A GOOD PRACTICE GUIDE FOR THE

ELECTROFUSION JOINTING OF LARGER DIAMETER POLYETHYLENE PRESSURE PIPES

teppfa

INTRODUCTION

Polyethylene piping systems are being increasingly accepted in larger diameters (above 315 mm) as a result of their proven performance advantages and the cost effective installation techniques which can be employed. Electrofusion (EF) is an important and reliable jointing method for polyethylene pipes and a wide range of EF fittings approved to EN 12201-3/ EN 1555-3 are offered in the market.

Usually EF training and certification is only applied to smaller dimensions, the common influencing factors for good installation practices and the preventive measures to avoid welding failures are often not understood.

This document aims to provide general guidance only, and should be used in conjunction with more detailed information from the specific pipe, fitting and equipment supplier.

1.1. Objectives of this document

The following guide provides universally valid recommendations for the safe and reliable jointing of large diameter PE pipes using electrofusion techniques with the intention of preventing installation failures. The code describes good installation practices independent of fitting design

1.2. Scope

The Electrofusion jointing of PE pipes and pipe components above dn315mm for buried Gas & Water Utilities and Sewage and Industrial Water applications.

1.3. Originators

This document was created by the Teppfa Utilities Application Group

1.4. Disclaimer

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2. 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.

2.1. Planning

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).

Additional Checklist see chapter 7.

Figure 1: *Retaining walls*

Figure 2: *Pipe end excavated in a suitable length*

Safety aspects: Storage conditions, handling and unloading of pipes

Figures 3 & 4: *Safety aspects, e.g. attention is drawn when handling floating load on site*

2.2. 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 a suitable length to enable flexibility for ease of alignment.

Safety aspects: Electrical power on site

The safety regulations must be complied with and attention must be paid to the safety provisions and the operational safety ordinance, particularly if any work is carried out with electrical voltage over 50 Volt. In general the fusion box shall be placed outside the trench or the electrical power source shall be GFCI equipped for outdoor use (symbol: snowflake). National safety regulations have to be respected!

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 Electrofusion is 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.

Figure 5: *Protect the fusion area with a tent*

Figure 6: *Ground water has to be pumped out from the working pit*

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.

3. Quality requirements

3.1. Quality control: Incoming goods

Incoming goods shall be inspected and conform to the relevant requirements with respect to dimensions, material, SDR and possible damages shall be confirmed before installation preparation.

3.2. Pipes and spigot fittings

As pipes and spigot fittings are components in the jointing process their quality is as important for the fusion result as the fitting, the fusion equipment and the craftsmanship of the welder.

Certification and delivery conditions

Pipe deliveries should be checked for conformity to EN12201-2/ EN1555-2/ ISO15494, as this generates the basis for any reliable jointing. Deviations from the permissible tolerance of the outer pipe diameter and excessive ovality are not acceptable as they may significantly influence the jointing quality.

Special attention is drawn to pipe bends which should be checked for local flattening and high ovality in the proposed jointing area. Geometrical deviations outside the permissible tolerance range shall not be accepted. Cutting back of bends is not allowed, please contact your supplier.

Furthermore the pipes have to be visually checked within the proposed fusion zone for unacceptable defects such as severe toe-in (pipe end reverse), flattening, scratches or damages that are not eliminated during mechanical scraping. In such cases the pipe ends have to be cut or for saddles an unaffected section of the pipe has to be selected.

Appropriate pipe storage, transportation and handling

Use appropriate devices for handling of pipes, e.g. a crane or excavator, tie bar, belts. Deviations from tolerances and defects may be caused by inadequate pipe storage or transportation. Appropriate pipe storage, cautious transportation and handling – also from storage to the working pit - shall be executed in a way that no excessive ovalisation or damage (flattening, scratches, cracks) occurs, which could adversely affect the life span of the pipe or the joint quality.

The ends of pipes which are intended for drinking water 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 sunlightpipes shall be covered by a bright tarpaulin. Heataccumulation shall be prevented. Pipes shall be stored so that changes in temperature will not cause the pipes to move.

When several different wall thicknesses of pipe are 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.

Figure 7: *Protection of pipe against direct sunlight*

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.
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.

