

**WELDING
MANUAL**
POLYETHYLENE PIPELINES



CONNECTING WORLDS

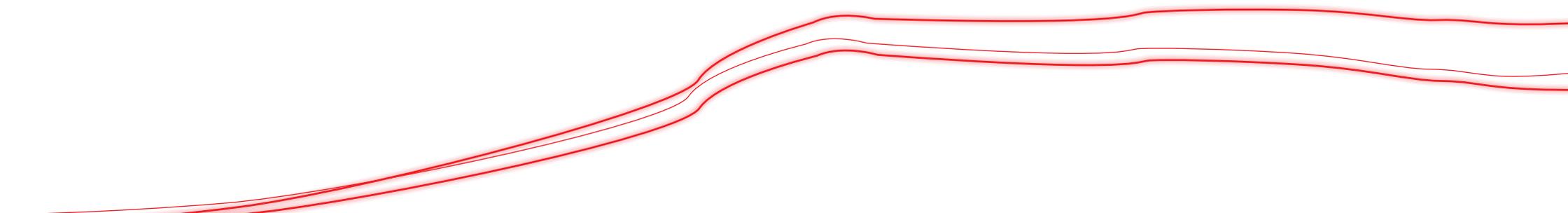
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// BUTTFUSION JOINTING

WELDING CYCLE AT SINGLE PRESSURE

“Welding with heated elements by contact”, commonly named “buttfusion jointing” is defined as the jointing proceeding of two elements (pipes and/or fittings) where the surfaces to be welded are at first heated by contact with an heating element and subsequently, after the removal of the heating plate, are joined together with pressure in order to obtain the welding. The process is defined by the standard UNI 10520 and applies to polyethylene elements with maximum wall thickness of 65 mm.

The welder, involved in the welding of the joints, must be qualified according to the standard UNI 9737 for the classes 3PE 3.4 and/or 3.5.

The buttfusion jointing is applicable to PE 80 and PE 100 pipes and fittings with the same nominal diameter (preferably higher than 50 mm), equal SDR (therefore, same nominal thickness) and melt flow index “MFR” comprised in the range:

$$0,2 \div 1,4 \text{ g} / 10 \text{ min} (190 \text{ }^\circ\text{C} / 5 \text{ kg})$$

PREPARATION

Welding must take place in a dry site and ambient temperature field comprised between:

$$-5 \text{ }^\circ\text{C} \div + 40 \text{ }^\circ\text{C}$$

When necessary, suitable protection measures must be taken to protect the welding operation from adverse ambient conditions such as portable tents, equipped boxes or others. It is absolutely forbidden the use of gas torch or flame burners in order to increase the temperature surfaces to be welded.

PRELIMINARY CONTROLS

The operator must arrange himself in order to have the complete visual control on the different operations and must have the necessary space to work without constraints, in a dry place and whatsoever possible on a level surface. The elements must be collected from storage according

PREPARATION // Welding must take place in a dry site and ambient temperature comprised between -5°C and $+40^\circ\text{C}$



PRELIMINARY CONTROLS // Verify that the inside and outside surfaces of the pipes and/or fittings, near to the ends to be welded, are free of cuts and abrasions



PRELIMINARY CONTROLS // Verify the thickness, the mean outside diameter and the ovalization of the pipes and/or fittings, with reference to tolerances detailed in the applicable product standards



PRELIMINARY CONTROLS // Evaluate the efficiency of the equipment which will be used with reference to the requirements of the standard UNI 10565



to the updated standards and must be checked before the start of the welding operations; particularly, it is necessary to verify that the inside and outside surfaces of the pipes and/or fittings, near to the ends to be welded, are free of cuts and abrasions that can compromise the correct welding and that the tolerances relative to thickness, to medium external diameter and to maximum ovalization allowed by the product standards are respected.

Furthermore, before starting the welding operations it is necessary to evaluate the efficiency of the equipment which will be used, with reference to the requirements of the standard UNI 10565.

The preparation of the surfaces to be welded are of main importance for the guarantee of the jointing quality and must be carried out following the next operations:

CLEANING AND FACING

Before positioning of the elements to be welded, it is necessary to clean their inside and outside surfaces in order to remove traces of dust, grease, earth residuals or mud and others. The operation is made by using a wet strong soft cloth drenched with proper detergent; avoid the use of water detergents. Following the same procedure, proceed by cleaning the facer tool and the heating plate.

The pipes/fittings must be closed in the welding machine jaws in the way to guarantee the possibility of axial movement without relevant frictions, by using special rollers where let the pipes slide. Misalignments must be reduced as much as possible, by rotating the two elements up to the most suitable connection condition or by working on the fixing systems of the jaws taking care to apply a correct clamping strength (if excessive, it can damage the surfaces of the pipes/fittings).

The facing operation must be carried out by moving both parts close to the rotating facer, only after starting up the tool and working a gradual pressure, in order to avoid an excessive heating of the contact surfaces or causing the tool stop. If the facing operation is correctly done, the shavings are continuous on both ends to be welded. The facer tool must be switched-off only after the moving away of the ends. The facer cutters must be sharpened or substituted whenever there are any problem or anomaly during the facing phase.

When facing is completed, the inside and outside shavings must be removed from the welding area using a clean cloth or brush. The faced ends cannot be touched any more with hands or get dirty; on the contrary, it is necessary to repeat the cleaning cycle.

CLEANING AND FACING // Clean the inside and outside surfaces of the ends to be welded with proper detergent



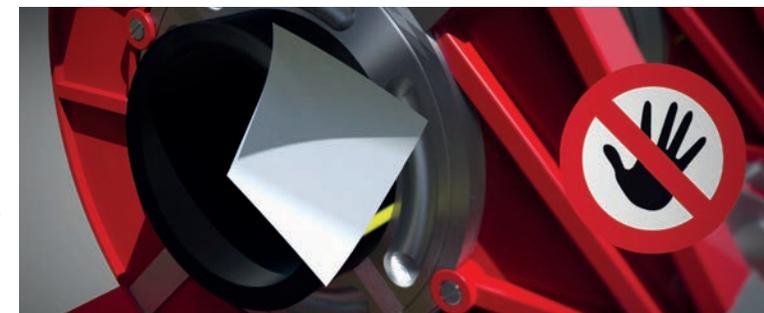
CLEANING AND FACING // Clean the facer tool and the heating plate with proper detergent



CLEANING AND FACING // Face the ends to be welded



CLEANING AND FACING // Remove the shavings and clean the ends to be welded with proper detergent, if necessary



CONTROLS

At end of the operation, after removing the facer tool, put into contact the surfaces to be welded in order to verify that:

- the maximum mismatch, measured on each point of the circumference, is not bigger than 10% of the thickness of the elements to be welded, with a maximum of 2 mm. On the contrary, it is necessary to repeat the aligning and facing operations;
- the possible detachment between the contact edges is lower than the values stated in the above table; on the contrary, the aligning and facing operations must be repeated.

EXTERNAL NOMINAL DIAMETER [d _n]	MAXIMUM DETACHMENT [mm]
up to 250	0,3
over 250 and up to 400	0,5
over 400 and up to 630	1,0
over 630	2/1000 d _n

HEATING PLATE TEMPERATURE

The heating plate necessary to heat the parts must guarantee the achievement of the working temperature within 20 minutes; after this time, on each point of both surfaces the temperature, read on the thermostat, must be comprised in a tolerance of ±10 °C with respect of the value set on the thermostat.

Independently from the material type (PE80 or PE100) and from the dimensions of the pipes/fittings to be welded (diameter and thickness), the heating plate temperature must be:

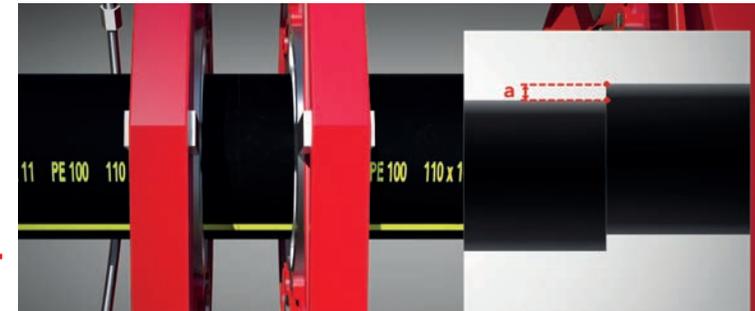
$$T = (215^{+10}_{-5}) \text{ } ^\circ\text{C}$$

CAUTIONS

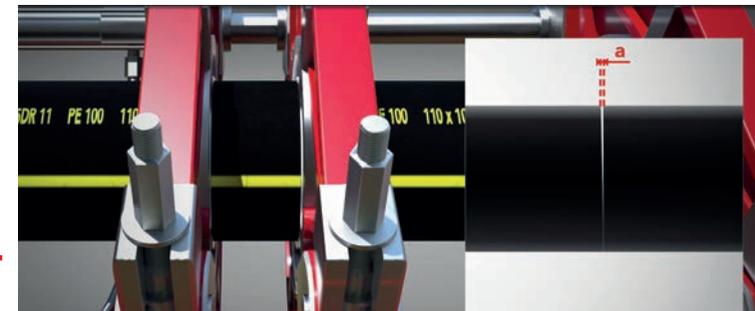
The operator must check that during the welding, no outside agents can occur to the correct performance of the jointing.

