RADIUS
Systems

Polyethylene Pipe Systems

Potable and Non Potable Water Applications

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POLYETHYLENE PIPE

Dimensions in Accordance to EN 12201 — Wall Thicknesses for Pipe Series

Nominal O/D (mm)	Maximum O/D (mm)	Average O/D (mm)	Maximum Straight Pipe Ovality (mm)	SDR 9 Minimum	SDR 9 Maximum	SDR 11 Minimum	SDR 11 Maximum	SDR11 Average Pipe Bore (mm)	SDR 13.6 Minimum	SDR 13.6 Maximum	SDR13.6 Average Pipe Bore (mm)	SDR 17 Minimum	SDR 17 Maximum	SDR17 Average Pipe Bore (mm)	SDR 21 Minimum	SDR 21 Maximum	SDR21 Average Pipe Bore (mm)	SDR 26 Maximum	SDR 26 Minimum	SDR26 Average Pipe Bore (mm)
16	16.3	16.15	1.2	2	2.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	20.3	20.15	1.2	2.3	2.7	2	2.3	**15.85**	-	-	-	-	-	-	-	-	-	-	-	-
25	25.3	25.15	1.2	3	3.4	2.3	2.7	**20.15**	2	2.3	**20.85**	-	-	-	-	-	-	-	-	-
32	32.3	32.15	1.3	3.6	4.1	3	3.4	**25.75**	2.4	2.8	**26.95**	2	2.3	**27.85**	-	-	-	-	-	-
40	40.4	40.2	1.4	4.5	5.1	3.7	4.2	**32.30**	3	3.5	**33.70**	2.4	2.8	**35.00**	2	2.3	**35.90**	-	-	-
50	50.4	50.2	1.4	5.6	6.3	4.6	5.2	**40.40**	3.7	4.2	**42.30**	3	3.4	**43.80**	2.4	2.8	**45.00**	2	2.3	**45.90**
63	63.4	63.2	1.5	7.1	8	5.8	6.5	**50.90**	4.7	5.3	**53.20**	3.8	4.3	**55.10**	3	3.4	**56.80**	2.5	2.9	**57.80**
75	75.5	75.25	1.6	8.4	9.4	6.8	7.6	**60.85**	5.6	6.3	**63.35**	4.5	5.1	**65.65**	3.6	4.1	**67.55**	2.9	3.3	**69.05**
90	90.6	90.3	1.8	10.1	11.3	8.2	9.2	**72.90**	6.7	7.5	**76.10**	5.4	6.1	**78.80**	4.3	4.9	**81.10**	3.5	4	**82.80**
110	110.7	110.35	2.2	12.3	13.7	10	11.1	**89.25**	8.1	9.1	**93.15**	6.6	7.4	**96.35**	5.3	6	**99.05**	4.2	4.8	**101.35**
125	125.8	125.4	2.5	14	15.6	11.4	12.7	**101.30**	9.2	10.3	**105.90**	7.4	8.3	**109.70**	6	6.7	**112.70**	4.8	5.4	**115.20**
140	140.9	140.45	2.8	15.7	17.4	12.7	14.1	**113.65**	10.3	11.5	**118.65**	8.3	9.3	**122.85**	6.7	7.5	**126.25**	5.4	6.1	**128.95**
160	161	160.5	3.2	17.9	19.8	14.6	16.2	**129.70**	11.8	13.1	**135.60**	9.5	10.6	**140.40**	7.7	8.6	**144.20**	6.2	7	**147.30**
180	181.1	180.55	3.6	20.1	22.3	16.4	18.2	**145.95**	13.3	14.8	**152.45**	10.7	11.9	**157.95**	8.6	9.6	**162.35**	6.9	7.7	**165.95**
200	201.2	200.6	4	22.4	24.8	18.2	20.2	**162.20**	14.7	16.3	**169.60**	11.9	13.2	**175.50**	9.6	10.7	**180.30**	7.7	8.6	**184.30**
225	226.4	225.7	4.5	25.2	27.9	20.5	22.7	**182.50**	16.6	18.4	**190.70**	13.4	14.9	**197.40**	10.8	12	**202.90**	8.6	9.6	**207.50**
250	251.5	250.75	5	27.9	30.8	22.7	25.1	**202.95**	18.4	20.4	**211.95**	14.8	16.4	**219.55**	11.9	13.2	**225.65**	9.6	10.7	**230.45**
280	281.7	280.85	9.8	31.3	34.6	25.4	28.1	**227.35**	20.6	22.8	**237.45**	16.6	18.4	**245.85**	13.4	14.9	**252.55**	10.7	11.9	**258.25**
315	316.9	315.95	11.1	35.2	38.9	28.6	31.6	**255.75**	23.2	25.7	**267.05**	18.7	20.7	**276.55**	15	16.6	**284.35**	12.1	13.5	**290.35**
355	357.2	356.1	12.5	39.7	43.8	32.2	35.6	**288.30**	26.1	28.9	**301.10**	21.1	23.4	**311.60**	16.9	18.7	**320.50**	13.6	15.1	**327.40**
400	402.4	401.2	14	44.7	49.3	36.3	40.1	**324.80**	29.4	32.5	**339.30**	23.7	26.2	**351.30**	19.1	21.2	**360.90**	15.3	17	**368.90**
450	452.7	451.35	15.6	50.3	55.5	40.9	45.1	**365.35**	33.1	36.6	**381.65**	26.7	29.5	**395.15**	21.5	23.8	**406.05**	17.2	19.1	**415.05**
500	503	501.5	17.5	55.8	61.5	45.4	50.1	**406.00**	36.8	40.6	**424.10**	29.7	32.8	**439.00**	23.9	26.4	**451.20**	19.1	21.2	**461.20**
560	563.4	561.7	19.6	-	-	50.8	56	**454.90**	41.2	45.5	**475.00**	33.2	36.7	**491.80**	26.7	29.5	**505.50**	21.4	23.7	**516.60**
630	633.8	631.9	22.1	-	-	57.2	63.1	**511.60**	46.3	51.1	**534.50**	37.4	41.3	**553.20**	30	33.1	**568.80**	24.1	26.7	**581.10**
710	716.4	713.2		-	-	64.6	71.3	**577.35**	52.2	57.6	**603.40**	42.1	46.5	**624.60**	33.9	37.4	**641.90**	27.2	30.1	**655.90**
800	807.2	803.6		-	-	72.7	80.3	**650.54**	58.8	64.8	**680.00**	47.4	52.3	**703.90**	38.1	42.1	**723.40**	30.6	33.8	**739.20**
900	908.1	904.05		-	-	-	-	-	66.2	73.1	**764.78**	53.3	58.8	**791.95**	42.9	47.3	**813.85**	34.4	38.3	**831.35**
1000	1009	1004.5		-	-	-	-	-	73.5	81.2	**849.76**	59.3	65.4	**879.80**	47.7	52.6	**904.20**	38.2	42.2	**924.10**
1100	1109.9	1104.95		-	-	-	-	-	-	-	-	64.7	71.27	**968.98**	52.38	57.72	**994.85**	42.3	46.63	**1016.02**
1200	1210.8	1205.4		-	-	-	-	-	-	-	-	70.6	77.76	**1057.06**	57.2	63.1	**1085.1**	45.9	50.6	**1108.90**

Due to manufacturing tolerances, smaller bores may be achieved. The figures stated are good working dimensions to the best of our knowledge