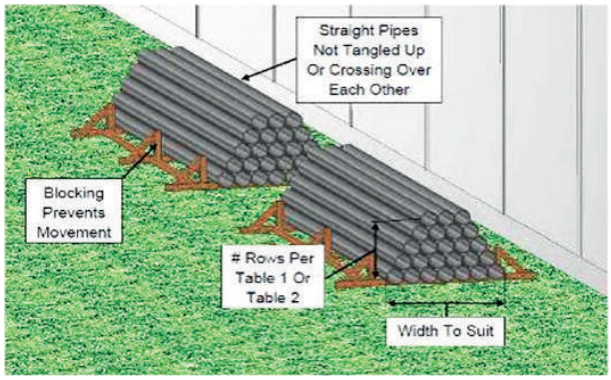

Figure 8: *shows the maximum level of PE pipes permitted for each DN/OD size on flat ground or on recommended planking for loose pipe storage.*

Nominal Pipe 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

Table 1. Number of Permitted Layers of PE Pipe for Stacking and Storage

Each level of pipes must be supported by timber when stored as shown in the example in Figure 9.

Figure 9: *Example of good on-site PE Pipe Packing and Storage*

3.3. EF fittings

Certification and pipe compatibility

Each delivery of EF fittings should be checked for conformity according to EN 12201-3/ EN1 555-3/ ISO 15494, as this generates the basis for any reliable jointing.

Additionally the specified pressure ratings (e.g. PN 10, PN 16), the pipe compatibility (e.g. SDR 11, SDR 26) and the correct voltage (e.g. 40V, 80V) in combination with the fusion unit has to be checked. The fusion bar code shall comply with ISO 13950, if not declared otherwise by the manufacturer.
In addition accredited quality marks, e.g. DVGW, BSI, KIWA and others guarantee an independent third party inspection of the products and a constant high quality level.

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 manufacturers storage and transportation instructions (e.g. storage in an up-right orientation as elevated ambient temperature can create fitting ovality).

Store electrofusion fittings in closed rooms or containers 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 10: *Transport of EF couplers d1200, packed on individual pallets in horizontal position*

3.4. Welder certification and training

Certification (where applicable)

In some European countries a certification system for Polyethylene Butt- and/ or Electrofusion welders is established. Most systems request frequent re-assessment of the welder skills with an official re-certification however Butt fusion and Electrofusion training/ certification is only usually applied on smaller dimensions.

Training on large diameter EF jointing from fitting manufacturer

The jointing quality in small but even in large diameter EF jointing is heavily influenced by adherence to the correct installation procedure. The Utility company/ end client shall require that only trained and skilled welders are specified. Therefore, it is the responsibility of the installation company to ensure that welders have the proper skills for installing the specific type of fitting being used.

Suppliers may offer hands-on training for demonstrating the appropriate installation procedure..

Manufacturer's information

Installation manuals and additional information accompanying the product must be complied with. Technical information, e.g. data sheets, installation manuals for fittings and operation instructions for fusion boxes and tools are also available, via the internet. Ensure that the generator and fusion box have the required power capacity and are compatible with the fitting being used. Contact your supplier if in doubt.

3.5. Machinery and preparation tools

Certification

The machinery and accessories have to be designed according to country specific regulations and guidelines.

Generators and cables

For the installation of Electrofusion fittings in field applications, it will be necessary to have a reliable source of AC power for the fusion processor to work properly in supplying the fitting the right amount of energy.

The common types of generator power control are Capacitor and Automatic Voltage Regulation (AVR). Better welding machine/generator performance is provided by Capacitor types as the current and voltage control are synchronized. Automatic Voltage Regulation is primarily designed for maintaining consistent voltage supply.

Generators shall

- Only supply current to the fusion unit 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 (48V, 110V, 400V).
- Keep the nominal voltage stable at 230V±15% (48V, 110V, 400V) during the fusion process under load.
- Remain at a stable frequency (50-60Hz) under load.
- Provide the required power considering the following circumstances: requirements of the connected fitting, power efficiency of the welding unit, use of extension cables, altitude and ambient temperature and others (e.g. 6kVA).

The length of extension cables shall not exceed 50m, they should be rolled out completely and have a cross section of at least 2.5 mm2. Recommended types of Generators may be found on a positive list, ask your supplier.

Fusion units

Fusion units according to ISO 12176-2 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.

Visual inspection

Regular monitoring of the fusion cable is necessary. Damaged cables must be replaced. Worn contacts can become hot during the fusion process and should be replaced.

Technical inspection approval

According to the information from the manufacturer the fusion equipment must be regularly inspected in accordance with the manufacturer's recommendations by an expert approved by the manufacturer concerned.

Appropriate power consumption

Special requirements for the energy output given by the fitting manufacturer must be adhered to (e.g. 90A @ 40V).

Temperature compensation

Equipment shall cover the full intended temperature range (-10°C to +45°C). It should be noted that fusion boxes and fittings with automatic temperature compensation are available

Fusion box cooling times

Fusion boxes may require cooling times when fittings with high power consumption are used or during high ambient temperatures on site. The use of a second fusion box allows a continuous work flow.