Frequently, for example, it can happen that the heating plate is cooled because of the air channelled inside the pipelines: in this case, take out the protection caps, normally inserted on the pipes only at end of the welding phase, or anyway close the pipe ends.

CONTROLS // Verify the mismatch of the ends between the contact edges



CONTROLS // Verify the detachment between the contact edges



The heating plate must be always placed in its special support to avoid damages to the superficial anti-adherent coating: this needs periodical reconditioning, according to the frequency use. Whenever traces of grease, dust or PE residuals are present, it is necessary to clean it at cold with proper detergent.

DRAG PRESSURE

The drag pressure P_t is the minimum pressure value necessary in order to win the friction of the movable part of the jaws of the welding machine (loaded with the pipe/fitting), which depends on the weight of the gear and of the pipes/fittings to be welded, from the oil temperature in the hydraulic circuit and the jaws clamping force. Its value has always to be traced experimentally using the pressure gauge or the pressure detector included with the welding machine, every time a welding process is carried out and then has to be added to the pre-heating (P_1) and welding (P_5) pressures given in the tables. Never exceed to this value.

WELDING PRESSURE

The welding pressure required by the polyethylene to which the surfaces at contact must be subject, is equal to:

$$(0,15 \pm 0,02) \text{ N / mm}^2$$

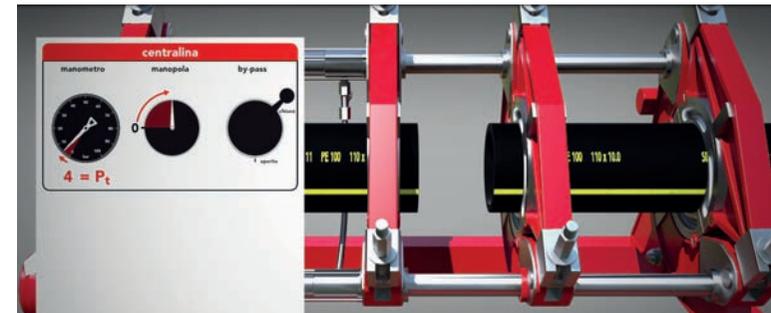
This pressure is calculated through the proper formulas, knowing the total pressure section of the hydraulic cylinders of the welding buttfusion machine. In general, the values are given on proper tables supplied by the manufacturer according to the weldable diameters and thicknesses. The drag pressure P_t must be always added to these values. The pressure, monitored on the pressure gauge, is adjusted using the specific device.

WELDING CYCLE AT SINGLE PRESSURE

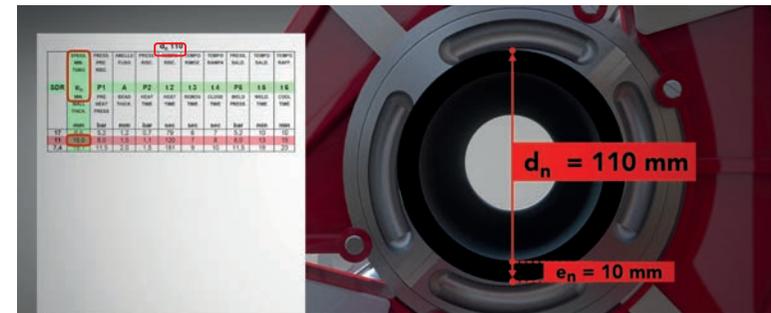
The welding operations must immediately follow the preparation phase of the ends. On trench site, if within the time between the facing phase and the welding starting operation, dust traces, grease or dirty are settled on the ends to be welded, it is necessary to repeat the cleaning. The welding parameters used for the operation of each single joint must be recorded in a proper report.

N.B.: The values shown on the following images are purely simplifying and can vary according to the elements to be welded and to the buttfusion machine.

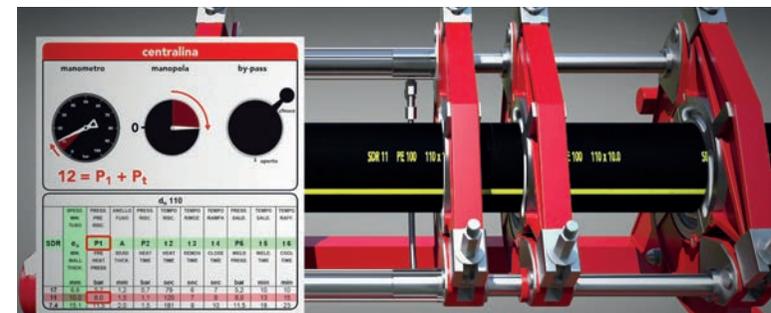
DRAG PRESSURE // Define the drag pressure P_t



WELDING PRESSURE // Define the welding pressure according to the buttfusion manufacturer table



DRAG AND WELDING PRESSURE // Set the pressure $P_1 + P_t$ on the hydraulic unit



PHASE 1 HAULING AND PRE-HEATING

Position the heating plate, taking care to insert it correctly in order to guarantee its steadiness. Afterwards, draw near both ends to the heating plate and apply the pressure:

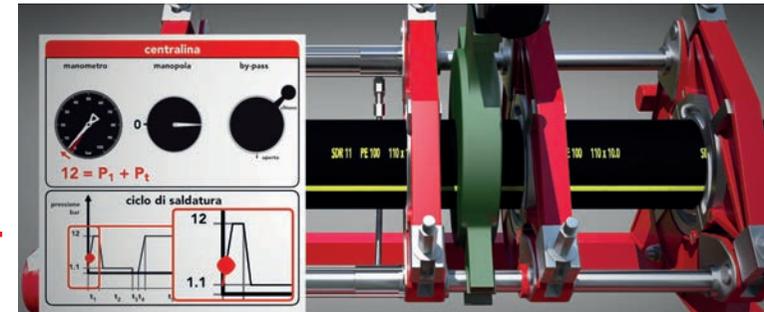
$$P_1 + P_t$$

where P_1 is shown on the tables supplied by the machine manufacturer and then summed to the drag pressure P_t . The pre-heating phase ends after a time t_1 sufficient as long as it forms on both welding ends a ring of melted material whose width is equal to:

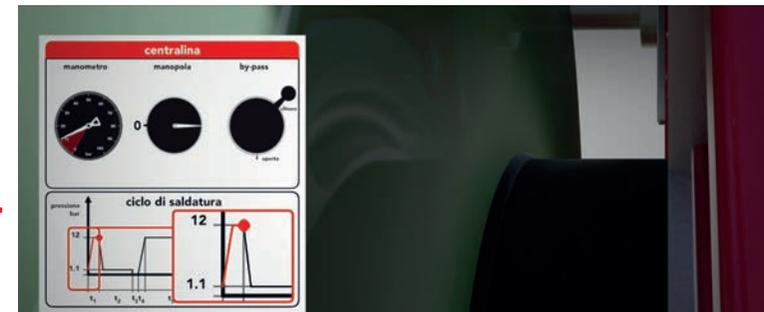
$$A = 0,5 + (0,1 \times e_n) \quad [\text{mm}]$$

where e_n is the nominal thickness of the pipe and/or fitting to be welded.

