	NEGEV Natural GAS
Ref. No. SWS-NNG-027	Client Project No: XXX-XXX-XXX-XXXX

PE welding procedure

0	16/12/2013	For Approval	RK	YL	DS
Rev.	**Date**	**Description**	**PRPD**	**CHD**	**APPD**

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1. Introduction

Negev Natural Gas (NNG) has been selected to construct a distribution pipeline network of natural gas in Negev area; the distribution network includes three major grids:

- Ramat Hovav Pressure Reduction Station (PRS) to Beer Sheva municipality.
- Eshel Hanasi Pressure Reduction Station (PRS) to the Ofakim industrial zone.
- Dimona Pressure Reduction Station (PRS) to the Yeruham industrial zone.

NNG will be using, as main pipe, PE100 material to connect the various industrial consumers in the Negev area.

2. References

- SI 5664 Part 3
- XXX-NNG-015 – PE welding procedure
- EN 1555-2 - Plastics piping systems for the supply of gaseous fuels – Polyethylene (PE) – Pipes
- ISO 14531 – Plastics pipes and fittings – Cross linked polyethylene (PE-X) pipe systems for the conveyance of gaseous fuels – Metric series - Specifications
- EN 1555-3 Plastics piping systems for the supply of gaseous fuels – Polyethylene (PE) – Fittings + A1:2005
- EN 1555-4 Plastics piping systems for the supply of gaseous fuels – Polyethylene (PE) – Valves:2002
- EN 13067 Qualification of welders
- Standard GGG-STD-CSE-0001 Rev03 - General Construction Standards
- ISO 12167 – Welding machines
- EN 1555-5 Plastics piping systems for the supply of gaseous fuels – Polyethylene (PE) fittings for purpose of the system
- PPI Handbook of PE Pipe, 2nd edition
- PPI TR33 - Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe
- PPI TR41 - Generic Saddle Fusion Joining Procedure for Polyethylene Gas Piping

3. Scope

This procedure specifies the requirements for joining of polyethylene (PE) pipe and fittings by butt fusion or electro fusion techniques approved by NNG. Butt fusion is to the primary joining technique however there will be instances in which electro fusion joining will be used. In any case that a different joining method is used or changed in the field, NNG must be notified and a deviation report filed.

This procedure is in direct reference to XXX-NNG-002 – Visual inspection procedure for PE welding. For proper inspection to occur, the fusing personnel must be familiar of all of the requirements set forth in the PE welding procedure and in accordance with the manufacturer's specifications. Only personnel with appropriate training in the specific PE joining procedure(s) being used shall be qualified in evaluating the acceptability of the joint itself.

The following words and all derivatives may be used synonymously for the connecting of PE pipe and fittings: "join", "fuse", and "weld".

4. General

Pipe joining (GGG-STD-CSE-0001 Rev04 section 9) will be conducted in accordance with all relevant laws, codes, and regulations. Of particular relevance is Israeli Standard 5664-3 Sections 820-827, 842.39 and 842.4, 831.4, 831.5, 833, 834, 835.

The following items are important aspects relating to PE welding/fusing. It is important that each step of the PE welding procedure is completed accurately and in the correct sequence.

- Joining of HDPE pipe should be undertaken by competent operators using approved procedures, based on ISO/TS 10839 equipment and material.
- Before any pipe joining is carried out, the area will be checked for the presence of a combustible gas mixture. Only when safe conditions are found may pipe joining proceed.
- In all cases, manufacturers' specifications should be referenced.
- Whenever possible, material and tools for joining plastic pipe should be chosen to ensure consistency and compatibility between the equipment (for example, the electro fusion machine should be able to join pipes of various manufacturers and read any type of bar code.)
- Ensure that conditions are suitable for fusing plastic pipe. Check all relevant parameters, including:

  - Ambient temperature (check with fusion machine manufacturer for maximum fuse ambient temperatures and climactic conditions during fusing).
  - Pipe material (i.e. PE 100)
  - Pipe wall thickness (i.e. SDR 11)
  - Time required for heating and cooling
  - Pipe condition (PE pipe, particularly larger diameter pipes delivered on coils, may require straightening before fusion).
- Always read the print line on the piping to verify correct diameter, material grade, and SDR. Do not install PE piping that is over 2 years old.
- The welds shall be executed in a dry environment to prevent moisture contamination.
- Protect the pipe ends and any fittings from extreme environmental and weather conditions including rain, high humidity, wind, and sunlight. Cover the work area and/or pipe ends to prevent rapid cooling, to keep the pipe ends and fittings at the same temperature, and to protect from the elements.
- NNG supervisor will approve the starting of the weld at the beginning of every day. The weld will not be executed if the temperature of below -5 degrees (Celsius) or higher then 40 (Celsius).
- All PE pipe shall be properly grounded prior to any fusing work.
- PE pipe ends and fittings to be joined will be inspected for damage including scratches, kinks, and gouges prior to welding. Defects greater than 10% of the pipe wall thickness or pipe out-of-round must be cut out. Damaged or otherwise defective fittings will not be used.
- PE pipes from coils are oval and bent immediately after uncoiling. The pipe ends will be prepared before welding, e.g. by re-rounding tool
- Clean the pipe, pipe ends, and joining fittings (if used) prior to the welding per the PE welding procedure with 90% isopropyl alcohol or other chemical approved by NNG and the pipe manufacturer to ensure the surface is free of contaminants such as mud, oil, grease, or water. Use clean, approved, lint-free, non-synthetic rags for wiping and drying.

- "End of Fusion Time (EOFT)" shall be written on the outside of the pipe adjacent to the weld when completed but not fully cooled.
- Proper cool down times shall be followed after the weld has been completed before handling the assembled pipe. No accelerated cooling is permitted.
- Upon acceptance of weld by visual inspection, the welder's ID number shall be written on the pipe adjacent to the weld and in permanent marker.

5. Butt welding procedure for joining PE pipe

Plastic butt fusion is the preferred method for joining sections of plastic pipe with like thickness and PE grade, particularly for longer stretches of straight pipes without many branch connections. When performed properly, butt fusion will result in strong, reliable welds

Plastic butt fusion should be carried out in accordance with manufacturers' instructions. Where deemed necessary by the manufacturer, a 'trial joint' will be made at the start of the jointing session, to ensure weld quality. SWS will perform a test weld at the beginning of every welding day.

5.1 Pre-conditions

- Fusilier to verify and inspect all butt welding equipment is onsite and in proper working order. Inspection of equipment should include but is not limited to electric cords, facer blades, heater plate condition and temperature.
    - Verify heating plate surfaces are clean and free of residue otherwise clean with approved chemical.
    - Continuously check the heating plate to verify temperature (within allowable range) the pipe manufacturer's specification using a properly calibrated pyrometer.
    - Temperatures my range from 204-232°C. Verify PE100 temperature requirements.
    - Adjust heater plate as necessary.
- Do not butt weld dissimilar pipe.
- Do not fuse in an explosive atmosphere with approved amendments to the weld procedure (which may include de-energizing the facer and heating plate).

- Measure to ensure the pipe ends are the correct diameter and wall thickness.
- Ensure all pipe is properly grounded.

5.2 Clean and Secure

- Clean pipe ends inside and outside with 90% isopropyl alcohol or other chemical approved by NNG and the pipe manufacturer. Use clean, approved, lint-free, non-synthetic towel or rag for wiping and drying. Ensure all foreign material is removed.
- Place pipe in fusion unit and tighten jaws to prevent slippage. Bring the pipe ends together and applying force. Ensure alignment and that jaw clamps are tight enough to prevent pipe slippage during fusion. Do not over tighten clamps due to risks of pipe deformation and subsequent fusing issues (hi-lo).