Tools

Generally tools shall be applied only for their intended use as shown in the instruction manual of the tool manufacturer. For all tools the following requirements must be guaranteed for a proper jointing and to respect the health and safety regulations:

- Tools should be inspected for any external damage or defects and any necessary repairs effected before use.
- No tools shall damage or contaminate the fusion areas.
- After use the tools must be cleaned from dirt, mud and other debris and checked for damage and defects and stored safely in their transportation boxes.

Cutting tools

Powered cutting tools are commercially available, but the following requirements shall be respected:

- Only plastic saws or other cutting tools suitable for PE should be used.
- When chain saws are used contamination from oil/ lubricants must be avoided.
- Ensure a square cut is achieved either by the design of the cutting tool or with an adequate, circumferential marking on the pipe.

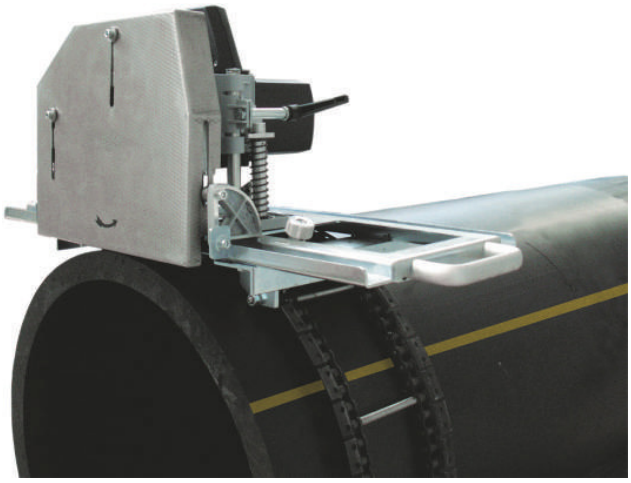

Figure 11: *Electrical cutting tool*

Tools for Re-Rounding before mechanical scraping/ fusion

Mechanical or hydraulic re-rounding tools/ clamps are commercially available and the following requirements must be considered:

- When re-rounding tools/ clamps are used damage to the pipe surface and any contamination of the fusion zone have to be avoided.
- Re-rounding tools shall be suitable to reduce the ovality in the fusion zone <3mm.

Tools for Scraping

As the removal of the oxide layer of the pipe is a critical factor for the fusion quality special attention has to be given to this process.

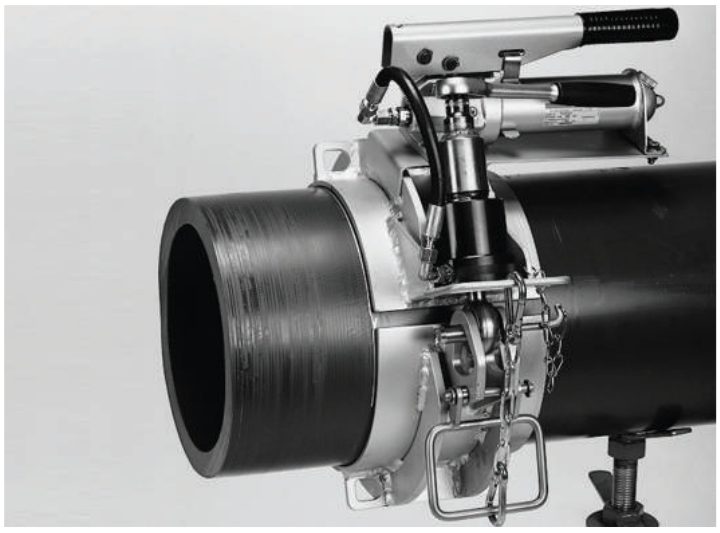

Figure 12: *Re-Rounding tool*

To provide reliable and consistent scraping results mechanical rotary/ window scraping tools shall be used, whenever possible.

Mechanical scraping tools shall

- Be well maintained and subject to a periodic maintenance schedule, especially with regards to the wear of the blade
- Provide a min. swarf removal of >= 0.2mm

  The condition and the wear of the scraper blade should be regularly checked, e.g. the swarf thickness with a vernier caliper. Worn blades must be replaced

Pipe dimension (mm)	Estimated swarf thickness (mm)	Abrasion limit (mm)
= d315 >	0.20 - 0.40	≤ 0.40
= d800 >	0.40 - 0.60	≤ 0.80

Table 2: *Swarf thickness and abrasion limits*

Abrasives, grinding wheels, or other devices that do not cleanly remove the oxide layer in an appropriate way should not be used!

