and block each row of stacked pipe to prevent it from rolling off the pile. If pipe is stored outdoors, make sure all blocks are made of material that won't deteriorate as it weathers. Material that cannot be stacked because of its size or shape should be stored on shelves capable of supporting the combined weight of the materials.

2.1.2 Job Site Storage Guidelines The storage area should have a relatively smooth, level surface free of stones, debris or other materials that could damage the pipe or fittings. Where adequate ground conditions do not exist or when a bed cannot be prepared, the pipe may be placed on planking evenly spaced along the pipe length.

Figure2.1 Storing PE Pipe

When pipes of variable wall thickness are received, it is recommended that the pipe be segregated into piles, each pile containing a single size and pressure rating to minimize confusion at a later date. The pile should be constructed in a pyramid, with each successive layer having one less pipe than the layer below. The bottom layer should be braced to prevent movement.

2.1.2 Indoor/ Outdoor Storage

Expansion and contraction caused by uneven heating during storage in the sun may cause the pipe to bow if not restrained by racks. This does not damage the pipe but may be inconvenient when the pipe is taken out of storage for installation.

Since black HDPE pipe generally contains greater than 2% carbon black, it will resist damage from sunlight indefinitely. Colored products are compounded with antioxidants, thermal stabilizers and UV stabilizers. Therefore, non-black products should remain in unprotected outdoor storage for no more than two years (or longer only as recommended by the pipe manufacturer). Black products with stripes are generally suitable for unprotected outdoor storage and service.

Self-Check -2	Written Test

Direction I: Write true if the statement is true and falseif the statement is false .the best answer for the following questions. Use the answer sheet provided in the next page**:** Each question worth two points.

1. Before pipe and/or fittings are placed into storage, they should be visually inspected for scratches.
2. Expansion and contraction caused by uneven heating during storage in the sun may cause the pipe to bow if not restrained by racks.
3. Non-black products should remain in unprotected outdoor storage for no more than two years.

Note: **Satisfactory rating – 3 points and above** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet -2

Name: _____ Date: _____

True or false items

1_____

2_____

3_____

Information Sheet-3	Determining requirements for installation including additional materials

3.1 Introduction to installation

After delivery the pipe length are firstplaced on a bed of sand beside the trench. After welding on-site, the assembled pipelines are then lowered into the trench with suitable lifting equipment.

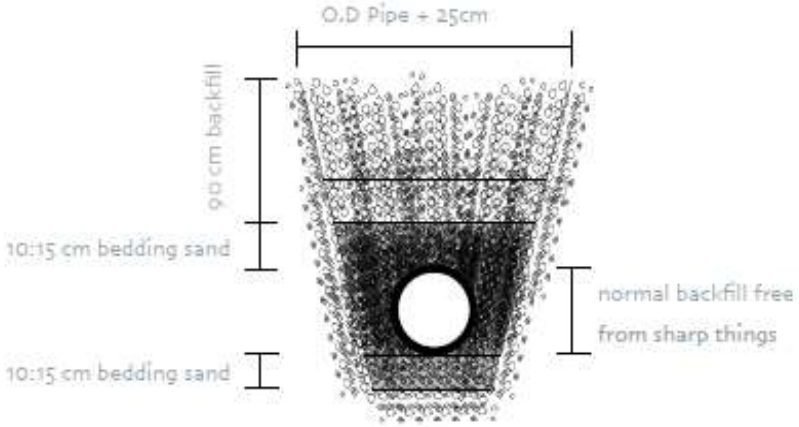
The trench is backfilled with stone chippings and sandy excavated soil.

The pipe lengths for the marine pipelines are welded on a suitable place on the lakeside by heated tool butt welding, simultaneously, sink weights were installed before the pipelines were pulled on the Reservoir.

3.2 Installation Techniques

Installation at open trench:-

Due to the possibility of welding PE pipes outside the trench and drawit after welding, the trench should has a narrow width which reduce the digging costs. In general, the trench width is about (outside diameter +25cm) the trench construction and dimensions are shown in the below.



Notes:

The dimensions mentioned in this figure one used as a reference dimensions, the contractors should review this dimension with GM technical support department

Directional drilling:

3.3 Pre-installation Requirements

Pipe Diameter– In the absence of specific requirements from the fitting manufacturer ensures that the pipe diameter is within the tolerances, at the specified temperature, of the applicable pipe standard. Standard tolerances are determined at 73°F. Measure pipe diameter with a Pi Tape at 2” and 6” from the pipe end to determine diameter. Pipe toe-in or reduction in diameter is a condition that occurs at the pipe end and should be checked to ensure that the

pipe diameter is within tolerance at 2” from the end. Severe toe-in may require the removal of up to one pipe diameter or 12” from the pipe end.

Figure 3.1 Measuring Diameter

In preparing a pipe for electro fusion the pipe outside diameter (OD) is reduced by at least .014” by scraping the outside surface. This OD reduction should be taken into consideration when accepting pipe extruded close to the above minimum tolerances.

Pipe Ovality– Determine if an ovality condition exists by measuring the pipe diameter to determine the amount of out-of-roundness. If ovality exceeds 2%, re-rounding clamps must be used. Pipe ends should be squarely cut to 90° ± 5°. A 4” or wider sling or strap can be used as a guide to mark the pipe for cutting. A level and protractor can be used to determine the angle of the cut.

Pipe Alignment– Pipe alignment should be inspected to ensure that no stresses are present in the assembly that might cause movement during fusion.

Power Source– An adequate power source is required. Ensure that power source is capable of delivering power for entire coupling fusion time without interruption (check generator for full fuel supply). Ensure that all connections are tight and clean. Loose connections can result in arcing or blown fuses.

Scraping Tools– pipe preparation is very critical to the electro fusion process. Careful attention must be given to proper cleaning and scraping procedures to remove contamination and surface oxidation from the pipe surface. Ensure that only mechanical type scraping tools designed specifically for electro fusion preparation are used to prepare the pipe surface. Do not use abrasives such as grinders, emery cloth, or sandpaper

Markers– Ensure that insertion depth and pipe scrape area markings are made with a non-greasy, non-petroleum based, fast-drying, permanent marker or paint pen.

Cleaning Agent / Wiping Cloth– A clean, dry, non-dyed, lint free cloth is used to clean pipe surfaces. 96% or higher Isopropyl alcohol without additive, except water, is recommended as

a cleaning agent. Pre-impregnated wipes without additives may also be suitable. Denatured alcohol may contain other impurities and is not suitable for use with electro fusion. Under no circumstances should a coupling fusion be made with any liquid (water, oil, sewage, etc.) flowing through the pipe or fusion area; fusion joint failure and possible electrical hazards could occur. The fusion zone must be clean and dry before and during fusion.

Weather Conditions-Observe manufacturer's recommended minimum and maximum installation temperatures for electro fusion fittings. The typical installation temperature range is -4°F to 120°F (-20ºC to 49ºC), but can vary above and below that range depending on the manufacturer.

Self-Check -3	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth one point

1. A typical installation temperaturefor electro fusion
   A. -20ºC to 49ºC
   B. -20ºC to 60ºC
   C. -20ºC to 80ºC
   D. -20ºC to 30ºC
2. One of the following is a pre-installation requirement
   A. Scraping tools
   B. Marker
   C. Cleaning agent
   D. all

Note: **Satisfactory rating – 2 points and above** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-3

Name: _____ Date: _____

Choose Item

1_____

2_____

Instruction Sheet	Learning Guide 33:Identify appropriate service connection and repair techniques

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Determining service connection requirements.
- Identifying alternative service connection methods
- Performing service connection
- Determining repair techniques
- Identifying alternative repair options.
- Performing repair installation

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Set up electro fusion welding equipment and work area as per enterprise procedures.
- Ensure safety equipment is available and operational as per enterprise procedures.
- Identify non-conformance, report and rectify according to enterprise procedures.
- Determine tools and equipment is operational according to specifications.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 5”.on page 75,78,82,86 and 92. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks 1,2,3,4 & 5” in each information sheets on pages 77, 81, 85, 91 and 95.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).

6. If you earned a satisfactory evaluation proceed to “Operation sheets 1 and 2 on pages 96 and 98 and do the LAP Test on page 99”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After you accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Determining service connection requirements.

1.1. Introduction Service connections.

Service connections are pipes that connect drains from toilets, baths, kitchens and laundryappliances in homes, businesses and industries to the city sewer system. ... These service connections, involving smaller diameter pipes, can be easily installed using trenchless technology such as impact moling.

1.2 Types of Service Connection:

- drinking water services
- recycled water services
- sewerage services
- Fire services...

Domestic services may be teed off fire connections before the edge of the right of way. Thus only onetap may be required; however, the services shall be considered separate domestic and fire.

Difficult construction conditions' include, but are not limited to:

- existing services in the construction path
- underground water
- geographical location
- trees
- rock
- requirements for traffic management

1.3 Service connection requirements

- Water meters will be released for installation based on conformance with the following requirements for development.
- The water and sewer system must be functionally complete. That is, the water must be environmentally safe and the sewer conveyance system must be complete to transport the sewage for treatment in an environmentally safe manner.
- The Private Development Coordinator or his representative will provide this information to the City of Savannah Water and Sewer Bureau.
- All fees have been paid.
- The system has an executed water and sewer agreement if applicable.

- Accounts have been set up with the City's Water Revenue Department for billing purposes.

1.4 Connections to Mains

There are many options available for hooking up a PE service line to a main. To help you select the best option you should consider:

- Type of installation (new or existing);
- Type of main (PE, PVC, Ductile Iron, etc.);
- Type of fittings (mechanical vs. fusion);
- Type of tap (pressure or non-pressure); and
- Type of PE service line you want to use (SIDR, CTS, and IPS).

If a new main is being installed, you have the option to install equal or smaller inline tees, wyes or crosses. If the main is already installed, you may use service saddles, branch saddles or tapping tees. Mechanical tapping saddles are available for larger diameter pipe branches.

If the main is made of Ductile Iron, PVC or Concrete, you must use mechanical fittings. If the main is made from PE, you may use either mechanical fittings or fusion. Fusion is the preferred method of connecting to a main because, when done properly, fusion joints do not leak.

If you are using mechanical saddles or fittings you need to ensure they are designed for use with polyethylene pipe. The physical characteristics of PE pipe may contribute to leaking joints when used with fittings that are designed for other materials. In addition, mechanical fittings that use screws or bolts that tighten into the wall of the pipe can cause point loading failures in PE pipe. Fittings that exhibit equal compressive stresses around the wall of PE pipe work best. Consult the fitting manufacturer for recommendations.

Another consideration is whether you will be making a live tap or connecting to a non-pressurized line. When making live taps, Self Tapping tees are recommended. Service saddles with corp. stops are also effective.

Transitioning to the service line is another consideration. You will need to transition from the corp. stop or tapping tee outlet to your service pipe. There are many transition fittings available that will allow you to transition from thread on a corp. stop to SIDR, CTS or IPS pipe. Depending on the brand, the outlet on the self-tapping tees may be stab, fusion or compression. Consult the fitting manufacturer.

Self-Check -1	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two points

2. One of the following is Difficult construction conditions during service connection
   A. underground water
   B. geographical location
   C. existing water services
   D. all
3. one is a domestic water service
   A. sewerage service
   B. Fire service
   C. Recycled water service
   D. Drinking water service

Note: **Satisfactory rating – 2 points and above** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet -1

Name: _____ Date: _____

Multiple choice items

1_____
2_____
3._____

Information Sheet-2	Identifying alternative service connection methods

2.1. Introduction to service connection methods

Polyethylene pipe or tubing can be joined to otherPE pipe or fittings or to pipe or appurtenances of other materials using one or more joining systems. The purchaser should verify with the pipe and fittings manufacturer that fittings are capable of restraining PE pipe or tubing from pullout, especially for larger-diameter products with thicker walls. In the case of mechanical coupling or compression fittings, make sure that the manufacturer recommends its fittings for polyethylene water service piping. Further information and specific procedures may be obtained from the pipe and fittings manufacturers.The following methods are used to joining the PE pipe

- Mechanical or Compression fittings
- Butt Fusion
- Saddle fusion
- Socket Fusion
- Electrofusion

2.2 Mechanical or Compression fittings

Mechanical or compression fittings are being increasingly used with PE water service pipes. The words mechanical and compression are used interchangeably when describing these fittings. Designs are available to fit pipe and tubing made to control inside and also to control outside diameters. When choosing fittings, make sure they are sized for the pipe, or tubing, with which they will be used. Most importantly, check to see that the fitting manufacturer specifically recommends the use of its fittings for PE water service piping applications.