5.3 Face

- Properly face pipe ends to a minimum of 2 mm depending on the square-ness of the pipe ends. Always bottom-out facer against fusion unit clamps.
- Turn off powered facers (electric or hydraulic).
- Separate the clamps and remove the facer.
- Remove debris, shavings, and/or other foreign material with a clean, approved, lint-free, non-synthetic towel or rag. Do not touch the pipe for fitting ends with your hands after this point.
- Bring pipe ends together with minimal force and inspect the face off to verify that the faces are square, perpendicular to the pipe centerline, and with no detectible gap.
- Perform light entrance check for alignment (if needed).

5.4 Align

Bring the pipe ends together to check for proper alignment. If alignment does not exist, adjust the high side clamp. Never loosen clamps to correct alignment! If adjustments are made, reface the pipe ends and remove and shavings with a clean, approved, lint-free, non-synthetic towel or rag

5.5 Melt

- Verify the heater plate surfaces are clean and free of residue, nicks, and scratches.
- Recheck heater temperature and proceed only if temperature is within acceptable range.
- Place heater plate in the fusion unit and move component ends against the heater plate. Initial contact should be under moderate pressure for only a brief moment and then released without breaking contact.
- Continue to hold the pipe ends and heater plate in contact without force to develop the molten PE bead.
- When proper bead size is formed around the full circumference of the pipe, remove from contact the pipe ends from the heater plate. Remove the heater plate. Refer to the table below for approximate melt bead size.

PE wall thickness (mm)	Bead width (mm)
3	4-6
4	4-7
5	5-8
6	6-9
8	7-10
9	8-11
11	9-12
13	10-14
16	11-15
18	12-16

- **Note:** Excessive pressure during the melting cycle causes a concave melt pattern also known as “race track” appearance. This effect results in an unacceptable fusion joint creating a “cold ring” in the center of the fusion joint and will weaken the final assembly.
- **Note:** When butt welding in cold weather, heating/melting time might be affected. Focus should be on developing the proper bead size rather than on time elapsed.
    - Do not increase the heater plate temperature
    - Do not apply additional pressure during melt
    - Do not increase butt welding joining pressure

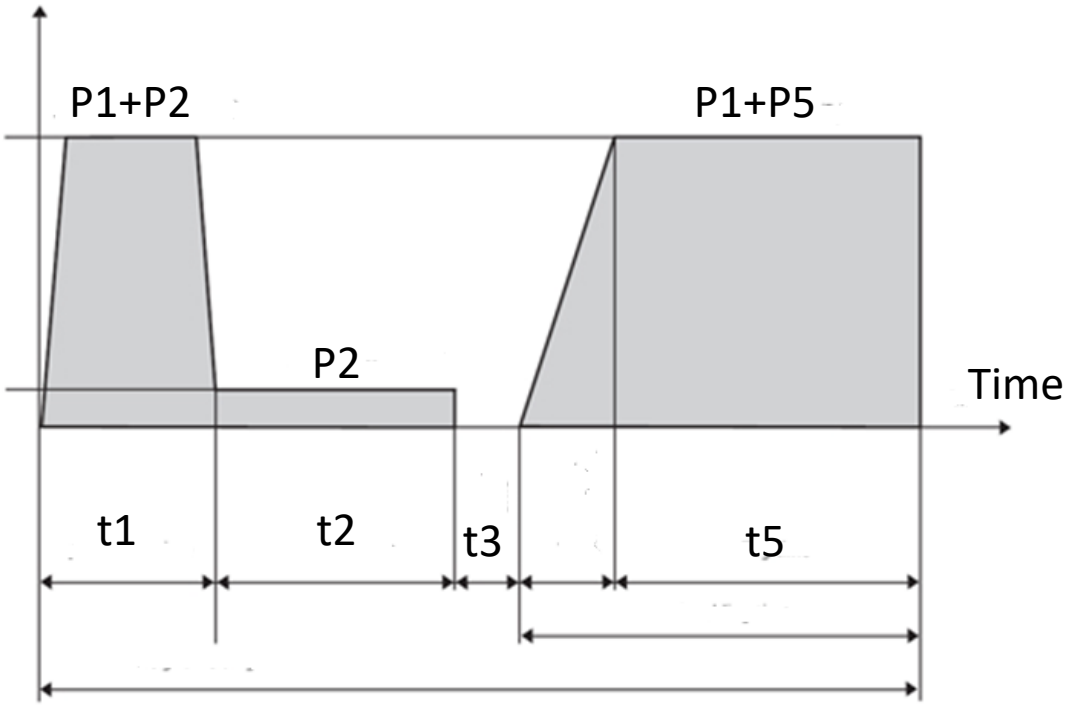
- Refer to the melt, join, and hold time and pressure plot in section 5.7.