Polyethylene Pipe Weight Per Metre

PIPE DIAMETER mm		SDR	Pipe Wall Thickness mm		Weight Kg / metre	
Min	Max		Min	Max	PE 80	PE 100
90	90.6	17	5.4	6.1	1.439	1.459
		11	8.2	9.2	2.108	2.13
110	110.6	17	6.6	7.4	2.140	2.17
		11	10.0	11.1	3.138	3.171
125	125.6	17	7.4	8.3	2.728	2.766
		11	11.4	12.7	4.052	4.095
160	161.0	17	9.5	10.6	4.475	4.557
		11	14.6	16.2	6.654	6.724
180	181.1	17	10.7	11.9	5.660	5.740
		11	16.4	18.2	8.388	8.477
225	226.4	17	13.4	14.9	8.859	9.071
		11	20.5	22.7	13.117	13.256
250	251.5	17	14.8	16.4	10.856	11.007
		11	22.7	25.1	16.228	16.299
315	316.9	17	18.7	20.7	17.271	17.509
		11	28.6	31.6	25.580	25.851
355	357.2	17	21.1	23.4		22.239
		11	32.2	35.6		32.856
400	402.4	17	23.7	26.2		28.164
		11	36.3	40.1		41.670
450	452.7	17	26.7	29.5		35.683
		11	40.9	45.1		52.846
500	503.0	17	29.7	32.8		44.024
		11	45.4	50.1		65.188
560	563.4	17	33.2	36.7		55.278
		11	50.8	56.0		81.514
630	633.8	17	37.4	41.3		70.047
		11	57.2	63.1		103.193

Polyethylene Pipe Volume

$$V = \pi r^2 l$$

PIPE DIAMETER mm	SDR	Litres Per Metre (l/m)
90	17	4.95
90	11	4.26
110	17	7.40
110	11	6.36
125	17	9.55
125	11	8.22
160	17	15.65
160	11	13.46
180	17	19.81
180	11	17.04
225	17	30.96
225	11	26.62
250	17	38.22
250	11	32.86
315	17	60.67
315	11	52.17
355	17	77.06
355	11	66.26
400	17	94.84
400	11	84.12
450	17	123.82
450	11	106.47
500	17	152.87
500	11	131.44
560	17	191.76
560	11	164.88
630	17	242.69
630	11	208.68

RADIUS Systems

Batch Numbering

Lot Numbers

Example Pipe

26 0908V31

26	09	08	V	3	1
Line nº	Date	Month	Year V=2005	Day of the week (Monday = 1)	Shift (day or night)

Example of Electrofusion Fittings

V 5 – 36

V	5	36
Year	Day of the week (Monday = 1)	Week nº

Polyethylene Pipe Bracket Spacing

Above ground applications using polyethylene frequently require non-continuous support. Support spacing depends upon the allowable deflection between the supports; this in turn depends upon the pipe size, the contents of the pipe and the ambient temperature of the pipeline.
The following tables have been calculated by Radius Systems to assist their customers in using the most suitable support spacing for a given application, the temperature of both sets of tables are calculated around a mean temperature of 23ºC.

Pipe Contents Water

Above Ground Pipe Support Spacing

Pipe Diameter (mm)	SDR 17 (Contents Water)		SDR 11 (Contents Water)	
	Vertical Deflection 1mm	Vertical Deflection 6.5mm	Vertical Deflection 1mm	Vertical Deflection 6.5mm
90	750	1200	810	1300
110	830	1350	900	1440
125	880	1400	960	1540
160	1000	1600	1090	1750
180	1060	1700	1160	1850
225	1190	1900	1290	2060
250	1250	2000	1360	2180
315	1400	2250	1530	2440
355	1500	2380	1620	2600

Pipe Contents Air

Above Ground Pipe Support Spacing

Pipe Diameter (mm)	SDR 17 (Contents Air)		SDR 11 (Contents Air)	
	Vertical Deflection 1mm	Vertical Deflection 6.5mm	Vertical Deflection 1mm	Vertical Deflection 6.5mm
90	1090	1740	1070	1710
110	1200	1920	1180	1890
125	1280	2050	1260	2020
160	1450	2320	1430	2280
180	1540	2460	1520	2420
225	1720	2750	1700	2710
250	1820	2900	1790	2850
315	2040	3260	2010	3200
355	2170	3460	2130	3400

Anchorage and Thrust Blocks on polyethylene systems

One of the fundamental features of fully integrated fusion welded polyethylene systems is that they are end load resistant and construction of thrust blocks is not normally required at junctions or bends.

However, an exception to this is at transition points to non-end load bearing pipe systems where thrust anchoring will be required. A typical example of this can be seen in the section entitled Thrust Block Worked Equation.

The use of concrete anchor blocks for PE pipes is descried in WRc Polyethylene Pipe Systems Manual Section 3.10.

The designer should consider all aspects of the system, including the imbalanced loads imposed be testing procedures, unusual configurations, large temperature variations, etc., and where excessive stress on the pipe system is envisaged, additional anchorage should be considered.

Polyethylene pipe may itself be partially or completely surrounded by concrete but should be protected by a heavy duty polyethylene membrane to a membrane should extend outside of the concrete to avoid possible damage during pouring or compaction and minimise local stresses.

Electrofusion Jointing Procedure

Electrofusion Fittings contain electrical filament wires which, when correctly connected to an appropriate power source for the specified period of time, will fuse the coupling onto the pipe.

The correct jointing procedures for the installation of electrofusion couplers are contained within WIS 3-32-08.

Electrofusion fittings for water and sewerage applications in both PE80 and PE100 are manufactured in accordance with WIS 4-32-14 and EN 12201-3

It is possible to join dissimilar polyethylene pipe and wall thickness by using electrofusion fittings. For example PE80 fittings may be used to join to PE100 pipe.

1. Tooling required for the welding of an electrofusion fitting is a suitable electrofusion control box with power supply and a scraper capable of removing 0.2-0.4mm from the outside of the polyethylene pipe.

   An alignment clamp should be used to ensure that the joint's movement is kept to a minimum during the heating and cooling cycle together, with cleaning cloths and an indelible pen. A welding shelter should also be used to provide protection of the welding area against adverse weather conditions and contamination.

2. Using cleaning cloths firstly clean the area of the pipe to be welded of any surface debris.

   Without removing the sealed packaging mark on the pipe the area which is to be scraped, ie approximately 15-20mm beyond the insertion depth of the coupler.

3. Using a suitable pipe surface preparation tool "scraper" remove the pipe surface in the selected area to a depth of

   0.2-0.4mm; it is imperative at this stage of the operation that this is preformed correctly.

   Wherever possible a mechanical end preparation tool is the preferred method of pipe surface preparation as it is capable of removing a continuous, even layer from the pipe surface.

Do not touch the scraped surface.

4. Open one side of the sealed bag containing the electrofusion fitting and slide it on to the pipe.

The electrofusion coupler is fitted with a centre stop. Slide the fitting along the pipe until it comes into contact with the centre stop. Mark the insertion depth using an indelible marker pen.

Leave the bag over the end of the coupler to protect against contamination coming into contact with the inside of the fitting.

Scrape the second pipe as demonstrated in 3.

5. Remove the bag covering the coupler and insert the second pipe up to the centre stop. Then mark the insertion depth using an indelible marker pen.

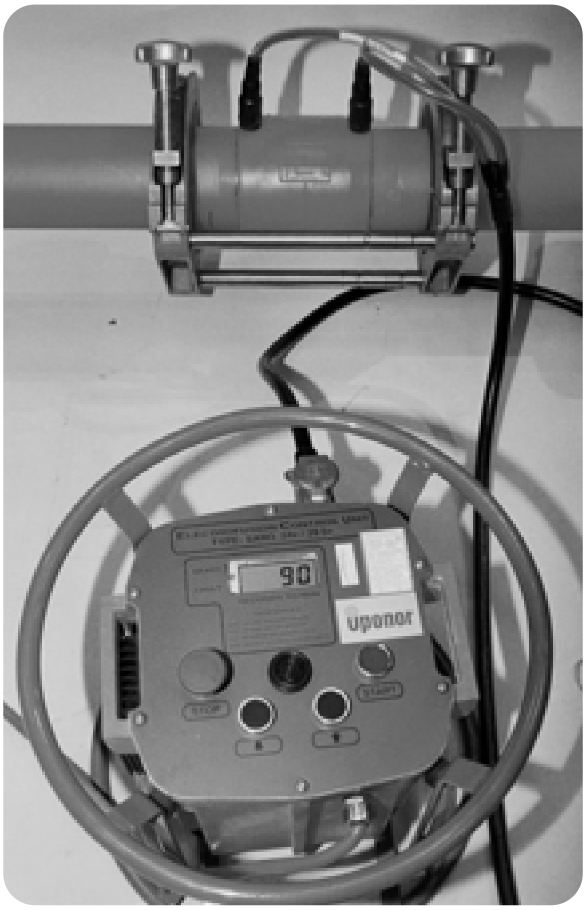
6. Correctly position and fit the restraining clamp to the assembly.

