7. JOINTING SYSTEMS

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PVC PIPE JOINTING SYSTEMS

PVC pipes employ two jointing systems:

1. Rubber Ring Joint ("Z" Joint)
A rubber ring joint system providing a flexible joint with capability of axial and angular movement. Simple, error free installation makes this joint suited to larger diameter underground work. Sizes 50 and larger.

2. Solvent Cement Joint
A chemically "welded" joint with capability of supporting axial thrust. Available in sizes to 300 but especially suited to smaller diameter systems.

7.1 RUBBER RING JOINTING

One end of the PVC pipe is accurately pressure formed to provide a purpose designed socket and groove into which is fitted a purpose made rubber sealing ring. The socket is strengthened by increasing its wall thickness in both socket and groove zone, to accommodate the increased Hoop Stress.

7.1.2 Specification

The "Z" joint socket and ring seal are designed to conform with the requirements of AS/NZS 1477.
The performance test in AS/NZS 1477 requires that the spigot side of a completed joint be flattened by 7.5% of the pipe diameter. While distorted the joint must withstand a negative pressure of 25 kPa for one hour without leaking.
Performance tests not required by the Standard show that the undistorted joint will not leak when a negative pressure of 100 kPa is applied.
These tests ensure that a Marley PVC water supply system, even under extreme conditions will neither leak nor admit contaminated ground water.

Cutting

PVC is notch sensitive and care should be taken when cutting.
During manufacture pipes are cut to standard by cut off saws. These saws have carbide-tipped circular blades which produce a neat cut without burrs.
However, pipes may be cut on site with a variety of cutting tools. These are:

1. Proprietry cutting tools
These tools can cut, deburr and chamfer the pipe in one operation. They are the best tools for cutting pipe.

2. Portable electric circular saw with cut off wheel
This is quick and easy to use and produces a neat clean cut requiring little deburring. It does, however, require a power supply and the operator has to be skilled in using it to produce a square cut.

3. A fine tooth hand saw and mitre box
This saw produces a square cut but requires more deburring. It takes comparatively more time and effort and requires a stand.
The use of roller cutters is not recommended because of the large burr resulting.

7.1.3 Rubber Ring Joints

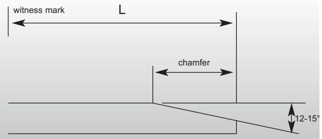
Jointing rings are supplied with the pipe. We recommend the use of a lubricant approved for use with potable water supply lines. Other lubricants may not be suitable for potable water contact and may affect the ring. They should not be substituted without specific knowledge of these effects.
The ring provides a fluid seal in the socket of a pipe or fitting and is compressed when the spigot is passed into the socket. Rings from other manufacturers cannot be interchanged.

7.1.4 Chamfering

If the pipe is to be used for making a rubber ring joint, a chamfer is required. Special chamfering tools are available for this purpose, but in the absence of this equipment a flat file can be used provided it does not leave any sharp edges which may cut the rubber ring. Do not make an excessively sharp edge at the rim or the bore and do not chip or break this edge. As a guide, cut the chamfer to 15° to the pipe surface to approx. half the wall thickness at the pipe end.
When a pipe is cut, a witness mark should be pencilled in and care should be taken to mark the correct position in accordance with Table 6.

Rubber Ring Spigot Dimensions

Size DN	Approx length of chamfer (mm)	Witness mark L (mm)
50	6	103
65	8	110
80	10	116
100	13	126
125	13	137
150	14	145
200	20	162
225	22	174
300	28	213



Pipe Chamfer

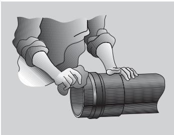
7.1.5 Procedure

Pipes may be jointed out of the trench but it is preferable that connections be made in the trench to prevent possible “pulling” of the joint.

Clean the socket, especially the ring groove and the rubber seal ring. Do not use a rag with lubricant on it - to prevent dust and grit adhering to these surfaces.

Check that the spigot end, if cut in the field, has a chamfer of approximately 12° to 15° (see Table 6).

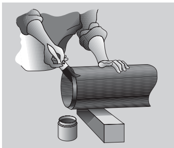
Insert the rubber ring into the groove. The rubber ring is correctly fitted when the thickest cross section of the ring is positioned towards the outside of the socket and the groove in the rubber ring is positioned inside the socket i.e. the flap should point into the pipe.



Run your finger around the lead-in angle of the rubber ring to check that it is correctly seated, not twisted, and that it is evenly distributed around the ring groove.

Remove dirt and dust from the spigot end of the pipe as far back as the witness mark.

Apply Marley jointing lubricant to the spigot end as far back as the witness mark and especially to the chamfered section.



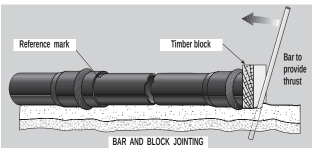
NOTE: Keep the rubber ring and ring groove free of jointing lubricant until the joint is actually being made.

Align the vertical and horizontal pipes and apply a firm, even thrust to push the spigot into the socket. Ensure allowance in the pipe bed for the socket shape. It is possible to joint 100 mm and 150 mm diameter pipes by hand. However, larger diameter pipes such as 200 mm and above may requre the use of a bar and timber block as illustrated. Alternatively, a pipe puller may be used to joint the pipe.

Brace the socket end of the joint so that previously jointed pipes are prevented from closing up.

Inspect each joint to ensure that the witness mark is visible at the face of each socket.