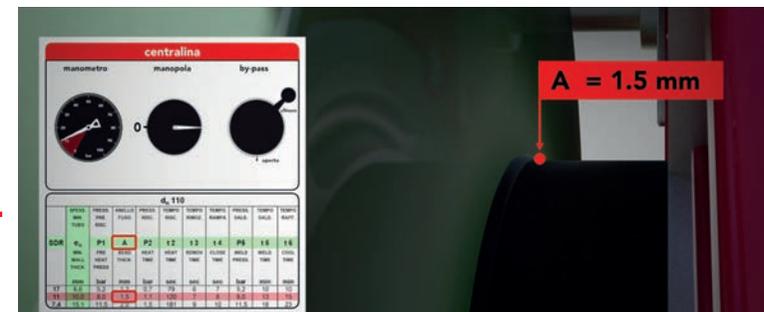
PHASE 1 – HAULING AND PRE-HEATING // Draw near both ends to the heating plate and apply the pressure P_1+P_t



PHASE 1 – HAULING AND PRE-HEATING // Wait till a ring of melted material, whose width is equal to A, is formed on both welding ends



PHASE 1 – HAULING AND PRE-HEATING // Wait till a ring of melted material, whose width is equal to A, is formed on both welding ends



PHASE 2
HEATING

In a relative short time it forms a melted plastic ring which shows that the material has started the fusion process. At this step, the pressure at contact of the ends with the heating plate must be released avoiding the push-out of the PE material from the welding zone, which is necessary for a good quality jointing obtaining only a “cold” welding, which is extremely fragile. Pressure is then released to its initial value $P_1 + P_t$ (Phase 1) up to a P_2 value which guarantees the contact between the ends and the heating plate during the whole heating time and which satisfies:

$$P_2 \leq 0,02 \text{ N / mm}^2$$

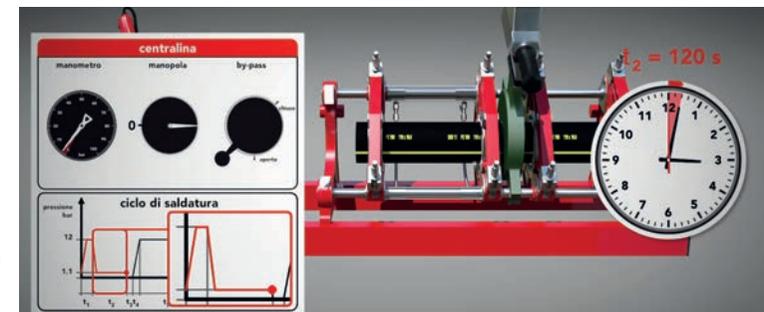
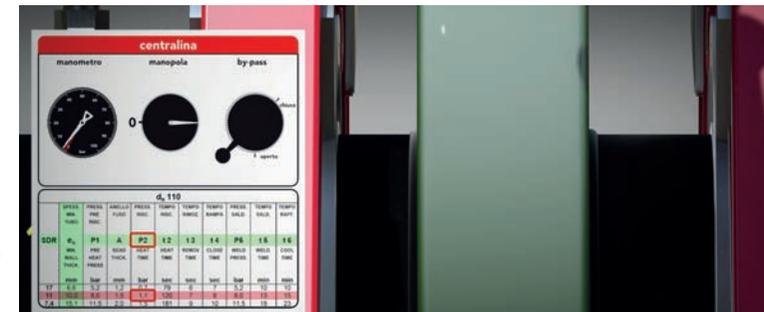
Whenever P_2 is not specified in the table supplied with the machine, in the operative practice it is advisable to set the pressure gauge on a value next to zero but never higher than the P_t . If the operation is correct, the surface heating continues without increasing the over-thickness of the ring. In this phase, the ends must remain in contact with the heating plate for a time equal to:

$$t_2 = 12 \times e_n \text{ [sec]}$$

where e_n is the nominal thickness of the pipe and/or fitting to be welded. A tolerance of (+8%, -0%) is admitted on the t_2 value.

PHASE 2 - HEATING // Release pressure up-to the value P_2

PHASE 2 - HEATING // Wait for a time equal to t_2



PHASE 3

REMOVAL OF THE HEATING PLATE

At the expiring of the time t_2 , the ends are separated to allow the heating plate removal (take care to avoid the damage of the ends to be welded) and then brought together for jointing. This phase is extremely critical and its correct performance is essential for a successful welding. The removal of the heating plate has to be as fast as possible in order to avoid the excessive cooling of the ends; at the same time it is necessary to reduce the closing speed for putting into contacts the two ends, in order to obtain a jointing that does not take to an abrupt out-coming of the melted material.

This allows to the two parts to correctly melt and avoid the formation of cold areas inside the joint. The entire operation must be anyway completed within a time shorter then:

$$t_3 = 4 + (0,3 \times e_n) \quad [\text{sec}]$$

where e_n is the nominal thickness of the pipe and/or fitting to be welded.

PHASE 4

BUILD-UP OF WELDING PRESSURE

Put into contact the ends by increasing the pressure progressively and anyway to avoid a harsh and excessive coming-out of the melted material from both surfaces, up to the value of:

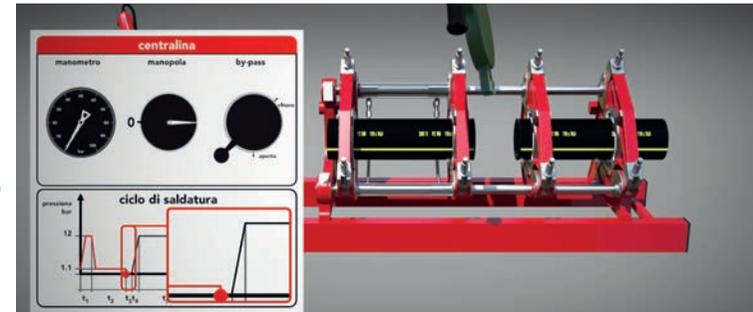
$$P_5 + P_t$$

where P_5 (equal to P_1) is shown on the tables supplied by the machine manufacturer and then summed to the drag pressure P_t .

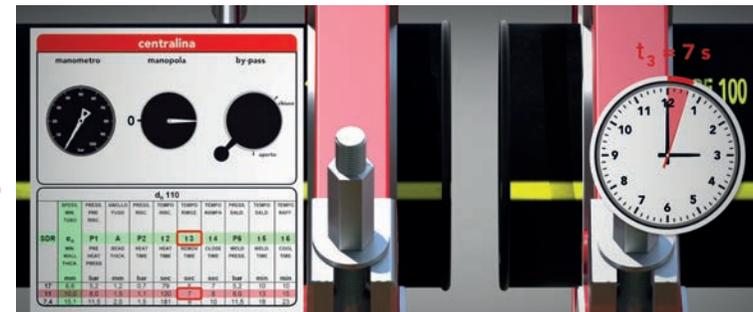
The reaching of this pressure must be within a time equal to:

$$t_4 = 4 + (0,4 \times e_n) \quad [\text{sec}]$$

where e_n is the nominal thickness of the pipe and/or fitting to be welded.



PHASE 3 – REMOVAL OF THE HEATING PLATE // Separate the ends, remove the heating plate as fast as possible and carefully bring the ends together within a time lower than t_3



PHASE 3 – REMOVAL OF THE HEATING PLATE // Separate the ends, remove the heating plate as fast as possible and carefully bring the ends together within a time lower than t_3



PHASE 4 – BUILD-UP OF WELDING PRESSURE // Increase progressively the pressure up-to the value $P_5 + P_t$ within a time equal to t_4

SYNOPTIC TABLE

Phases and parameters of the welding cycle **AT SINGLE PRESSURE**

PHASE	PRESSURE	TIME (SECONDS)	NOTES
hauling and pre-heating	$\leq 0,02 \text{ N/mm}^2$	-	time t_1 which allows to form a ring with width: $A = 0,5 + (0,1 \times e_n)$ [mm]
heating	$\leq 0,02 \text{ N/mm}^2$	$12 \times e_n$	release pressure and maintain the ends into contact with the heating plate
removal of the heating plate	-	$< 4 + (0,3 \times e_n)$	remove the heating plate avoiding to damage both ends
build-up of the welding pressure	$0,15 \text{ N/mm}^2 + P_t$	$4 + (0,4 \times e_n)$	put into contact the ends avoiding an excessive coming out of melted material
welding	$0,15 \text{ N/mm}^2 + P_t$	$(3 + e_n) \times 60$	maintain the ends into contact
cooling	-	$1,5 \times e_n \times 60$	the joint cannot be subjected to stress

N.B. Within the formulas, e_n indicates the nominal thickness of the pipe/fitting to be welded.

WELDING TABLES

All typical parameters (times and pressures) of the buttfusion welding process are included in the specific tables supplied by the machine manufacturer according to weldable diameters and thicknesses.

As, the calculated pressure values depend from the total pressure section of the hydraulic cylinders of the buttfusion machine, consequently these tables **are specific for each type of machine**; THEREFORE THEY ARE NOT INTERCHANGEABLE.

The welding tables must be always available whenever the welding machine is used; therefore a copy should be filed in a safe place.

INSPECTION OF WELDED JOINTINGS

VISUAL CONTROL

The visual control is relative to the following checks:

- **the carving** by the centre of the ring must be **above the external diameter** of the welded elements, as too deep carvings trace back to temperature or welding pressure values lower than those foreseen;
- on the external surface of the ring there cannot be **porosity, dust inclusions** or other contaminations, as these are indicative of not sufficient cleaning of the elements to be welded;
- after cooling, the external surface of the ring cannot be excessively **bright**, as this is index of **overheating of the welded material**.