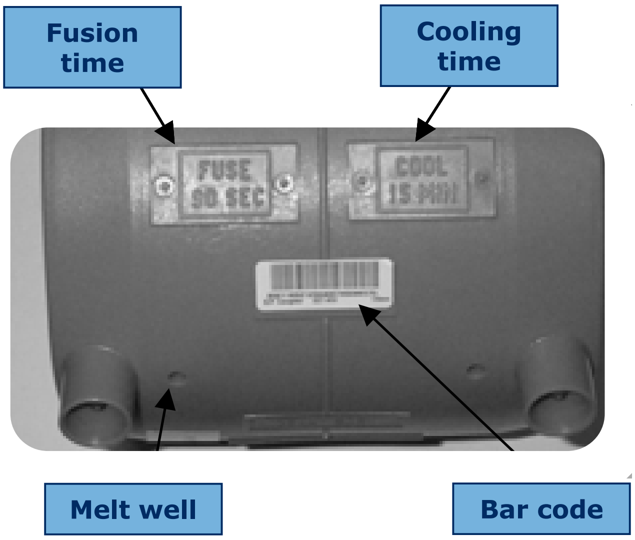
   Clamps should always be used to secure an electrofusion assembly during the fusion cycle.

7. Having ensured the power supply is working correctly connect the electrofusion control box to the fitting and power supply.

   Follow the instructions given on the fusion box's display screen.

   Input the fusion time either by using the information embossed on the coupler or by using the bar code affixed to the fitting. The method used will depend on the type of control box being used.





Once the coupler has completed the fusion cycle check that the melt indicators/melt wells show a successful fusion cycle has taken place. Melt wells, as shown above, should fill with melt to a point approximately flush to the surface of the fitting. The melt indicators fitted to predominantly smaller fittings will rise beyond the body of the electrofusion fitting.

The coupler must be left in retaining clamps for the full cooling time specified on the fitting although the terminal leads may be removed with care at the end of the fusion time.

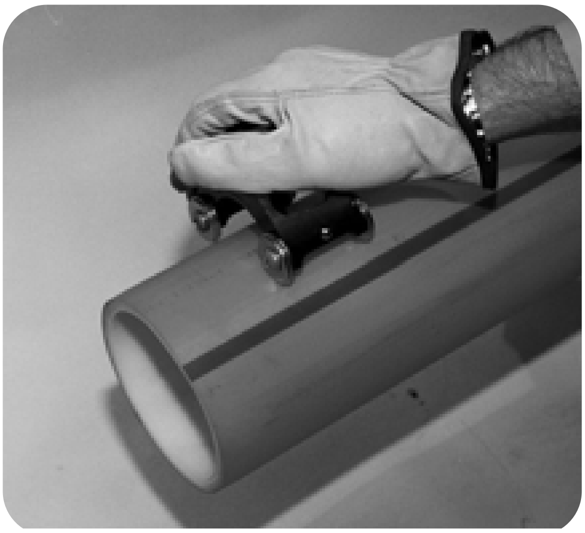
Installing Electrofusion Couplers when using ProFuse Pipe

Profuse pipe allows electrofusion couplers to be installed without the pipe having to be scraped in the area to be welded.

A. Firstly remove any surface debris and clean the general area of pipe to be welded.

B. Score the ProFuse pipe skin beyond the insertion depth of the coupler.

   Guide the Pipe Exposure Tool in the direction of the arrow on the cutter around the pipe whilst depressing the cutter to lift the skin, resulting in a flared edge.



C. Turn the tool 90º and hook the cutting tool under the edge of the flared skin. Then cut along the pipe.

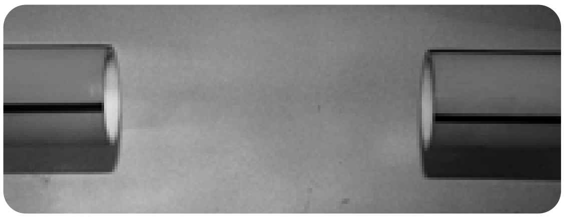
D. Hold the edge of the skin and steadily peel the skin to expose the naturally coloured pipe beneath.

E. Open one side of the bag containing the coupler and slide it on to the pipe. Then follow Electrofusion Procedure From stage 4.

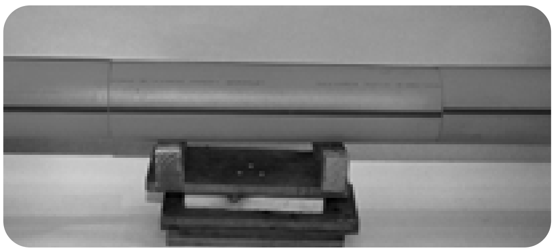
Using Electrofusion Couplers in the Slip Mode

The centre stops fitted in the Radius coupler have been designed to be removable, enabling the coupler to slip completely along the pipe thereby allowing electrofusion to be used for pipe repairs and connections.

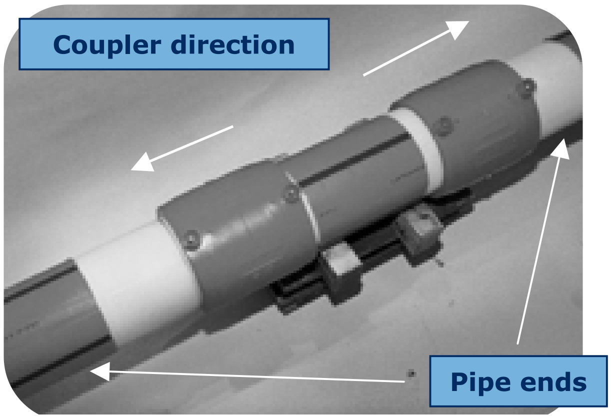
1. In the first instance of a pipe repair, the pipe ends must be cut square.



2. Cut a section of pipe to bridge the two exposed pipe ends. Also position timbers to support the gap section of pipe.

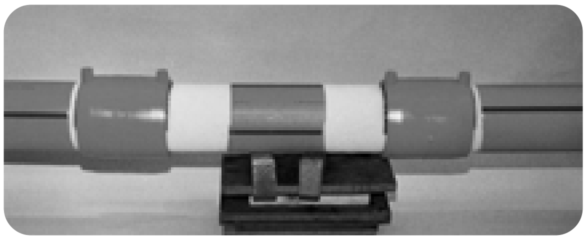


3. Scrape or in this case score the Profuse pipe skin and peel beyond the full length of the couplers. Remove the centre stops and position the fittings onto the pipe.



4. Slide the couplers back into position and mark the pipe with an indelible pen, making sure the pipe joint is central to the couplers.

As with the electrofusion procedure the assembly should be clamped prior to fusing.



Electrofusion Tapping Tee Assembly Procedure.

Electrofusion Tapping Tees are available in a range of sizes with both 32 and 63mm outlets. These fittings are suitable for joining to a range of pipe sizes and wall thicknesses, the details of which are normally printed on each individual fitting.

1. Tooling required for the fitting of the tee is a 40volt control box, a top loading clamp, scraper, a 12mm hexagon-tapping key, cleaning cloths and an indelible pen. Begin by checking that the pipe and fitting sizes are compatible.

2. Using cleaning cloths firstly **clean the area of pipe**, where you intend to weld the fitting.

3. **Without removing the fitting from its packaging** place the fitting over the required position on the pipe. With an indelible pen, mark on to the pipe around the fitting the area to be scraped.