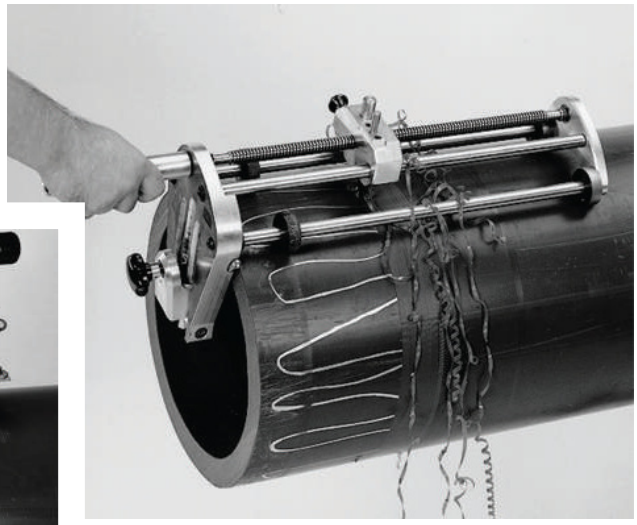

Figure 13: *Example of mechanical scraping tool*

Figure 14: Example of mechanical scraping tool

Use a handscraper to deburr the pipe edge.

Figure 15: Deburr the pipe edge

Alignment clamps

Alignment tools are commercially available, either as a stand-alone clamp or combined with re-rounding clamps. Functional test of the aligning result is recommended before use

Pipe support

Pipe supports are used for a simple and damage-free movement of pipes. They help to improve pipe alignment and pipe movement with lower forces to achieve a stress-free installation.

Measurement tools (Pi Tape, yard stick)

Pi Tapes are used to check the compliance of the pipe or spigot fitting with the diameter tolerance in the standard (EN 12201-2, EN 1555-2, ISO 15494). Clean, state of the art yardsticks are used to mark the insertion depth of the pipe into the fitting.

PE cleaner and tissues where applicable

Use only an appropriate cleaner (e.g. Ethyl-Alcohol >99.8%) and colourless, lint-free, absorbent, non-dyed and clean paper towel. Check on a hand mirror that the cleaning solvent completely evaporates without residues, to guarantee the quality of cleaning solvents.

PE-Marker

Use recommended markers only which do not affect the pipe material.

Figure 16: Pipe support

Figure 17: Checking the outer diameter of the pipe

4. Installation procedure for Electrofusion socket fittings

4.1 Prepare working space

Prepare necessary machines, tools and components for the installation (See checklist in 7, incl. SDR compatibility etc.). Ensure sufficient clearance and cleanliness around the pipe in the working area.

4.2. Prevent escaping media

Fusion with escaping media will negatively influence the jointing quality and is therefore not permissible!

4.3. Pre-cleaning of pipes and components

Remove dirt, mud and other debris from the pipe and other components to reduce the wear on the mechanical scrapers and cutting tools. Do not use cloths or rags which may contain oily or greasy substances.

Clean water can be used, but the pipe components must be dry and clean before starting the installation process.

Figure 18: *Pre-cleaning the pipe*

Fig 19

Fig 20

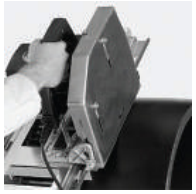

Fig 21

Fig 22

Toe-in of pipe ends, Marking the cutting position, Cutting the pipe end / Deburr the pipe end

4.4. Pipe cutting and check of pipe diameter

The pipe surfaces have to be visually checked within the fusion zone for unacceptable defects like severe toe-in (pipe end reverse), flattening, scratches or damage that will not be eliminated during mechanical scraping. Where damage is apparent the pipe ends should be cut at right angles with appropriate pipe cutter and if necessary edges have to be deburred.

The cutting surfaces of the pipe ends shall be smooth and flat.

Toe-in of pipe end: Cut-back required if longer than inner cold zone of the fitting.

Check pipe diameters with a Pi tape before and after mechanical scraping. Check compliance with the tolerance specified in the standard (EN 12201-2, EN 1555-2, ISO 15494).

4.5. Re-Rounding

Pre-check the ovality with fitting insertion test up to 1cm of the cold zone to verify if the assembly is feasible.

If not, check ovality of the pipes with a yardstick. Pipe ovality (dmax-dmin) in the area of fitting positioning shall be ≤3.0 mm, unless specified differently by the fitting manufacturer.

Do not over-scrape to remove high sides of oval pipes!

If required apply re-rounding tool/ place re-rounding clamp on the pipes immediately outside of the proposed fitting position. Re-check out of roundness of the pipes and reposition the tool, if required.

