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POP001

Electrofusion Jointing of PE Pipe and Fittings for Pressure Applications

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ELECTROFUSION JOINTING OF PE PIPES AND FITTINGS FOR PRESSURE APPLICATIONS

1.0 INTRODUCTION

Using electrofusion to connect pipes and fittings allows safe, economical, and efficient installation of underground and aboveground polyethylene (PE) piping systems. First used in the 1970s electrofusion has grown in popularity. Millions of electrofusion joints are installed worldwide each year.

The purpose of this technical guideline is to provide guidance on industry best practice techniques for safe and reliable jointing of PE pipe using electrofusion jointing. It includes building an understanding of electrofusion and providing vital information on all the critical factors for successful fusion, quality requirements, welder certification and training, and appropriate tools and equipment. This guideline also provides an overview on the considerations of installation, including post fusion quality checks and quality control records.

Supplementary guideline POP001A Guide to electrofusion assembly and welding should be read in conjunction with this guideline.

POP001A provides step-by step instruction for common installation techniques including socket assemblies, slip couplings and saddles.

Good fusion results in high strength and ductility at the interface between the pipe and the fitting. To achieve this, every step of the electrofusion process must be completed in full.[1&2] "Pipe preparation is perhaps the most important and least understood aspect of making a correct electrofusion joint. Improper pipe preparation is overwhelmingly the leading cause of unsuccessful electrofusion joint attempts."[3]

While there are variations amongst fitting brands and pipe sizes, electrofusion installation follows a broadly consistent procedure. This guideline describes best installation practices independent of fitting design.

The guideline provides specifications and recommendations suitable for:

- Pipe conforming to *AS/NZS 4130 – Polyethylene pipes for pressure applications.*
- Fittings conforming to *AS/NZS 4129 – Fittings for polyethylene (PE) pipes for pressure applications.*

Some manufacturers produce electrofusion fittings for use with non-pressure or low-pressure PE pipe. These are commonly used in gravity sewer and wastewater applications. The standards relevant to these fittings are:

- AS/NZS 5065 – *Polyethylene and polypropylene pipes and fittings for drainage and sewerage applications,* or
- AS/NZS 4401 – *Plastics piping systems for soil and waste discharge (low and high temperature) inside building – Polyethylene (PE)*

Installers, asset owners and other stakeholders can use this guideline to ensure electrofusion joints are installed correctly following best practice processes ensuring long term joint performance for the expected service life of the asset.

2.0 WHAT IS ELECTROFUSION?

Electrofusion (EF) is the fusion or welding together of polyethylene (PE) pipe and specialised fittings which have electrical resistance wires incorporated into the fitting. These wires are either embedded beneath the internal surface of the fitting or exposed at the internal surface of the fitting.

EF welding requires application of an electric current for a defined period of time (fusion time) to the resistance heating wires contained within the fitting. Heat generated in the wires raises the temperature of the surrounding PE material above the crystalline melting point. At either end of the heating zone the molten PE solidifies first (in regions known as "cold zones"), creating a cavity within which the PE melt is constrained. The expanding PE creates pressure within the cavity so that fusion takes place between the pipe and fitting interfaces.

Colour indicators or fusion indicator pins on the fittings become visible when the temperature or melt pressure has been created. Once the fusion time has elapsed, the joint assembly is left to cool undisturbed for a set time (cooling time). This cooling phase is critical to ensuring strong joints.

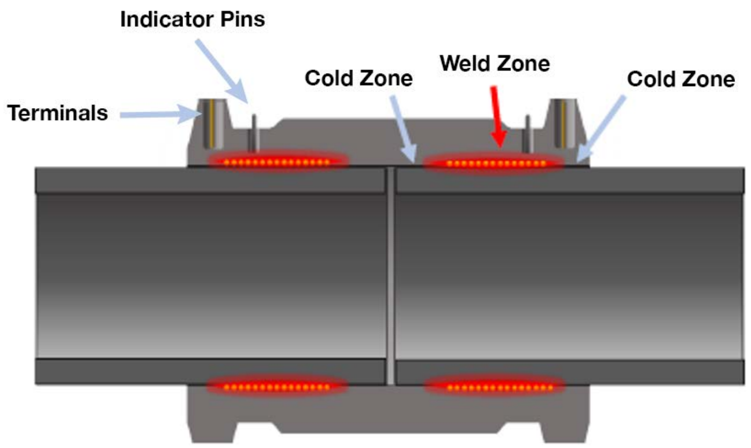


Figure 1 – The electrofusion weld zone (also referred to as the fusion zone or weld zone) on an electrofusion coupling.

3.0 QUALITY REQUIREMENTS

3.1 ELECTROFUSION FITTINGS

Electrofusion fittings should be manufactured in accordance with the relevant AS/NZS standards. The common electrofusion fittings are:

Electrofusion sockets, used for joining pipes and spigot fittings. These include couplers, elbows and tees.