Compression fittings accomplish the functions of pressure seal and pullout resistance through a variety of proprietary designs. They all require an internal tubular stiffener to support the PE pipe against compressive forces and for gripping. If loose stiffeners are used in the makeup of a compression joint, make sure that the end of the stiffener has no sharp edges and that the stiffener does not extend beyond the clamp or coupling nut. Some proprietary mechanical fitting designs have self-contained “floating” stiffeners which compensate for the stiffener’s extension beyond the end of the fitting (See Figure 2.2). Again, check to see that the fitting is designed for use in PE water pressure piping systems. If loose stiffeners (not self-contained in the fitting), use only stiffeners approved by the fitting manufacturer. Because the exact pipe/fitting assembly procedure can vary depending on fitting design, the user should obtain this information from the fitting manufacturer, and the fitting manufacturer’s directionsshould be closelyfollowed.

Figure 2.1: Mechanical or compression insert fittings

2.3 Heat Fusion

There are three types of heat fusion joints currently used in the industry - butt fusion welding, electrofusion welding and saddle fusion welding. The principle of heat fusion is to heat two surfaces to a designated temperature, and then hold them together by application of a sufficient force. This force can be applied either by a direct force holding the ends of the pipe together as in butt fusion welding and saddle fusion welding or by indirect forces caused by the melting of two surfaces in a confined space as in electrofusion welding. In all three cases this causes the melted materials to flow and mix, thereby resulting in welding or fusion. As soon as the joint cools to near ambient temperature, it is ready for handling.

2.3.1 Electro-fusion Jointing

The effectiveness of electro-fusion jointing depends on attention to preparation of the jointing surfaces and the geometry of the assembly, in particular the removal of the oxidized surface of the pipe over the socket depth or saddle mounting area, ensuring the jointing surfaces are clean and free from contamination, and the assembly and clamping instructions are correctly followed.

Good practices of fusion preparation are as follows:

- Rectangular cut of pipe ends
- Roughly cleaning of jointing area
- Marking of peeling area
- Scrapping the fusion zone
- Cleaning of prepared area
- Marking of insertion depth
- Mounting of components such as coupler and saddle
- Fusion process
- Cooling time

- Records

2.3.2 Butt fusion Jointing

Butt fusion is a process of welding PE pipes and fittings using an electrically heated plate. It is suitable for jointing a straight pipe. However, only pipes and fittings of the same material type, size and rating shall be butt welded.

The process of butt fusion jointing's are consists of:

- Preparation of equipment
- Setting up
- Trimming
- Bead up
- Heat soak
- Plate removal
- Fusion jointing
- Cooling
- Debeading
- Records
- Maintenance, service and calibration

Fittings Connections of two PE pipes to each other, or between a PE pipe and a PE fitting, can also be made by the use of one of two heat fusion methods, hot plate fusion (including butt, socket, or saddlefusion) or electrofusion. These methods involvepreparing PE pipesurfaces, heating the surfaces to proper fusion temperatures, and joining the surfaces in a prescribed manner to effect the fusion bond. ASTM D 2657 describes the hotplate heat-joining practice; ASTM F 1290 describes the electrofusion method. Detailed procedures vary depending on the specific equipment and materials involved.

Special tools to provide heat and alignment are required for heat-fusion connections**.** These tools are available from the fusion joining system's manufacturer.

Insert fittings. Insert fittings are perhaps the oldest method for joining PE water service pipe. This method is intended to be used only with PE piping with controlled inside diameters that is with pipe that carries IDR, or SIDR markings. Check that the manufacturer recommends the specific insert fitting joining method for PE water service piping, and make sure that the manufacturer's joining methods are followed.

Self-Check -2	Written Test

Direction I: Answer all the questions listed below. Use the answer sheet provided in the next page: Each question worth two points

Answer all Questions with either T for True or F for False.

1. It is acceptable to perform an electro fusion with a slight trickle of water running across the fusion area.
2. The purpose of scraping is to remove the oxidized layer of PE pipe from the pipesurface prior to electro fusion
3. Keep electro fusion fittings in original packaging until install.
4. There is no need to support hanging pipe ends during fusion.
5. A process of welding PE pipes and fittings using an electrically heated plate is butt fusion

Note: **Satisfactory rating – 5 points and above** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet -2

Name: _____ Date: _____

Multiple choice items

1_____
2_____
3_____
4._____
5._____

Information Sheet-3	Performing service connection

3.1. IntroductionService connections

Service connections shall be electrofusion saddles with sidewall fusion branch saddles, or tapping tees. Electro fusion saddles shall be made from materials suitable for EF.

For sidewall fusion saddles, the size of the saddle shall be as indicated on the plans. The saddlecan be made in accordance to ASTM D 3261 or ASTM F 2206. After installation, approximately ¼-inch of the PE pipe shall be visible beyond the saddle to confirm that proper surface preparation occurred. Saddle faces that do not provide ¼-inch of area beyond the saddle are not acceptable.Electrofusion saddles are the preferred method of service connections. Mechanical strap-onsaddles can only be used where approved by the Engineer. The body of the mechanical saddle shall be stainless steel. The gasket material and design must be acceptable for PE pipe. Install mechanical strap-on saddles per the manufacturer's instructions.

3.2 Service connection by Electro fusion

- Connect the electro fusion control unit (ECU) leads to the tapping tee and key in the correct fusion time, as shown on the fitting.
- Check the loading pressure is correct by ensuring that the central indicator is still flush with the top face of the spring carrier.
- Press the fusion start button.
- On completion of the cycle remove the leads and allow the joint to cool for the required time, as shown on the fitting, before removing the tool.
- Replace the threaded cap ensuring that the 'O' ring seal is in position

3.3 Service Connections-Tapping Tee to Service Pipe

The service connections between the tapping tee and the service pipes are made using either service couplers or service reducers in conjunction with a suitable alignment clamp.

The procedure for making a service connection is as described for the electrofusion couplers.

Any hydrostatic pressure tests should be carried out on the service pipe before the hole is cut through the wall of the mains pipe using the integral cutter.

3.4 Service Connections -Tapping into a Water Main

Tapping into the water main should not be carried outuntil at least 30 minutes have elapsed following the end of the cooling cycle. After this time period the tapping procedure is as follows:

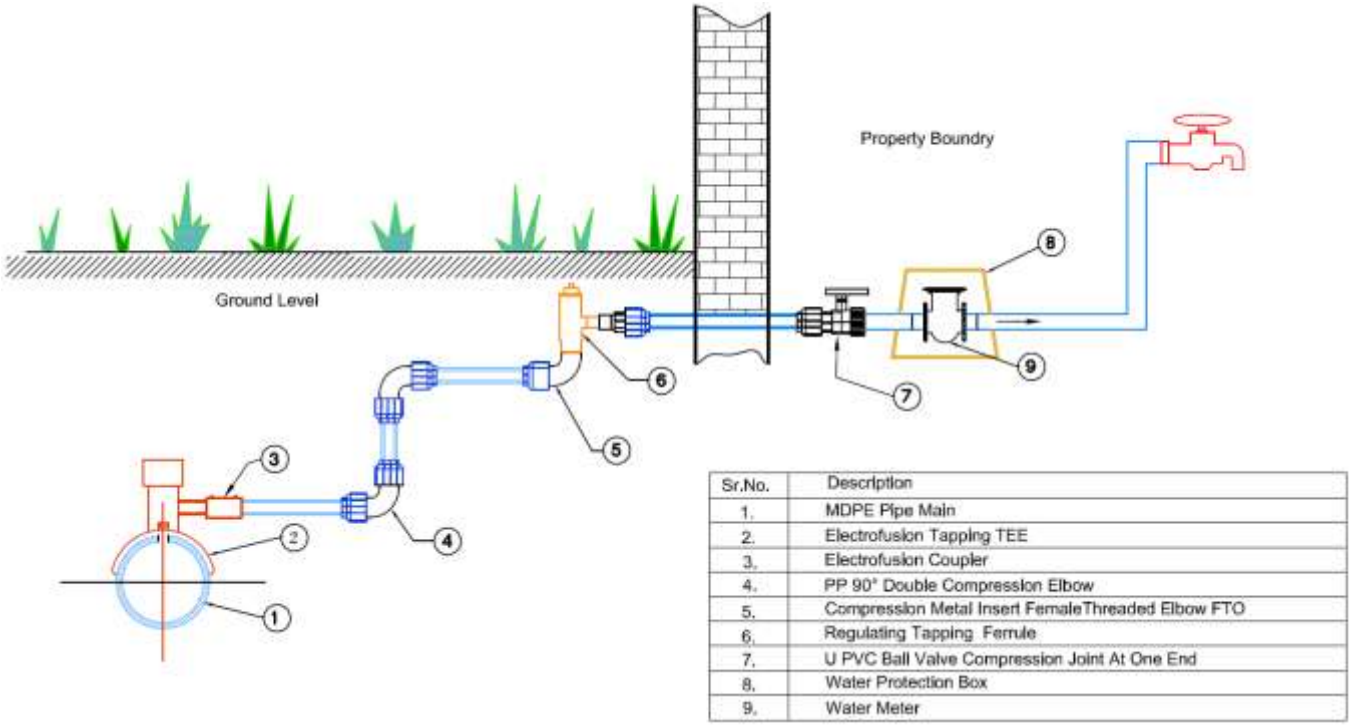
- Insert the tapping key into the recess in the top of the metal cutter and turn in a clockwise direction. Continue until the pipe wall is completely cut through (indicated by a reduction in the force necessary to turn the key).
- Retract the cutter by turning the key in an anticlockwise direction until the top of the cutter is flush with the top of the threaded stack, showing that the cutter is clear of the branch.

The coupon of material cut from the pipe wall will be retained in the end of the cutter.

• Check that the 'O' ring seal is in place in the cap and screw it down hand tight onto the threaded stack of the tee.

3.5 House Service Connection

Now days the water service connections are mainly given using PE Pipe & compression fittings due to various advantages over Metal distribution system. Also the Exiting Metal (DI/CI) piping can be tapped to provide house service connection using DI Saddle. The following Layouts give idea about typical installation of House Service Connections using different methods.

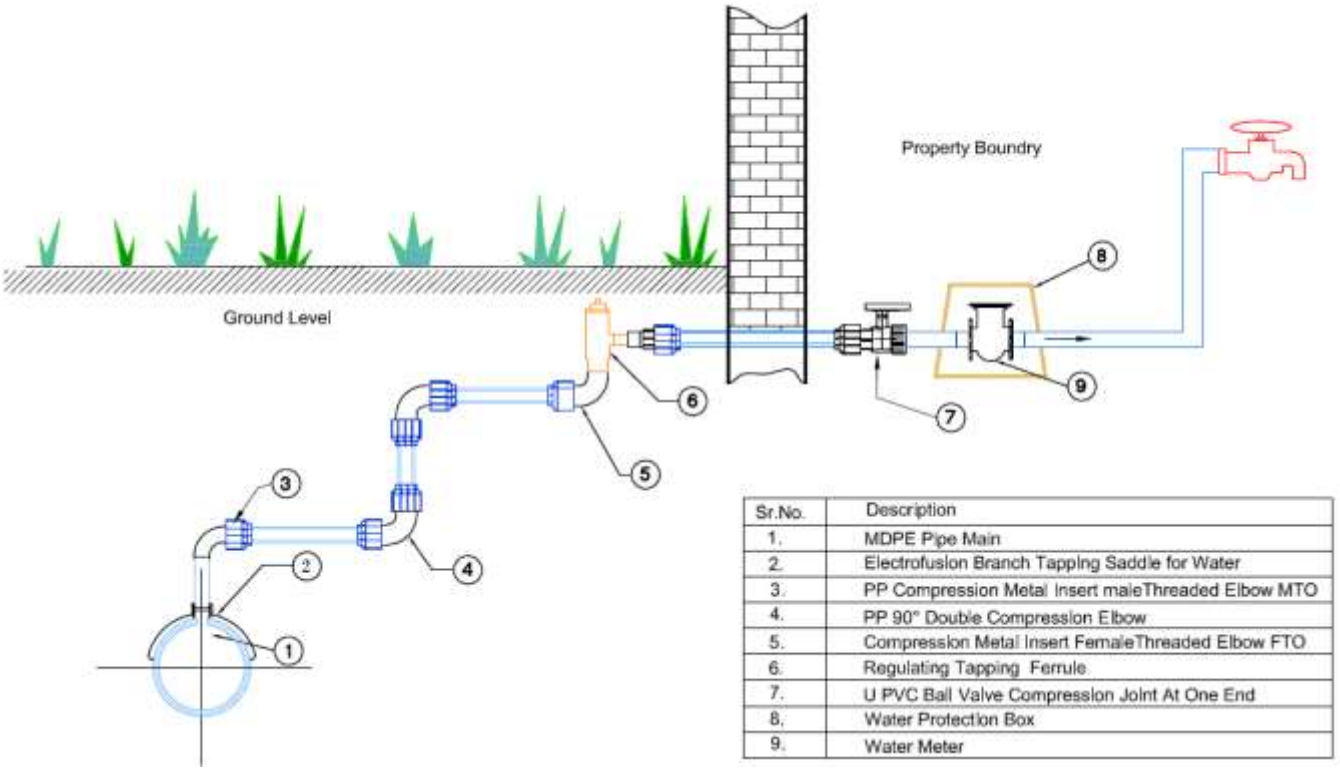


Sr.No.	Description
1.	MDPE Pipe Main
2.	Electrofusion Tapping TEE
3.	Electrofusion Coupler
4.	PP 90° Double Compression Elbow
5.	Compression Metal Insert FemaleThreaded Elbow FTO
6.	Regulating Tapping Ferrule
7.	U PVC Ball Valve Compression Joint At One End
8.	Water Protection Box
9.	Water Meter

Figure 3.1Typical House Service Connection with EF Tapping Tee on PE Pipe

Firstly Join the Tapping Tee and Couple by Electrofusion jointing. Fixthe pipe with the compression fitting as per site conditions using 900 double compression elbow, compression Metal FTO, and Regulating Brass ferrule, UPVC Ball valve with compression end & Water meter respectively.