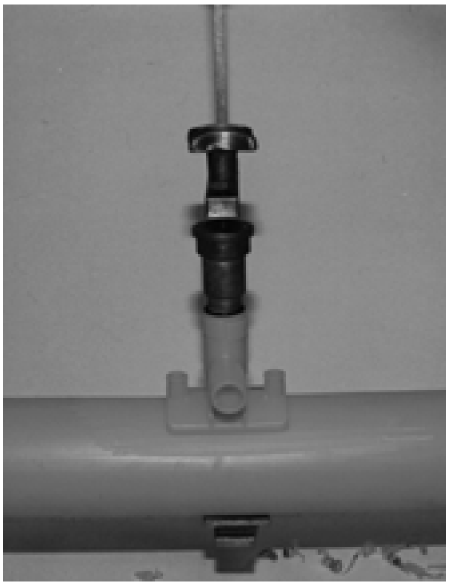
4. Using a suitable scraping tool, scrape the surface of the pipe to a depth of 0.2 to 0.4mm over the whole of the identified area.

5. Remove the fitting from its packaging and then remove the cap, exposing the cutter, which should be flush. Do not touch the fitting base.

6. Ensure the loading screw on top of the loading clamp is screwed out fully, and then secure the fitting onto the clamp.

DO NOT TOUCH SCRAPED SURFACE

7. Remove the filament protection cover and position the fitting over the prepared area of the pipe securing the clamp to the manufactures instructions at the same time.
During this operation it is imperative that the scraped pipe surface and the fusion pad are kept **clean and free from contamination.**



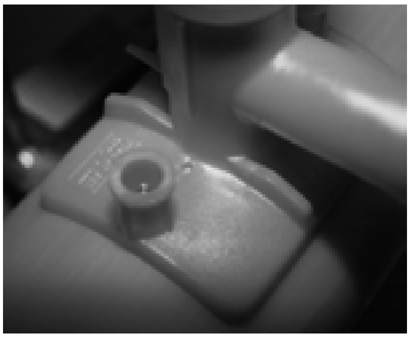
8. Apply the correct loading by winding down on the clamp until the correct load is indicated. The preset load indicator may vary slightly between tools. The procedure recommended by the clamp manufactures should be followed to **apply the correct loading onto the fitting.**

Check that there is sufficient fuel in the generator to fuse the service connection and that the fusion box and leads are in a good serviceable condition.

9. Start the generator and connect the fusion box. Then connect the leads from the fusion box to the terminals of the tee. **Follow the instructions given on the fusion boxes display screen** and input the fusion time either by using the fusion time embossed on the fitting or by using the bar code affixed to the fitting, the method used will depend on the type of control box being employed.

Once fused the fitting must be left with the clamp on for the **full cooling time**, which is also embossed on the fitting.

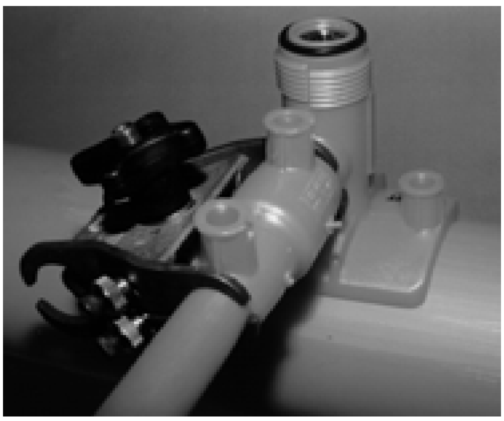
Check that melt well has been filled with melt before proceeding.



10. During the cooling time it is the ideal time to assemble the service pipe, fittings and equipment needed to connect the tapping tee outlet to the surface pipe.

The tee outlet is classified as pipe and as such, follow the Radius Systems procedure for jointing couplers.
The service outlet requires scraping and clamping

An even layer 0.2 to 0.4mm should be removed from the outside of the outlet

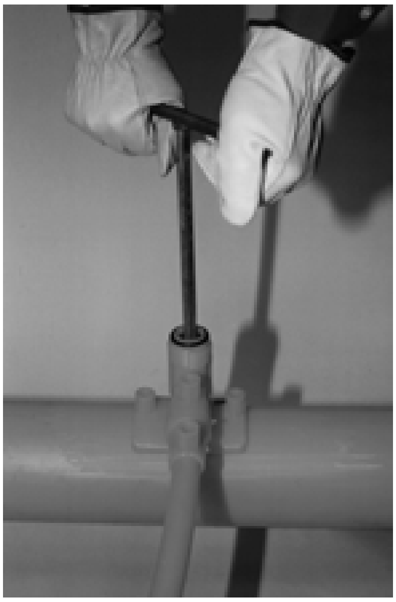


and from the service pipe. A range of mechanical scrapers are on the market, which best perform this function.

Clamps are available for all combinations of surface connection.

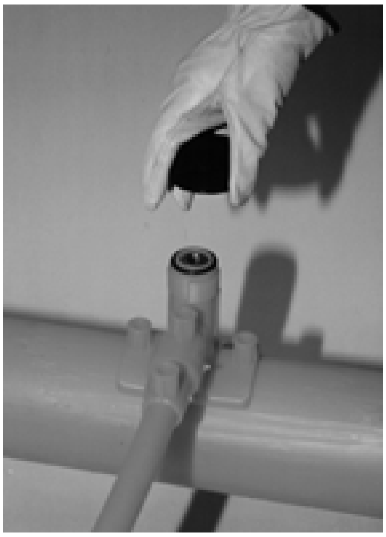
A number of industry specifications advise that service connections are pressure tested before tapping into the host main. Details of this operation should be sourced from the relevant industry specifications.

11. When the service pipe is in place and has been successfully tested then the host main may be tapped.
The pipeline may be tapped in or out of service. Firstly engage the hexagon drive key into the cutter then wind the cutter down in a continuous clockwise direction until the cutter comes into contact with the pipe.



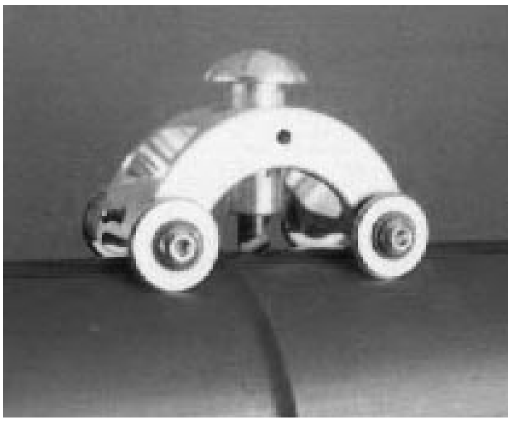
When you are ready to tap the main, continue screwing the cutter in a **continuous clockwise direction** through the wall of the pipe. This forces a coupon of polyethylene up into the cutter body to form a seal. The load needed to rotate the tapping key will drop as soon as the main is tapped. Continue rotating the cutter clockwise for another two revolutions before retracting the cutter in an anticlockwise direction.

12. Retract the cutter until the cutter is nearly flush with the top of the fitting, remove the tapping key and then replace the cap.



<u>Installing Tapping Tees using ProFuse Pipe</u>

ProFuse pipe allows electrofusion fittings to be installed without having to scrape the area of pipe to be

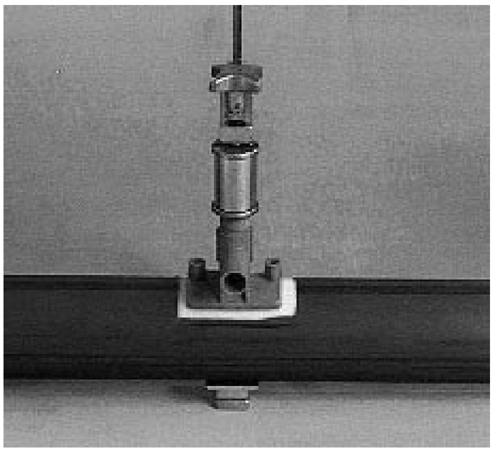


jointed.

A. Firstly follow stages 1,2 and 3 of the Tapping Tee assembly procedure but instead of a scraper, when using ProFuse pipe, a peeling tool is required.