Electrofusion saddles, which are used to assemble branch connections or connect to pipe mains. Two common variations of saddle fittings are available:

- Under clamp-type saddle fittings that fully encircle the pipe, with an integral clamp. These fittings are often used with live tapping saddles.
- Top loading-type saddle fittings where joint assembly requires a manufacturer-specific mounting tool to securely position and restrain the fitting during welding. These fittings are often used on larger branch off-takes. The mounting tool is removed from the prepared joint following each welding and cooling process.

Electrofusion fittings are typically supplied individually sealed in transparent PE plastic bags and additionally packed in cardboard boxes. These should be stored undercover where the temperature range is 0°C to 50°C. The packaging is designed to protect the welding surface from contamination and direct sunlight exposure. The fitting must be stored in its original packaging until immediately before use. More information can be found in PIPA Industry Guideline POP005 – Packing, Handling and Storage of Polyethylene Pipes and Fittings.

3.2 POLYETHYLENE PIPE & SPIGOT FITTINGS

PE pipes and spigot fittings are components in the jointing process and therefore it is important they are manufactured in accordance with the relevant AS/NZS standards and are stored and handled correctly to prevent deviations from tolerances and damage. More information can be found in PIPA Industry Guideline POP005 – Packing, Handling and Storage of Polyethylene Pipes and Fittings

Electrofusion welding can be used to join pipes manufactured from different PE material grades (i.e. PE80 and PE100) and Standard Dimensional Ratios (SDRs). In addition, EF fittings are capable of welding a range of SDRs. Always check the fitting barcode or packaging and consult the manufacturer if unsure.

Where different materials or SDRs are used, the PN rating of the pipeline system is equivalent to that of the lowest-rated pipe or fitting component. Therefore, it is important that each component's PN rating is verified before assembly.

PE pipes develop a thin surface layer of oxidised polyethylene during manufacture and / or exposure to sunlight over time. This oxidised layer along with any surface contaminants act as a physical barrier, inhibiting fusion between surfaces. Consequently, it is critical that correct peeling of the pipe is undertaken to expose clean virgin PE material in preparation for welding. Incorrect removal of the oxidised layer may result in the brittle failure of the weld.

4.0 WELDER CERTIFICATION AND TRAINING

The value of having competent welders cannot be overstated. The biggest single contribution to a successful electrofusion weld is the competency of the welder and their dedication to correct surface preparation and weld procedures. It is important the competency level of the welder be considered in relation to the criticality of the pipeline.

As per AS/NZS 2033 *Design and Installation of polyolefin pipe systems*, electrofusion installers must be trained and certified to PMBWELD302E – *Electrofusion Weld Polyethylene Pipelines* and hold a current installer's certificate before undertaking electrofusion jointing. Installers require experience using equipment and pipe sizes relevant to the work being undertaken.

Training is provided by Registered Training Organisations (RTOs) accredited by state or territory training authorities under the Training.gov.au (TGA) guidelines. The training must conform to PMB 07 Competency Standards prepared by Manufacturing Industry Skills Alliance for the plastics, rubber and cable making industry.

The RTO should issue an accreditation certificate to successful candidates on completion of training and maintain a register of accredited welders. PIPA recommends the reaccreditation of welders every 2-3 years to ensure the welder maintains understanding of current standards, procedures, and technical advances. It also ensures the welder skills are reviewed and current. More information is available within the welder training section of the PIPA website.

5.0 TOOLS AND EQUIPMENT

To achieve a good weld, it is critical for installers to be equipped with the correct tools and measuring equipment. This is to ensure factors including welding parameters, the environmental conditions, inspection and measurement of pipe and joint preparation are correctly managed to achieve a successful weld. Refer to the list below:

- A serviced and correctly calibrated electrofusion welding machine
- Generator and cables
- Diameter tape (Pi tape)
- Straight edge or builder's square
- Pipe cutting equipment
- Metal ruler
- White or silver colour permanent marker
- Re-rounding tools
- Pipe ovality gauge
- Rotational peeling tool
- Calliper or micrometer
- Deburring tool
- Alignment/clamping tool
- Approved electrofusion disposable cleaning wipes
- A temperature measuring device e.g., infrared thermometer

6.0 CONSIDERATIONS FOR INSTALLATION

Appropriate measures should be undertaken to ensure a safe and healthy working environment. It is important to have all necessary components, tools and equipment and machines available on site and ensure they are suitable for the application. POP001A Guide to electrofusion assembly and welding provides step-by step instruction for common installation techniques including socket assemblies, slip couplings and saddles.

When planning modifications or repairs to pipelines that are currently or have been in service, there are additional factors that need to be considered. These factors include the following:

- Polyethylene pipes can change their dimensions once in service i.e., diameter will increase particularly in the case of pressure pipelines. This is a perfectly normal and an expected response. Re-rounding tools may be required.
- Products used in the repair process must be compatible with the existing pipeline and maintain the design basis of the pipeline, this includes considering thrust loads.
- Ensuring that any residual water flow in the pipeline is managed to prevent water entering the electrofusion work area.