Figure 23: *Mechanical Re-Rounding*

Figure 24: *Hydraulic Re-Rounding*

4.6. Peeling of Multi-Layer Pipes, if applicable

Consult your pipe supplier about the tools and procedure for removal of the peelable skin and then continue with the procedure.

4.7. Mechanical Scraping

Measure lengths which must be mechanically scraped (insertion length plus 2 cm or complete fitting length for slide over installation) with a yardstick on the pipes / components and mark the area with a permanent marker.

Figure 25: *Marking the length for peeling*

Figure 26: *Peeling the pipe end*

Scrape the pipes with rotary scraping tool until the outer surfaces of the pipe have been removed to expose a clean, virgin pipe material. Inspect the entire circumference of the scraped areas to ensure total scraping coverage.

Repeated scraping may be necessary, depending on actual pipe diameter. Min. chip removal of approx. 0.2 mm has to be achieved. Ensure the min. allowable pipe diameter given in the table below is maintained or consult the fitting manufacturer.

Pipe dimension	Pipe dimension min	Pipe dimension min s'
355	355,0	354,2
400	400,0	399,2
450	450,0	449,2
500	500,0	499,2
560	560,0	559,2
630	630,0	629,2
710	710,0	709,2
800	800,0	798,4
900	900,0	898,4
1000	1000,0	998,4
1200	1200,0	1198,4
1400	1400,0	1399,0
1600	1600,0	1599,0
2000	2000,0	1999,0

dn, dn,min according to EN 1555, EN 12201
1) Min pipe diameter after scraping: dn, minS = dn,min – 2 x chip (according to Table 2)

Figure 27: *Checking the pipe diameter*

4.8. Cleaning

The Electrofusion fitting should only be removed from its packaging directly before the planned jointing process. Avoid touching the fusion zone. Clean pipes only in the scraped area and fittings internally with an appropriate cleaner (e.g. Ethyl-Alcohol >99.8%) and colourless, lint-free, absorbent, non-dyed and clean paper towel. Use several new paper towels for larger areas and for each component. Avoid cross-contamination of the pipes from outside of the scraped zone. Let the cleaner evaporate.

Avoid possible recontamination of the prepared surfaces (these should not be touched with bare hands due to body oils), as this could affect the jointing quality!

Make sure that any possible moisture, dew or frost is removed.

4.9. Marking of Insertion depth

Pipe-Pipe-Installation

Measure the insertion depths (half-length of the fitting) with a yardstick and mark with a permanent pen in multiple positions around the circumferences of both pipe ends.

Figure 28: *Cleaning of the fusion zone*

Figure 29: *Cleaning of the EF coupler*

Integration and Repair

For sliding cases, on the first pipe end measure full fitting length and insertion depth with a yardstick and mark both with a permanent pen in multiple positions around the circumference. On the second pipe end measure the half-length of the fitting with a yardstick and mark with a permanent pen in multiple positions around the circumference.

Figure 30: *Measuring the coupler length*

Figure 31: *Marking the insertion depth*

4.10. Pipe insertion

Insert pipe or spigot end into the Electrofusion fitting. Leave plastic bag over the other fitting end to prevent contamination and debris from entering the open end. Assembly can be assisted by tapping around the face with a plastic hammer at the same time. Care should be taken for a low stress installation and do not tilt. Secure pipe and fitting against dislocation. Check that full insertion has been achieved up to the markings. Repeat process on second pipe end. Check the correct end position of the fitting between the marks on both pipe ends. Additional information for Integration and Repair: Sufficient scraping and cleaning for the entire fitting length is required on the first pipe, to prevent contamination of the fitting during sliding over. Push the fitting completely onto the first pipe (full fitting length) until the marking is reached. Then install second pipe face to face with first pipe without a gap and slide fitting backwards until the end aligns with the marking on the second pipe (half-length of the fitting). Check that the distance between fitting and marking on the first pipe is equal to half fitting length, to ensure that no gap has been created between the pipe ends during insertion.

4.11. Clamping and alignment

All joints prepared for fusion must be stress-free (no bending, self-loading or misalignment stresses)! If required use alignment tools or similar measures, to guarantee a stress-free installation.

4.12. Fusion

Check compatibility before starting the fusion (Diameter, SDR).

Start the fusion process – using a preheating phase, if applicable – in accordance with the user manual supplied by the specific manufacturers of the fitting and fusion unit.

Figure 32: *Sliding over of the coupler*

Fusion parameters are given by a bar code label on the fitting and are automatically converted by the reader wand or scanner of the fusion box. It is recommended to use automatic fusion process documentation and traceability function, which have to be activated at the fusion box. Keep a distance of one metre to the fusion site during the fusion process for general safety reasons and control and supervise the fusion process. (See next section "Cooling and quality control of fusion")

In case of interruption during the fusion process (generator, fusion unit break-down), consult the fitting manufacturer's installation manual for re-heating process.