Pipe joints must not be pushed home to the bottom of the socket. They must go no further than the witness mark. This is to allow for possible expansion of the pipe, and ground movement.



BAR AND BLOCK JOINTING

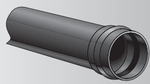
NOTE: If excessive force is required to make a joint, this may mean the rubber ring has been displaced. To check placement of the ring without having to dismantle the joint, a feeler gauge can be inserted between the socket and the pipe to check even placement of the ring, or use a torch to check the pipe joint.

Details of the construction of a pipe puller are available.

7.1.6 How to make a Rubber Ring Joint

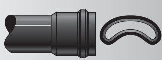
Check Spigot End
Ensure pipe spigot has full 15°chamfer and entry depth mark.

Clean Socket
Clean socket and ring groove of dirt and loose gravel.

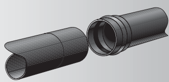


Clean Rubber Ring

Fit Rubber Ring
Place rubber Z ring in groove and check for proper sealing. Fin must point into pipe.



Align Pipes
Align pipes horizontally and vertically. Do not try to insert pipe at an angle to socket.



Lubricate Spigot
Clean of dust and dirt and apply jointing lubricant to chamfer. Keep end free from dirt.

Insert Pipe
Insert spigot into socket to the marked distance. Do not use undue force. If force is required, check ring seating, using a torch to look up the pipe.

DO NOT LEAVE SOLVENT CEMENT ON YOUR SKIN.

Jointing Lubricant

This lubricant is a specially formulated organic preparation enabling easy jointing of rubber ring joint pressure pipe. The use of petroleum based greases or other substitutes may affect the ring or potability of the water supply and cannot be recommended.

This lubricant dries after a short period of time and the joint cannot be easily dismantled. For situations where it may be necessary to dismantle the rubber ring joint after assembly, the use of silicone based jointing lubricant is recommended. Where it is necessary to joint in wet conditions, it may also be advantageous to use silicone lubricant. If dismantled, joints should be fitted with new rings.

7.2 SOLVENT CEMENT JOINTING

Solvent cement pressure pipe joints require an interference fit between the spigot and socket in pipes and fittings. Solvent cement jointing is a welding and not a glueing process. It is very important that the spigot achieve an interference fit in the socket. Do not attempt to make a joint that does not achieve an interference fit when dry. The actual area of contact between the spigot and the socket may only be a few millimetres. The ends must therefore be square to make a good joint. Before proceeding make sure that the spigots and sockets are not cracked or damaged. A pipe with minor damage to the spigot end may be cut back and used as a shorter pipe.

7.2.1 Procedure (NZS 2032)

Before jointing, check that the spigot has been cut square and all burrs removed from the inside and outside pipe edge. Remove all dirt, swarf, and moisture from spigot and socket. Chamfer the spigot end on pipes over 80 mm diameter.

Mark the pipe spigot with a pencil line at a distance equal to the internal depth of the socket. Other marking methods may be used provided that they do not damage or score the pipe.

Dry fit the spigot into the socket. The spigot should interfere in the socket before it is fully inserted to the pencil line.

Dry and degrease each spigot and socket with a cloth dampened with Methylated Spirits. Prepare the pipe spigot and socket with Marley primer fluid. Wipe the surfaces firmly, to remove all dirt and the glossy surface on both the spigot and socket. (Do not paint surfaces with primer. Primed areas will be slightly tacky.) Prime the surface just before applying the solvent.

Using a suitably sized brush, apply a thin, even coat of solvent cement to the internal surface of the socket first. Then apply a thin, even coat of solvent cement up to the mark on the spigot.

Do not use excess solvent cement, and do not dilute or add anything to the solvent cement.

As a guide, the brush should be approximately one third to one half the pipe diameter and large enough to apply the solvent cement to the joint in about thirty seconds.

Make the joint immediately. In one movement insert and twist the spigot into the socket so that it rotates to about a 1/4 turn. The spigot should be fully homed in the socket. Mechanical force will be required for larger joints, over 100 mm. Pipe pullers are commercially available for this purpose. Hold for a minimum of 30 seconds.

With a clean rag, wipe off any excess solvent cement which may have built up externally on a pipe or fitting socket.

Once the joint is made, do not disturb it for five minutes or rough handle it for at least one hour.

Do not pressurise the line for at least 24 hours.

7.2.2 Health

Marley Solvent Cement has been specially formulated for jointing Marley PVC pipe. It releases flammable and toxic vapours. Forced ventilation should be used in confined spaces. Do not bring a naked flame within the vicinity of solvent cement operations.

After using solvent cement wash the hands thoroughly before eating or smoking. Do not eat or smoke while using solvent cement.

Spillage onto the skin should be washed off immediately with soap and water. Should the solvent cement affect the eyes, wash them in clean water for at least 15 minutes. If solvent cement is accidentally swallowed induce vomiting and seek medical advice immediately.

7.2.3 Precautions

Make sure that the end of each pipe is square in its socket and in the same alignment and grade as the preceding pipes or fittings.

While applying solvent cement, support the spigot and socket clear of the ground to avoid contaminating joint with sand or soil.

Take care not to spill solvent cement onto pipes or fittings. Accidental spillage should be wiped off immediately.

The process of curing is a function of temperature, humidity and time. Joints cure faster when the humidity is low and the temperature is high. The higher the temperature the faster the joints will cure. Avoid making solvent cement joints when the temperature is more than 35°C and provide some form of protection when jointing in windy and dusty conditions.

When jointing under wet and very cold conditions, make sure that the mating surfaces are dry and free from ice, as moisture may prevent the solvent cement from obtaining its maximum strength.