B. With the ProFuse peeling tool score the marked area

C. Remove the peeled section of ProFuse skin. Follow the Tapping Tee assembly procedure from number 5. Weld to the exposed section of pipe

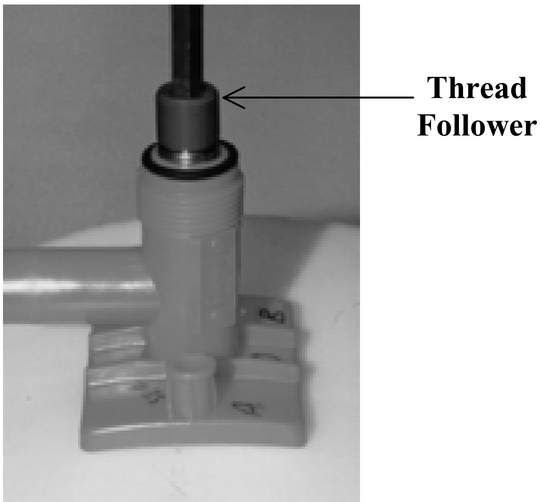


<u>Tapping thick wall Polyethylene</u>

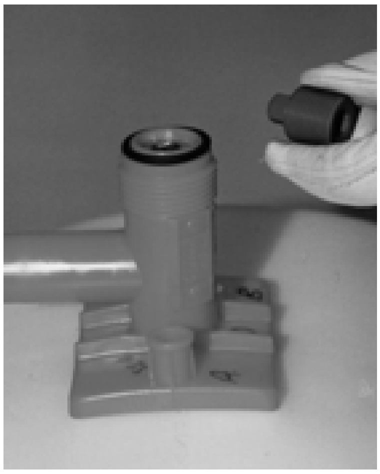
When tapping larger diameter and thicker walled pipes with Radius Systems tapping tees, the fittings are fitted with a two-part cutter.

The operation to tap the main is the same as already mentioned, until the point of retraction of the cutter. At this point the cutter and thread follower ‘coloured red’ are retracted to the point where the cutter is nearly flush to the top of the fitting, at which point the thread follower is removed.

A. Retract the cutter and thread follower until the thread follower can be removed.



B. Remove the thread follower *‘if the follower is not removed it will restrict the outlet’*



C. Replace the cap

Underclamp Service Connections Fitting Instructions

The electrofusion underclamp fittings are available in a range of outlet sizes 20mm, 25mm and 32mm and are available in diameters from 40mm to 180mm.

1. Tooling required for installing of the undercamp fitting is a 40volt control unit, a 13mm spanner or socket, a pipe scraper, a 12mm hexagon-tapping key, cleaning cloths and an indelible marker pen.
Begin by checking that the pipe and fitting sizes are compatible.

2. Using cleaning cloths firstly clean the area of pipe, where you intend to weld the fitting.

3. Remove the fitting from its protective bag and slacken the retaining nuts on one side of the underclamp.

4. Without removing the protective cardboard matt cover, place the fitting over the required position on the pipe.

With an indelible pen, mark the area to be scraped on the pipe.

5. Using a suitable scraping tool, scrape the surface of the pipe to a depth of 0.2 to 0.4mm over the whole of the identified area.

6. Remove the cardboard matt cover and place the fitting in position.

7. Firmly clamp the fitting into position by tightening the clamping straps up to a positive stop using a 13mm spanner or socket.

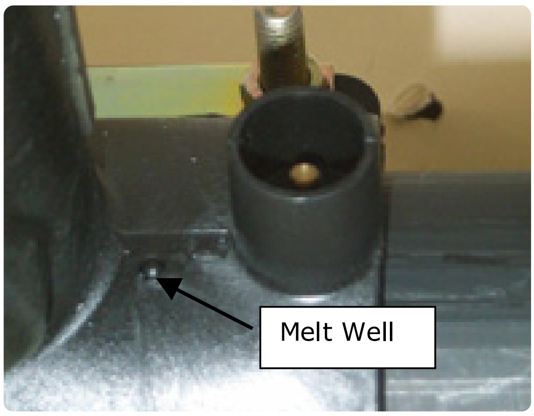
Check that there is sufficient fuel in the generator to fuse the service connection and that and that the fusion box leads are in a good serviceable condition.

9. Start the generator and connect the fusion box. Then connect the leads from the fusion box to the terminals of the tee.

Follow the instructions given on the fusion box display screen and input the fusion time either by swiping the bar code label affixed to the fitting with the LED pen connected to the control box, or alternatively the fusion time can be inputted into the fusion box manually. The manual fusion time is embossed onto the fitting body.

Once the fitting has completed its fusion time it must be left to cool. The cooling time will be indicated by the fusion box or is embossed on the body of the fitting.

Before continuing to install the service check that the melt well has filled



When you are ready to tap the main, continue screwing the cutter in a **continuous clockwise direction** through the wall of the pipe. This forces a coupon of polyethylene up into the cutter body to form a seal. The load needed to rotate the tapping key will drop as soon as the main is tapped. Continue rotating the cutter clockwise for another two revolutions before retracting the cutter in an anticlockwise direction.

11. Retract the cutter until the cutter is nearly flush with the top of the fitting, remove the tapping key and then replace the cap.

10. When the service pipe is in place and has been successfully tested then the host main may be tapped.
The pipeline may be tapped in or out of service. Firstly engage the 12mm hexagon drive key into the cutter then wind the cutter down in a continuous clockwise direction until the cutter comes into contact with the pipe.

Butt Fusion Principles and Jointing

Polyethylene is a thermoplastic, which can be fusion welded. Butt Fusion undertaken correctly using the correct well maintained equipment and with trained operators will result in producing fully end load resistant pipe joints, which when tested will display the same properties as the parent pipe material.
Butt Fusion welding involves simultaneously heating the two pipe ends by means of an electrically heated plate until a sufficient heat reservoir has been created on the ends of the pipe. The two pipe sections are brought together under a controlled fusion pressure for a cooling period (dependent on the pipe size).

Butt Fusion is a suitable process for the jointing of both PE80 and PE100materials, though only similar materials and wall thicknesses should be welded to each other unlike electrofusion which may be used for jointing dissimilar materials as shown in Figure One.

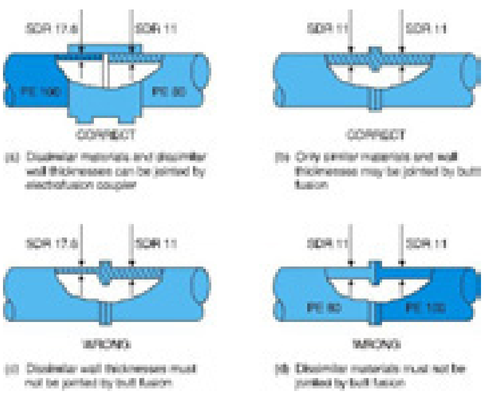


Figure 1

Most of the Butt Fusion welding undertaken in the UK on small and medium pipe sizes is now undertaken using fully automatic Butt Fusion equipment. This negates the need for site operatives to calculate or interpret welding parameters.
Automatic Butt Fusion machines should be programmed with the welding parameters detailed in the current issue of Water Industry Specification 4-32-08 which is the water industry's specification for site fusion jointing of both PE100 and PE80 Blue and Black materials.

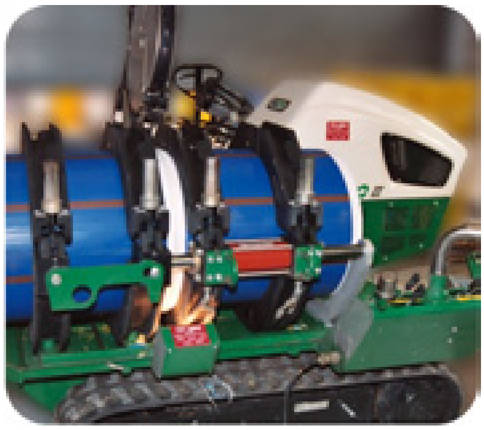


Figure 2

Fusion machines and ancillary equipment may be bought or hired from several manufacturers and agents suitable for welding up to 1200mm pipe diameters. Larger diameter jointing equipment has been produced but is less common.

All reputable manufacturers issue comprehensive literature on the operation procedures of their products.