6.1 ELECTROFUSION WELDING MACHINES

Use electrofusion welding machines that are manufactured in accordance with *ISO 12176-2 – Plastic pipes and fittings – Equipment for fusion jointing polyethylene systems – Part 2: Electrofusion.*

In addition, welding machines should operate with barcode-marked fittings according to *ISO 13950 – Plastic pipes and fittings – Automatic recognition systems for electrofusion joints.*

Barcode reading welding machines automatically adjust for variable ambient temperature conditions. Most welding machines allow manual entry of the fusion welding time.

Welding machines should include safety devices to prevent voltages greater than recommended by the manufacturer. The safety device should operate in less than 0.5 seconds.

Electrofusion welding machines (or control boxes).

Maintenance and calibration

Manufacturers recommend regular service and calibration intervals, typically every 12 months or a prescribed number of working hours. Regular maintenance will ensure that the welding machine is functioning normally and continues to accurately measure the welding parameters.

Welding machines past their calibration interval will normally provide an alert at power-up but will continue to function.

Consult equipment manufacturers for calibration and servicing recommendations.

Supplying power – Generators and Cables

The electrical power required by electrofusion fittings varies with fitting design and size.

Generators used for power supply should be calibrated and serviced to ensure they provide the voltage and current input required for the electrofusion welding machine.

Welding machine error is usually due to unstable or inadequate power supply. To avoid this, generators shall:

- Only supply current to the EF welding machine during the fusion process and not to other machinery.
- Be well maintained and subject to a periodic maintenance schedule.
- Provide a nominal voltage in unloaded conditions around 230V-240V.
- Keep the nominal input voltage stable at 230V±15% (48V, 110V, 400V) during the fusion process under load.
- Remain at a stable frequency (50-60Hz) under load.
- The length of extension cables shall not exceed 50m and they should be completely rolled out.

6.2 SETTING UP THE SITE TO MANAGE ENVIRONMENTAL CONDITIONS

Welding in high ambient temperatures

When exposed to direct sunlight, black pipe and fittings can absorb solar energy and may reach well above ambient environmental temperature. Pipe surface temperatures may be as high as 70°C.

Electrofusion welding machines have upper and lower temperature operating limits of -10°C to 45°C. For installations outside these limits contact the supplier.

Use sun protection (such as a portable gazebo) to reduce the pipe's surface temperature to 45°C or less , shield the EF welding machine, pipe and fitting assembly from direct sunlight during installation. This reduces the risk of excessive temperature differential between the EF assembly and the welding machine.

Protecting the site from rain, moisture and contamination

The surfaces of components to be welded must be clean and dry. The electrofusion assembly should be adequately sheltered from rain, welding should not be undertaken if protection cannot be provided.

Mud and water often accumulate in trenches. Fittings cannot be safely welded in these conditions, so trenches may need to be dewatered. Alternatively, a polyethylene sheet (or similar) can be used to line the trench walls and under the pipe, keeping the weld surfaces clean and dry.

The assembly should also be shielded from dust and airborne particles carried by wind. These particles can contaminate the weld surfaces.

Providing adequate workspace

There should be space available to easily access the jointing area during assembly and welding.

In trenches, a minimum clearance of 150 mm is required around the pipe. As the fitting diameter increases, greater clearance may be needed to efficiently peel, re-round and use alignment tooling in the trench.

Pre-cleaning of the pipe surface

Remove dirt, mud and other debris from the pipe end to prepare the pipe for electrofusion jointing. This will prevent cross contamination and reduce wear on the mechanical peelers and cutting tools. Clean water and a 100% cotton rag can be used but the pipe components must be dry before starting the installation process.

When pipe has been installed by directional drilling, bentonite clay drilling lubricant residue will often remain on the pipe surface. Drilling lubricants, even when dried, can be very difficult to see with the naked eye and are easily spread by wiping. This increases the risk of cross contamination. Therefore, it is recommended that cleaning of the pipe extends beyond the fittings location.

6.3 INSPECTION AND MEASUREMENT OF THE PIPE

The pipe ends should be inspected to ensure they are suitable for electrofusion welding. The following should be checked:

- Pipe surface for damage such as gouges that are too deep to be removed by peeling.
- The pipe outside diameter is in tolerance
- Excessive end reversion
- End squareness
- Pipe ovality
- Flat spots

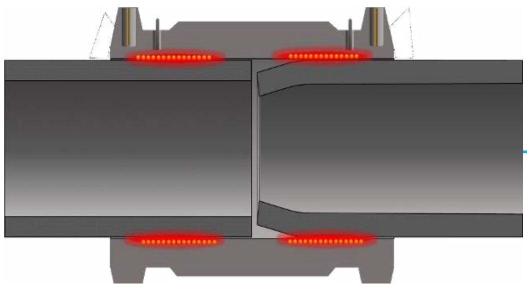
Measuring pipe outside diameter

Pi tapes are the most reliable tool for accurately measuring pipe mean OD. Select a Pi tape graduated in millimetres with each gradient being 0.5mm. On the vernier scale each gradient shall be 0.05mm or less.