4.13. Cooling and quality control of fusion

During and after the fusion process check the following:

- No error message on the fusion unit
- No melt exudation outside the fitting confines
- No unusual deformations of pipe or fitting
- Fusion indicators show correct result
- Fitting remains stress-free and avoid dislocation until complete cooling time has elapsed

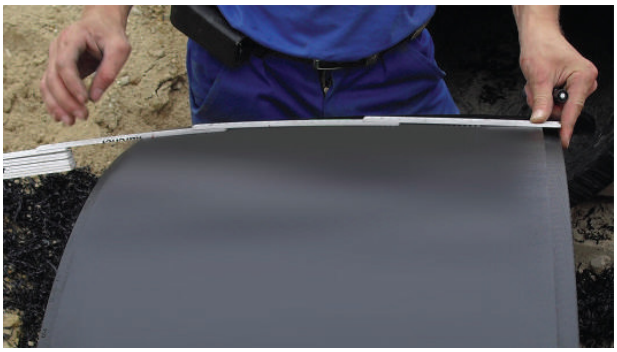

Figure 34: *Scanning the fusion bar code*

Comply with the specific cooling times given by the fitting manufacturer, before conducting any operations which could cause joint movement e.g removal of clamps, pressurising the system or carrying out pressure tests.

4.14. Mark fusion parameters

Mark the relevant fusion parameters (date, joint number, fusion time, cooling time and welder name) on the fitting / pipe and in the job site documentation.

Electronically processed documentation and traceability via fusion box is recommended.

5. Saddles

5.1. Prepare workspace

Prepare all necessary machines, tools and components for the installation (See checklist in appendix, incl. SDR compatibility etc.). Ensure there is sufficient clearance and cleanliness around the pipe in the working area.

5.2. Prevent escaping media

Fusion with escaping media will negatively influence the jointing quality and is therefore not permissible!

5.3. Pre-cleaning of pipe

Clean the pipes initially by hand to remove dirt, mud and other debris to reduce the wear on the mechanical scrapers and cutting tools. Clean water can be used, but the pipe components must be dry and clean before starting the installation process.

5.4. Re-Rounding / Scratches

As flattening, excessive ovality and scratches may have a negative influence on the fusion quality, select an appropriate area for the saddle placement. The shape of the pipe in the related fusion zone must comply with the requirements of the fitting manufacturer.

Check shape of the pipe with fitting curvature or similar gauges and compare with the required tolerance given by the fitting manufacturer. If required apply re-rounding tool/ place re-rounding clamp on the pipe immediately outside of the proposed fitting position. Re-check out of roundness of the pipe and reposition tool, if required.

5.5. Peeling of Multi-Layer Pipes, if applicable

Consult the specific pipe supplier regarding the tools and procedure for removal of the peelable skin and then continue with procedure.

5.6. Mechanical Scraping

Measure area which must be mechanically scraped (fitting area, length and with plus 2 cm) with a yardstick on the pipe and mark with a permanent pen. Scrape the pipe with rotary or window scraping tool or with a hand scraper. Scrape the pipe surface until the outer "skin" of the pipe has been removed to expose a clean, virgin pipe material. Inspect the entire fusion area to ensure total scraping coverage. Min. swarf removal of 0.2 mm has to be fulfilled.

Figure 35 & 36: *Marking the area for scraping*

Figure 37: *Window scraping tool*

Figure 38: *Rotary scraping tool*

5.7. Cleaning

The Electrofusion saddle fitting should only be removed from its packaging immediately before the planned jointing process and without touching the fusion zone.

Clean pipes only in the scraped area with Ethyl-Alcohol (>99.8%) and saddle fusion zone with colourless, lint-free, absorbent, non-dyed and clean paper towel. Use several new paper towels for larger areas and for each component. Avoid cross-contamination of the pipes from outside of the scraped zone. Let the cleaner evaporate.

Avoid all possible recontaminations of the prepared surfaces (should not be touched with bare hands due to body oils), as this could affect the jointing quality!

Make sure that any possible moisture, dew or frost is removed.

Figure 39: *Cleaning of the scraped area*

5.8. Clamping of the saddle

The installation manual supplied by the specific saddle manufacturer should be strictly complied with as the requirements for clamping/ top-loading of the saddles and the clamping techniques and procedures for each brand of saddle can vary significantly. Place saddle in the correct position and within the prepared pipe area. After clamping check to confirm that the gaps between saddle and pipe are within recommended levels.