Pre-Production Checks

Ensure that the welding equipment has been sited on a suitable hard standing which can easily be kept clean.

Check the generator has sufficient fuel for the operation.

Check that the heater plate is free from surface debris, prior to connecting the heater plate to the power source.

The heater plate should be washed thoroughly with copious amounts of water. Only clean lint-free materials shall be used when cleaning and drying the surface heater.

Once connected and the heater plate has reached operating temperature, check the heater plate is within the operating range of 230ºC (+10-5ºC). The heater plate should be checked with a calibrated surface probe.

When the heater is within the operating range dummy or cleaning welds can be produced. Although washing the heater plate removes heavy concentrations of debris, very fine particles may still be present within the hollows of the textured plate surface.

To remove the fine concentrations of surface contaminants from the plate surface, either go through the motions of welding without bring the melted pipe ends together, when cooled re-trim the pipe ends. Alternatively produce welds of short pipe sections of the same size and diameter. For pipes up to and including 180mm diameter one dummy joint should be undertaken. For pipes greater than 180mm two dummy joints / cleaning welds should be undertaken prior to the production welding.

Production Welding

Clean the pipe ends to be welded. Also if welding Profuse pipes then remove 25mm of the protective blue polypropylene skin from the pipe ends.

Position the pipes within the butt fusion machine leaving a suitable gap between the two pipes to allow the trimmer to be inserted. When the pipes are in the correct position the clamps can be secured in place and the trimmer can be inserted.

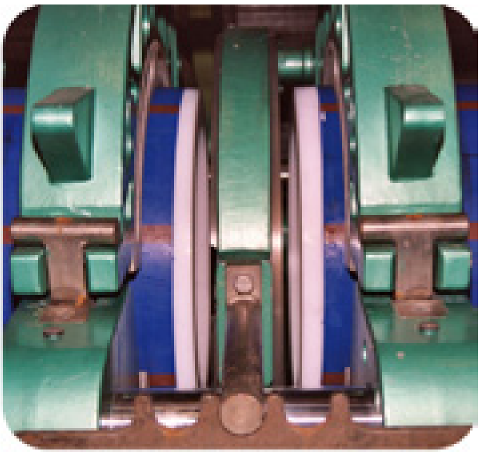


Figure 3

Switch the trimmer tool on and close the pipes together. Pressure should be maintained onto the trimmer blades until a continuous ribbon of material has been planed from the pipe ends as shown below.

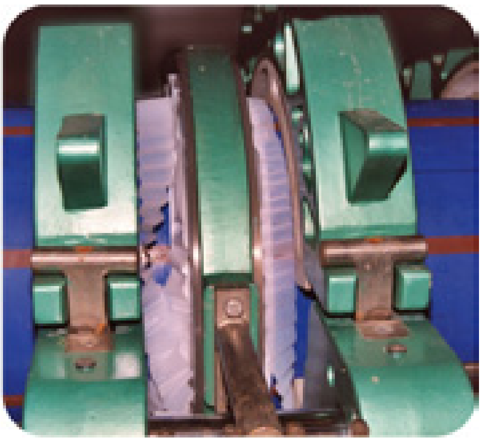


Figure 4

Remove the shavings (this operation is normally best undertaken from the bottom of the machine). **Do not touch the pipe ends.**

Remove the trimmer and bring the pipes together under full welding pressure and check for mismatch, pipe slippage and that there is no visible gap between the pipe ends. If there is a visible gap between the pipe ends, or if there is excessive mismatch or the pipes have slipped then the pipe ends should be repositioned and re-trimmed.

Mismatch

WIS 4-32-08 issue 3 states that there should be no discernable mismatch on pipe sizes up to and including 180mm.
For pipes above 180mm the amount of allowable mismatch should be less than 10% of the pipe wall thickness.

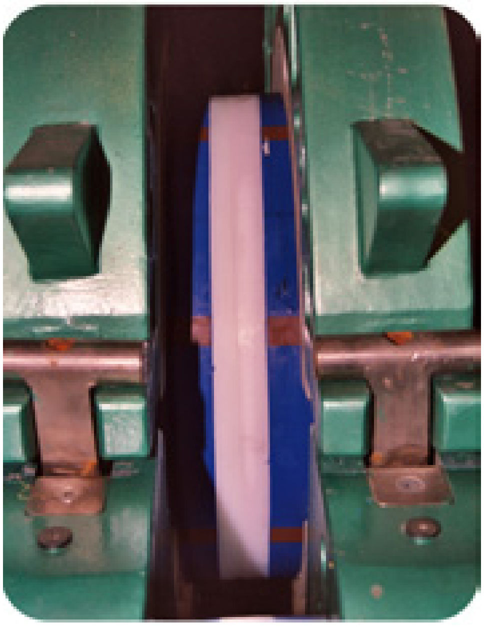


Figure 5

Butt Fusion Check Cycle

The correct welding parameters are detailed in the attached tables and also documented in WIS 4-32-08. The times and pressures stated should not be modified or deviated from in any way as this may result in production of welds which do not meet the required standards of Water Industry Specification
4-32-17.

When the pipes have been trimmed and checked for mismatch they are separated and the heater plate is positioned between the two pipe ends.

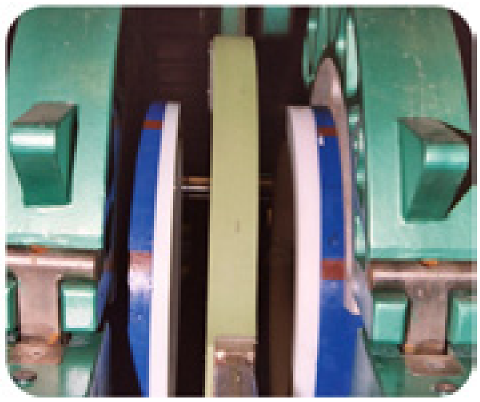


Figure 6

The pipe ends are brought up to the heater plate at a pressure of 0.15MPa until the initial bead has formed.

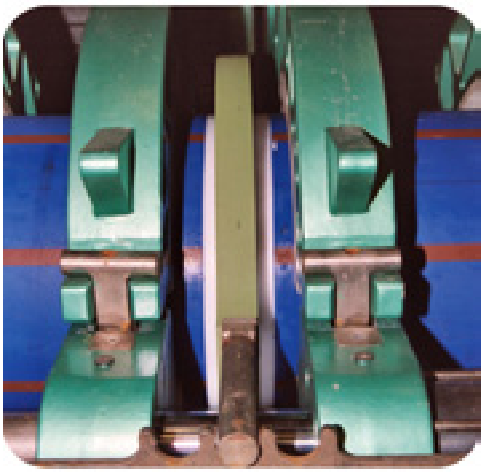


Figure 7

Once the initial bead has formed, the pressure is dropped to between zero and drag pressure (drag pressure is the hydraulic pressure needed to overcome friction). The reason for dropping the pressure is to create a stress free environment, which will result in establishing a reservoir of molten polymer on the pipe ends to be jointed.

The correct soak time for any given diameter can be established by consulting the data tables contained within this document.

A point of interest when welding ProFuse pipes is that the pipe material in contact with the heater plate becomes clear when the material reaches a molten state. When the material cools it reverts to its normal white appearance.

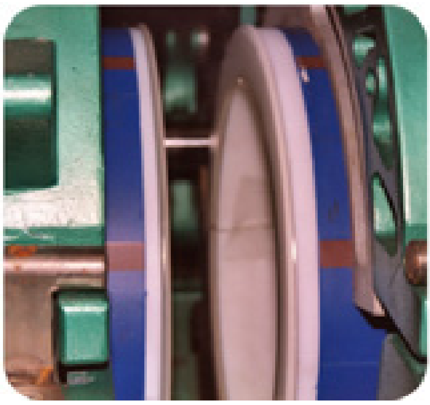


Figure 8

At the point when the soak time has been completed the machine is opened, separating the pipe from the heater plate.

The heater plate is removed from between the two pipes as quickly as possible.