5.6 Join

- After heater plate removal, quickly inspect the pipe ends for concave melt and verify the melted surfaces are neither damaged nor contaminated. If concave melt exists, **do not continue**. Allow time to cool and restart procedure.
- Immediately bring the pipe ends together with sufficient force to generate the required interfacial fusion pressure per the manufacturer's requirements. A double rollback bead will form against the pipe wall. Do not slam or apply excessive pressure.
    - Interfacial pressure is determined by multiplying the manufacturer's recommended interfacial pressure, usually 4.14 to 6.21 bar, by the pipe area.
    - Hydraulic machine will need to account for additional drag force (if pulling strung pipe), the fusion machine design, the pipe diameter, and standard dimension ratio (SDR).
- Refer to the melt, join, and hold time and pressure plot in section 5.7.

5.7 Hold

- Hold the joint immobile under fusion force until the joint has cooled adequately to develop strength and ultimate integrity of the assembly.
- Hold time at constant fusion force should be from approximately 30 to 90 seconds per inch nominal pipe size or longer until surface of the melt bead is cool to the touch.
- Avoid pulling, installation, or rough handling for an additional 30 minutes. Additional cool down time may be required for wall thicknesses above 50 mm.
- Refer to the melt, join, and hold time and pressure plot in below.



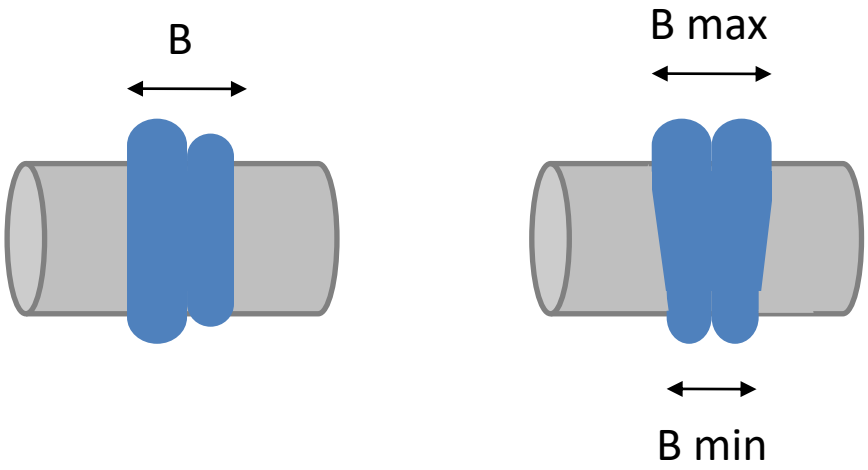
1	2	3	4	5	
Nominal wall thickness	Alignment	Heating-up	Changeover	Joining	
	Bead height on heated tool at the end of the alignment time (alignment with 0.15 N/mm²)	t2 Heating-up time = 10 x wallthickness (heating-up with ≤0.02 N/mm²)	t3	t4 Joining pressure build-up time	t5 Cooling time under joining pressure p=0.15 N/mm² ±0.01
mm	mm (minimum values)	s	s maximum time	s	min (minimum values)
bis 4.5	0.5	45	5	5	6
4.5 ... 7	1.0	45 ... 70	5 ... 6	5 ... 6	6 ... 10
7 ... 12	1.5	70 ... 120	6 ... 8	6 ... 8	10 ... 16
12 ... 19	2.0	120 ... 190	8 ... 10	8 ... 11	16 ... 24
19 ... 26	2.5	190 ... 260	10 ... 12	11 ... 14	24 ... 32
26 ... 37	3.0	260 ... 370	12 ... 16	14 ... 19	32 ... 45
37 ... 50	3.5	370 ... 500	16 ... 20	19 ... 25	45 ... 60
50 ... 70	4.0	500 ... 700	20 ... 25	25 ... 35	60 ... 80

5.8 Inspect

This inspection should be completed by both the fusilier and the inspector. Both are liable for completing acceptable welds.