At temperatures over 16°C, joints will require 24 hours to cure. When the temperature is between 0°C and 15°C 48 hours should be allowed. See also the precautions in NZS 2032.

Do not fill the pipe with water for at least one hour after making the last joint.

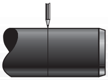
Keep the containers of solvent cement tightly sealed when not in use to prevent evaporation of the solvent and consequent loss of bond strength.

Do not use solvent cement that has gone cloudy or has started to gel in the can.

When applying solvent cement to a pipe or fitting socket take special care to prevent excessive solvent cement from entering the joint as this can cause future “solvent cracking” of the joint. Wipe excess solvent cement from the outside and where possible, from the inside of the joint.

An unsatisfactory solvent cement joint cannot be re-executed, nor can previously solvented spigots and sockets be re-used. To effect repairs, cut off the spigot and socket and use a solvent cement coupling, or use mechanical fittings.

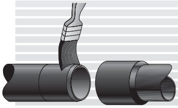
7.2.4 How to make a Solvent Cement Joint



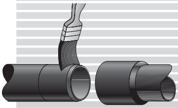
Mark & Chamfer
Mark the socket depth on the pipe end.
Cut a 15° chamfer on larger pipes.

Clean
Clean, dry and degrease the sock and spigot.

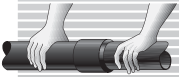
Check the Fit
Insert the spigot into the socket (without solvent cement). An interference fit should occur between 1/3 and 2/3 of full entry.



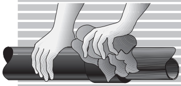
Apply Primer
Prepare the pipe spigot and socket with Marley primer fluid.



Apply Solvent
Apply an even coat of solvent to the socket and then the spigot to the full marked length.



Joint
Insert the spigot the full marked depth in the socket and HOLD for a minimum of 30 seconds, depending on temperature.



Clean Off
Remove surplus solvent cement.

Solvent Cement

Marley Solvent Cement is designed for solvent welding uPVC pipe joints. IT IS NOT AN ADHESIVE. It is a blend of three aggressive solvents and sufficient resin to provide a brushing consistency.

When applied to the pipe surface these solvents cause the uPVC to soften and swell. When two such surfaces are placed in close contact (as in a spigot and socket joint) the softened surfaces mix and on hardening produce a chemically welded joint. Oil, grease, water or dust on the uPVC surface prevents the softening: dust or similar material prevents the intimate contact between the surfaces thus preventing the making of a full strength joint.

Solvent which has thickened in the can through evaporation of the solvents should not be used as it will not soften the pipe surface sufficiently.
The solvents attack the natural oils in human skin eventually causing serious dermatitis.

7.3 JOINTING MATERIALS

7.3.1 Solvent Cement and Jointing Lubricant Coverage

The approximate number of joints that may be jointed with one litre is as follows:

SIZE DN	SOLVENT CEMENT	JOINTING LUBRICANT
15	600	
20	350	
25	260	
32	190	
40	140	
50	85	170
65	70	150
80	60	120
100	50	100
125	40	75
150	30	60
155	25	60
195	17	50
200	25	50
225	15	45
300	10	30
375	10	25

7.4 PE ELECTROFUSION

7.4.1 Preparation

All electrofusion processes must be carried out inside a suitable shelter to prevent dirt and dust contamination of the pipes, couplings and power leads.

The pipes must be aligned so the same centreline height of the coupling clamps and supported evenly support the pipe on both sides of the joint. The pipes should be leveled to prevent pulling away from the coupling joint during welding, or allowing water or dirt inside the pipe to contaminate the weld zone.
An inbuilt resistor is contained within the terminal pin. The resistor pins are colour coded and require the correct colour coded lead to be connected to the resistor.

7.4.2 Fusion Welding Equipment Preparation, Control Systems

Ensure that the generator is operating correctly and that the power output conforms to the control box requirements. Excessive fluctuations in the power source, outside +10%, -10% from a nominal 240 volt, may cause control box to shut down using a safety cut out device.
Both the fusion and cooling times are entered manually or entered by a bar code reader into the control box by the operator.
Care needs to be taken to ensure that the pins are compatible with the control box being used.
Position the welding cables so as to prevent there weight from twisting the welding socket.
During the welding process including the total cooling time the clamps should remain in place

7.4.3 Fusion Welding Pipe Spigot Ends

Successful electrofusion jointing depends correct gap alignment between the end of the pipe spigot and the coupling. Pipes which are oval must be rerounded and clamped. Pipes should not be forced into the coupling as this can damage the coupling and misplace the heating element wires.
Where pipe ends have a “toe in” or diameter reduction at the end, or flats from storage this can affect the strength of the joint and lead to peel strength reduction. The Spigot ends must be recut square to remove the imperfections.
The pipe ends must be aligned evenly along the centreline of the coupling and pipes, especially coiled pipe, must be held in clamps to prevent movement and stressing during the fusion process.
All jointing surfaces must be clean and free from all contamination.
This includes dirt, dust and oil films. Surfaces must not be handled after cleaning. If the sections are contaminated they must be cleaned with a clean cloth and a non depositing alcohol.
All jointing faces must be dry before being assembled.
Mark the end of the pipe at a distance equal to half the length of the coupling and scrape the outside diameter of the pipe over this distance to remove all oxidation layers on the pipe surface. This should be in the order of a layer of 0.3mm and removed with a sharp scraper.
All rough edges and swarf from the pipe ends must be removed.