DIMENSIONAL CONTROL OF THE BEAD

The dimensional control of the bead foresees the following checks:

- the width B of the bead must be uniform on the whole area of the welding. At any point of the welding, the width B of the bead cannot vary more than $\pm 10\%$ with respect to the average value B_m :

$$B_m = (B_{min} + B_{max}) / 2$$

where B_{min} e B_{max} respectively are the minimum and maximum measured value;

- at any point of the welding, the maximum difference between the two beads which form the ring must be lower than 10% of the width B of the bead in case of pipe-pipe joint and 20% in case of joint of pipe-fitting and fitting-fitting;
- the maximum misalignment of the two welded elements must be lower than 10% of their thickness;

- at any point of the welding, the width B of the bead must be comprised in the value shown in the next table:

THICKNESS OF WELDED ELEMENTS (mm)	WIDTH OF THE BEAD B (mm)	THICKNESS OF WELDED ELEMENTS (mm)	WIDTH OF THE BEAD B (mm)
3	4 - 6	29	15 - 21
4	4 - 7	30	15 - 21
5	5 - 8	31	15 - 21
6	6 - 9	32	15 - 22
7	7 - 10	33	16 - 22
8	7 - 10	34	16 - 22
9	8 - 11	35	16 - 22
10	8 - 12	36	16 - 23
11	9 - 13	37	17 - 23
12	9 - 13	38	17 - 23
13	10 - 14	39	17 - 23
14	10 - 15	40	17 - 24
15	10 - 15	41	18 - 24
16	11 - 16	42	18 - 24
17	11 - 16	43	18 - 25
18	12 - 17	44	19 - 25
19	12 - 17	45	19 - 25
20	12 - 18	46	19 - 25
21	13 - 18	47	20 - 26
22	13 - 18	48	20 - 26
23	13 - 19	49	20 - 26
24	13 - 19	50	21 - 27
25	14 - 20	55	23 - 29
26	14 - 20	60	26 - 32
27	14 - 20	65	29 - 36
28	14 - 21		

NON PERFECTLY CONNECTED BEAD

If the bead is not perfectly connected to the plain surface of the pipe, the welding is anyway considered acceptable.

In case of welding of pipes and/or fittings with thickness lower or equal to 10 mm, if the bead is not connected with the typical form at “gull wings”, the welding cycle must be modified working on the phase 3 and 4 in the following way:

- Phase 3: the time t_3 cannot be higher than 4 seconds;
- Phase 4: the time t_4 cannot be higher than 6 seconds.



non perfectly connected bead



bead "at gull wings"

// BUTTFUSION JOINTING

WELDING ERRORS

The following images report several jointings performed without respecting the welding instructions defined by the standard UNI 10520. The experience gained in the years on trench sites by Eurostandard personnel, in the testing laboratories and at the Technical Training Centre allowed the characterization and the filing of the most common welding error types:

MISALIGNMENT

PROBABLE CAUSE inefficient preparation of the ends to be welded

CORRECTION remove and repeat the welding if the misalignment is higher than 10% of the nominal thickness of the welded elements

PREVENTIVE MEASURES correctly align the elements to be welded inside the buttfusion machine, adjusting the clamping forces of the jaws, by means of rollers or other supports under the pipes in order to guarantee the coaxiality, and by rotating them in the way to reach the most suitable matching condition. If possible, line up the marked lines and wordings on the pipes, (if they are of the same production batch)



IRREGULARITY OF THE BEAD

PROBABLE CAUSE inefficient preparation of the ends to be welded

CORRECTION remove and repeat the buttfusion welding if the irregularity is excessive referring to dimensional requirements of the bead

PREVENTIVE MEASURES carefully carry out the facing of the ends to be welded and then carry out all necessary controls



INSUFFICIENT WIDTH OF THE BEAD

PROBABLE CAUSE wrong setting of the welding parameters. When the width of the bead is widely below the minimum limits specified by the standard, often the cause is due to lack of Phase 2 “Heating” where the elements have been welded by directly passing from Phase 1 “Hauling and pre-heating” to Phase 3 “Removal of the heating plate”

CORRECTION remove and repeat the buttfusion welding

PREVENTIVE MEASURES carry out the welding strictly respecting all parameters foreseen by each single phase



// ELECTROFUSION JOINTING

SOCKETS AND INTEGRATED FITTINGS

The electrofusion welding system is the jointing process of pipes and/or fittings of the same connection diameter, carried out by fusion of the contact surfaces through an electrical resistance inserted in the electrofusion fitting; the process is defined by the standard UNI 10521. In case of sockets and integrated fittings, the welder in charge of the jointings must be adequately qualified in conformity to the standard UNI 9737 for the **classes 3PE 3.6 and/or 3.7**.

The electrofusion welding is applicable to pipes and/or fittings made in **PE 80 and PE 100 having same nominal diameter and equal or different SDR**. In order to achieve a quality jointing, the welding must be carried out strictly observing the following instruction.

PREPARATION

The jointing process must be carried out in a dry and protect place. In case of adverse ambient conditions (humidity, rain, snow, blast, excessive solar irradiance), suitable measures must be taken to protect the working zone.

The ambient temperature must always be between:

$$-5\text{ °C} \div +40\text{ °C}$$

PRELIMINARY CONTROLS

The above described procedure, also if here referred to pipes, is equally applied if instead of a pipe, a **buttfusion spigot fitting** is inserted into the electrofusion fitting.

The operator must be prepared in order to always maintain the complete visual control of the various operations and the necessary space must be guaranteed without constraints, in a dry location and as far as possible in flat.



PREPARATION // Welding must take place in a dry site and ambient temperature comprised between -5°C and +40°C



PRELIMINARY CONTROLS // Equipment necessary for welding process

Critical element for the jointing reliability is the preparation of the pipe surface where the electrofusion fitting will be welded, through the removal of the oxidized layer and the accurate cleaning of the whole contact area with the fitting itself.

Check and prepare all equipment necessary for the welding process:

1. electrofusion welding unit
2. electrofusion fitting
3. aligning clamp
4. manual or mechanical scraper
5. pipe cutter
6. detergent
7. cleaned cloth or strong soft paper
8. indelible marker pen or wax pencil
9. roller measuring tape

Visually check that the pipes are free of **cuts and abrasions** (the maximum depth admitted is equal to 10% of the wall thickness). Eventual anomalies must be taken out by cutting the interested pipe section. The pipes ends to be welded must be cut **at right angle** preferably using proper **pipe cutters**.

Avoid to use excessive ovalized pipes. In any case, the **ovalization cannot exceed 1,5%** calculated as follows:

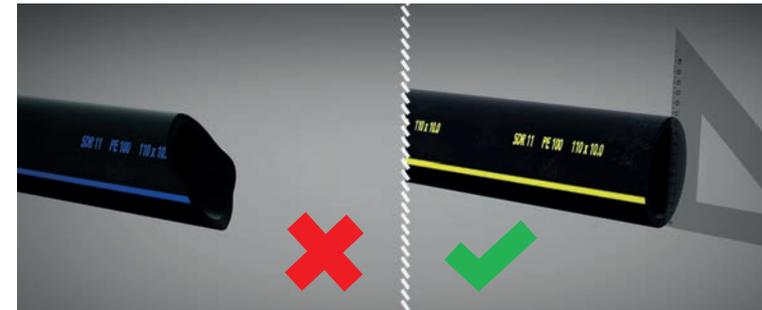
$$OV = \frac{d_{e,max} - d_{e,min}}{d_n} \times 100$$

d_e = external diameter at any point
 d_n = nominal diameter

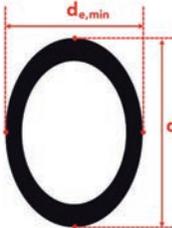
Ovalization and bending are reduced by using special re-rounders. The coiled pipes must be unrolled at least 24 hours before its use. **Avoid the use of heat sources** to recover possible ovalizations or to reduce the pipe bending.