- The double bead should be rolled over the surface on both sized and be uniformly rounded and consistent in size all around the joint (full circumference).
- Refer to bead tolerance information below.

Pipe to pipe: $B_m = (B_{max}+B_{min}) / 2 \pm 10\%$
Pipe to fitting: $B_m = (B_{max}+B_{min}) / 2 \pm 20\%$
Fitting to fitting: $B_m = (B_{max}+B_{min}) / 2 \pm 20\%$



- The double bead width should be 2 to 2-1/2 times its height above the pipe to the top of the beads. The V-groove between the beads should not be deeper than half the bead height above the (outside) pipe surface.
- When butt fusing to molded fittings, the fitting-side bead may display shape irregularities such as minor indentations, deflections, and non-uniform bead rollover from the molded part cooling and knit lines. Visual inspection should be based mainly on the size and shape of the pipe-size bead.
- Ensure all steps of the butt weld procedure were completed accurately and in the proper sequence.
- Once fusion time as elapsed, the fusilier writes the EOFT on the pipe wall adjacent to the weld in permanent marker. If accepted by the inspector, the inspector shall also write the fusilier's ID number adjacent to the weld on the opposite side in permanent marker.

- Any unaccepted joint shall be cut out and re-welded. Unacceptable joints include:
    - V-shaped rollback bead
    - Angled, off-set (“miter” looking misalignment)
    - Bead too small
    - Bead too large
    - Longitudinal misalignment
    - Incomplete facing

5.9 Heater plate care

- Clean both sides of the heater plate after each fusion joint with a clean, approved, lint-free, non-synthetic towel or rag to prevent contamination. Apply pressure while cleaning.
- Store heater plate in an insulated bag or stand.
- Never spray chemicals on metal tools on heater plate surfaces.

6. Electro fusion procedure for joining PE pipe

Electro fusion is an acceptable technique for connecting pipes and/or fittings, and can be used to join pipes with different grades of PE or wall thickness. It can also be convenient for fusing long lengths of coil pipe. Preferably automatic control units with data retrieval units will be used. Fittings with barcodes that can be read automatically by the control unit allow for reliable, fast installations.

Electro fusion should be carried out in accordance with manufacturer’s instructions. As such, careful attention should be paid to proper heating and cooling times per manufacturer’s specifications.