For Tapping PE pipes use EF Branch Saddle with female threaded outlet and Metal compression threaded elbow (MTO) as shown in the same sequence as above.



Sr.No.	Description
1.	MDPE Pipe Main
2.	Electrofusion Branch Tapping Saddle for Water
3.	PP Compression Metal Insert maleThreaded Elbow MTO
4.	PP 90° Double Compression Elbow
5.	Compression Metal Insert FemaleThreaded Elbow FTO
6.	Regulating Tapping Ferrule
7.	U PVC Ball Valve Compression Joint At One End
8.	Water Protection Box
9.	Water Meter

Figure 3.2 Typical House Service Connections with EF Tapping Branch Saddle on PE Pipes

Self-Check -3	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two points

1. One of the following is method of service connection
   A. Butt fusion
   B. Saddle fusion
   C. Electro fusion
   D. All
2. Electrofusion saddles are the preferred method of service connections
   A. True B. False

Note: **Satisfactory rating – 2 points and above** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-3

Name: _____ Date: _____

Choice question items

1_____

2_____

Information Sheet-4	Identifying alternative repair options

4.1 Introduction repair

There are different alternative repair option some of are the following

4.2 Temporary Field Repairs with Full Circle Band Clamp

Many system operators will have full circle band clamps in their specifications as a repair option. In general these types of repair clamps have proven to be a great method of temporary repair, especially in emergency situations.

Some general design considerations for the successful use of full circle band clamps are as follows:

- Full Circle Band Clamps are recommended for repairs only where the pipe is able to maintain its structural integrity. Consider repairs only to a clean-cut round hole or deep scratches or gouges of maximum dimension, less than the nominal diameter of the pipe divided by three. Do not use band clamps when the pipe has cracks, jagged punctures, long tears, or deep scratches or gouges which could propagate outside the clamp under anticipated field loads.
- Do not exceed the manufacturer's recommended maximum operating parameters such as temperature and pressure.
- The installer should always follow the clamp manufacturer's recommend installation guidelines. Whenever possible, use a product that has been specifically designed for use with polyethylene pipe.
- The manufacturer should always be consulted on the use of their product on polyethylene pipe if the clamp was not manufactured specifically for use with polyethylene pipe.
- Pipe movement due to thermal expansion, thermal contraction and creep, as well as, surge events must be considered when repairing polyethylene pipe with a full circle band clamp.
- Generally, full circle band clamps are intended for use in underground applications. If your application is of a different nature, contact the manufacturer of the band clamp.

If the band clamp is to be used as a permanent repair, contact the fitting manufacturer for the suitability of use as a permanent repair.

Figure 5.1: Full Circle Band Clamps

4.3Permanent Field Repairs

Saddle Fusion Repair

If the size of the puncture damage is very small (1inch or smaller puncture on one pipe wall), a capped off Tapping Tee or High Volume Tapping Tee or patch can be saddle fused to the main over the damaged area, provided the water flow can be stopped and the repair area kept dry during the repair process. Before adding the patch or fitting, drill a small hole at each end of the damage to prevent the crack from propagating further.

Then, butt fuse a cap on the service outlet of the Tapping Tee selected for the repair.

Turn off the water and prepare the surface area around the damage for the saddle fusion process. Saddles fuse the fitting over the damaged area using the Generic Procedure and allow the joint to cool. Wait 30 minutes, turn the water back on.

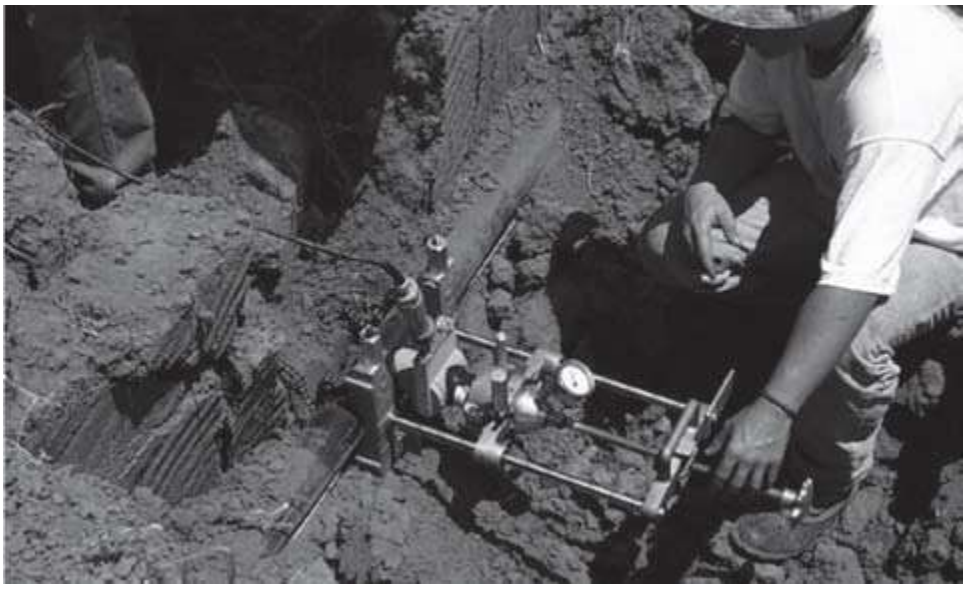


Figure 5.2 Saddle Fusion Repair

4.4Electro fusion Patch Repair

An electrofusion patch can also be used to repair small puncture damage in the pipe (3 inches or smaller puncture in one wall of the pipe) as long as the water flow can be stopped and the

repair area kept dry during the repair process. Use the manufacturer's recommended electrofusion procedure and equipment for saddle fusion.

Figure5.3 Electrofusion Patch Repair

4.5Mechanical Fitting Repair

In some cases where the damage is slight but has severed the pipe, the line can be shut off and a small section of the pipe cut out to install a mechanical coupling in the damaged area (see Figures 5.3a, 5.3b, & 5.3c). Contact the coupling manufacturer for the size of damage that can be repaired. A certain amount of the piping system will need to be exposed to allow the pipe to be bent for the installation of the coupling.

Some couplings are self-restrained and others are not. Some require a stainless steel stiffener inside the PE pipe and some do not.

For damage to small diameter water service lines (2 inches and smaller), mechanical compression fittings appropriate for PE pipe or tubing are commonly used for the repair. Water flow is stopped, generally using a pinch off tool, and the damaged area evaluated. If it is a small cut or hole, the pipe can be cut in the damaged area and a compression fitting installed between the pipe ends. As required for larger pipe sizes, this method may require a certain amount of the piping system be exposed to allow the pipe to be bent for the installation of the coupling. If the damage is more extensive, a section of pipe is cut out and replaced with a replacement piece of pipe and two compression fittings. It is recommended that all couplings used with PE should have a stiffener installed to increase the sealing capability of

the coupling by minimizing the effects of creep and dimensional changes due to temperature variations.

Figure 5.3a Mechanical Couplings

Figure 5.3b Mechanical Couplings

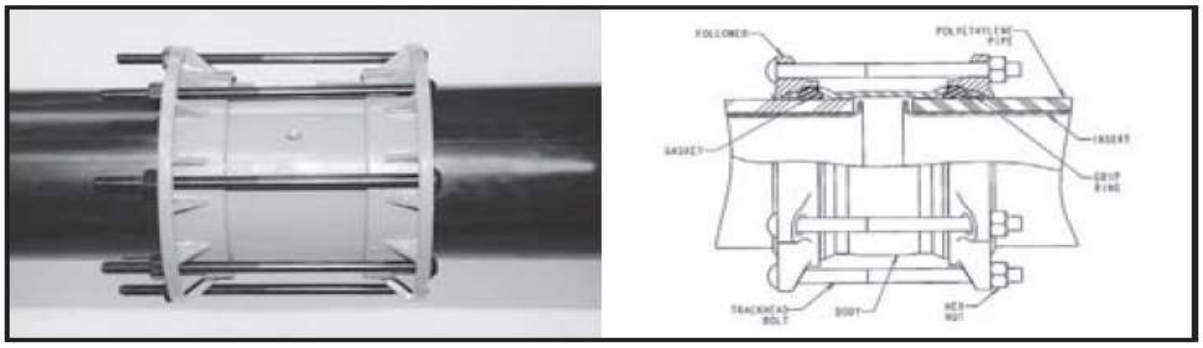


Figure 5.3c Mechanical Couplings

4.6 Large Field Repairs

Mechanical Fitting Repair

If the damage to the pipeline cannot be repaired with a single mechanical coupling as described above, two mechanical fittings can be used by cutting out the damaged pipe (Figure 5.4a & 5.4b) and making up an assembly with two mechanical fittings and a properly sized and length of polyethylene pipe in the middle. Again, install per the fitting manufacturer's instructions. (Figure5.4c) a repair to larger pipes requires joining devices for the size of pipe being repaired. However, the various types of joining devices discussed in this section may not be available for all pipe sizes. Contact the joining device manufacturer or supplier for availability and applicability with polyethylene pipe.

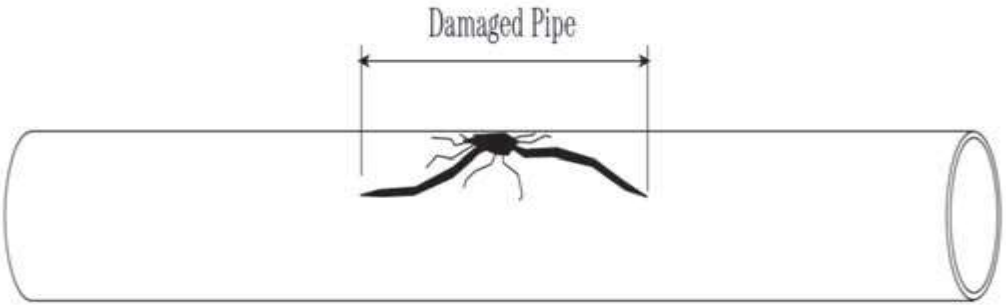


Figure 5.4a Damaged Pipe

Figure5.4b Cut out Damaged Section of Pipe

A saw is needed to cut out the damaged pipe and to cut the replacement section between the cut ends. A wrench is also needed to tighten the bolts. After the damaged section is examined, it can be removed. Damaged PE pipe is usually cut using a dry chain saw. Measure the distance between the cut pipe ends and cut and PE replacement section approximately ½-inch shorter than that length. Install the insert stiffeners in both ends of the existing PE pipes and in both ends of the replacement section.