PRELIMINARY CONTROLS // Verify that the pipes are free of cuts and abrasions



PRELIMINARY CONTROLS // Verify that the pipes ends to be welded are cut square



EXAMPLE 1

$d_n = 110 \text{ mm}$
 $d_{e,max} = 112 \text{ mm}$
 $d_{e,min} = 108 \text{ mm}$

$OV \leq 1,5\%$

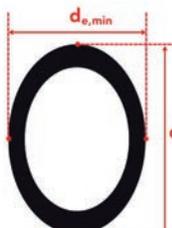
$OV = \frac{d_{e,max} - d_{e,min}}{d_n} \times 100$

$OV = \frac{112-108}{110} \times 100$

$OV = 3,6\% > 1,5\%$

✗

PRELIMINARY CONTROLS // Verify the ovalization of the ends to be welded



EXAMPLE 2

$d_n = 110 \text{ mm}$
 $d_{e,max} = 111 \text{ mm}$
 $d_{e,min} = 110 \text{ mm}$

$OV \leq 1,5\%$

$OV = \frac{d_{e,max} - d_{e,min}}{d_n} \times 100$

$OV = \frac{111-110}{110} \times 100$

$OV = 0,9\% < 1,5\%$

✓

PRELIMINARY CONTROLS // Verify the ovalization of the ends to be welded

SCRAPING

Clean the pipes ends from dust, mud, grease and dirt using a strong soft paper slightly drenched with a suitable detergent (i.e. isopropyl alcohol or methylene chloride). **Do not use** products such as trichloroethylene, denatured alcohol, gasoline, acetone or paint diluent. Mark the scraping area with an indelible marker pen or wax pencil, the pipe length interested to scraping must be larger than the insertion depth of the electrofusion fitting **for at least 10 mm**. The electrofusion fitting must not be scraped.

To remove the superficial oxidized layer, proceed to scraping of the external surfaces of the pipes.

The operation must be done using a manual scraper supplied with the welding unit, or using the special mechanical pipe scrapers.

Avoid the use of abrasive paper, rasp, emery wheels, saw blades or other equipment.

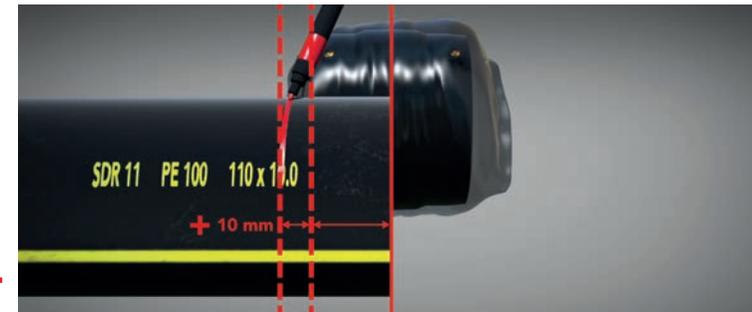
A uniform layer of material must be removed for **a depth of approximately 0,1 mm for pipe diameters up to 63 mm and of approx. 0,2 mm for diameters bigger than 63 mm**.

Using the manual scraper, consider the procedure as correct, when an uniform PE shaving is attached to the pipe end. Then remove it by slightly rounding off at 45° angle the pipe/fitting end.

SCRAPING // Clean the inside and outside surfaces of the ends to be welded with proper detergent



SCRAPING // Mark the scraping area



SCRAPING // Scrape the marked ends



SCRAPING // Scrape the marked ends



CLEANING

Just before the jointing with the electrofusion fitting, once more **clean all scraped surfaces** using a strong soft paper slightly drenched with a suitable detergent.

Clean in the same way the inner surface of the electrofusion fitting, which has to be removed from its protective wrapping only at the moment of use.

Do not touch with hands the just cleaned surfaces; on the contrary, repeat cleaning.
Before starting the next operations, make sure that the surfaces are well dry.

CLEANING // Clean the outside surfaces of the ends to be welded with proper detergent



CLEANING // Clean the inside surfaces with proper detergent



POSITIONING

It is compulsory the use of the **aligning clamp**, for all diameters to be welded, which:

- removes the jointing stresses during the fusion of material and the subsequent cooling time;
- allows to revise possible off-centering between the elements to be welded;
- allows to recover the out-of-round of parts, if ovalized.

In order to set the aligning clamp to the different diameters, it is necessary to insert the reducing inserts and in case adjust the internal distance between the movable jaws.

In case of electrofusion fittings installation such as 90° and 45° elbows, suitable aligning clamps are available with adjustable joint.

When the use of aligning clamps is not possible, alternative systems are allowed. In this case, the procedure must be qualified within the same assembling conditions, verifying the welding quality by the visual control and overall by carrying out the decohesion test and resistance to internal pressure test according to standard UNI 10521.

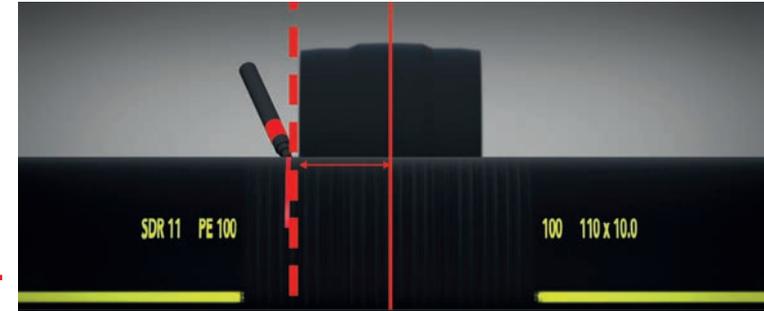
By using a coloured pen or wax pencil sign on at least one third of the pipe circumference, in correspondence to the ends to be welded, the **insertion depth** in the electrofusion fitting. This operation must be carried out also in case of fittings with central stop.

This mark, beyond helping the positioning of the fitting on the pipe, will permit the control at welding end that there are no movements of the jointing.

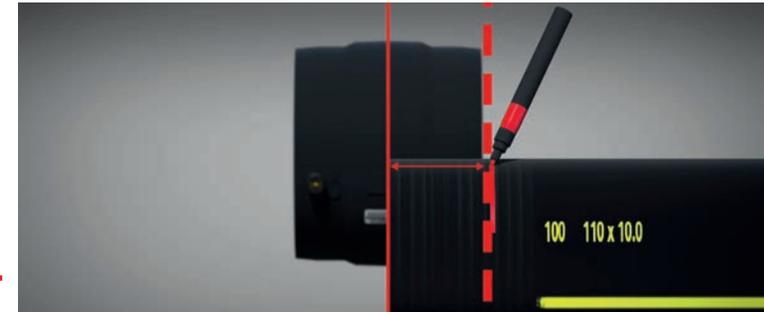
Insert the electrofusion fitting on the end of the first pipe up to the location mark. Fasten the pipe into the aligning clamp.

Insert the second pipe into the fitting up to its location mark and fasten it into the aligning clamp.

POSITIONING // Mark the insertion depth



POSITIONING // Mark the insertion depth



POSITIONING // Insert the fitting on the ends to be welded



POSITIONING // Fasten the joint into the aligning clamp



WELDING

Connect the plugs of the welding unit to the terminals of the fitting and proceed with the set-up of the welding parameters according to the instructions of the welding unit.

N.B.: If there is an accidental interruption of the welding cycle, **the operation can only be repeated after the electrofusion joint has been totally cooled at touch.** Anyway it is necessary to refer to instruction of the fittings manufacturer. When the fusion cycle is completed, verify the fusion indicators coming out.

WARNING: the coming out of the fusion indicators cannot be the guarantee of good success of the welding, but it must be exclusively interpreted as indication of the completed material fusion.

WELDING // Connect the welding unit plugs to the fitting



WELDING // Set-up the welding parameters and start the fusion cycle



WELDING // Verify, when fusion cycle is completed, the coming out of fusion indicators



COOLING

The time which is necessary to wait before removing the aligning clamp can normally vary from 10 up to 30 minutes and anyway it is always **shown on the fitting by the manufacturer.**

At fusion cycle end, it is advisable to write with a coloured pen or wax pencil the time when the aligning clamp can be removed. Anyway, up to the complete cooling (temperature in the external welding area must be equal to that of the next raw material), the jointing cannot be moved or externally stressed and must be adequately protected in case of adverse ambient conditions.

It is absolutely forbidden the use of external cooling methods (water, compressed air, etc) to speed up the cooling.

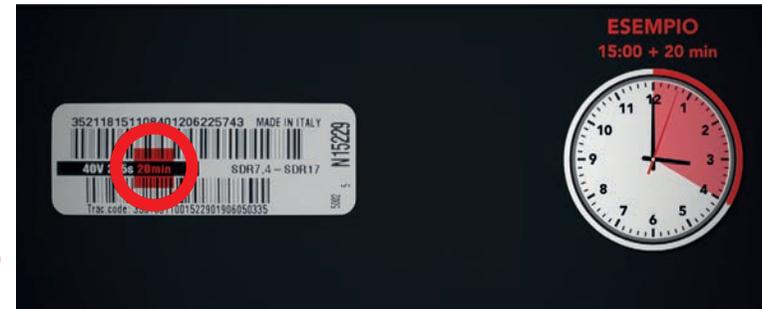
Precautionarily, it is suggested to put the pipeline under pressure **not before 2 hours from the last fitting welding.**

The welding parameters used for the jointing of each fitting must be recorded in a proper report.