7.4.4 Fusion Welding Fusion Cycle

Only the recommended fusion and cooling times recommended by the manufacture of the fitting must be used. Where any doubt exists that the proper cycle has taken place, the coupling should be cut out of the line and discarded.
No attempt must be made to rerun the fusion cycle as this will lead to overheating of the PE and degradation.
The full cooling times must be allowed. No attempt must be made to accelerate the rate of cooling. See cooling time in Butt welding section before allowing pressure testing

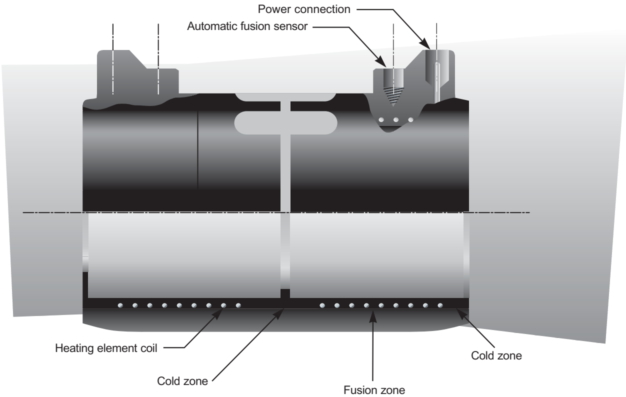
7.4.5 Fusion Welding Coupling Storage

Couplings, saddles and electrofusion fittings must be stored in the original containers until actual use. Where fittings are sealed in plastic bags, the bags must not be perforated before the couplings are used.
Saddles may be protected with a cardboard insert wrapped around the heating element and fitted over the terminal posts. These should not be removed before use.
Terminals may have a plastic cap fitted over the terminal post and these should be left in place until connecting the control box leads.
Couplings should be stored under cover to prevent any oxidation of the fitting materials in the element zone.
The fusion surfaces must not be handled after they are cleaned and prepared for welding.

Fusion Welding Minimum Cooling Times

Size (mm)	Cooling Time (minutes)
OD20-63	6
OD75-110	11
OD 125-160	16
OD180-225	20
OD250-355	30

Electrofusion Coupling Section



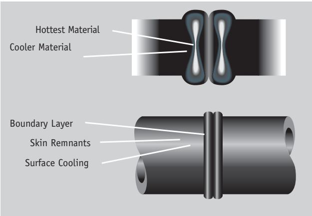
7.5 BUTT WELDING

BUTT WELDING

7.5.1 Introduction Thermal Welding

All thermal welding joint systems require the PE materials to be heated and raised well above the crystalline melt temperature of nominally 130°C, creating a melt pool of the PE material, placing that melt pool under steady pressure, and then allowing the PE melt zones to cool down to ambient temperature.
After the heat source is removed, the temperature will drop and as the cooling continues, the crystalline structure of the MDPE will gradually develop. PE is a poor conductor of heat and the internal pipe sections will remain considerably hotter than the outer surfaces. Accelerated cooling of the melt zone must not be attempted in any type of thermally welded joint. This will lead to smaller crystalline structures and decrease impact strength of the joint.

Temperature Distribution Through Pipe Wall At Final Weld Stage



Introduction Butt Welding

Butt welding is normally only used in pipe size from 90mm to 1000mm for jointing pipe and fittings. Butt fusion brings the molten surfaces together under precise temperature pressure and time to provide a homogeneous material which has the same properties as the original pipe. Butt Fusion is a precise operation and must be carried out with equipment which is well maintained and calibrated by qualified staff in an appropriate working environment. Clean, dry working conditions are imperative as is consistency in the procedure and process.

7.5.2 Butt Weld Detail Environment

The working environment is important that the pipe are correctly aligned and that the machinery can accommodate the pipe drag.
The welding equipment needs to be suitably sited so dirt, dust ,water, rain, oil or drafts will not prevent proper weld strength developing.
All welding must be performed under controlled environmental conditions. Field welding must be carried out in shelters to prevent dust and water contamination. Pipe ends must be blocked off to prevent wind chill and dirt contamination.

7.5.3 Butt Weld Detail Heater Plates

The heater plate **surface** temperature should be set at 230°C with an evenly distributed tolerance of **plus/minus** 10°C.
Temperatures **above** this will lead to possible failure due to thermal degradation.
Temperatures **below** this may be adopted, as it may be necessary to adopt these values for thick wall pipes to prevent overheating, or for PE materials with a high Melt Flow Index.
Only plates in good order should be used and they need to be kept scrupulously clean.

Butt Weld Detail Interface Pressure

The gauge pressure adopted **must have drag pressures added** to any calculated values.

7.5.4 Butt Weld Detail Pipe Alignment

Any misalignment between pipe outside diameter and the ends will reduce the strength of the completed weld. Pipe and fitting must be accurately aligned in the welding machine before the ends are faced. The alignment of the welding machine also needs to be checked after the trimming procedure has been completed.

Misalignment arises from:

- Ovality of pipes
- Eccentric wall thickness around the circumference of the pipe.
- Pipes not being properly aligned in support rollers on either side of the welding machine.
- Pipe spigot end diameter reduction due to in built stresses in the pipes.
- Bent, or misaligned, welding machine frames.

Pipes should be supported on free running rollers on either side of the welding machine and the height and alignment of these rollers should be adjusted to ensure that the pipe centrelines are level with the welding machine.
The alignment should be checked after the pipe ends are trimmed and brought together. The outside diameters should be even around the circumference of the pipes and any offsets adjusted using the adjusting clamps in the welding machine (when fitted).