Pipe end reversion

PE pipes often exhibit circumferential reversion (also known as toe-in) at pipe ends which can cause reduction of the pipe OD. Reversion can occur due to the residual stress introduced during the manufacturing process.

Reversion can create excessive gaps between the pipe and fitting surfaces, which can compromise weld integrity.



Pipe end reversion.

You can use the following calculation to determine if the reverted pipe end can be welded:

- Prior to peeling, measure the distance equivalent to DN x 5% from the pipe end. At this position, the pipe OD must be no smaller than the DN.
- Place a straight edge, such as a spirit level or ruler, on the pipe end. If reversion is present, cut the pipe end at the position where the pipe end begins to toe-in.

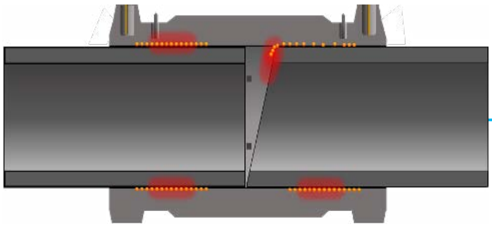
For example, when checking reversion on a DN500 pipe end:

1. *500mm x 0.05 =25 mm. Measure 25 mm back from the pipe end.*
2. *25 mm from the pipe end, the pipe OD should be no smaller than 500 mm.*
3. *If the OD is less than 500 mm, cut the pipe squarely at that position.*

Residual stresses where present will still remain. This means that freshly cut pipe can revert again, sometimes within a few hours. To avoid the risk of recurrent reversion complete electrofusion jointing as soon as possible after the pipe has been prepared.

Pipe end squareness

Pipe ends must be cut squarely with a suitable pipe-cutting tool. An angled pipe end may reduce contact between the pipe and fitting fusion zone leading to a loss of pressure in the fusion zone and premature heat loss during the weld. This will reduce the joint strength and can result in weld failure.



Poorly cut pipe ends may lead to weld failure.

A range of tools is available for cutting pipe ends square.

Tools are available for cutting pipe ends square.

On smaller diameters, handheld rotary cutting tools can be used. As pipe diameters increase, mechanised tools, such as chain saws or rotary cutters, are used.

It is recommended if using a chainsaw, not to use any lubricating oils as these can contaminate the weld surface. Note: using a dry chainsaw may lead to harder wear. Chainsaws can also leave exhaust residues. When using these tools, ensure any residue is cleaned away before continuing.

A circular guide can be wrapped around the pipe circumference to help easily mark the cutting position on the pipe surface with a coloured permanent marker.

Ovality and flat spots

Pipe ovality (out of roundness) and flat spots can develop during manufacture, coiling or storage and handling.

Ovality creates an uneven annular gap between the pipe and the fitting, which can comprise the weld integrity. Some pipes may be too oval to fit into electrofusion sockets or exceed the ovality tolerance for saddle-type fittings. Re-rounding tools can be used to correct ovality, reducing the uneven annular gap between the pipe and fitting surfaces in the fusion zone. Re-rounding tools must remain in place during the welding and cooling phases.

Pipe can also have one or several flat spots on the outer surface. Flat spots and cause difficulty peeling the oxidised material from the pipe surface and create excessive localised annular gaps between the pipe and fitting. Re-rounding tools may be unable to correct flat spots.

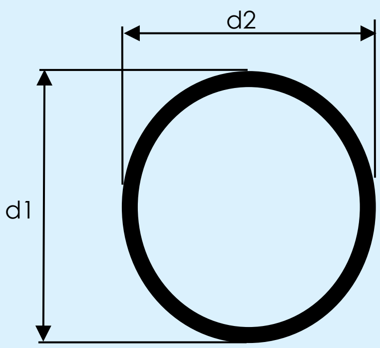
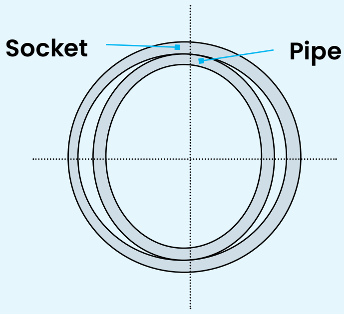
The acceptable limits of pipe ovality and flat spots are described in Table 1.

Pipe ovality gauge

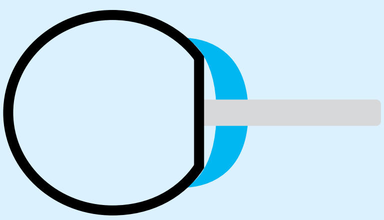
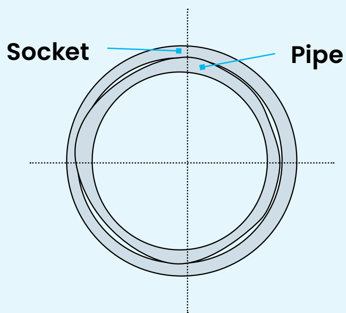
Note: Where pipe cannot be re-rounded within the acceptance criteria, other methods may be applied such as:

- Trimming back the end of the pipe until the flat spot is removed.
- Relocating a saddle to an alternative position or rotating the pipe.
- Butt-welding pipe tails to allow compliance with the acceptance criteria.