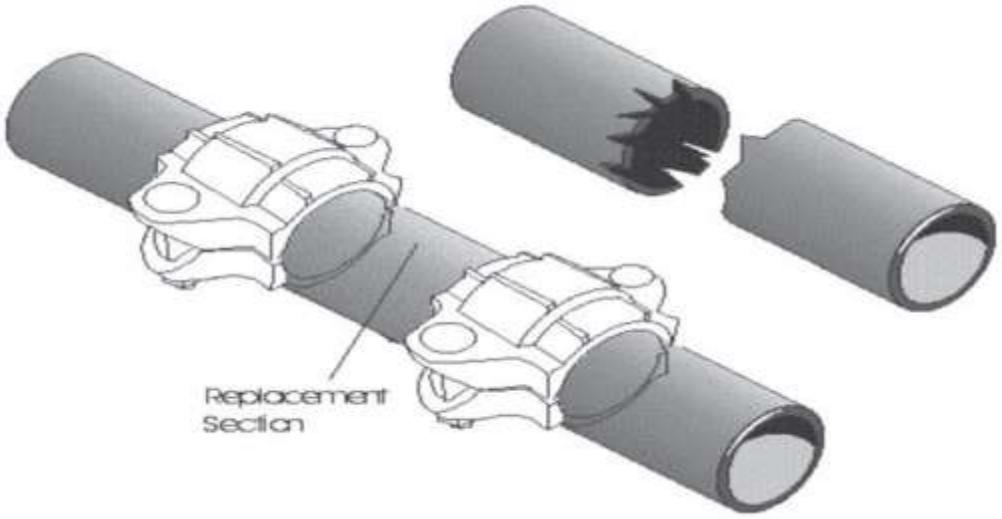


Figure 5.4c Mechanical Coupling Repair Assembly

Self-Check -4	Written Test

Direction I: write the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two points.

Write T for true or F for false

1. Full Circle Band Clamps are recommended for repairs structural integrity ofpipe
2. Damaged PE pipe is usually cut using a dry chain saw
3. For small diameter of pipe damage mechanical compression fittings appropriate for repair

Note: **Satisfactory rating – 3 points and above** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers

Answer Sheet-4

Name: _____ Date: _____

True or false question

1._____
2. _____
3. _____

Information Sheet-5	Performing repair installation

5.1 Introduction to installation

The method of repairing damaged PE pipe depends upon the degree of damage sustained. Localized damage may be repaired by use of an electro fusion saddle or clamp fixed around the damaged area. Such a repair may not be suitable where gas or other flammable fluid is present in the pipe, due to the heat generated in the fusion process. PE encapsulation techniques have recently been developed and may be suitable for localized repairs. Information on these techniques can be obtained from the pipe manufacturers.

More extensive damage will require the section of pipe to be cut out and replaced. This is a relatively simple process, firstly isolating the damaged section by the use of squeeze-off tools, cutting out the section and replacing with new pipe using electro fusion couplers to tie-in the sections. It is important that the replacement section is of suitable diameter and pressure rating to maintain the integrity of the pipeline.

Polyethylene pipe comes in very long rolls and is used in many areas for the water main between the meter and the house. Just like any other type of pipe poly pipe does not last forever and can develop leaks with time and with the help of tree roots. As roots grow they push against the pipe and eventually break it.

Repairs in this type of pipe can be difficult if it is installed deep in the ground and the hole is not big enough to allow for plenty of pipe movement. Locating the source of the leak can also be difficult. Sometimes you will be able to locate the problem by digging up the wet area in your yard. You may not always get so lucky and the wet spot will be a long way from the actual leak if the water follows a gopher hole or something. Either way, a bit of digging will be involved.

To fix a leaking black polyethylene pipe:

Shut the water off - You don't want to be bailing water while you are trying to dig. You can always turn the water on if you think you are getting close to the leak. Or turn the water on once the pipe is exposed to see exactly where the leak is at.

Dig carefully - Unless you know about how deep the pipe is located you need to dig carefully so that you don't end up hitting the pipe. If you know about how deep it is then you can dig the first bit quickly until you get closer. Otherwise, dig slowly. As you get close to the right depth switch to a smaller trenching style shovel if you have one to have more control while digging

in the hole. Make sure to expose all the way around and under the pipe to make it easy for you to work. Cut back any roots that may impose on the water line later since you are down there already.

Plan the cut - First double check the location of the leak. It's important to pinpoint where the leak actually is so that you can decide what fittings you'll use for the repair (Polyethylene pipe repair fittings). If the leak is at a tee you may be able to loosen the clamps and remove the barbed tee from the pipe so that only one pipe has to be cut. Since you will have only a little room to work with you want to avoid shortening the pipe on more than one side of a fitting if possible. So, decide how best to cut the pipe to make the repair based on where it is located. Then use a pipe cutter to cut the pipe.

Install fittings - Put the clamps onto the pipe before inserting the barbed fittings into the pipe. Insert one end of the fitting into the pipe pushing it in as far as it will go. Use WD-40 or a little liquid soap to lubricate the barbs if you have trouble pushing the fitting in. Then lift both ends of the pipe, line up the other end of the fitting to the opposite pipe and push the fitting into the pipe as you push the pipe down.Tip: It's a good idea to use two clamps on each side of a fitting for the extra hold. Stagger the clamps so that they pull in different directions.

Tighten the clamps - Slide the hose clamps up so they are positioned over the barbs. Tighten each of the hose clamps with a screwdriver. Make sure the clamps are secure and don't move around.

Check for leaks - Turn the water on to check for leaks before any backfilling. Sometimes the clamps will need a little extra tightening, so give them plenty of time to be sure they aren't going to leak before you cover them up. Once you are certain nothing is leaking backfill the dirt being careful to pack the dirt down around the pipe as you go to prevent disturbing the fittings.

5.2 General Guidelines for Repairing Buried PE Potable Water Pressure Pipes

Traditional piping systems have gasket-sealed bell and spigot joints every 20 feet, which can be a potential maintenance and repair point at each connection. Metallic pipes are subject to corrosion which can require constant maintenance over the life of the pipes. A heat fused high density polyethylene (PE) pipeline is not only corrosion and chemical resistant but the leak free joints at 40 to 50 foot intervals are as strong as the pipe itself which provides a maintenance free system except for infrequent unforeseen third party damage. IfPE is damaged by a third party, repair methods may be requiredto bring the piping system back into service as soon as possible. This document will provide general guidelines for **repairing PE.** They should be useful in establishing procedures and/or specifications for various repair methods to PE piping systems.

For above ground repairs, when the pipe can be moved, the damage can be cut out and replacement pipe can be butt fused or electro- fused into the system.

Restraint Methods

Mechanical Repair Fitting Restraint

The most common method of restraining a mechanical repair fitting is to add a back- up flange to each pipe and electro-fuse the appropriate number of Flex Restraints to each end of the mechanical fitting. The number of Flex Restraints fused to each end depends on the pipe diameter (contact the fitting manufacturer for proper assembly instructions). Once the Flex Restraints have been cooled properly, the mechanical components such as the sleeve, glands, gaskets and bolts can be installed per the manufacturer's procedures to complete the restraining process.

Self-Check -5	Written Test

Direction I:choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two points.

1. One of the following activity done during fixing a leaking black PE pipe
   A. Shut the water off
   B. Tighten the clamps
   C. Install fittings
   D. All

Note: **Satisfactory rating – 1 points Unsatisfactory - below 1points**

You can ask you teacher for the copy of the correct answers

Answer Sheet-5

Name: _____ Date: _____

Choose question item

1._____

Operation Sheet -1	Technique of PE pipe connection

OPERATIONTITLE: Connect PE pipe

PURPOSE: To connect PE pipe

EQUIPMENT TOOLS AND MATERIALS: - PPE, pipe cutter, wrench, pipe, fitting, marker,

Step to connect PE pipe

Step1: Cut Pipe Square

Clean the pipe end and ensure it is free from burrs.

Chamfering or lubrication of pipe is not required.

Step2: pre-assemble fitting and ready to use

Step3: Witness marks the section of pipe that is alongside the nut opening.

Step4: Insert the pipe up to the witness mark, or if not using a witness mark until the first point of resistance is felt

Step 5: tighten the nut by hand and then firmlywith a wrench. Tighten the nut all the way to the flange on the body of the fitting.

Step6: check fully installation of pipe

Operation Sheet -2	Technique of repairing buried PE potable water pressure pipes

Operation title: Repair buried PE potable water pressure pipes

Purpose: To repair buried PE potable water pressure pipes

Equipment tools and materials: - PPE, pipe cutter, wrench, pipe, fitting, marker,

Step to connect repairburied PE pipe

Step1: prepare tools and equipment

Step2: wear appropriate PPE

Step3: Identify damage pipe

Step4: cut out damage pipe section

Step5: install restrain coupling, stiffener & gasket to both cut end of the remaining good pipe

Step6: install new section of HDPE pipe and two solid sleeves in place of the cut out damage pipe

Step7: restore worksite

LAP Test 1	Practical Demonstration

Name: _____ **Date:** _____

Time started: _____ **Time finished:** _____

Instructions: Given necessary reagents, tools and materials you are required to perform the following tasks within 1hour.

Task1.Perform service connection

Task2: Repair buried damage pipe

Instruction Sheet	Learning Guide 34:Perform electro fusion welding to required standard

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Preparing pipe and fittings
- Performing heating, welding and cooling phases
- Monitoring and recording electro fusion parameters
- Cleaning up Equipments and worksite

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Prepare pipe and fitting as per specification.
- Perform heating, welding and cooling phases using selected electro fusion welding parameters.
- Monitor and record achieved electro fusion weld parameters for each joint as per enterprise procedures.
- Clean up equipment when completed as per enterprise procedures.
- Cleanup work site, dispose of scrap materials as per operational procedures

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 4”. On page 102,105,111 & 114.Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks 1, 2, 3, & 4” in each information sheets on pages 104, 110, 113 and 116.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1, 2, 3 and 4 on pages 117,118,120& 121 and do the LAP Test on page 122”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After you accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Preparing pipe and fittings

1.1 Introduction to Pipe Preparation

Pipe preparation is perhaps the most important and least understood aspect of making a sound electro fusion joint. Improper pipe preparation is the leading cause of unsuccessful electro fusion joint attempts because there is to remove a thin layer of the outer pipe surface to expose clean virgin material beneath. Improper pipe preparation is the leading cause of unsuccessful electro fusion joint attempts

Cleaning

During the initial pipe inspection and prior to scraping, the pipe can be cleaned of mud and debris with clean water. Use no detergents as wetting agents and other substances contained in detergents can be difficult to remove from the pipe and will interfere with the fusion process later. If oils are suspected to be on the pipe surface at this point, additional cleaning with 90% or greater isopropyl alcohol may be necessary.

Marking

A permanent visible marker, Markers should be visible on the pipe color being used. For black pipe, a silver colored Sharpie, or equivalent, permanent marker works well. The marker dries fast and contains no 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. Markers that are slow-drying or contain oils that could be spread onto fusion surfaces should not be used.

Scraping

Pipe surfaces exhibit surface oxidation from the extrusion process, transportation, and outdoor exposure. Surface oxidation is a normal chemical reaction that results in a physical change to the molecular structure of the polymer chains on the pipe surface. Oxidation acts as a physical barrier and therefore those surfaces cannot be heat fused. Simply roughing the pipe surface is not sufficient. In order to achieve fusion, this layer must be removed. Even new pipe must be properly scraped before a fusion will be successful.

The outer oxidation layer on a pipe surface is very thin. It does not increase in depth of more than a few thousandths of an inch even over long periods of exposure, so regardless of the amount of time the pipe has been stored before scraping; the scraping depth requirement is the same. An adequate minimum amount of material that must be removed is just seven one-

thousandths of an inch (.007”). That thickness is approximately the same as two sheets of ordinary paper.

It is strongly recommended that, no matter what type of tool is used, witness marks should be made on the pipe surface with a permanent marker prior to scraping so that any marking that remains after scraping is evidence that areas were missed or that more scraping is required.

Electro-fusion Fittings

Electro-fusion fittings consist of straight coupler, reducing coupler, elbow/bend, transition adaptor, saddle and etc. Figure 1.2 below shows the varioustypes of electro-fusion fittings that available for electro-fusion jointing method

Figure1.2: electro-fusion fittting

Self-Check -1	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two points.

1. One of the following is a pre-requirement for electro fusion welding
   E. Scrapping tools
   F. Power source
   G. Cleaning agent
   H. All
2. One of the following cleaning agent is not used for pipe cleaning
   A. Any Water
   B. 96% Isopropyl alcohol
   C. Dry cloth
   D. Pre-impregnated wipes

Note: **Satisfactory rating – 2 points and above** **Unsatisfactory - below 2points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet -1

Name: _____ Date: _____

Multiple choice items

1_____

2_____

Information Sheet-2	Performing heating, welding and cooling phases using selected electro fusion welding parameters

2.1 Introductions to Fusion Parameters

Fusion parameters such as fusion time, voltage, and cooling time, can be entered into the control box by various means.