The **maximum** offsets at the **outside diameter** between abutting pipe ends should not exceed 5 – 10% of the pipe wall thickness when measured at any cross-section.

Butt Welding Procedure

Precise adherence to the procedure, set-up and cleanliness is critical for consistent welding and long-term pipe performance.
The current PIPA (Plastic Industry Pipe Association) procedures are aligned to ISO procedures. These procedures have been confirmed by long-term testing from in-field tests and the resin suppliers.
Welding procedures are detailed at www.pipa.com.au or www.pe100plus.net under ISO Standards.

7.5.5 Butt Weld Welding Times

The times adopted for each section of the weld process must be adhered to and care needs to be taken to recognize the units in seconds or minutes as appropriate.

When the welding process has been completed, the pipe joint **must** be held **under compression** for the full period of the cooling time. The interface pressure can be backed off from the welding pressure, however, the pressure **must** be **above** the drag pressure.

Any attempt to shorten the cooling times will damage the final joint.

Each joint needs to be numbered and the identifiable records as shown in the **pipe weld record** sheets must be completed and signed by the welding operator. A copy of the records should be held by the contractor and an additional copy submitted to the client as part of the Quality Assurance program for each installation.

Weld Parameters: Sample Calculation

Machine Type:	Dixon HF 225
Cylinder Area:	753 mm^2
Pipe Details:	160 PN10 PE80B
	D = 160.0mm
	t = 11.8mm
Weld Procedure:	Single Phase

$$\text{Pipe Area} = \frac{22}{7} \times (160.0 - 11.8)11.8$$

$$= 5496\text{mm}^2$$

Pressure Calculations

(As per PIPA - Industry guidelines for Butt Fusion parameters POP 003/2000)

i) Weld Pressure P1 and P3. (180kPa (0.18 MPa)

$$= \frac{5496}{753} \times 0.18 = 1.31 \text{ MPa + DRAG}$$

ii) Soak Pressure P2 (5 kPa (0.005 MPa)

$$= \frac{549}{753} \times 0.005 = 0.036 \text{ MPa + DRAG}$$

Time Calculations

i) T1 (Until weld bead established)

ii) T2 Heat Soak
= 15 x 11.8 = 177 seconds

iii) T3 Changeover
= (160 x 0.01) + 3 = 4.6 seconds (**maximum**)

iv) T4 Pressure Rise
= (160 x 0.03) + 3 = 7.8 seconds

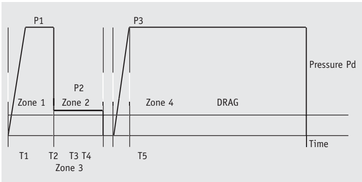
v) Weld Time & Cooling Time (t<15mm)
= 10 + (0.5 x 11.8) = 15.9 minutes

Recording for both Butt and Fusion Weld Conditions

The welding conditions actually applied must be recorded for each weld joint made.

Each joint needs to be numbered and the identifiable records as shown in the pipe weld record sheets must be completed and signed by the welding operator. A copy of the records should be held by the contractor and an additional copy submitted to the client as part of the Quality Assurance program for each installation.

Butt Weld Detail Welding Parameters



The **maximum gap** between the **faces** when brought together under slight pressure should be no more than shown in the following table:

Pipe Diameter DN mm	Maximum Gap mm
Up to 225	0.3
280 to 450	0.5
500 to 630	0.6
710 to 900	0.7
1000 and above	1.0

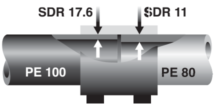
Where finished gaps exceed these values, the pipe ends should be re trimmed, or the pipes rotated in the in the welding machine frame.

Butt Fusion Parameter		Units	Value
Heater plate temperature		°C	220 ± 15
Pressure value: Bead up	P1	kPa	175 ± 25
Approx. bead width after bead up		mm	0.5 + 0.1t
Bead up time	T1	second	Approx. 6t
Pressure value: Heat soak	P2	kPa	Drag only
Heat soak time	T2	second	15t
Max changeover time	T3	second	3 + 0.01D
Maximum time to achieve welding pressure	T4	second	3 + 0.03D
Pressure value: Welding & Cooling	P3	kPa	175 ± 25
Welding & cooling time: t<15mm	T5	minute	10 + 0.5t
Welding & cooling time: t>15mm	T5	minute	1.5t
Min bead width after cooling		mm	3 + 0.5t
Max bead width after cooling		mm	5 + 0.75t

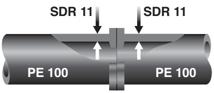
* Drag Pressure measured for each joint must be added to give the final applied pressure, eg. P = Pi + Pd. P = Pinterface + Pdrag

7.5.6 Polyethylene Fusion Jointing Compatibility

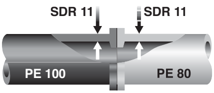
CORRECT



(a) Dissimilar materials and dissimilar wall thicknesses can be jointed by electrofusion coupler

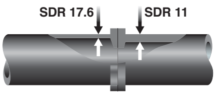


(b) Only similar materials and wall thicknesses may be jointed by butt fusion



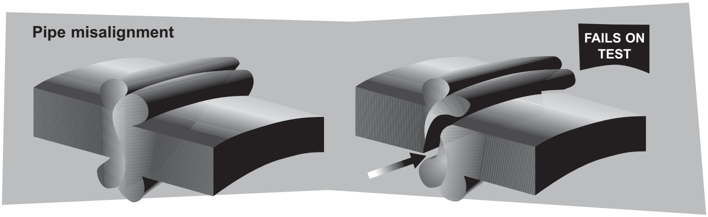
(c) Dissimilar materials may be jointed by butt fusion. However, care is required to ensure a ductile weld is produced.