Table 1: Ovality and Flat Spots

WELD FEATURE	COMMENTS	ACCEPTANCE CRITERIA
1. PIPE OVALITY  d1 = maximum OD of pipe d2 = minimum OD of pipe	Ovality can create an uneven annular gap between the pipe and the EF fittings. This gap can be tolerated up to a certain limit. **EXAMPLES** 	Pipe ovality at the fusion zone should not exceed the limits below: **Pipe DN <315** d1-d2 < 1.5% DN or 3mm (whichever is the smallest value) **Pipe DN ≥315** Pipe DN ≤ 1% DN or 5mm (whichever is the smallest value)

EXAMPLE CALCULATION		
Pipe nominal diameter (DN) = 110 Measured maximum outside diameter (d1) = 111.0mm Measure minimum outside diameter (d2) = 109.5mm	Calculate the pipes ovality where Ovality = d1 – d2 = (111.0 – 109.5) = 1.5mm	Maximum allowable ovality for DN110 pipe is the smallest of 1.5%xDN or 3mm. 1.5%DN = (1.5/100)x110 = 1.65mm Pipe ovality of 1.5mm is less than maximum allowable of 1.65mm

WELD FEATURE	COMMENTS	ACCEPTANCE CRITERIA
2. PIPE FLAT SPOTS  **Measuring pipe flat spots** Following pipe-re-rounding, accurately measure the flat post depth using a pipe ovality gauge, intersected with a steel ruler.	Flat spots can create excessive localised annular gaps between the pipe and EF fitting. This gap can be tolerated up to a certain limit. **EXAMPLES** 	Maximum flat spot depth is 3mm.

6.4 JOINT PREPARATION

Measuring the peel length

Measure a distance of half the fitting length plus 20mm from the end of the pipe. This is used to allow the peeled surface to be visible after welding. Make a mark on the pipe surface.

Peeling

PE pipe and spigot fittings can have a thin surface layer of oxidised polyethylene formed during manufacture and exposure to outdoor UV (photo-oxidation). This oxidised layer and other surface contaminants act as a physical barrier, inhibiting welding between surfaces. The surface must be fully peeled from the pipe or fitting for successful electrofusion welding.

Incorrect removal of the surface layer may result in the brittle failure of the weld.

Mechanical peeling tools are designed to evenly remove the correct peel thickness around the pipe surface. Hand scrapers must not be used for peeling, however these can be used to remove or debur the ends of pipes prior to welding.

A minimum of 0.2mm thickness must be removed from the pipe surface (refer to Table 2). However, this may be insufficient for larger pipe diameters, where more than one rotation of the peeler may be necessary. Ensure the minimum pipe OD after peeling is not less than that in Table 3.

Mechanical peeling tool cutting blades require regular service and maintenance, or replacement as required, to ensure uniform and continuous removal of a minimum 0.20mm PE strip thickness per pass.

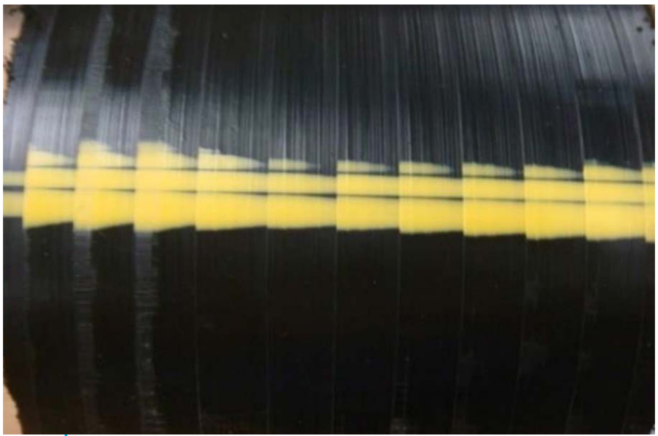
Table 2: Minimum pipe peel depth requirements

PIPE DN	PEEL DEPTH (MM)
DN25-DN225	0.2
>DN225	0.3

Measuring the peel thickness

The peel strip thickness should be measured with a micrometer or callipers to confirm the minimum required peel depth has been uniformly removed from the pipe surface.

Should a change in strip thickness occur, the peeling blades may be blunt and should be replaced.



Example of blunt leading edge

Example of blunt leading edge

A rotary peeled pipe displaying a wedge-shaped peeling pattern along the yellow stripe. This indicates that the cutting blade has a blunt leading edge.