Figure 40: *Mechanically clamped system*

Figure 41: *Vacuum system*

5.9. Fusion

Check compatibility before starting the fusion (dimensions, SDR).

Start the fusion process in accordance with the user manual supplied by the specific manufacturer of the fitting and fusion unit.

Keep a distance of at least one metre away from the fusion site during the fusion process for general safety reasons and in order to control and supervise the fusion process. (See next section "Cooling and quality control of fusion")

In case of interruption during the fusion process (generator, fusion unit break-down), consult the fitting manufacturer's installation manual for the recommended re-heating process.

5.10. Quality control of fusion

During and after the fusion process check the following:

- No error message on the fusion unit
- No melt exudation outside the saddle confines
- No unusual deformations of pipe or saddle
- Fusion indicators show correct result
- Fitting remains stress-free and avoid dislocation until complete cooling time has elapsed

5.11. Mark fusion parameters

Mark the relevant fusion parameters (date, joint number, fusion time, cooling time and welder name) on the fitting and in the job site documentation. Electronically processed documentation and traceability is recommended.

5.12. Cooling

Consider different cooling times for leak-tightness-test and tapping.

5.13. Leak tightness test

Following the welding of saddles a leak-tightness-test through the outlet before tapping the outlet is recommended.

5.14. Tapping Equipment / Tapping under pressure

If separate tapping equipment is used the installation procedures have to be followed. Special attention is drawn to tapping of pipes under pressure.

5.15

The excess materials from cutting, scraping and peelable layer shall be removed after the installation.

6. Typical failures and root causes

6.1. Misaligned pipes

Due to high stresses on the joints, moving wires result in overheating and melt flow at the inner or outer cold zone. Overheating can cause voids or pipe/ fitting deformation.

> Use alignment clamps to avoid misalignment

6.2. Pipe joint not centred

If the pipe is not centered, not properly cut or not fully inserted into the fitting, melt and wires can cause uncontrolled flow into the pipe gap. Overheating can cause voids or pipe/ fitting deformation.

> Mark insertion depth and control penetration to avoid

> Use alignment clamp to avoid pipe movement

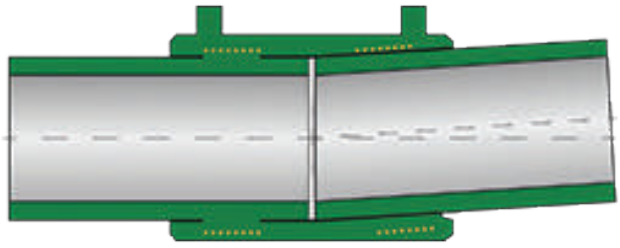

Figure 42: *Misalignment*

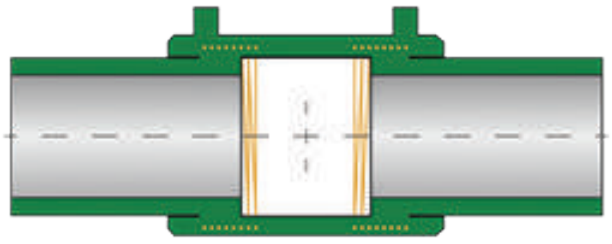

Figure 43: *Insufficient insertion*

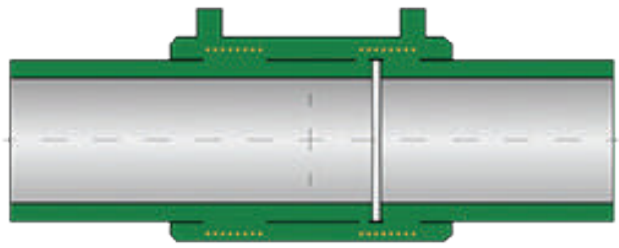

Figure 44: *Pipe not centered*

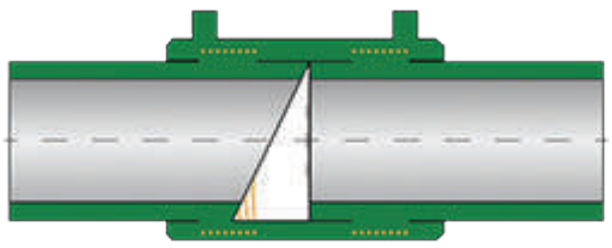

Figure 45: *Pipe not cut properly*

6.3. Excessive pipe toe in, pipe scratches, flattenings

Excessive pipe toe-in may result in melt exudation into the pipe gap.

Pipe scratches (even minor ones) that are not peeled off during mechanical scraping, can result in poor bonding, as the surface in the scratch is not prepared (scraped). This can result in the formation of a leak path.