6.1 Pre-conditions

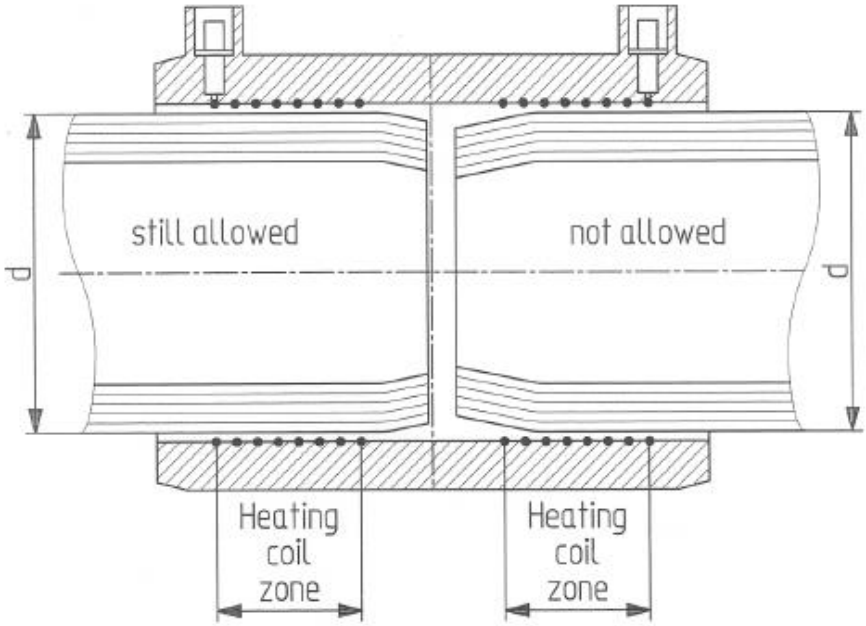
- Fusilier to verify and inspect all electro fusion equipment is onsite and in proper working order. Inspection of equipment should include but is not limited to electric cords, connection cables/leads, power source, barcode scanner, etc.
- Electro fusion couplings/welding can be used to fuse dissimilar pipe materials. Consult fit the pipe, fitting, and electro fusion control box manufacturer’s to ensure proper settings (voltages, currents, etc.) are set up for the fitting barcode scan and eventual fusion.
- Measure to ensure pipe ends are the correct diameter and wall thickness.

- Ensure all piping is properly grounded.

6.2 Surface preparation, cleaning, and marking

6.2.1 Coupling installation for end joints

- Cut pipe ends to ends square using a PE guillotine, shears, or wheel cutters. Thoroughly clean pipe or fitting ends and coupling inside and out with90% isopropyl alcohol or other chemical approved by NNG and the pipe manufacturer. Use clean, approved, lint-free, non-synthetic towel or rag for wiping and drying. Ensure all foreign material is removed.
- Insert each end into the coupling to its full fitting penetration depth. With a permanent marker, mark this maximum bury depth on each side of the coupling.



- Remove ends, scrape, and remove all surface oxidation past the previous penetration depth markings with approved scraper tools. No more than 2 mm or 10% of wall thickness shall be removed. Virax and Upon or circumferential scrapers are preferred. Paint scrapers are also acceptable. Knives, sandpaper, utility cloths and files are unacceptable tools for removing surface oxidation.
- Re-insert the pipe ends into the coupling to its full fitting penetration depth. With a permanent marker,

mark this maximum bury depth on each side of the coupling. Remove the ends from the coupling.

- Rounding rings can be installed on the pipe ends if needed. Maximum out-of-roundness will not be more than 1.5%:

$$\frac{D_{max} - D_{min}}{D_n} \times 100 \leq 1.5$$

- Clean scraped pipe ends and coupling using 90% isopropyl alcohol or other chemical approved by NNG and the pipe manufacturer. Use clean, approved, lint-free, non-synthetic towel or rag for wiping and drying. Do not allow air drying and do not touch the pipe for fitting ends with your hands after this point!

6.2.2 Saddle installation for branch or tee connections

- Clean the pipe surface using 90% isopropyl alcohol or other chemical approved by NNG and the pipe manufacturer. Use clean, approved, lint-free, non-synthetic towel or rag for wiping and drying.
- Lay fitting saddle on pipe and mark pipe are to be scraped while still in plastic bag.
- Scrape and remove all surface oxidation past the pipe markings by at least 12 mm with approved scraper tools. No more than 2 mm or 10% of wall thickness shall be removed. Virax and Upon or circumferential scrapers are preferred. Paint scrapers are also acceptable. Knives, sandpaper, utility cloths and files are unacceptable tools for removing surface oxidation
- Again, lay fitting saddle on pipe while still in plastic bag to verify limits of scraping are large enough.
- Clean the scraped surface using 90% isopropyl alcohol or other chemical approved by NNG and the pipe manufacturer. Use clean, approved, lint-free, non-synthetic towel or rag for wiping and drying. Do not allow air drying and do not touch the pipe for fitting ends with your hands after this point!