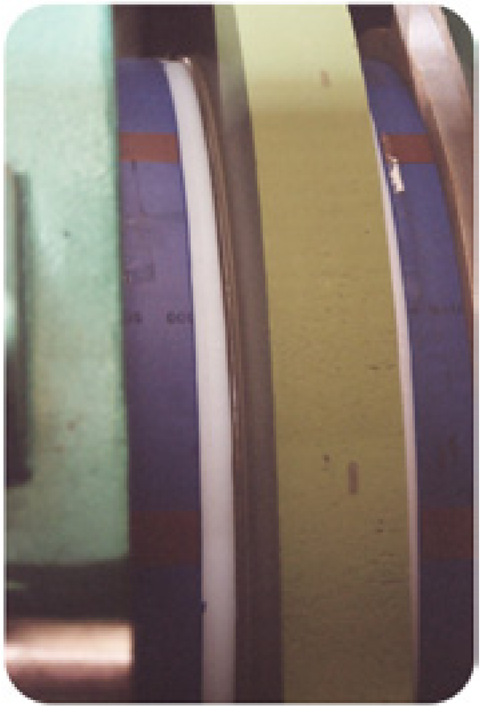


Figure 9

The two pipe ends are brought back together in a smooth action up to an interface stress of 0.15MPa.

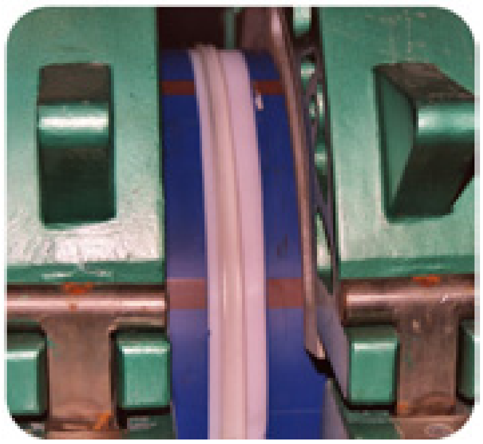


Figure 10

The process of removing the heater plate and moving the two pipe lengths back together should take no longer than ten seconds, from the point the pipe separates from the heater plate to the point the two pipe ends are brought together at an interface stress of 0.15 MPa.

For single pressure welding this interface stress is maintained for the full cooling time. For dual pressure welding the interface stress of 0.15 MPa is dropped after ten seconds to a stress of 0.025 MPa.
The tables included highlight the pipe sixes which need to be welded using the dual and single pressure welding cycles, through as a general rule, pipes having a wall thickness of above 21mm will require jointing with dual pressure parameters.

When the weld has been allowed to cool for the recommended cooling time it can be removed from the machine and the next weld can be prepared.

During the cooling time of any further welds it is an ideal opportunity to remove external weld bead from the previous weld. Beads can be removed at any point following the cooling time of the weld. The weld beads are removed using specific tooling as shown below.

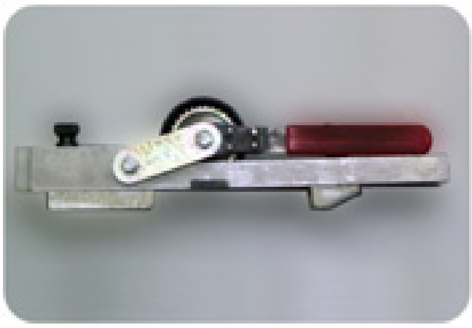


Figure 11

The de-beading tool can remove the outer bead in one-piece, which may then be used as an on-site quality inspection of the weld.

Figure 12

Twisting the bead as shown along its total length gives a very good indication of the quality of the weld. Should faults be noted then the weld should be cut from the pipe string and re-welded.

It is good practice to mark the beads and welds with a unique number which would help with identification should it be necessary.

Table 1 - Single Pressure Butt Fusion Welding Conditions For both PE 80 and PE 100 Pipes

Outside Diameter (mm)	SDR	Wall Thickness (Minimum) (mm)	Bead-Up Stress (1) +/- 0.02 (Mpa)	Initial Bead Size (approx) (mm)	Soak Time +/- 3 (Secs)	Minimum Soak Stress (2) (Mpa)	Maximum Plate Removal Time (3) (Secs)	Fusion & Cooling Stress (1) +/- 0.02 (Mpg)	Cooling Time in Clamps (Minutes)	Cooling Time Out of Clamps (Minutes)	Typical Final Overall Bead Width (4) (mm) Min	Max
90	26	3.5	0.150	2	95	0	10	0.150	10	5	8	15
90	17.6	5.1	0.150	2	110	0	10	0.150	10	5	8	15
90	11	8.2	0.150	2	140	0	10	0.150	10	5	9	16
110	26	4.2	0.150	2	100	0	10	0.150	10	5	8	15
110	17.6	6.3	0.150	2	125	0	10	0.150	10	5	9	16
110	11	10.0	0.150	2	160	0	10	0.150	10	5	10	17
125	26	4.8	0.150	2	110	0	10	0.150	10	5	8	15
125	17.6	7.1	0.150	2	130	0	10	0.150	10	5	9	16
125	11	11.4	0.150	2	175	0	10	0.150	10	5	10	17
160	26	6.2	0.150	2	120	0	10	0.150	10	5	9	16
160	17.6	9.1	0.150	2	150	0	10	0.150	10	5	9	16
160	11	14.5	0.150	2	205	0	10	0.150	10	5	11	18
180	26	6.9	0.150	2	130	0	10	0.150	10	5	9	16
180	17.6	10.2	0.150	2	160	0	10	0.150	10	5	10	17
180	11	16.4	0.150	2	225	0	10	0.150	10	5	11	18
225	26	8.7	0.150	2	145	0	10	0.150	10	5	9	16
225	17.6	12.8	0.150	2	190	0	10	0.150	10	5	10	17
225	11	20.5	0.150	2	265	0	10	0.150	10	5	12	19
250	11	Use Dual Pressure technique (see dual pressure table)										
250	26	9.6	0.150	2	155	0	10	0.150	10	5	9	16
250	17.6	14.2	0.150	2	200	0	10	0.150	10	5	10	17
280	11	Use Dual Pressure technique (see dual pressure table)										
280	26	10.8	0.150	2	170	0	10	0.150	10	5	13	22
280	17.6	15.9	0.150	2	220	0	10	0.150	10	5	14	23
315	11	Use Dual Pressure technique (see dual pressure table)										
315	26	12.1	0.150	2	180	0	10	0.150	10	5	13	22
315	17.6	17.9	0.150	2	240	0	10	0.150	10	5	14	23