Visual inspection

After peeling, visually inspect the pipe surface for any remaining scores or deep gouges. Any surface irregularities can cause problems in the fusion zone, resulting in incomplete welds, or formation of voids.

If scores or gouges remain on the surface, peel the pipe a second time to remove. Ensure the minimum pipe OD after peeling is not less than that in Table 3.

If the scores or gouges cannot be removed by peeling, cut the damaged section of pipe out.

Moulded PE spigot fittings

Moulded PE spigot fittings require mechanical peeling, unless otherwise specified by the manufacturer.

Moulded spigot fittings fabricated with welded pipe tails (intended to extend the fitting length) must be mechanically peeled and prepared for electrofusion jointing in the same manner as PE pipe ends. Ensure the appropriate peeling tool is used.

Table 3: Minimum pipe OD after peeling

Table 3 lists the minimum allowable diameter of pipe after peeling.

PIPE DN	MINIMUM MEAN OUTSIDE DIAMETER (OD) OF PREPARED PIPE(MM)
16	15.6
20	19.6
25	24.6
32	31.5
40	39.5
50	49.5
63	62.5
75	74.4
90	89.4
110	109.4
125	124.4
140	139.4
160	159.4
180	179.4
200	199.4
225	224.4
250	249.3
280	279.3
315	314.3
355	354.2
400	399.2
450	449.2
500	499.2
560	559.2
630	629.2
710	709.2
800	799.2
900	899.2
1000	999.2
1200	1199.2

Cleaning the weld zone

Pipe and fitting surfaces must be clean, dry and free of contamination before welding.

Contaminants in the weld zone will compromise the integrity of the welded joint.

Common contaminants may include dirt, mud, sand, sweat, grease, sunscreen, and directional drilling lubricant residue.

Cleaning wipes

Disposable electrofusion welding wipes should be used to clean weld surfaces. These wipes contain high-purity alcohol (typically Ethanol or Isopropanol) dissolved in a small amount of distilled water. The alcohol solution will evaporate quickly after the weld surfaces are cleaned. Use the cleaning wipes recommended by the fitting manufacture.

Do NOT use:

- Wipes not designed for electrofusion. These do not meet these strict formulation requirements and should not be used.
- Cleaning rags. These may contain detergents, dyes or softening agent residuals which can contaminate the weld surfaces.
- Other solvents such as methylated spirits, acetone, methyl ethyl ketone (MEK) to clean the fusion area

Cleaning Technique

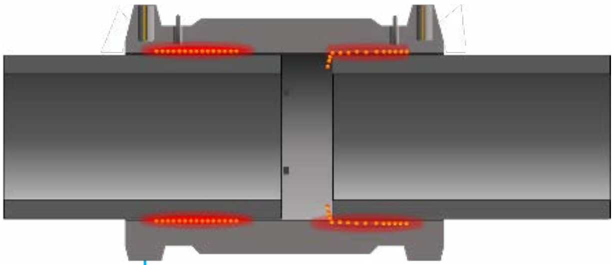
The following cleaning techniques and considerations will ensure that the weld zone is cleaned correctly and minimises the risk of cross contamination.

- Do not use wipes that have dried out.
- Wipe away from the pipe end. Work from the peeled surface towards the unpeeled area but discard the wipe after contact with any unpeeled areas.
- Do not use a wipe that has cleaned an unpeeled surface on a peeled surface.
- Do not wipe over the witness mark. Witness marks should also be visible for post installation inspection.
- Ensure that no part of the cleaning wipe that has been in contact with hands touches the weld surface.
- After wiping the surface, do not touch the surface with bare or contaminated hands. Sweat, sunscreen, barrier cream, soap, detergent, dirt, and skin oils are potential sources of contamination.
- Ensure the alcohol wipe fluid has fully evaporated from the weld surface before welding commences.

Disposable latex or nitrile powder-free gloves can be used when handling the wipes to prevent surface contamination and skin irritation.

Witness marks

Successful electrofusion welds require the fitting weld zone to be in full contact with the pipe surface. If the pipe is not inserted to the full depth in the fitting, polymer melt depressurisation and premature heat loss in the weld zone can reduce the joint strength. There is also a risk of molten PE igniting and burning the joint assembly.



Witness marks ensure the weld zone is correctly located in relation to the pipe end.

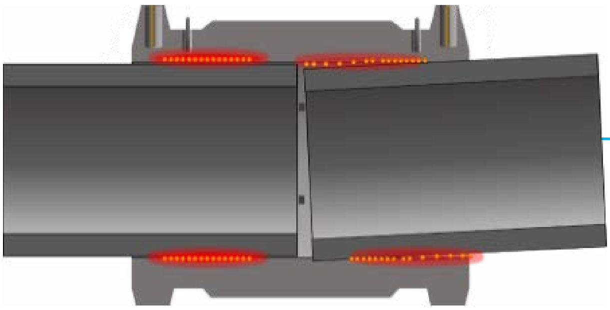
Some brands of fittings and some fitting diameters do not use centre stops or have centre stops that can be removed. In these cases, using witness marks is critical to ensure the fusion zone and pipe end are correctly aligned.