6.3 Align

6.3.1 Coupling installation for end joints

- Insert ends into the coupling for final assembly. Ensure the ends are butted flush against one another to eliminate an excessive gap at the middle which can result in a short stab, unacceptable joining.
- Ensure the ends are inserted to the marked depths.
- Install alignment bar clamps or equivalent so they are equally spaced from the coupling. NNG plans to use air force standard strips (**רצועות חיל האוויר**) with fast unlock option. Use slings to attach the strips to the pipe.
- Apply tension to the clamps but do not over tighten. The coupling should turn freely.

6.3.2 Saddle installation for branch or tee connections

- Remove the electro fusion saddle fitting from the plastic bag.
- Clean the surface of the saddle that will contact the pipe using 90% isopropyl alcohol or other chemical approved by NNG and the pipe manufacturer. Use clean, approved, lint-free, non-synthetic towel or rag for wiping and drying. Do not allow air drying and do not touch the pipe for fitting ends with your hands after this point!
- Position the fitting on the pipe within the limits of scraping. Install the under saddle component by sliding action until it contacts the stop. The under saddle should only go on in one direction and may need to be tapped with a mallet to reach the mechanical stop. Ensure the fitting has not shifted off of the scraped area of the pipe.

6.4 Electro fusion control box setup

- Connect control box to power source or ensure batteries have been installed.
- Turn the power on and verify unit charge and fitness for operation. Refer to manufacturer's operating instructions and follow the setup procedure to prepare the unit for barcode scanning and subsequent fusing cycle.
- Connect the wire leads or cables to the electro fusion fitting.

- Scan the fitting's barcode and verify the control box identifies the correct fitting on the display.
- Press the start button on the control box to initiate the fusion cycle.

6.5 Fusion cycle

- Once the start button has been pressed, the control box will apply the correct voltage and amperage to the wire coil in the fitting to initiate fusing.
- Watch for rising material from the indicator wells during fusion.
- The control box will usually alarm or beep when the fusion duration has elapsed. Record the EOFT on the pipe and log for future reference.
- Wait an additional minute before disconnecting the control box leads.

6.6 Cool down

- Avoid disengaging alignment support, pulling, installation, or rough handling for the entire cool down duration listed on the fitting barcode. Coiled pipe requires double the cool down period listed on the barcode.
- Do not disturb the assembly during cool down because this can create thermal expansion/contraction issues with is an unacceptable weld.
- If fusing the connections of a single fitting separately, the second (or next) fuse can start immediately after the control box ends the first. However, the cool down period does not start until the last fusion cycle has finished.

6.7 Inspect

- After the fusion duration and cool down, inspect the fusion fitting and weld for the following indicators of an unacceptable weld:
    - Improper alignment and significant PE material outflow at pipe surface(s)
    - Short stab conditions with depth markings beyond the electro fusion fitting's ends.
    - Surface scraping does not extend beyond the fitting

- No visible outflow from the fitting's molten material wells (if equipped)
- Excessive space between the pipe outside diameter and the fitting inside diameter

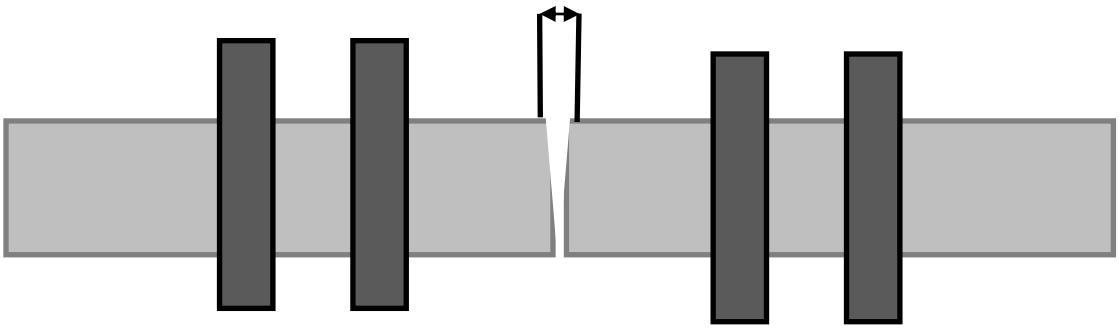
- If accepted by the inspector, write the fusilier's ID number adjacent to the weld on the opposite side of the EOFT in permanent marker.