COOLING // Disconnect the fitting from the welding unit



COOLING // Wait for the cooling time defined by the fitting manufacturer



COOLING // Mark on the fitting the time of removal from the aligning clamp



INSPECTION OF WELDED JOINTINGS

VISUAL CONTROL

The visual control is relative to the following checks:

- if fusion indicators (proof of the correct fusion cycle) are present on the fitting, they must fulfil the direction of the fitting manufacturer (usually, come out of their cavities);
- the welded elements must be correctly aligned;
- the scraped area must be clearly visible;
- the insertion deep previously marked on the elements to be welded must be respected;
- no protrusion of melted material and damages on the outside surface of the welded elements.

The possible error messages which can appear on the display of the electrofusion welding unit used for the jointing operation must be taken into account.

// ELECTROFUSION JOINTING

SPIGOT AND TAPPING SADDLES

The electrofusion welding system is the jointing process of pipes and/or fittings of the same coupling diameter carried out by fusion of the contact surfaces through an electrical resistance inserted in the electrofusion fitting; the process is defined by the standard UNI 10521.

In case of electrofusion saddles, the welder in charge of the jointings must be adequately qualified in conformity to the standard UNI 9737 for the **class 3PE 3.8**.

The electrofusion welding is applicable to pipes and/or fittings made in **PE 80 and PE 100 having same nominal diameter and equal or different SDR**. In order to achieve a quality jointing, the welding must be carried out strictly observing the following instruction.

PREPARATION

The jointing process must be carried out in a dry and protect place. In case of adverse ambient conditions (humidity, rain, snow, blast, excessive solar irradiance), suitable measures must be taken to protect the working zone.

The ambient temperature must be always between:

$$-5\text{ °C} \div +40\text{ °C}$$

PRELIMINARY CONTROLS

The operator must be prepared in order to always maintain the complete visual control of the various operations and the necessary space must be guaranteed without constraints, in a dry location and as far as possible in flat.



PREPARATION // Welding must take place in a dry site and ambient temperature comprised between -5 °C and $+40\text{ °C}$



PRELIMINARY CONTROLS // Equipment necessary for welding process

Critical element for the jointing reliability is the preparation of the pipe surface where the electrofusion fitting will be welded, through the removal of the oxidized layer and the accurate cleaning of the whole contact area with the fitting itself.

Check and prepare all the equipment necessary for the welding process:

1. electrofusion welding unit
2. electrofusion saddle
3. manual scraper
4. detergent
5. cleaned cloth or strong soft paper
6. manual or pneumatic screwdriver for the bolts tightening
7. manual hexagonal key for the cutter screw
8. indelible marker pen or wax pencil

Visually check that the pipe is free of defects such as **cuts and abrasions** (the maximum admitted depth is equal to 10% of the wall thickness). Eventual anomalies must be taken out by cutting the interested pipe section.

Avoid to use excessive ovalized pipes. In any case, **the ovalization cannot exceed 1,5%** calculated as follows:

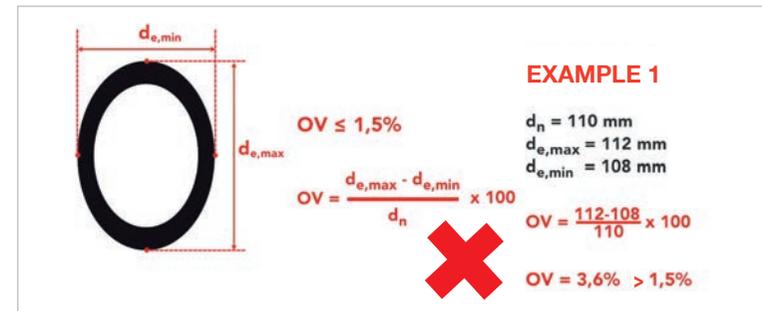
$$OV = \frac{d_{e,max} - d_{e,min}}{d_n} \times 100$$

d_e = external diameter at any point
 d_n = nominal diameter

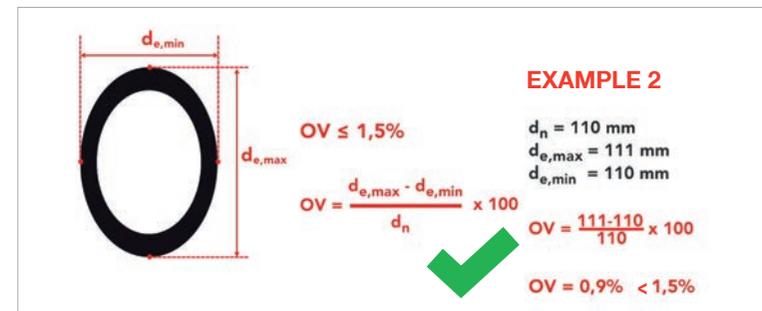
Ovalization and bending are reduced by using special re-rounders. The coiled pipes must be unrolled at least 24 hours before its use. **Avoid the use of heat sources** to recover possible ovalizations or to reduce the pipe bending.



PRELIMINARY CONTROLS // Verify that the pipe is free of cuts and abrasions



PRELIMINARY CONTROLS // Verify the ovalization of the pipe to be welded



PRELIMINARY CONTROLS // Verify the ovalization of the pipe to be welded

SCRAPING

Clean the pipe from dust, dirt and grease using a strong soft paper slightly drenched with a suitable detergent (i.e. isopropyl alcohol or methylene chloride).

Do not use products such as trichloroethylene, denatured alcohol, gasoline, acetone or paint diluent.

Place the saddle on the pipe and mark the scraping area with a coloured pen or wax pencil.

Remove the oxidized surface layer by scraping the external pipe surface for **at least 10 mm** over the previous marked area.

The operation must be done by using the manual scraper supplied with the electrofusion welding unit.

AVOID the use of abrasive paper, rasp, emery wheels, saw blades or other equipment.

Remove a uniform surface layer of material for a **depth of approximately 0,1 mm for diameters up to 63 mm and of approx. 0,2 mm for diameters greater than 63 mm.**

SCRAPING // Clean the surface where the saddle will be welded with proper detergent



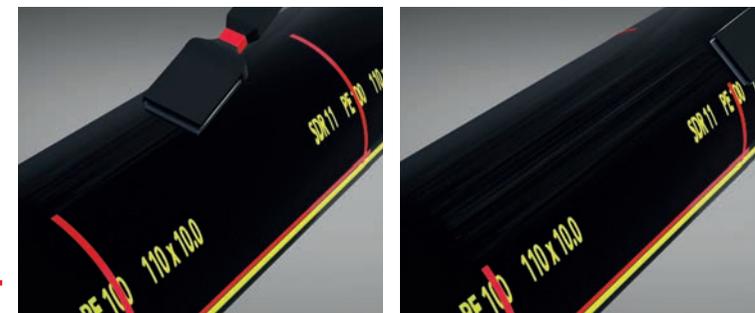
SCRAPING // Mark the scraping area



SCRAPING // Scrape the marked area



SCRAPING // Scrape the marked area



CLEANING

Just before positioning the saddle on the pipe, once again clean the scraped surface with a clean cloth or strong soft paper slightly drenched with suitable detergent.

Clean in the same way the inner welding surface of the saddle, which has to be removed from its protective wrapping only at the moment of use.

Do not touch with hands the just cleaned surfaces; on the contrary, repeat cleaning.

Before starting the next operations, make sure that the surfaces are well dry.

CLEANING // Clean the scraped area with proper detergent



CLEANING // Clean the welding surface of the saddle with proper detergent



SADDLE POSITIONING ON THE PIPE

Install the bolts in the special lower supports of the saddle and screw in the nuts. Position the saddle on the pipe, centering the welding part on the scraped surface.

Attach the bolts in the upper parts and block the saddle on the pipe by using a screw key M10, up to the contact of the ends.

N.B.: The values shown on the following images are purely simplifying and can vary according to the elements to be welded and to the electrofusion welding unit.

SADDLE POSITIONING ON THE PIPE //

Position and block the saddle on the pipe, within the centre of the scraped area



SADDLE POSITIONING ON THE PIPE //

Position and block the saddle on the pipe, within the centre of the scraped area



SADDLE POSITIONING ON THE PIPE //

Position and block the saddle on the pipe, within the centre of the scraped area



WELDING

Connect the plugs of the welding unit to the terminals of the fitting and proceed with the set-up of the welding parameters, strictly following the instructions of the electrofusion welding unit.