WRONG

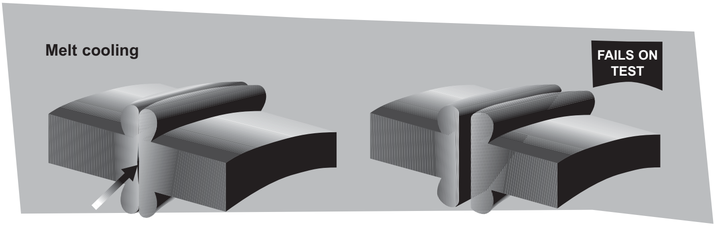


(d) Dissimilar wall thicknesses must not be jointed by butt fusion

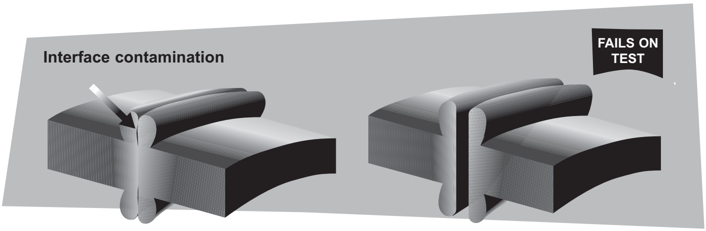
7.5.7 Pipe Misalignment



Pipe misalignment, combined with high fusion pressure, creates an excessively sharp weld bead notch. This can cause premature stress crack failure and reduced impact resistance. Bead removal will reveal the offset.



Re-crystallisation of melt surface, due to excess cooling before fusion gives a low bond strength brittle region at the interface. The weld bead interface can be good, but the weld bead may be small. this causes a joint with poor impact strength and brittleness in bending. stress crack resistance may be adequate.



In an otherwise well-made joint, contamination (eg. from a dusty hotplate) may be retained at the interface. Butt fusion is **not** fully self-cleaning. Weld bead removal will reveal a slit defect. The weld bead interface is weak. This causes very poor properties in bending or impact when the very sharp slit crack can grow. Pressure tests may fail to detect poor stress crack resistance.

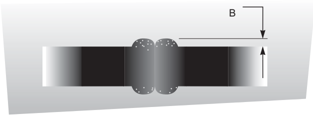
Butt Weld Bead Appearance

The size, shape and surface appearance of the completed weld bead is good first order guide to the quality of the weld.

The weld beads should be evenly formed around the circumference of the pipe and be even sized on both sides of the weld line.

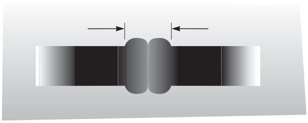
The weld bead must project above the outside diameter of the pipe at all times and be smooth and free from all voids and pitting.

Where pitting or bubbling is observed on the weld bead surfaces, **the welding procedure must be immediately stopped**. This appearance is due to moisture or volatiles being present in the weld face due to moisture in the pipe materials or the heater plate surfaces.



B = 0.5 + 0.1t

As a general guide the **minimum** set-up bead width should be a 1mm with a **maximum** set-up bead width of 5mm.



MIN W = 3 + 0.5t
MAX W = 5 + 0.75t

a) The weld width should not exceed 40mm for any pipe size.
b) These are general guidelines and the weld bead dimensions may vary with different PE materials.
c) The size and appearance applies to the outside diameter weld bead only, as the residual stress left in the pipe may result in a different shaped internal bead section.

7.5.8 Butt Weld QA Recording

All jointing procedures performed on site must be recorded and identified to the numbered joints.

The procedures which have been demonstrated as being suitable before field construction is suitable. To complete this requirement, pilot welds should be made using the equipment, operators and procedures proposed for use with the particular pipeline system and the resultant joints tested for compliance with the specification test stipulations.

7.5.9 Butt Weld Testing

There are several methods currently adopted to evaluate the strength of the completed weld.

Current research shows that none of these methods alone will fully evaluate a joint and that they need to be used in combination. The requirements for a joint will depend on the end application of the pipeline.

The strength of a butt weld will be less than that of a plain pipe section due to the interruption of the wall section due to differences in wall thickness, slight misalignment of the diameters and the effect on the pipe material structure due to the welding process.

For pipe to pipe welding with equal wall sections, a minimum weld strength factor of 90% can be assumed (Dedrich and Dempe Kunststoffe 1980).

a) Hydrostatic Pressure Testing

Pressure testing the completed pipeline is routinely adopted to detect leaks at assemblies or joints.

For PE Pressure pipelines, this is commonly performed at a nominal test pressure of 1.3 times the maximum working pressure in the line, for a period of 15 minutes.

A hydrostatic pressure test of 1.3WP will only detect a weld with a strength of **less than 70%**. A pipe tested to the maximum pressure class rating will **pass a weld with a strength of 50%** of the pipe strength.

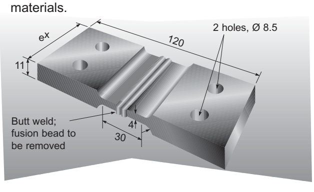
Welds of these strength levels are regarded as reject. **Hydrostatic pressure testing is not adequately evaluate of weld strength.**

Minimum Cooling Time Before Applying Pressure Test Minutes

Diameter	Test Pressure Range	
	≤ 0.60 MPa	≤ 2.0 MPa
20 – 63	10	30
75 – 110	20	60
125 – 160	30	75
180 – 225	45	90
250 – 315	60	150

b) Tensile Testing

Tensile test specimens taken along the length of the pipe with the weld zone at the mid point of the specimen have been extensively used as a standard method of test using the standard 'dog bone' specimen shape as detailed in AS1145 – Determination of tensile properties of plastics materials.