Using alignment clamps

Alignment clamps restrain the joint assembly during fusion and cooling processes. The clamps have a number of important roles in the welding process and will:

- restrain the joint assembly free of stress, protecting against disturbance of the molten PE, until the joint assembly has cooled and regained its material strength
- ensure the joint assembly remains stationary with the pipe and fitting weld surfaces correctly aligned.

EF fitting manufacturers provide guidance on length of cooling time before the joint can be moved and before the pipe can be pressurised.



Misalignment can lead to resistance wire displacement, premature heat loss, melt extrusion and depressurisation of the weld.

Coiled pipe

Misalignment can occur with coiled pipe where alignment clamps alone are unable to address the problem. There are several other measures that can be employed to correct misalignment with coiled pipe including:

- Butt Welding short lengths of straight pipe to the end of the coiled pipe
- On warmer days layout the coil and restrain at several points along the pipe to aid in controlling pipe curvature.
- Use coil straightening equipment as the coil is unrolled.
- Use two alignment clamps, both mounted eccentrically to the joint. Both clamps reinforce each other acting as quadruple clamp, forming a stress-free joint.

6.5 THE ELECTROFUSION PROCESS

The fusion parameters are provided on the barcode and are automatically read by the barcode scanner into the EF welding machine. Alternatively, some fittings operate on an auto recognition system when the cable is connected to the welding machine. Check that the welding time and voltage marked on the fitting label/barcode match the weld time and voltage displayed on the EF welding machine display.

Before welding, it is important to check that the generator has enough fuel to complete the weld. If power is interrupted or the generator cuts out during the weld, some fitting manufacturers allow the fitting to be re-welded once the fitting has cooled to ambient temperature. Other manufacturers may recommend the weld is abandoned and cut out from the pipeline. Note: the time for the complete assembly to cool below 45°C could be up to 24 hours depending on fitting size and environmental conditions.

At the end of the weld time, wait for the full cooling down time stated on the fitting label to elapse before removing the welding terminals, re-rounding tools and/or alignment clamps.

7.0 POST FUSION QUALITY CHECKS

During and after the welding process it is important to check the following:

- → The welding cycle is complete and there is no error message on the electrofusion unit.
- → There are no unusual deformation of pipe or fittings.
- → Inspect the fitting socket to ensure that molten polyethylene has not escaped from the socket. In addition, heating wires should not be visible or displaced between the socket annular gap.
- → The melt indicator pins confirm that some melt pressure has developed in the weld. They are not a confirmation of a successful weld.
- → The pipe has not moved during welding by ensuring the insertion depth mark is in the same position during joint assembly.
- → The peeling is visible beyond the ends of electrofusion fitting.

More information on visual examination of electrofusion joints can be found in PIPA's Technical Guideline POP014 Assessment of Polyethylene Welds

8.0 QUALITY CONTROL RECORDS

A critical part of successful electrofusion welding is ensuring the joint has been prepared correctly. It's important for the installer to record information for each weld to demonstrate the joint was prepared by a qualified welder and following industry best practice.

Appendix A provides a checklist of minimum quality requirements and traceability for a weld record including project, welder, equipment, pipe, fitting and installation information. It should be noted the asset owner may require additional information to be recorded.

In addition to quality control records a field fusion quality assurance plan which details the inspection and test requirements for electrofusion welds in the project may be required. Refer to Appendix B for more information.

Digital tools for welding data capture

There are a variety of digital tools and apps available to capture electrofusion welding data including photographs and geolocation capability. These tools simplify the task of capturing the welding process and traceability information. These apps are supplied by electrofusion fitting manufacturers and are valuable QA tools.

Electrofusion welding machines can offer wireless connectivity, collecting welding data captured during the fusion process. Electronic data is stored and typically downloaded via a mobile phone app to the cloud for immediate storage or future retrieval by interested parties e.g., asset owners, consultants, contractors.

9.0 TECHNICAL REFERENCES

[1] Bowman. J, A review of the electrofusion joining process for polyethylene pipe systems, Polymer Engineering and Science, April 1997, Vol 37, No4. https://pipa.com.au/wp-content/uploads/2024/08/Bowman_-A_review_of_the_electrofusion_joining_process_for_polyethylene_pipe_systems_1997.pdf

[2] Grimes. C, Electrofusion: Making sure you get the basics right, Plumbing Connection, 30 May 2018 https://plumbingconnection.com.au/electrofusion-making-sure-you-get-the-basics-right/

[3] Municipal Advisory Board, Plastics Pipe Institute, MAB Generic Electrofusion Procedure for Field Joining of 12 Inch and Smaller Polyethylene (PE) Pipe, 2022 https://plasticpipe.org/common/Uploaded%20files/Technical/MAB-01.pdf

PIPA Technical Guideline POP001A — Guide to Electrofusion Assembly and Welding

PIPA Technical Guideline POP005 — Packing, Handling and Storage of Polyethylene Pipes and Fittings