7. Light entrance check and alignment

- When pipes are pressured just before welding the light visual entrance inspection will be done:

Diameter	Light [mm]
>250 mm	0.3
250-400 mm	0.5

- Alignment of 10%, but not more than 2 mm, is allowed
- See diagram below



8. Welding machines

Welding machines should be in accordance with ISO 12167 and GGG-STD-CSE-0001 Rev04. The welding machines will have the following features:

8.1 Butt welding machine

	Mandatory	Full CNC (Optional)
Ambient temp. sensor	X	X
Universal welding machine (bar code reader)		X
Hydraulic operation	X	X
Automatic drag force calculation		X
USB connection and data logger	X	X
Alarm indication	X	X
Wind sensor		X
Torsion pressure auto calculation		X
Welding pressure auto display	X	X

The welding machine to be used in this project will not be full CNC, in case of machine change, NNG will be notified

8.2 Electro fusion machine

	Mandatory	Full CNC (Optional)
Ambient temp. sensor	X	X
Universal welding machine (bar code reader)	X	X
USB connection and data logger	X	X
Alarm indication	X	X
Wind sensor		X

Protocol form for the Electrofusion welding of pipes and pipeline components

	o laid overground	Material	Sheet	of
	o laid underground			

Customer	Executive company	Welding equipment:	Weather 1 = sonny 2 = dry 3 = rain or snow 4 = windy	Preventive measures 1 = none 2 = umbrella 3 = tent 4 = heating
Name of order	Name of welder / Identification No.	Label: Type:		
No. of order	Name and company of the welding supervisor	Machine No.: Year of construction:	Order as above in case of multiple nominations (e. g. 34 = rain and wind)	

Weld No.	Date	pipe dimension ø d × s mm	Fitting data A	Fitting data B	Fitting data Serial No.	Unit setting manual	Unit setting automatic	Resistance of the fitting[1] Ohm	Secondary voltage[1] Volt	Welding times[2] joining s	Welding times[2] Cooling s	Environmental temperature °C	Code-No. Weather	Code-No. Preventive measures	Operating mode Mains	Operating mode Generator

Welding signature:	Date and signature of welding supervisor:

[1] Enter where applicable according to system used.
[2] Enter measured values.

A = Manufacturer's code
B = Fitting code
1 = Coupler 2 = Angle 3 = T-piece 4 = Reduction
5 = Saddle 6 = Cap 7 = Connecting piece 8 = Fitting

Protocol form for the Heated tool butt welding of pipes and pipelines components

o laid overground
o laid underground

Material

Sheet | of

Customer	Executive company		Welding equipment:	Weather	Preventive measures
				1 = sunny	1 = none
Name of order	Name of welder	Identifi-cation No.	Label:	2 = dry	2 = umbrella
			Type:	3 = rain or snow	3 = tent
No. of order	Name and company of the welding supervisor		Machine No.:	4 = windy	4 = heating
			Year of construction:	Order as above in case of multiple nominations (e. g. 34 = rain and wind)	

Weld No.	Date	pipe dimensions ø d × s mm	checked heated tool temperature[1] °C min/max	workpiece movin pressure bar	Joining pressure (data of manufacturer) bar	Set values[2] heating up bar	Set values[2] alignment joining bar	heating-up time[3] s	Joining pressure build-up time[3] s	Change-over time[3] s	Cooling time under joining pressure[3] s	Environmental temperature °C	Code-No. Weather	Code-No. Preventive measures	Notes

Welder signature:

Date and signature of welding supervisor:

[1] From periodic interval, frequency according to 4.1.2.
[2] According to data of equipment manufacturer resp. welding equipment test plus workpiece moving pressure.
[3] Enter measured values.

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