Short term tensile testing using crosshead speeds around 10mm per minute, are useful to detect extremely low strength welds.

$$\% = \frac{\text{weld strength}}{\text{pipe strength}}$$

c) Tensile Fracture Testing

Any testing needs to concentrate the stress at the weld plane, in order to obtain an understanding of the strength of the weld, and by forcing the stress into the weld plane enables an evaluation of any contamination in the weld material
This enables a comparison to be made with the parent pipe material and a short term weld strength factor as a percentage to be calculated.
Weld specimens should generally fracture in ductile manner, with yield being evident in the weld zone material. However, once the pipe wall thickness increases beyond a particular level (typically 20mm for PE80B materials) then the samples will behave in a brittle manner.

This **does not** mean the welds are brittle.

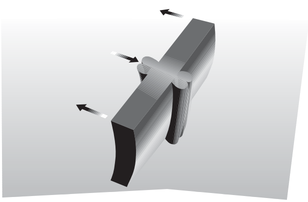
No evidence of contamination, or dislocations should be present on the weld plan fracture surfaces. Any such appearance is sufficient to reject the welds.

d) Long Term Creep Testing

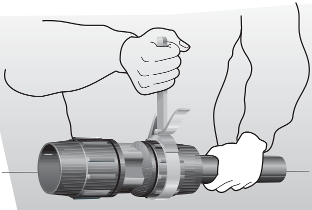
The long term behavior of the weld strength may be evaluated by constant load creep testing at an elevated temperature using an accelerating medium, typically this means using a tensile specimen immersed in a water/detergent mixture around 5% concentration and applying a static load.
The test proceeds until the specimen fractures and the elapsed time is recorded.

e) Flexural Beam Testing

Welded PE pipelines are subject to flexural stressing during installation when lifted, or lowered into the trench and under these conditions the welded joints are placed in bending with tensile, and compression stresses on opposite faces of the pipe wall. Any misalignment of the butting wall sections will increase localised stresses in the weld joint.



7.6 MECHANICAL JOINTS



Mechanical jointing utilises compression of elastomeric seals with the pipe being restrained with a gripper ring, either locked by a mechanical locking nut or a self wedging lock onto the pipe. They are available in pipe diameters from 20mm to 110mm. The fittings are all demountable.

The elastomeric seal ring material requires consideration. In addition, the temperature of the fluids and the environment must be taken into account. Sealing rings supplied are produced in nitrile rubber.

Compression fittings may be assembled by directly pushing the PE pipes into the coupling ends. When using fittings with a compression nut care needs to be taken to ensure that the nuts are not damaged in installation. The fitting should not be disassembled, loosen and insert the chamfered pipe fully home before tightening. Only tightening by hand, strap wrench or specialised assembly spanner. Serrated teeth spanners, or wrenches must not be used.

7.6.1 Flange Ends

Flange ends are adopted for connections between PE pipes and valves, fitting or other materials such as ductile iron, PVC, or FRP pipes.

The flange method of jointing PE pipes consists of a PE stub end which is connected to the PE pipe by butt welding or electrofusion and the sealing carried out with an elastomeric gasket being compressed within the mating surfaces. Metal backing plates are bolted together to provide the compression in the gasket material.

The thickness and the bolt dimensions of the back up plate, need to be sized on the operating pressures of the specific pipeline. The guidelines contained within AS/NZS2129 need to be followed for plate thickness.

The suitability of the gasket sealing materials needs to be checked in terms of the fluids being carried in the pipeline and the external groundwater surrounding the pipeline. Sealing gasket materials may be the limiting feature in the pipeline.

The tightening of the bolts must be carried out evenly around the flange to permit an even seal in the gasket material. A torque wrench should be used to prevent over tightening of the bolts.

In corrosive soil conditions, the metal back up plates and bolts needs to have appropriate protection, such as sacrificial anodes, applied.

7.6.2 Repair Joints

Repairs to PE pipelines may be carried out using electrofusion jointswith the centre register removed or with compression couplings.

7.6.3 Threaded Joints

Where threaded joints are used in PE pipelines, only moulded thread forms should be used.

Direct cut threads must not be used.

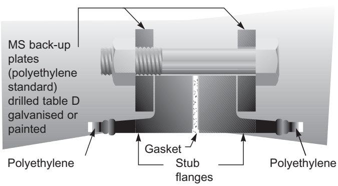
Threaded fittings must be only assembled by hand, strap wrench, flat face tools. Serrated jaw spanners, or wrenches must not be used.

Damage to the moulding can easily occur.

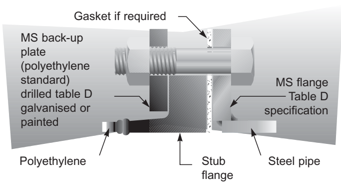
Only inert PTFE tape, or PTFE compounds should be used to seal threaded joints. Sealing compounds can stress crack either PE or other plastics used in the fittings and must be avoided.

Stub Flanges and Backup Plates

(a) Polyethylene to Polyethylene



(b) Polyethylene to Steel



7.7 TAPPING SYSTEMS

7.7.1 General Considerations

PVC/PE pipelines may be tapped using specialist tapping saddles or tees connected to the PE main by either thermal welding methods or compressed rubber seals.
Tapping systems are limited to the size of the off take pipe diameter compared to the main line pipe diameter and the pressure classes of the PVC/PE pipes used in both the service and main lines.