N.B.: If there is an accidental interruption of the welding cycle, the operation can only be repeated after the electrofusion joint has been totally cooled at touch. Anyway it is necessary to refer to instruction of the fittings manufacturer. When the fusion cycle is completed, verify the fusion indicators coming out.

WARNING: the coming out of the fusion indicators cannot be the guarantee of good success of the welding, but it must be exclusively interpreted as indication of the completed material fusion.

WELDING // Connect the welding unit plugs to the saddle



WELDING // Set-up the welding parameters and start the fusion cycle



WELDING // Verify, when fusion cycle is completed, the coming out of fusion indicator



COOLING

The cooling time of the jointing is always **shown on the fitting by the manufacturer**. At fusion cycle end, it is advisable to write with a coloured pen or wax pencil the time when the jointing will be completely cooled.

Anyway, up to the complete cooling (temperature in the external welding area must be equal to that of the next raw material) the jointing cannot be moved or externally stressed and must be adequately protected in case of adverse ambient conditions.

It is absolutely forbidden the use of external cooling methods (water, compressed air, etc) to speed up the cooling.

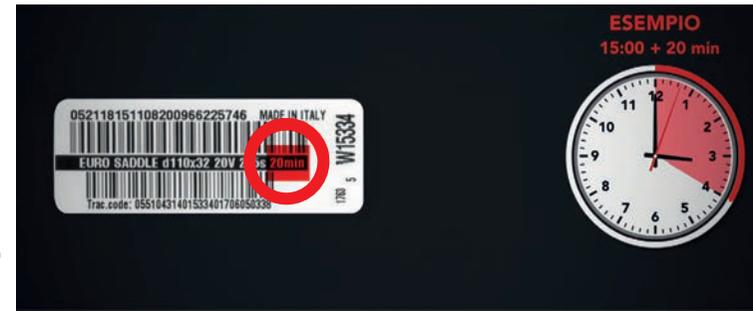
Precautionarily, it is suggested to put the pipeline into pressure **not before 2 hours from the last fitting welding**.

The welding parameters used for the jointing of each fitting must be recorded in a proper report.

COOLING // Disconnect the saddle from the welding unit



COOLING // Wait for the cooling time defined by the saddle manufacturer



COOLING // Mark on the fitting the cooling time ending



BORING // Drill the pipe only after complete cooling of the joint



BORING

The saddle boring must be carried out only after a complete cooling of the welded joint, independently from the type of saddle. In order to reach the complete cooling of the joint (temperature in the external welding area must be equal to that of the next raw material) it is often necessary to wait a time greater than that shown on the fitting.

TAPPING SADDLE

Unscrew the outlet cap of the saddle.
 Insert the manual hexagonal key into the built-in cutter. Avoid the use of pneumatic or electrical drillers, which due to the excessive rotation speed can damage the cutter thread.
 Screw clockwise until the pipe perforation, this is evidenced by a great decrease in the screwing force. Do not continue in order to avoid any damage in the cutter thread. Screw anticlockwise and retract the cutter back to its original position.
 Remove the hexagonal key and strongly screw the cap, checking the presence of the internal O-ring gasket.

SPIGOT SADDLE

The saddle boring is carried out by using a normal hole-saw, whose external diameter is a little bit smaller than the internal branch diameter. Pay attention avoiding damages on the branch internal walls.

WARNING: the coming out of the fusion indicators cannot be the guarantee of good success of the welding, but it must be exclusively interpreted as indication of the completed material fusion.

BORING // Drill the pipe only after complete cooling of the joint



BORING // Drill the pipe only after complete cooling of the joint



BORING // Drill the pipe only after complete cooling of the joint



BORING // Drill the pipe only after complete cooling of the joint



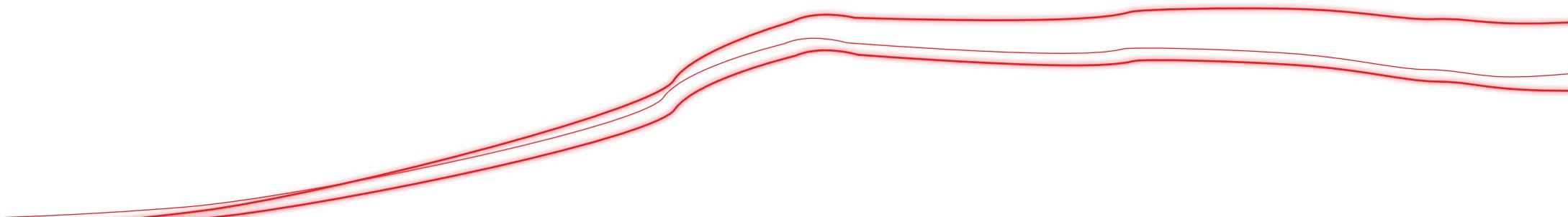
INSPECTION OF WELDED JOINTINGS

VISUAL CONTROL

The visual control is relative to the following checks:

- if fusion indicators are present on the fitting, as proof of the correct fusion cycle, they must fulfil the direction of the fitting manufacturer (usually, come out of their cavities);
- the scraped area must be clearly visible;
- no protrusion of melted material and damages on the outside surface of the welded elements are shown.

The possible error messages which can appear on the display of the electrofusion welding unit used for the jointing operation must be taken into account.



// ELECTROFUSION JOINTING

WELDING ERRORS

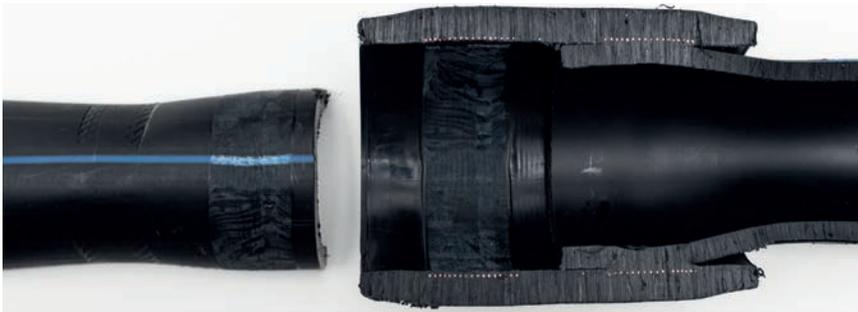
The following images report several jointings performed without respecting the welding instructions defined by the standard UNI 10521. The experience gained in the years on trench sites by Eurostandard personnel, in the testing laboratories and at the Technical Training Centre allowed the characterization and the filing of the most common welding error types:

LACK OF SCRAPING

PROBABLE CAUSE lack of scraping on the outside surface of the pipes and/or ends to be welded

CORRECTION remove and repeat the welding

PREVENTIVE MEASURES carefully carry out the scraping on the outside surface of the pipes and/or ends to be welded

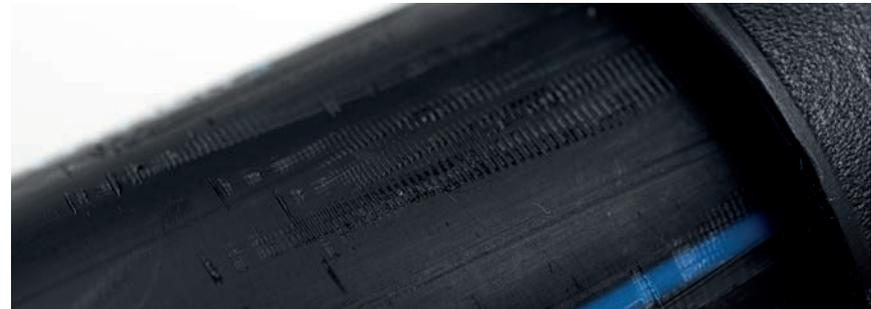


INSUFFICIENT SCRAPING

PROBABLE CAUSE insufficient scraping depth and uniformity on the outside surface of the pipes and/or ends to be welded

CORRECTION remove and repeat the welding

PREVENTIVE MEASURES carefully carry out the scraping on the outside surface of the pipes and/or ends to be welded



INCORRECT SCRAPING

PROBABLE CAUSE scraping carried out using not proper equipment

CORRECTION remove and repeat the welding

PREVENTIVE MEASURES carefully carry out the scraping on the outside surface of the pipes and/or ends to be welded