Barcode

All electro fusion fittings have a barcode attached that contains all of the information needed by the control box to perform the fusion process. Barcodes contain additional information about the fitting manufacturer, fitting size, fitting resistance, and temperature correction values if required by the fitting manufacturer.

- Codes are displayed on the fitting label in an interleaved barcode format that can be read by a barcode wand or hand-held scanner. Bar code scanners should be kept clean to insure proper working order.
- The 24-digit numerical value is also printed on the label, either directly above or below the barcode that can be entered into the control box in the event that the code cannot be scanned.

Barcode Scanning:

Barcodes should be kept clean and as flat as possible.

- ✓ Barcode Wands – These devices are handheld “pens” with a light source at the tip. The wand/pen should be held at a 10° to 30° angle against the barcode. Place the wand/pen against the barcode starting in the white area on one side and scan across the barcode in a fluid motion ending in the white area on the opposite side. The control box will beep when the barcode has been accepted.
- ✓ Barcode Scanners – These devices are handheld imagers with a trigger. When ready to scan a code, squeeze the trigger. The scanner will emit a circular red light onto the barcode to aid in aiming. Once the barcode is accepted, the light will turn green and the control box will beep.

Figure 2.1 Barcode Wandfigure 2.2 Barcode Scanner

Identification Resistors

Identification resistors are supplied in some fitting designs that can be read by a compatible control box to automatically set the fusion time, voltage, and cooling time. The resistor pin is usually identified by a colored insert in the center of the pin that can be matched to a colored end of the control box cable.

Figure 2.1resistore

Manual Entry

Manual entry of fusion time and voltage entry may be possible if printed on the fitting label. The fusion time is typically preceded by the word “WELD” or “FUSE” and displayed in seconds. The voltage is displayed and followed by “V”. It is always preferable to use the bar code method. All PE EF fittings are manufactured using PE 4710/PE100 and must be fusible to the piping system.

2.1 Performing heating, welding and cooling phases

Heating phase

Check the heater temperature. Periodically verify the proper surface temperature using a pyrometer or other surface temperature measuring device. If temperature indicating markers are used, do not use them on a surface that will come in contact with the pipe or fitting. Bring the hot clean tool faces into contact with the outside surface of the end of the pipe and with the inside surface of the socket fitting, in accordance with pipe and fitting manufacturers’ instructions.

When making electro fusion joints, it is important to ensure that the generator (power supply) and the electro fusion control box are compatible with one another and must be capable of delivering the maximum power requirements at the stated voltage to the fitting.

The following table identifies the fittings' maximum power requirements at the stated voltage for the electro fusion process. These must be delivered to the fitting without interruption, for the full duration of the electro fusion heating cycle:

Table 2.1 fittings' maximum power requirement

Fitting type	Terminal pin diameter	Fitting's maximum power requirement	Fitting voltage supply
Saddle fittings	4.0 mm	2.5 kW at 40 V rms	39 to 40 V rms
Socket fittings up to 280 mm	4.0 mm	2.5 kW at 40 V rms	39 to 40 V rms
Socket fittings 315 to 400 mm	4.0 mm	4.0 kW at 40 V rms	39 to 40 V rms
Socket fittings 315 to 400 mm	5.7 mm	4.0 kW at 80 V rms	78 to 80 V rms
Socket fittings above 400 mm	5.7 mm	4.8 kW at 80 V rms	78 to 80 V rms

Welding

The area where the welding takes place must be protected from adverse climatic conditions, such as humidity, temperatures below -10°C, temperatures above +40°C, strong winds and direct sunshine.

The pipes/fittings/couplers to be welded must be made of the same material, or at least compatible materials; proof of compatibility must be given by the coupler manufacturer.

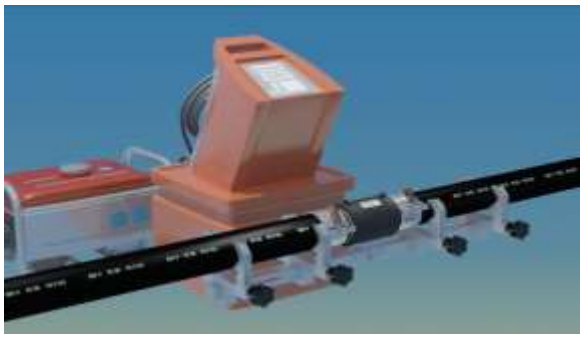


Figure 2.1 Full assemblies ready for welding

Cooling phase

One of the most misunderstood and often ignored components of the entire electro fusionprocess is the cooling phase. It is often assumed that if the fitting is cool enough to touch it must be cool enough to remove the restraint device or even pressure tests the connections. The cooling phase is critical to the success of the electro fusion process and careful attention should be given to insure that the stated cooling times are properly adhered to.

The importance of the cooling phase can be illustrated in the actions of the melt pool. The cooling time varies according to the diameter of the coupler and the ambient temperature. The cooling time suggested by the coupler manufacturer must be respected. To avoid mechanical strain (e.g., flexion, traction, torsion) on the newly made joint, disconnect the lead ends from the coupler with caution. Remove the clamps only after the cooling phase is completed.Proper observation of cooling time is important. During the heating phase of the fusion process the PE material of the pipe and fitting is heated to melting in order to allow co-mingling of the molecular structures. As the materials cool and co-crystallize into a solid state again the structures cannot be disturbed. PE is a thermoplastic that softens when heated and does not regain its full strength until cooled.

Cooling time is typically expressed by three different terms in the following tables for fusion and cooling times:

- Clamped cooling time: The minimum time the fitting must remain clamped after the fusion cycle is complete. This is the time displayed by the control box.
- Time before pressure test & tapping: The minimum time before the joint can be pressurized to 150% of MOAP and the main can be tapped.
- Time before rough handling:The minimum time before the joint can be subjected to forces such as pulling, lifting, or back filling.

Using the following Figure we will look closer at the melt pool stages created during the electrofusion process.

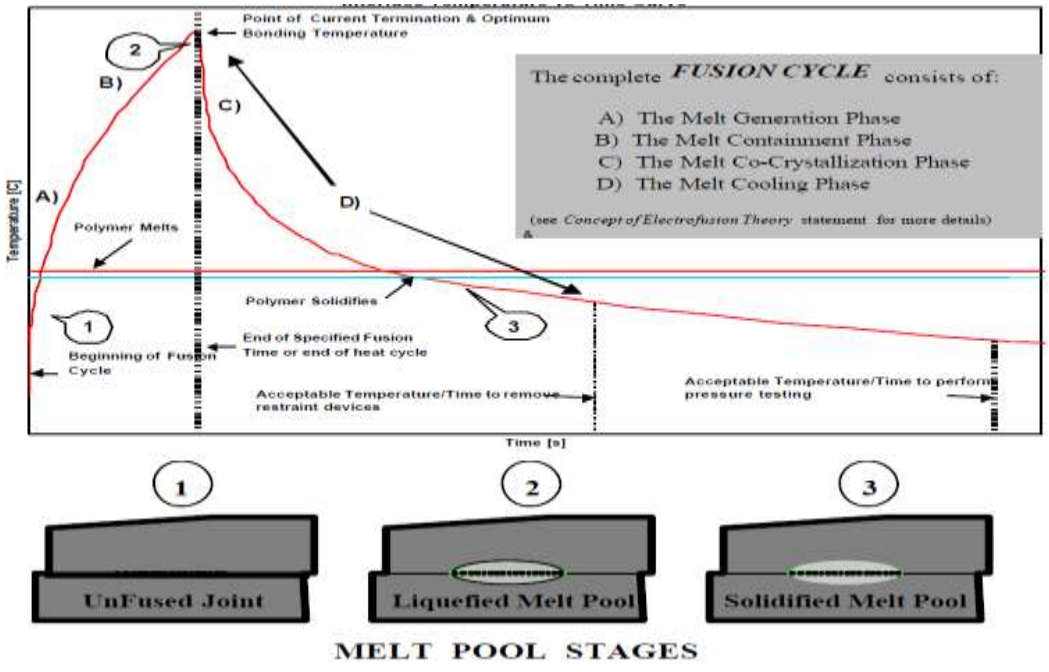


Figure 3.1 Electro fusions Fitting Fusion Cycle

Interface Temperature vs Time Curve

When current is applied to the fitting, the plastic in the fitting and on the pipe surfacebegins to melt and form a melt pool (A & B). With continued application of current, the melt pool deepens at the pipe and fitting interface which in turn forces internal pressures to build up. This process is known as co-crystallization between the melted pipe and fitting material (C). The cooling phase (D) (combined with the design of the fitting) provides a controlled environment between the pipe and the fitting where re-solidification can effectively take place. This cooling phase begins immediately following the termination of current being supplied to the fitting and continues for a period of time beyond the point where the PE polymer re-solidifies (also known as clamping time). This allows ample time for the fusion area to regain the strength and flexibility it exhibited prior to fusion. Any movement or external stresses (binding, pulling, etc.) applied to the fused area during this cooling phase may result in a compromised fusion joint**.**

Self-Check -2	Written Test

Direction I: Choose the best answer for the following questions. Use the answer sheet provided in the next page: Each question worth one point

1. One of the following is a fusion parameter
   A. fusion time
   B. voltage
   C. cooling time
   D. all
2. the complete fusion cycle consists one of the following
   A. the melt generation phase
   B. the melt cooling phase
   C. the melt containment phase
   D. all

Note: **Satisfactory rating – 2 points and above** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet -2

Name: _____ Date: _____

Multiple choice items

1_____

2_____

Information Sheet-3	Monitoring and recording achieved electro fusion weld parameters for each joint

3.1 Joint information and record keeping

A critical part of successful electro fusion jointing is ensuring that the joint has been prepared correctly. The constructor should be able to provide documentation linkedto each weld to demonstrate that the joint was prepared by suitably qualified welders using the correct installation equipment, joint geometry and environmental controls to ensure the weld was constructed according to as per enterprise procedures. It is suggested that a system is used to link each weld with the record keeping data such as a joint identification code stamped on the fitting or as part of the geographic information system for the project. The records should document:

- The identity of the welder(s) and accreditation information
- Identify the fitting manufacturer, type and identification code
- Data to show prepared pipe ends (or pipe surface for saddles) are within the dimensional range specified in enterprise procedures.
- The operator has correctly removed the required depth of oxidised material from the surface of the pipes
- The type of manufacturer approved welding wipe used
- The joint has been assembled correctly including correct insertion depth, pipe rounding (if necessary), pipe alignment and clamping to prevent movement during the welding process
- Suitable environmental controls have been used to prevent damage to the joint from factors such as dust, water and excessive heat or cold from environmental factors
- The type of rounding and alignment clamps used
- That the control box used was correctly calibrated and compliant to ISO 12176-2
- That the weld was allowed to cool for the correct amount of time in the alignment clamps prior to removal of the clamps and that the fitting was not pressure tested before the end of the second cooling period.

3.2 Fusion Data Recording:

- For 6" and larger pipe sizes, equivalent fusion data recorder shall be used to record all fusion welds on hydraulically operated fusion machines. The device shall be capable of meeting the requirements of ASTM F 3124, "Standard Practice for Data Recording the Procedure used to Produce Heat Butt Fusion Joints in Plastic Piping Systems or Fittings". The device, or combination of devices, shall record the following variables of each fused joint:
  - ✓ Heater surface temperature- immediately before inserting the heater plate, measure with a pyrometer and manually enter into the weld record.
  - ✓ Gauge pressure during the initial heat cycle
  - ✓ Gauge pressure and elapsed time during the heat-soak cycle
  - ✓ Heater removal (dwell) time
  - ✓ Gauge pressure and elapsed time during the fusing/cool cycle
  - ✓ Drag pressure
  - ✓ Pipe diameter and wall thickness
  - ✓ Type of HDPE material(Specification and Classification) and manufacturer
  - ✓ Fusion Machine Identification
- The device shall record the operator name and a unique operator ID number, along with the date and time of each weld.
- Records showing the device is up to date on all required calibration should be available for presentation when requested.
- All fusion welds should be traceable to the report (via operator and weld ID) with an indentation weld stamp or by permanent paint marker/pen next to fusion weld.
- A weld location map may be requested, prior to commencement of work, by the owner or owner's representative.