PIPA Technical Guideline POP014 — Assessment of Polyethylene Welds

PMBWELD302E – *Electrofusion Weld Polyethylene Pipelines*

The European Plastic Pipes & Fittings Association (TEPPFA), A good practice guide for the electrofusion jointing of large diameter polyethylene pressure pipes, July 2021 https://www.teppfa.eu/wp-content/uploads/A-Good-Practice-Guide-for-the-Electrofusion-Jointing-of-Larger-Diameter-Polyethylene-Pressure-Pipes.pdf

10.0 STANDARDS REFERENCES

AS/NZS 2033 – *Design and Installation of polyolefin pipe systems*

AS/NZS 4129 – *Fittings for polyethylene (PE) pipes for pressure applications*

AS/NZS 4130 – *Polyethylene pipes for pressure applications*

AS/NZS 4401 – *Plastics piping systems for soil and waste discharge (low and high temperature) inside building – Polyethylene (PE) Designation*

AS/NZS 5065 – *Polyethylene and polypropylene pipes and fittings for drainage and sewerage applications*

[1] ISO 13954 – *Plastics pipes and fittings — Peel decohesion test for polyethylene (PE) electrofusion assemblies of nominal outside diameter greater than or equal to 90 mm*

[2] ISO 13955 - *Plastics pipes and fittings — Crushing decohesion test for polyethylene (PE) electrofusion assemblies*

[3] ISO 13956 - *Plastics pipes and fittings — Decohesion test of polyethylene (PE) saddle fusion joints — Evaluation of ductility of fusion joint interface by tear test*

[4] ISO 21751 - *Plastics pipes and fittings — Decohesion test of electrofusion assemblies — Strip-bend test*

APPENDIX A

CHECKLIST OF MINIMUM REQUIREMENTS FOR WELD RECORD

The following provides minimum requirements to capture for a weld record. Note this will be dependent on the requirements of individual projects.

Project Details	
Date	
Project Details	
Customer Details	
Welder Details	
Name	
Company Details	
Welder ID Number	
Welding Machine Details	
Machine brand	
Machine ID	
Weld Information	
Weld Number	
Location	
Time weld commences and finishes	
Time cooling commences and finishes	
Fittings Information	
Brand/Part Number	
Compatible pipe SDR range (confirm fits pipe SDR) Yes No	
Pipe Information	
Material grade	
DN	
SDR	
Pipe Manufacturer	
Measured mean OD	
Measured Ovality	
Check pipe ends square	☐ Yes ☐ No
Pipe End Reversion	Corrective Action ☐ Yes ☐ No
Re-rounding clamps used	☐ Yes ☐ No
Alignment clamps used	☐ Yes ☐ No
Evidence of flat spots	Corrective Action ☐ Yes ☐ No

Installation	
Weather conditions	
Shelter	Yes No
Checked for damage	Yes No
Pipe peeled - OD	
Cleaning completed	Yes No
Post-weld	
Indicator pins risen	Yes No
Visual Examination completed	Yes No
Timing marks on fittings	Yes No
Any welding machine fault codes and corrective action	

Date and signature of operator

Note: Assest owners may require additional product information.

APPENDIX B

INSPECTION AND TESTING OF ELECTOFUSION WELDS

It is recommended that the constructor and asset owner utilise a system for monitoring and checking installation quality. A field fusion quality assurance plan may be required for approval by the asset owner. This plan could include pre-qualification of welders and an inspection and test program.

Pre-qualification of Welders

Welders are required to prepare test samples on site using the equipment they have provided for the project. Each welder prepares a weld for each size required in the project. The welds are then tested using accredited third-party destructive testing laboratories to either ISO 13954[1], ISO 13955[2], ISO 13956[3] or ISO 21751[4] showing pass results.

Visual Inspection

Visual examination of welds is a useful technique as it yields a great deal of information about the weld preparation, potential contamination, alignment, and weld pressures.

A quality plan may include a schedule of random visual inspections of weld quality as per the visual inspection guidelines shown in *POP014 Assessment of Polyethylene Welds*. Where welds or processes are identified as non-compliant the identified joint or a random selection of joints prepared by the installer should be cut out for destructive testing using either ISO 13954[1], ISO 13955[2], ISO 13956[3] or ISO 21751[4] as appropriate.

Destructive Testing

A program of destructive testing is often established for the duration of each project. Typically, these programs will involve several phases with reduced frequency as welder competence is established. The phases usually consist of pre welder qualification, initial construction checks and then ongoing monitoring.

Initial Construction Testing

During initial construction samples are selected from each installer and joint size prepared in actual construction conditions and tested as above.

Ongoing Construction Testing

A random destructive testing regime is often established with the constructor. In the event of a random joint failing a test, samples of other welds made by the same welder are tested. These samples are assessed to determine if the failure is isolated or a systematic failure. Appropriate corrective actions should be taken following the assessment as outlined in the quality assurance plan.

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