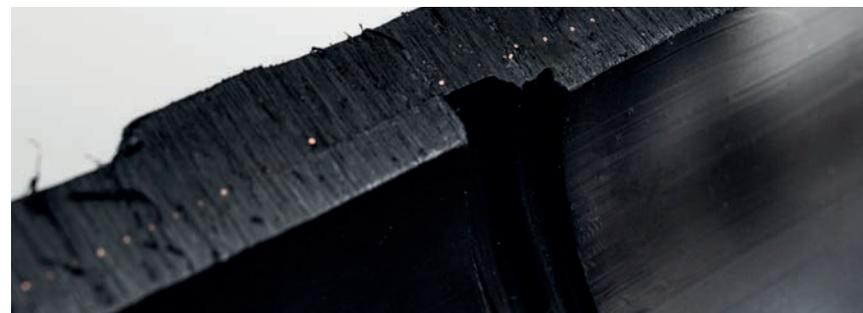
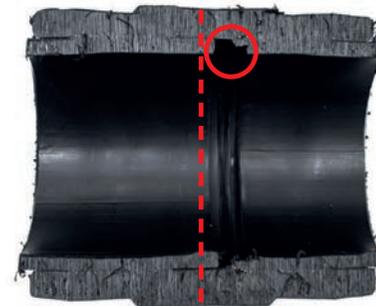


OFF-CENTERING

PROBABLE CAUSE lack of marking – on the outside surface of the pipes and/or ends to be welded – of the insertion depth of the electrofusion fitting

CORRECTION remove and repeat the welding

PREVENTIVE MEASURES measure and previously mark on the outside surface of the pipes and/or ends to be welded the insertion depth in the electrofusion fitting

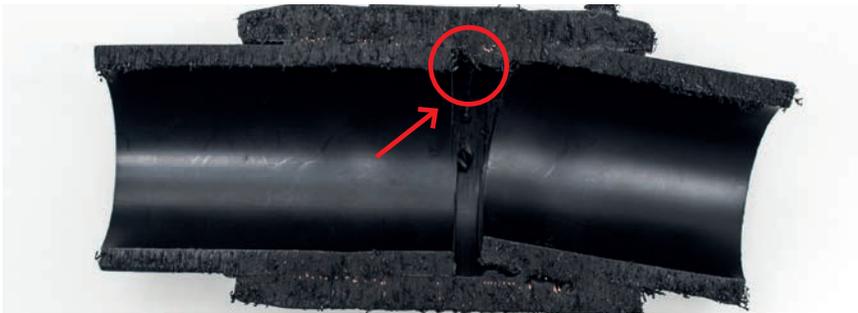


MISALIGNMENT

PROBABLE CAUSE lack of aligning clamp during the electrofusion cycle

CORRECTION remove and repeat the welding

PREVENTIVE MEASURES correctly align the elements to be welded, fastening them in the aligning clamps



LEAKAGE OF MELTED MATERIAL

PROBABLE CAUSE wrong setting of the welding parameters (excessive time and/or welding voltage)

CORRECTION remove and repeat the welding

PREVENTIVE MEASURES correctly set the welding parameters for the fitting, taking particular care when using manual welding units and comparing the values shown on the display of the welding unit with those marked on the fitting, before starting a jointing cycle

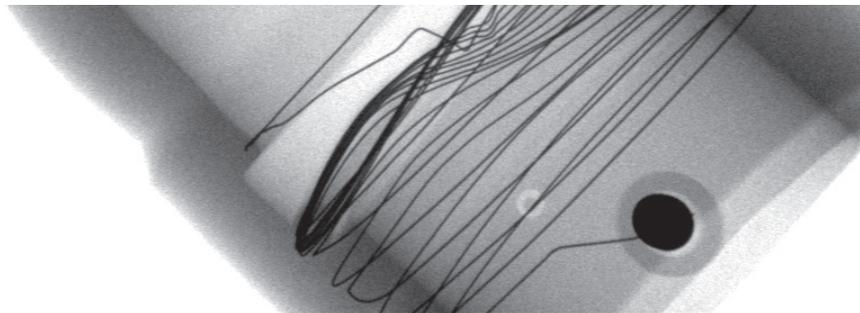


INCOMPLETE INSERTION

PROBABLE CAUSE no marking – on the outside surface of the pipes and/or ends to be welded – of the insertion depth in the electrofusion fitting

CORRECTION remove and repeat the welding

PREVENTIVE MEASURES measure and previously mark on the outside surface of the pipes and/or ends to be welded the insertion depth in the electrofusion fitting



INCORRECT CUT

PROBABLE CAUSE cutting of the pipe ends using not proper equipment

CORRECTION remove and repeat the welding

PREVENTIVE MEASURES previously carry out the cut of the pipes ends using appropriate pipe cutters, carefully checking that the ends are plane and orthogonal to its axis



BORING - INCOMPLETE COOLING

PROBABLE CAUSE boring phase of the pipe before the complete cooling of the welded joint

CORRECTION remove and repeat the welding

PREVENTIVE MEASURES carry out the boring of the pipe only after the complete cooling of the welded joint



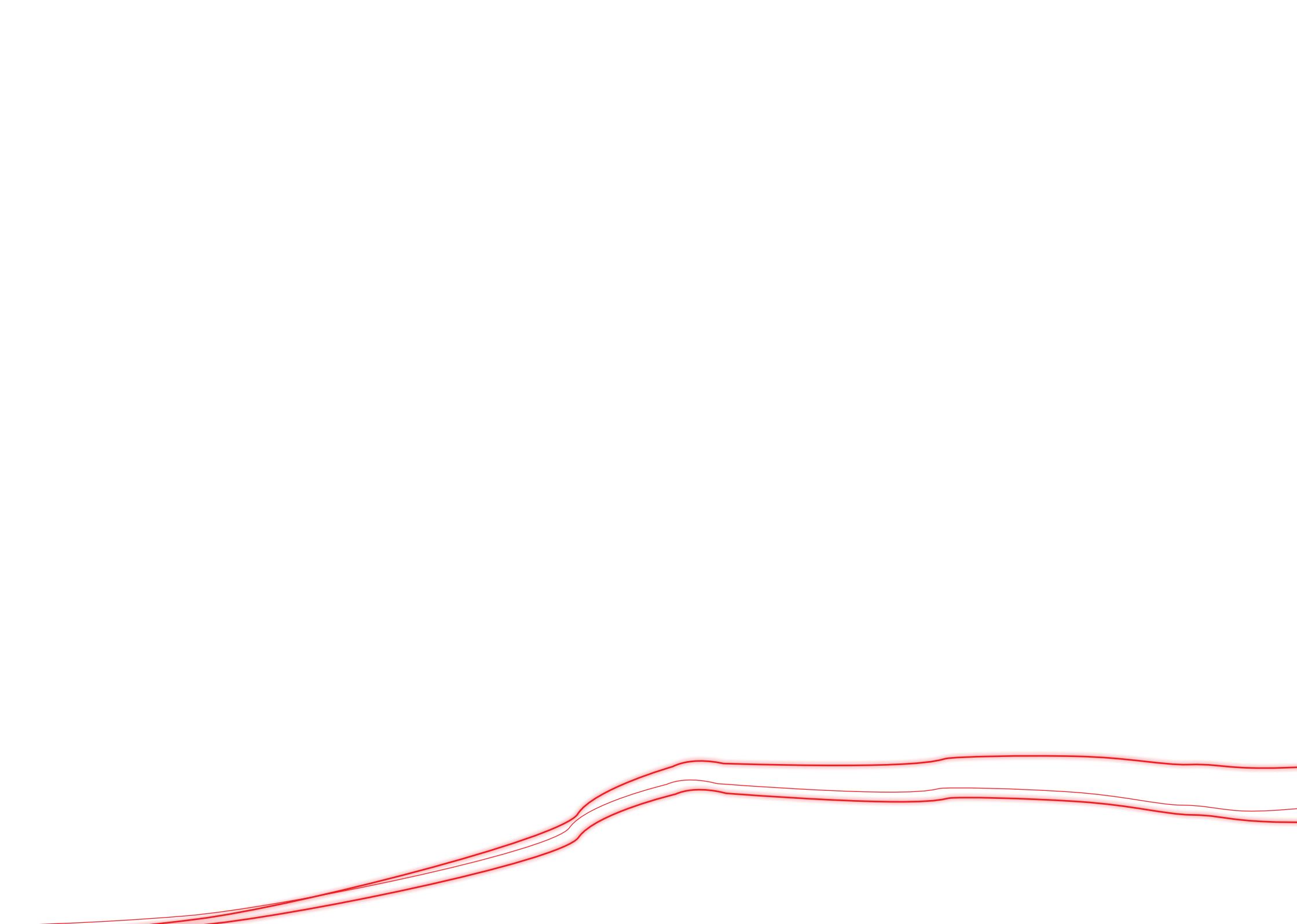
BORING BEFORE WELDING

PROBABLE CAUSE boring of the pipe before the welding of spigot and tapping saddle

CORRECTION remove and repeat the welding

PREVENTIVE MEASURES carry out the boring of the saddle and after the complete cooling of the joint







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