3.3 Quality control and assurance

It is recommended that the constructor and asset owner utilize a system for monitoring and checking installation quality. The system should include:

- System of traceability to enable information on each weld is linked to the installer and the weld information record for that weld e.g. weld identification code and welder ID stamped or marked permanently on each fitting
- Audit to ensure the installer is following enterprise procedures and is complying with the requirements of the electro fusion weld specifications as suggested in this document . System to record and store weld information linked to the weld identification system to enable retrieval of the weld data

Self-Check -3	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth one point

1. one of the following is recorded by fusion device
   A. heater surface temperature
   B. gauge pressure
   C. heater removal time
   D. all
2. A critical part of successful electro fusion jointing is ensuring that the joint has been prepared correctly
   A. True B. false

Note: **Satisfactory rating – 2 points and above** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-3

Name: _____ Date: _____

Multiple choice items

1._____
2. _____

Information Sheet-4	Cleaning up Equipments and worksite

4.1 introduction to cleaning up equipment

Cleaning is important for infection control – particularly in work areas – because deposits of dust, soil and microbes on surfaces can transmit infection. Contaminated areas such as operating rooms or isolation rooms must be cleaned after each session, and spot cleaned after each case or thoroughly cleaned as necessary.

The importance of a clean work place

- Maintaining a clean workplace is vital for employers to reduce their workers compensation claims and keep efficiency high. Essential to safety.
- When employees work in a messy environment, they may not notice all hazards, which increases the risk of an accident.
- Employees are greatly influenced by their workplace environment.
- Attempting workplace creates a good level of comfort in the employees. Keeping a workplaceclean helps in creating a good environment. There are several essential measures that can help maintain the hygiene of the workplace

4.2 Safe Procedures for equipment

- Never use any machine you have not been trained to use.
- Pull plug or throw switch to off position before cleaning or adjusting any machine. Keep fingers, hands, spoons, etc., away from moving parts. Wait until machine stops before moving food.
- Check all switches to see that they are off before plugging into the outlet.
- Particular care must be taken when cleaning the slicing machine.
  - ✓ First pull the plug.
  - ✓ Turn the gauge to zero in order to cover the edge of the blade
  - ✓ Do not touch the edge of the blade
  - ✓ Clean the blade from the center out.
  - ✓ Clean the inside edge of the blade with a stick that has a cloth wrapped around one end.
- Do not start a mixer until the bowl is locked in place and the attachments are securely fastened.
- When using a mixer, turn off motor before you scrape down the sides of the bowl.
- Use a wooden or plastic plunger rather than your hands or spoons to push meat down into a meat grinder.

- Never start a machine until you are sure all parts are in their proper places. If it is a machine that operates with gears, check the gear position.
- You must be aware of the lock-out procedures that are to be followed before repairing or cleaning any machine. Lock-out procedures must be clearly posted by management near each machine.
- When using electrical power equipment, always follow the manufacturer's instructions and recommendations. Do not wear rings, a wristwatch, or a tie when operating electrical power equipment.

4.3 Dispose of scrape material properly

- Place pipe scraps in proper containers.
- Do not allow containers to overflow. Empty them before they are completely full.
- Do not stack full refuse containers.
- Report broken or defective containers.
- If wearing gloves while disposing of refuse, you should remove the soiled gloves once the job is done and, when returning to work, wash and sanitize hands properly
- Push garbage down using a tamper or other tool. Do not push it down with your hand or foot!
- Handle different types of waste
- Know correct disposal procedures
- Understand mechanical disposal machines
- Take precautions when handling waste

Self-Check -4	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth one point

1. One of the following is a safety while disposing scraping /refuse pipe
   A. allow a container to overflow
   B. Do not stack full refuse containers
   C. Push garbage down using hand
   D. stack full refuse containers

Note: **Satisfactory rating – 1 points and above** **Unsatisfactory - below 1points**

You can ask you teacher for the copy of the

Answer Sheet-4

Name: _____ Date: _____

Multiple choice items

1._____

Operation Sheet -1	Techniques of PE pipe preparation for EF

OPERATION TITLE: PE pipe preparation for EF

PURPOSE: to prepare PE pipe for EF

EQUIPMENT TOOLS AND MATERIALS: - Pickaxe and shovel, Piece of pipe, a wide mouthed container of known capacity (volume), Stop watch (having a second counter)

Steps toprepare PE pipe for EF

Step 1: Cut the pipe at right angles with a pipe cutter

Step2: Scrape the pipe or spigot surface up to 0.4" (1 cm) beyond the insertion length of the fitting, to remove the oxidized PE layer. Mechanical scrapers are recommended. Hand scrapers can be used.

Step 3: Remove any mud, dust, grease or other traces of dirt from the pipe or spigot ends and the welding area of the fitting. Use only isopropanol and a soft wiping cotton cloth without any printing

Step 4:Wait until the cleaned parts are completely dry, and then mark the welding length on the pipes or spigot ends with a marker pen.

Step 5: Insert the pipe or spigot ends straight into the fitting up to the marked insertion length.

Step 6: Install the aligners in order to keep straight position and avoid stresses during the welding.

Operation Sheet -2	techniques of electro fusion coupling installation

Operation title: electro fusion coupling installation

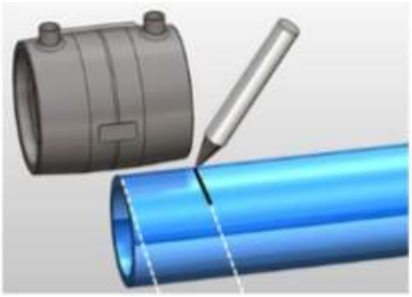
Purpose: to electro fusion coupling installation

Equipment tools and materials: - Pipe cutter, pen, scraper, isopropyl alcohol, control box, PE pipe, fitting

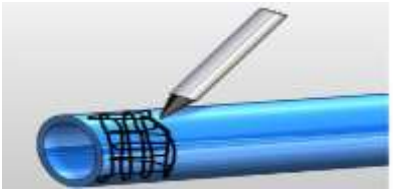
Steps toinstall electro fusion coupling

Step 1: clean pipe ends with clean water and cut squarely (+_ 3degree) as possible

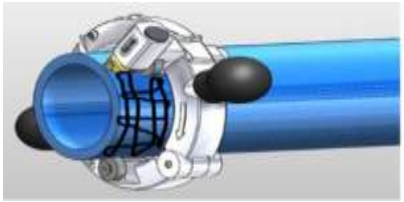
Step 2: measure and mark the stab depth on both pipe ends



Step3: mark the pipe surface to be scraped in a criss-cross pattern



Step 4: mount the scraper over the area to be scraped



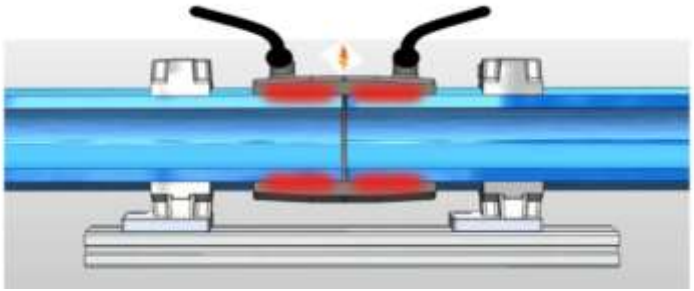
Step 5: scrape or peel the pipe to remove the surface layer and expose clean vergin pipe beneath

Step 6: inspect the scraped pipe surface thoroughly to ensure that all marks are removed and that only virgin pipe surface is exposed

Step7: clean surface with isopropyl alcohol if necessary, avoid touching cleaned surfaces

Step8: insert the pipe ends to the stab depth marks made in step one. Secure in alignment clamp with coupling centered between stab depth marks.

Step 9: connect the control box leads to the fitting and fuse the joint, do not move or disturb joint for recommended cooling time. Mark time of day on fitting when fusion cycle ends.



Operation Sheet -3	techniques of fittings Assembly

Operation title: fitting assembly by EF method

Purpose: to electro fusion coupling installation

Equipment tools and materials: - Pipe cutter, pen, scraper, isopropyl alcohol, control box, PE pipe, fitting

Steps toassemble fitting

Step1: Clean pipe of rough contaminations

Step2: Mark the insertion depth

Step3: Remove the oxide layer of the pipe using a scraper tool

Step4: Chamfer the raw edges on the outside and inside. Remove any chips from thepipe interior

Step5: If required, restore the roundness of irregular/oval pipes using rounding clamps

Step6: Clean the pipe surface and the fitting interior with PE cleaner, let evaporate, mark insertion depth again

Step7: Insert the pipe up to the marking, do not jam. Ensure a tension free assembly of the component parts

Step8: Safety fitting with electro fusion unit, read barcode, start fusion

Step9: Document fusion parameters on the pipe. Allow to cool (cooling times!)

Operation Sheet -4	techniques of cleaning work site

Operation title: cleaning work site

Purpose: to clean work site

Equipment tools and materials: - shovel, container/wheelbarrow, broom

Steps to clean worksite

Step 1: Wear PPE

Step 2: Select tools and materials

Step 3: Identify types of waste

Step 4: Sorting waste by their type.

Step 5: Reuse, recycle; dispose by the nature of waste

Step 6: Clean tools and equipment's

LAP Test 1	Practical Demonstration

Name: _____ **Date:** _____

Time started: _____ **Time finished:** _____

Instructions: Given necessary reagents, tools and materials you are required to perform the following tasks within 1hour.

Task1.prepare pipe and fitting for EF

Task2: perform EF coupling installation

Task 3: assembly the fitting by EF method

Task 4: clean work site

Instruction Sheet	**Learning Guide 35: Assess quality of completed installation, electro fusion joints. By determining appropriate testing and commissioning procedures**.

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Determining specific installation test
- Identifying alternative test procedures
- Identifying quality requirements of electro fusion joints
- Assessing joints and reporting
- Identifying and reporting non conformances

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Determine specific installation test requirements.
- Identify alternative test procedures to meet requirements.
- Identify quality requirements for electro fusion joints as per specifications.
- Assess joints against specification requirements and report results.
- Identify and report non-conformances according to enterprise requirements

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 4”. On page 124,129,132& 134.Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks 1, 2, 3, & 4” in each information sheets on pages 128, 131, 133, and 137.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “the next LG. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After you accomplish Operation sheets and, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Determining specific installation test

1.1. Method of testing for electro fusion fitting qualification

The following test methods are useful as an evaluation of bonding strength and quality between the pipes and fitting. Similar tests can be used as user qualification criteria. As these methods are destructive, they are only useful in determining joint quality of a fusion to verify that proper procedures were followed.

The tests for a coupling (socket) joiner are any one or more of the following:

- Minimum Hydraulic Burst Pressure Test
- Sustained Pressure Test
- Tensile Strength Test
- Joint Integrity Test (Crush test)

The destructive tests to qualify a saddle (sidewall) joiner are any one or more of the following:

- Minimum Hydraulic Burst Pressure Test
- Sustained Pressure Test
- Impact Test
- Joint Integrity Test (Crush test)

Passing results for visual inspection and any one of the above tests on specimen joints for couplings and saddles qualifies the installer to the requirements.

- **COUPLINGS**

The pipe and fitting specimen should be cut and subjected to joint evaluation tests. Bend tests, peel tests, and crush tests are helpful in locating fusion weaknesses.

To prepare a specimen for crush testing, it is necessary to cut the pipe and coupling longitudinally in half as near to the centerline of the pipe and coupling as possible as shown in the image to the right. It is desirable to leave at least 3"(75mm) of pipe length for 2 inch and smaller diameter pipes and 8"(125mm) of pipe length for up to 12 inch diameter pipes at each end of the coupler for gripping by the vise/press.