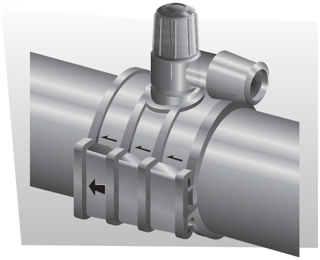
7.7.2 PVC/PE pipes must not be direct tapped using ferrules threaded into the PVC/PE pipe wall section.

Only those tapping systems which have been authorised by the relevant Local Authority shall be used for potable water installations and the standard details for tapping need to be followed.
Tapping saddles rely on compression of a rubber seal ring to complete the seal ensure that the fitting is assembled and locked onto the pipe in the required position before drilling the service outlet hole with a appropriate hole saw.
Multiple Tapping Saddles may be use on a service line but these should not be installed at no closer than 5 times the pipe Diameter
All tapping activities and service connections in PVC/PE pipes should be made where practical before backfilling is completed. So the service line is not stress in its alignment to the tapping band.
Where the tapping takes place at a predetermined location on the allotment boundary, then the tapping can be carried out before the PVC/PE pipe is placed into the trench.
Where tapping and service connections are performed in hot weather conditions, then care needs to be exercised to allow for any thermal expansion/contraction in the PVC/PE pipes so that the final service connection pipe sits evenly into the side trench and does not bear against the side wall of the trench.
Where thermal fusion tapping saddles or tees are used, then tapping must not take place until the welded joints have fully cooled. Any attempt at tapping before this occurs may cause debonding of the joint area and subsequent leakage at the tapping point. Thermal fusion tapping saddles must not be used for PE main line pipes with a pressure class rating of PN6.3 and below, unless they have been designed to prevent localised collapse of the PE main line pipe at the heat applied area.
Where PVC/PE pipes are tapped, the tapping system should contain a cutter which removes the tapping plug material from the PVC/PE main pipe as a single piece and either retains the plug in the cutter or allows the plug to be removed.
Once the tapping and service connections are completed and if thermal welding has been adopted the adequate cooling time allowed, then the standard pressure testing procedures can be applied .

7.7.3 Mechanical Jointing and Service Connections

7.7.4 Tapping Saddles

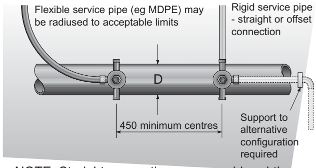
Only tapping saddles designed for use with PVC /PEpipe should be used. These saddles should:
• Be contoured to fit around the pipe and not have lugs or sharp edges that dig in.
• Have a positive stop to avoid overtightening of the saddle around the pipe.



Talbot plastic self tapping ferrule strap

The maximim hole size that should be drilled in a PVC/PE pipe for tapping purposes is 50mm, or 1/3 the pipe diameter, whichever is smaller.
This does not prevent the connection of larger branch lines via tapping saddles, provided the hydraulic loss through the restricted hole size is acceptable.
For larger branches generally, a tee is preferred.
When moving crates of pipes with a forkhoist ensure sockets are not scuffed on hard surfaces.

Holes should not be drilled into PVC/PE pipe:
- Less than 300 mm from a spigot end.
- Closer than 450 mm to another hole on a common parallel line.
- Where significant bending stress is applied to the pipe.



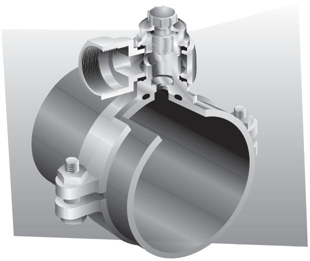
NOTE: Straight connections are considered the norm in most cases

7.7.5 Live Tapping

Various tools are available to allow live tapping of a line using a specially adapted tapping band.
The tapping band should be fitted to the pipe and correctly tightened. A specially adapted main cock for live tapping should be fitted to the tapping saddle using PTFE tape and a drilling machine fitted with a “shell” cutter or hole saw only. The hole is drilled and the tapping flushed. The hole saw is then withdrawn and the main cock sealed. The tapping machine is removed along with the hole cut out and the main cock plunger or cap is then fitted.

7.7.6 Dry Tapping

The procedure is the same as above except that the hole can be drilled before the main cock is fitted. It is also possible to dry tap using a twist drill with razor sharp cutting edges ground to an angle of 80°. Removal of the swarf, however, is more difficult and wherever possible the use of a hole saw is recommended.



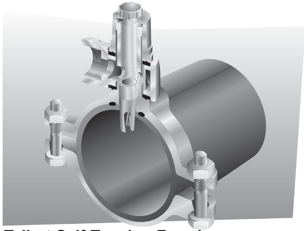
Swivel Ferrule/Strap

7.7.7 Direct Tapping

Marley does not recommend direct tapping (threading of the pipe wall) for PVC/PE pressure lines.

7.7.8 Self Tapping Ferrule

Live mains may be tapped for service connections using the Talbot self tapping ferrule, available with 20mm male outlet.
The ferrule should be screwed into the threaded boss (20 mm) of the tapping band so that the base of the ferrule is within 5 mm of the pipe surface. The cutter is then wound down using a 6mm square drive until fully down. When wound back the cutter will retain the 10 mm diameter uPVC plug and when fully up allows the water to flow to the connections.



Talbot Self-Tapping Ferrule