Flattened sections on the pipe locally can increase the gap excessively. Flattened pipes do not comply with the specification and cannot be re-rounded!

- Cut away the pipe toe-in.
- Avoid positions with scratches or flattened sections or apply a second mechanical scraping, providing the pipe will remain within the dimensional specification.

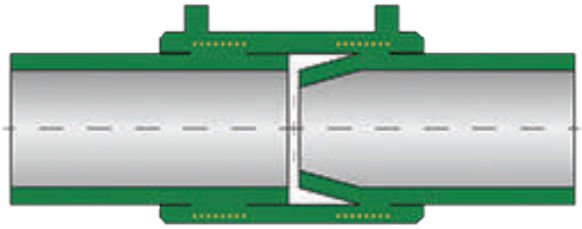

Figure 46: *Pipe toe-in*

6.4. Insufficient peeling

The oxidized surface is not sufficiently removed by mechanical scraping. This will result in insufficient bonding and leakage may occur.

- Use mechanical scraping tool and control chip removal frequently to create a consistent and reliable scraping result.

6.5. Insufficient cleaning/ cross contamination

A contaminating layer prevents the pipe surface from bonding with the fitting. This may be caused by body oils, other lubricants or trench contaminations.

- Avoid touching, contaminating fusion areas after peeling
- Clean pipe surfaces and fittings in the appropriate way

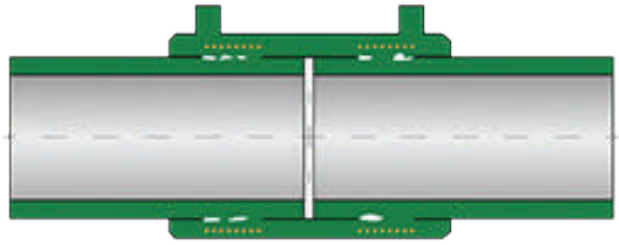

Figure 47: *Insufficient peeling*

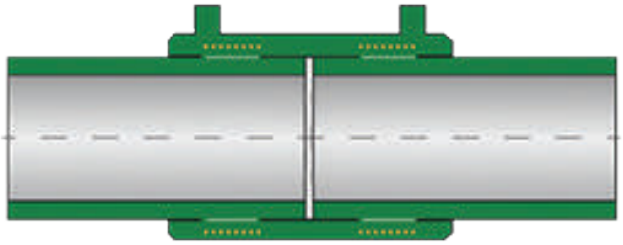

Figure 48: *Insufficient cleaning*

6.6. Intended use and operation

Gas and Water according to EN 1555, EN 12201, ISO 4427, ISO 4437 and Industrial applications according to ISO 15494.

6.7. Pressure test

Pressure test of the piping system should be conducted in accordance with the national regulations. Typically a 1.1 x PN test pressure is applied with medium drinking water. A conditioning time of minimum 12 hours and a conditioning pressure of minimum the nominal pressure should be carried out when filling and conditioning with water. Make sure that the pipe section is completely free from air before testing.

7. Checklist for planning

Documents	Availability	Criteria	Check
		Welder pass	
		Certificates	
		Instructions	
Generator		In working order	
Fusion Box		Suitable for the job	
Ext. cables		Application range	
Scraper Tool		Valid calibration (EF box, scraper tool)	
Cutting Tool		Check generator fuel tank is full	
Specific installation tools		Manuals available	
Re-Rounding tool		Application range	
Clamps		Application range	
Rollers		Application range	
Cleaning Solvent		Sufficient cleaner (e.g. highly pure Ethyl-Alcohol (>99.8%))	
Lint free cloth			
Marker pen			
Yardstick, Pi tape			
Handling device		Safety on site	
Pipes		Correct dimensions	
		Compatibility, application range, colour	
Fittings		Pressure class, SDR	
• Socket		Visual aspects	
• Saddle		Quality aspects	
Site installation conditions		Clean	
		Dry	
		Free from grease	

About TEPPFA TEPPFA is The European Plastic Pipe and Fittings Association founded in 1992 with headquarters in Brussels. TEPPFA's multinational company members and national associations across Europe represent 350 companies that manufacture plastic pipes and fittings. TEPPFA's members have an annual production volume of 3 million tonnes directly employing 40,000 people with €12 billion combined annual sales. TEPPFA positions itself as polymer neutral. Its final products are subdivided into 3 application groups: 1. Building (above ground systems for hot & cold-water supply, surface heating & cooling, waste water discharge and rainwater drainage); 2. Civils (below ground pipe systems for sewers, stormwater management and sub soil drainage); 3. Utilities (below ground pipe systems for distribution of drinking water, gas, energy and telecommunications).

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