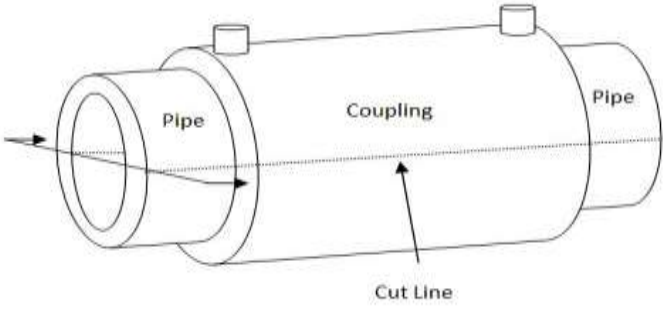
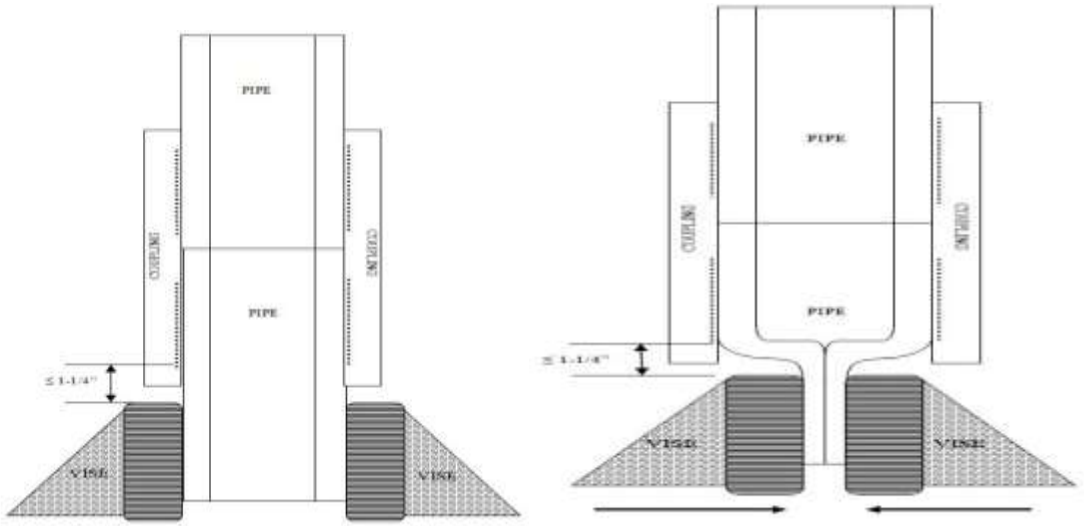


Figure 1.1Crush Test Cut

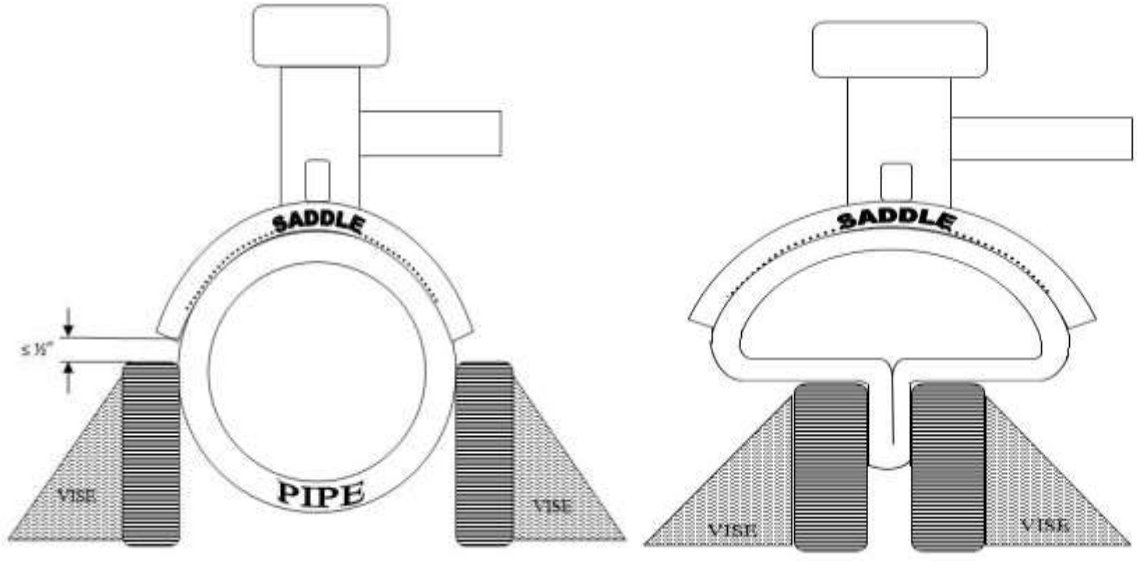
Place a specimen half in a vise or press so that the outermost wire of the fusion zone is approximately 1 1/4" (32mm) from the vise jaws. Close the vise jaws until the pipe walls meet.Repeat this process for each end of both halves of the coupling.



Inspect the crushed specimens for separation of the pipe and fitting in the fusion zone**.** Some minor separation at the fusion interface (up to 15%) may be seen at the outermost region of the fusion zone, this does not constitute failure. Ductile failure of the pipe, fitting, or PE insulation around the wires is acceptable. There should be no separation at the fusion interface of the pipe and fitting beyond the 15% at the outer most edges.Refer to the images in the Destructive Test Results section of this manual for examples of passing and failing results.

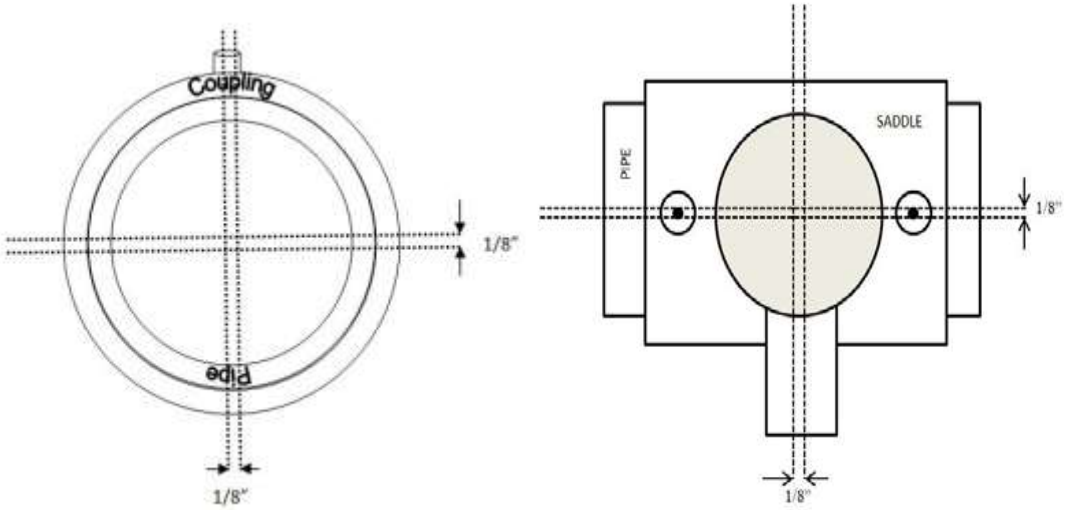
- **Saddles (Sidewall)**

Tapping tees should be left intact for crush testing. Pipe lengths can be cut to the edges of the fitting base. Place the pipe and fitting into a vise so that the jaws are within 1/2" (13mm) of the bottom of the saddle. Close the vise until the inner pipe walls meet.

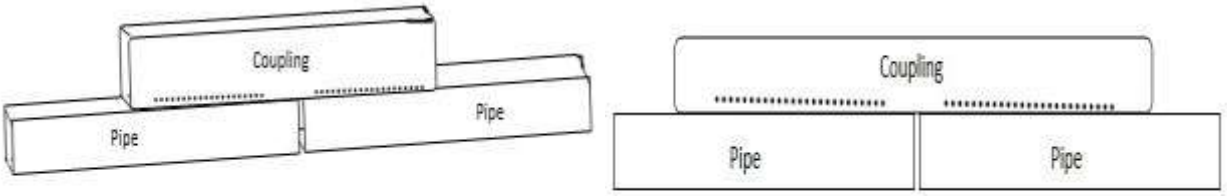


Inspect the crushed specimens for separationof the pipe and fitting in the fusion zone. Some minor separation (up to 15%) may be seen at the outermost region of the fusion zone, this does not constitute failure. Ductile failure of the pipe, fitting, or PE insulation around the wires is acceptable. There should be no separation at the fusion interface of the pipe and fitting beyond the 15% at the outermost edges**.** Refer to the images in the Destructive Test Results section of this manual for examples of passing and failing results.

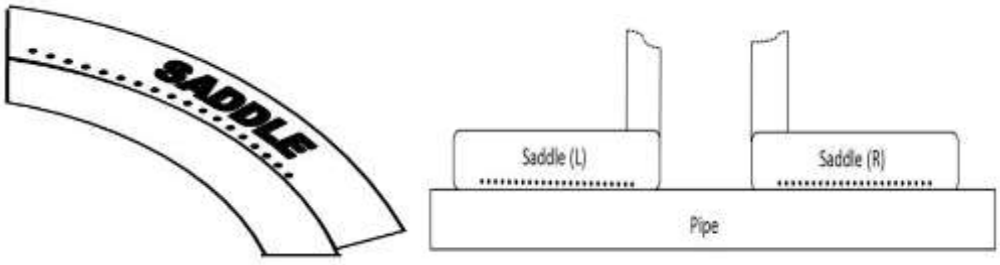
Slit the socket or saddle into four sectionsas illustrated below. If desired, radially cut the socket in half along the centerline of the joint. Pipe extending from fittings may be cut back to about 1 in. from the fitting edges.



Cut FET specimens approximately 1⁄16 to 1/8 inches wide from each fusion or joint half. A minimum of four FET stripsshall be cut from each end of the socket and from the saddle spaced approximately 90° apart:

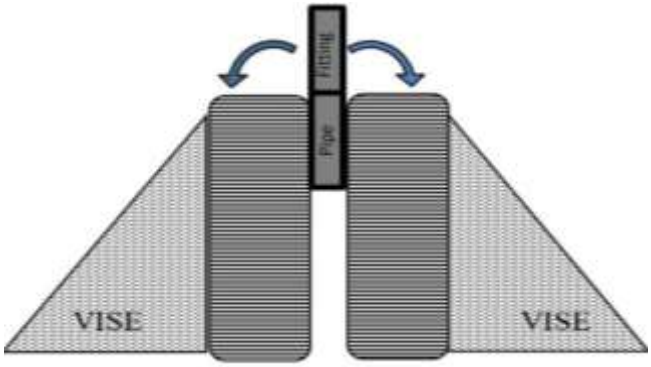


Coupling/Socket specimens- 4 from each socket end at 90 degree intervals x 1/8” wide



Saddle Specimens – 4 total, 2 radial from each side, 2 axial from each side at 90 degree intervals x 1/8” wide.

Grip the FET specimen in a vise or clamping device so that the bond line between the pipe and fitting is at least 1⁄16 in. from the edges of the vise jaws. Flex the specimen four times 90° in both directionsso that the bending moment is applied directly along the length of the fusion interface bond line. For small specimens pliers may be used in lieu of a vise as long as the entire length of the fusion is flexed.



Separation of the specimen along the bond line constitutes failure of the specimen. Some minor separation at the outer limits of the fusion heat source may be seen or there may be voids between wires. This does not constitute failure as long as the void does not exceed 10% of the total fusion length, or in the case of multiple voids, 20% of the total fusion length when combined. Ductile failure in the pipe, fitting, or the wire insulation material is acceptable as long as the bond interface remains intact. Refer to the images in the Destructive Test Results section of this manual for examples of passing and failing results.

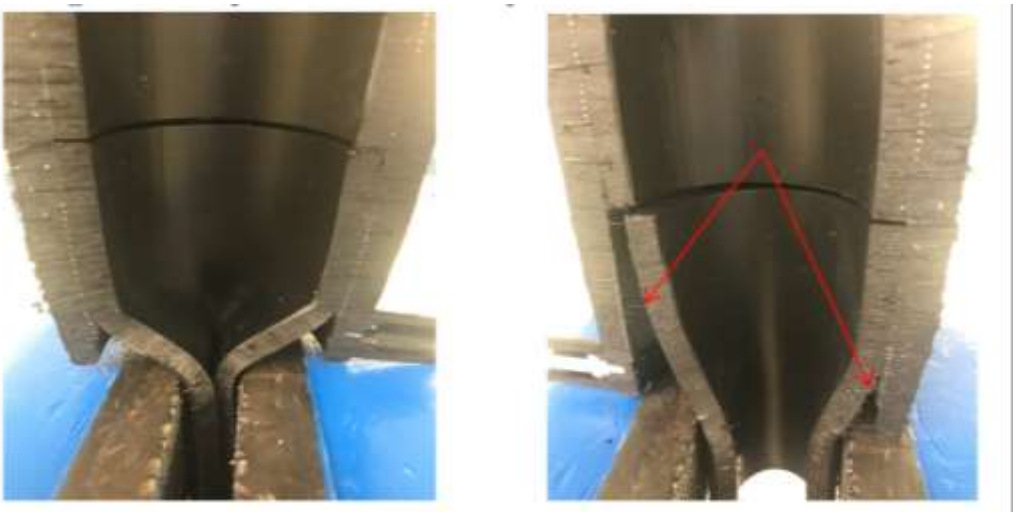


Figure 1.2b Coupling Crush Test - Passing Result

Figure1.2b Coupling Crush Test - Failing Result

Self-Check -1	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth one point

1. One of the following method used to test coupling joint
   A. Sustained Pressure Test
   B. Tensile Strength Test
   C. Joint Integrity Test
   D. All

Note: **Satisfactory rating – 1 points and above** **Unsatisfactory - below 1 point**

You can ask you teacher for the copy of the correct answers.

Answer Sheet -1

Name: _____ Date: _____

Multiple choice items

1_____

Information Sheet-2	Identifying alternative test procedures

2.1 Testing and commissioning

TEST PRESSURE:

PE pipe system should be pressure tested up to maximum of 1.5 times the rated pressure of the pipes. However, for practical purposes it is usual and may only be necessary to pressure test up to 1.5 times the pipeline working pressure.

Test Section Preparation:

- Test in sections of 1000 Mtr. or less
- Pipe work should be back filled, with joints left exposed at the engineer's discretion.
- Pipe work must not be tested at temperatures in excess of30°C.
- Air valve should be placed at all high points in the system.

Type 1 pressure test:

This is a short simple test where by the creep in the PE pipe is sustained by maintaining the test pressure for a period of 30 minutes. By opening the control valve the pressure is then reduced to a nominal amount before reclosing the valve. The subsequent "recovery" of pressure in the pipeline is indicative of a sound pipeline. This simple PASS/FAIL test may be found appropriate for short lengths of small diameter main where there is no residual air in the test section.

The detailed test procedure is as follow:

1. The selected test pressure is applied and this pressure is maintained by additional pumping as required for a period of 30 minutes. During this time an inspection should be carried out to identify any obvious leaks at this pressure within the system under test.

2. The pressure should then be reduced by rapidly bleeding water from the system to a nominal pressure of, say 2 bars at the test gauge. Close the control valve to isolate the installation.

3. Record and plot the pressure gauge readings at the following intervals:

0 - 10 mins @ 2 minute 5 readings

10 - 30 mins @ 5 minute 4 readings

30 - 90 mins @ 10 minute 6 readings

The pressure should be seen to rise due to the visco-elastic response of the pipe material.

4. The resulting graph for a leak-tight system should have a characteristic profile similar to that shown in figure below.

5. The degreetowhichthecreepinthematerialaffectsthepressuregraphandthetimeforresponse to reduced pressure will be influenced by:

- The length of the test section

- The diameter of the pipe
- The pressure of air
- The efficiency of the bedding and compaction

Within about a 90-minute period a good indication will normally be available. If during that period there is a falling away of pressure, this would indicate a leak within the system. It is advisable to check all mechanical fittings before visually inspecting the welded joints. Any defects in the installation revealed by the test should, of course be rectified and the test repeated after the line has been allowed to relax for an appropriate period of time.

Type 2 pressure test:

This is a more sophisticated and comprehensive testthanthetype1 Test and is used for large diameter pipes and long pipeline installations. Full details of the Type 2 Pressure Test are included in the WRc .Manual for Polyethylene Pipe Systems for Water Supply Applications.

Commissioning

Upon the successful completion of a test the remaining pressure in the pipeline should be released slowly.

Following successful pressure testing all new mains, line door refurbished, should be commissioned inthe following manner and in accordance with any local requirements.

- Cleaning and / or swabbing of the main
- Filling and sterilization
- Flushing and / or neutralization
- Refilling the main
- Bacteriological sampling
- Acceptance certification
- Introduction of the main into service

Self-Check -2	Written Test

Direction I: Choose the best answer for the following questions. Use the answer sheet provided in the next page: Each question worth two points

1. One of the following is a commissioning procedure
   A. Cleaning of the main
   B. Filling and sterilization
   C. Refilling the main
   D. All
2. pressuregraphandthetimeforresponse toreduced pressure will be influenced by
   A. The diameter of the pipe
   B. The pressure of air
   C. The length of the test section
   D. all

Note: **Satisfactory rating – 2 points and above** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet -2

Name: _____ Date: _____

Multiple choice items

1_____

2_____

Information Sheet-3	Identifying quality requirements of electro fusion joints

3.1. Introduction to Quality assessment

Following the electrofusion process, the fitting should be inspected to ensure that the fusion indicator raised. The fusion indicator identifies that the electro fusion process has taken place. It is not confirmation of a quality joint.

- For a good quality joint, there should be no visible melted material outside the fitting's fusion zone
- At the end of the electro fusion cycle, the control box should be checked to confirm that the cycle has completed without error
- Each joint should be marked with the joint reference details
- Follow industry approved pressure test procedures before commissioning the joint

Requirements to achieve a successful electro fusion join

- The electro fusion process must be carried out as one continuous process from pipe surface preparation to fitting cooling
- Electro fusion jointing should be undertaken in a clean, dry and dust free environment. A shelter must be used to protect the surfaces to be joined from environmental contamination
- Where there is evidence of pipe ovality, the pipe must be re-rounded using industry approved equipment. Greater levels of ovality are found in coiled pipes, in pipes with higher SDRs and in diameters above 400mm
- The electro fusion equipment must be compatible, calibrated and capable of providing the correct fusion voltage for the full duration of the electro fusion cycle
- Clamps are used to ensure that there is no movement between the pipe and fitting during the jointing process
- For socket fittings, alignment clamps must be used during the full electro fusion heating and cooling cycles. For large diameter couplers, combined hydraulic re-rounding and alignment clamps must be used.
- For saddle fittings, where a top loading clamp is used, this should be calibrated and capable of applying the correct clamping force.

Self-Check -3	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two points

1. One is Requirements to achieve a successful electro fusion join
   A. EF jointing should be undertaken in a clean environment
   B. EF equipment must be compatible, and calibrated
   C. Pipe ovality must be re-rounded using industry approved equipment.
   D. All
2. For a good quality joint, there should be no visible melted material outside the fitting's fusion zone
   A. True
   B. false

Note: **Satisfactory rating – 2 points and above** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-3

Name: _____ Date: _____

Choice question items

1_____

2_____

Information Sheet-4	Assessing joints against specification requirements and reporting results

4.1 Common electro fusion failures

Electro fusion has proven to be an extremely reliable joining system. The most common reasons for failure account for more than 95% of all fusion failures:

- Contamination----inadequate pipe preparation
  - ✓ Inadequate scraping
  - ✓ Dirt, mud, dust
  - ✓ Grease, oils
  - ✓ Moisture
  - ✓ Hands (body oil, sunscreen, etc.)
  - ✓ Solvents, unsuitable wiping fluids
  - ✓ Unclean or unsuitable wiping rags
- Geometry – pipe out of round or not cut square
  - ✓ Alignment Errors
    - ➢ Pipe Mis-Stab: pipe not cut square and pipe ends not being centered in the fitting.
    - ➢ Short Stab: can result from improper insertion of the pipe or movement during weld due to incorrect restraint
    - ➢ Mis-alignment of pipes and fitting
    - ➢ Flat spots on pipe
    - ➢ Excessive Gap
      - → excessive gap between pipe and fitting due to pipe out of roundness, undersized pipe or over scraping of pipe surface.
      - → Pipe ends not butted together
      - → Pipe ends are not cut square.
    - ➢ Pipe Movement during Fusion Cycle – due to external forces or forces induced by the welding process, when the pipes are not clamped properly.
    - ➢ Movement – pipe not properly restrained during fusion process
    - ➢ Unusual conditions - Contact EF manufacturers if you observe smoke or melt flow outside the fitting.
    - ➢ Over Scraping (never exceed 0.040 inches)
- Removal of clamping equipment before observance of minimum Cooling Time

There are many procedural factors that can affect weld quality. Taking each factor separately, it is possible to describe the potential fault.

- **Fusion Pressure**

Fusion pressure is an important parameter in the butt fusion process since it produces the mixing of molten materials to form the joint. Too high a pressure and all of the molten material will be pushed into the weld bead leaving 'cooler' material at the joint interface at a temperature insufficient to achieve a good fusion joint. Too low a pressure can lead to insufficient mixing of the molten material at the pipe surfaces and the possibility of an incomplete joint with very poor strength

In the early days, fusion pressures were set out in a table attached to each butt fusion machine and it was the responsibility of the operator to adhere to the correct pressure for the material and pipe diameter to be jointed. The pressure was applied using a hand operated hydraulic pump attached via hoses to the chassis of the butt fusion equipment. A pressure gauge within the hydraulic pump was used to observe the applied pressure.

Incorrect application of fusion pressure could be attributed to operator error and would be apparent in oversize or undersize external weld bead widths. Too low a pressure and the beads would be narrow and vice versa at too high a pressure

- **Drag Pressure**

Drag pressure is the pressure required to overcome both the weight of the pipe and the friction within the butt fusion machine. Before a joint is made, the pipes are set up in the machine and moved together using the hydraulic pump. Prior to the introduction of automatic machines, the operator was required to observe the pressure gauge and note the pressure required to move the pipes. This is the drag pressure and must be added to the fusion pressure as was shown on a label on the machine.

The drag pressure differs for each pipe diameter and length of pipe being moved (6m, 12m or more), and it is important to measure this every time a joint is made. In some cases, the drag pressure can be significantly higher than the actual fusion pressure although with careful setting up and the use of pipe rollers, quite long lengths of pipe can be moved with an acceptable drag pressure. Incorrect measurement of drag pressure can only be attributed to operator error and problems present themselves in oversize or undersize weld beads.

- **Melt Temperature**

To achieve a fusion joint in PE, the surfaces to be joined must be above the materials melting point of 140oC. The fusion temperature currently used in butt fusion is 233oC which is sufficient to melt the material but not sufficiently high to cause thermal degradation. Insufficient melt temperature will be result in higher viscosity melt, resistance to melt and molecular mixing and ultimately poor fusion.

- **Pipe Ovality**

The fusion weld a butt fusion joint is restricted to the pipe end area; subsequently it is important that full use is made of the maximum available area. Pipe ovality is inevitable on PE pipe because of the way it is transported and stored. Circularity is important for all joint types and with butt fusion equipment, the pipe clamps used to grip the pipe also act as re-rounding clamps. By adjusting the clamping pressures on each pipe it is possible to minimize any pipe ovality before making a butt fusion joint. Pipe ovality is not generally considered a problem on butt fusion joints and is an unlikely source of premature failure unless the pipes are grossly mismatched.

4.2 Pipe End Preparation (Trimming) and Contamination

If trimming is incomplete, the pipe ends will be uneven, some areas will still be oxidized or contaminated with dirt and dust and when placed in contact with the heater plate, there will be gaps resulting in an uneven heat transfer across the pipeends. It is the responsibility of the operator to ensure that the pipe ends are completely trimmed before making the joint.

- **Pipe Alignment**

Pipe alignment impacts on drag pressure and thermal contact between pipe and heater plate. In the first instance, in the case where long lengths of pipe are jointed and no rollers are used to assist its movement or align the pipes, a significant increase in the drag pressure results. Secondly, with no alignment, the actual weight of the pipes will bend the butt fusion machine chassis thus giving rise to the potential for a gap to occur between the pipe ends and the top of the heater plate. Each of these factors put at risk the joint integrity. A certain amount of misalignment is inevitable (maximum 1mm <180 mm diameter, 10% wall thickness >180mm) assuming beads widths are within acceptable limits.

- **Heat Soak Time**

This is the time for which the pipe ends are in contact with the butt fusion heater plate. If the heat soak time is too short, the molten surfaces will not reach the required temperature and when the pipes are removed from the heater plate, the surfaces will cool quickly. The result would be an increase in melt viscosity, crystallization prior to fusion and ultimately a ‘cold’ lap joint. A ‘cold’ lap joint may not exhibit any contamination, may be well aligned and perfectly trimmed. However, there will be no strength in the joint and if subjected to bending will separate completely.

- **Dwell Time**

This is the time taken to remove the heater plate and bring the pipe ends together in a controlled manner to complete the joint. The faster the pipe ends can be brought together, the less likelihood that the molten surfaces will have time to cool down. The effect of a long dwell

time in a butt fusion joint will be exactly the same as a short heat soak time in the joint will be 'cold' lap. The joint will have no strength and if subjected to bending, will separate completely.

Self-Check -4	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two points

1. One of the following is a contamination cause failure of EP joint
   A. Alignment error
   B. Inadequate scraping
   C. Excessive gap
   D. Short stab
2. One of the following is a factors that can affect weld quality
   A. fusion pressure
   B. dwell time
   C. pipe alignment
   D. all

Note: **Satisfactory rating – 2 points** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-4

Name: _____ Date: _____

Multiple choice items

1._____
2. _____

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