Table 2 - Dual Pressure Butt Fusion Jointing Conditions for PE80 & PE100 Pipes

Outside Diameter (mm)	SDR	Wall Thickness (Min) (mm)	Bead-Up Stress (1) +/- 0.02 (Mpa)	Initial Bead Size (approx) (mm)	Soak Time +/- 3 (Secs)	Minimum Soak Stress (2) (Mpa)	Maximum Plate Removal Time (3) (Secs)	Fusion Stress (1) +/- 0.02 (Mpa)	Cooling Stress (1) +/- 0.01 (Mpa)	Cooling Time in Clamps (Minutes)	Cooling Time Out of Clamps (Minutes)	Typical Final Overall Bead Width (4) (mm)	
												Min	Max
250	11	22.7	0.150	3	285	0	10	0.150	0.025	15	7.5	15	24
280	11	25.5	0.150	3	315	0	10	0.150	0.025	15	7.5	16	25
315	11	28.6	0.150	3	345	0	10	0.150	0.025	15	7.5	17	26
355	26	13.7	0.150	3	195	0	10	0.150	0.025	10	5	13	22
355	17.6	20.2	0.150	3	260	0	10	0.150	0.025	15	7.5	15	24
355	11	32.3	0.150	3	385	0	10	0.150	0.025	15	7.5	18	27
400	26	15.4	0.150	3	215	0	10	0.150	0.025	10	5	14	23
400	17.6	22.7	0.150	3	285	0	10	0.150	0.025	15	7.5	15	24
400	11	36.4	0.150	3	425	0	10	0.150	0.025	20	10	18	27
450	26	17.3	0.150	3	235	0	10	0.150	0.025	10	5	14	23
450	17.6	25.6	0.150	3	315	0	10	0.150	0.025	15	7.5	16	25
450	11	40.9	0.150	3	470	0	10	0.150	0.025	20	10	19	28
500	26	19.2	0.150	3	250	0	10	0.150	0.025	10	5	15	24
500	17.6	28.4	0.150	3	345	0	10	0.150	0.025	15	7.5	17	26
500	11	45.5	0.150	3	515	0	10	0.150	0.025	20	10	20	29
560	26	21.5	0.150	3	275	0	10	0.150	0.025	15	7.5	15	24
560	17.6	31.8	0.150	3	380	0	10	0.150	0.025	15	7.5	17	26
560	11	50.9	0.150	3	570	0	10	0.150	0.025	20	10	22	31
630	26	24.2	0.150	3	300	0	10	0.15	0.025	15	7.5	16	25
630	17.6	35.8	0.150	3	420	0	10	0.150	0.025	15	7.5	18	27
630	11	57.3	0.150	3	635	0	10	0.150	0.025	25	12.5	23	32
710	26	27.3	0.150	3	335	0	10	0.15	0.025	15	7.5	16	25
710	17.6	40.3	0.150	3	465	0	10	0.150	0.025	20	10	19	28
800	26	30.8	0.150	3	370	0	10	0.150	0.025	15	7.5	17	26
800	17.6	45.5	0.150	3	515	0	10	0.15	0.025	20	10	20	29
900	26	34.6	0.150	3	405	0	10	0.150	0.025	20	10	18	27
900	17.6	51.1	0.150	3	570	0	10	0.150	0.025	20	10	22	31
1000	26	38.5	0.150	3	445	0	10	0.150	0.025	20	10	19	28
1000	17.6	56.8	0.150	3	630	0	10	0.150	0.025	25	12.5	23	32

250-630MM SDR 17 &11 BUTT FUSION WELDING PARAMETER

FOR UK MANUFACTURED POLYETHELENE PIPELINES

This document has been prepared as a briefing note for those companies and individuals who are required to configure a butt fusion machine for welding Polyethylene pipes supplied by Radius Systems. The parameters are only for use in the construction of pipelines that require to welded together in accordance with Water Industry Standard 4-32-08.

Welding Parameters
The table below provides a summary of the butt fusion welding parameters for PE pipes in the size range 250 to 630mm, and **SDR 17 and 11**.

Outside Diameter	SDR	Wall Thickness (Min.)	Bead-up Interface stress	Initial bead size (approx)	Soak Time	Soak Pressure	Fusion Interface Stress (first ten seconds) MPa	Cooling Interface Stress (after ten Seconds)	Cooling time in clamps	Cooling time out of clamps
mm		mm	MPa	mm	Sec	Bar	MPa add drag	MPa add drag	mins	mins
250	11	22.7	0.15	2	285	Drag	0.15	0.025	15	7.5
315	11	28.6	0.15	3	345	Drag	0.15	0.025	15	7.5
355	17	20.9	0.15	3	270	Drag	0.15	0.025	15	7.5
355	11	32.3	0.15	3	385	Drag	0.15	0.025	15	7.5
400	17	23.5	0.15	3	295	Drag	0.15	0.025	15	7.5
400	11	36.4	0.15	3	425	Drag	0.15	0.025	20	10
450	17	26.5	0.15	3	325	Drag	0.15	0.025	15	7.5
450	11	41.0	0.15	3	470	Drag	0.15	0.025	20	10
500	17	29.4	0.15	3	355	Drag	0.15	0.025	15	7.5
500	11	45.5	0.15	3	515	Drag	0.15	0.025	20	10
560	17	32.9	0.15	3	390	Drag	0.15	0.025	15	7.5
560	11	50.8	0.15	3	570	Drag	0.15	0.025	20	10
630	17	37.1	0.15	3	430	Drag	0.15	0.025	15	7.5
630	11	57.2	0.15	3	635	Drag	0.15	0.025	25	12.5

NOTES

1. Butt fusion machines shall comply with the requirements of WIS 4-32-08
2. Heater plate temperature should be min 225°C, maximum 240°C

Calculation of Ram Pressure

To convert the interface stress in the table to ram pressure, the effective cylinder area of the machine has to be known (cm²). The ram pressure to achieve an interfacial stress of 0.15MPa can then be calculated by using the formula given.

Calculation of Ram Pressure = $\dfrac{(0.15 \times \pi \times (\text{O/D} - \text{Wall Thickness}) \times \text{Wall Thickness})}{\text{Effective Cylinder Area}(cm^2)}$

The above formula has proven confusing to a number of operatives, in an attempt to simplify the calculation the top line of the equation has been calculated and is given as a factor shown in the table below.

Outside Diameter	SDR	Factor
250	17	163
315	17	259
355	17	329
400	17	417
450	17	529
500	17	652
560	17	817
630	17	1037

Outside Diameter	SDR	Factor
250	11	243
315	11	386
355	11	491
400	11	624
450	11	788
500	11	975
560	11	1219
630	11	1544

PE Pipe Systems – Flange Connections

Specification of flanges

Flanges are normally specified in the following format:

[PE pipe diameter] x [flange nominal diameter]

For example, to connect a 315 pipe to a 300 nominal diameter flange, a PE stub flange would be requested using the following definition:

315 SDR 17.6 x 300 PN16

The PN16 refers to an industry flange specification that is detailed in BS4504. It is a reference to the backing ring to be supplied and is not a measure of the pressure capability of the flange.

Flange bolts

Flange bolts and gaskets should be purchased with the flange. By this route the bolt lengths will be correct and the relevant approved coating will have been added to the bolts during the manufacturing process.

Bolts should be tightened in the correct sequence, i.e. starting at top dead center, then the bolt diametrically opposite, the next bolt clockwise from top dead center, repeating the process around the flange ring.

All bolts should be tightened to a defined torque using a torque wrench, values for which are given in the table below. Ideally, final torquing up should be repeated after the assembly has been allowed to relax for an hour or so.

Flange nominal diameter (mm)	Flange OD (mm)	PCD	Nº Holes	Hole diam.	Bolt	Bolt Torque (Nm)
50	165	125	4	18	M16	35
80	200	160	8	18	M16	30
100	220	180	8	18	M16	40
150	285	240	8	22	M20	70
200	340	295	12	22	M20	80
250	405	355	12	26	M24	100
300	460	410	12	26	M24	120
400	580	525	16	30	M27	200
450	640	585	20	30	M27	200
500	715	650	20	33	M30	300

As there are large differences in the total Effective Cylinder Areas of machines used in the field, it is important if the machine does not carry a data plate affixed to its chassis, check with the butt fusion machine manufacturer for the correct Ram/ Effective Cylinder Area.

$$\text{Ram pressure} = \frac{\text{Factor}}{\text{Effective Cylinder Area}}$$

Example Hy-Ram BFM 315 Machine which has an Effective Cylinder Area of 11.15cm^2 welding 250mm SDR 11 Pipe

$$\text{Fusion pressure} = \frac{243}{11.15}$$ **= <u>21.8</u> bar Welding Pressure for the first ten seconds**

The Welding parameters issued in WIS 4-32-08 require the use of Dual Pressure welding, this requires the pressure to be dropped from 0.15 MPa to 0.025 MPa after ten seconds.

$$\text{Fusion pressure} = \frac{243}{11.15}$$ **= <u>21.8</u> Cooling pressure 21.8 ÷ 6 = <u>3.63 bar</u>**

Typical Puddle Flange Assembly onto PE Pipe

Within the water industry there exists a body of knowledge on the construction of high pressure water distribution networks using fittings technology which is not classed as end load bearing (type 1 jointing in water industry)

Most flange constructions subjected to end loads are associated with the connection to valve assemblies or to blanking plates. The standard method employed for a non-end load bearing structure would be to use a component known as a puddle flange, in conjunction with a concrete thrust block. Figure 1.0 below shows how such an arrangement would be used for the installation of a line valve.

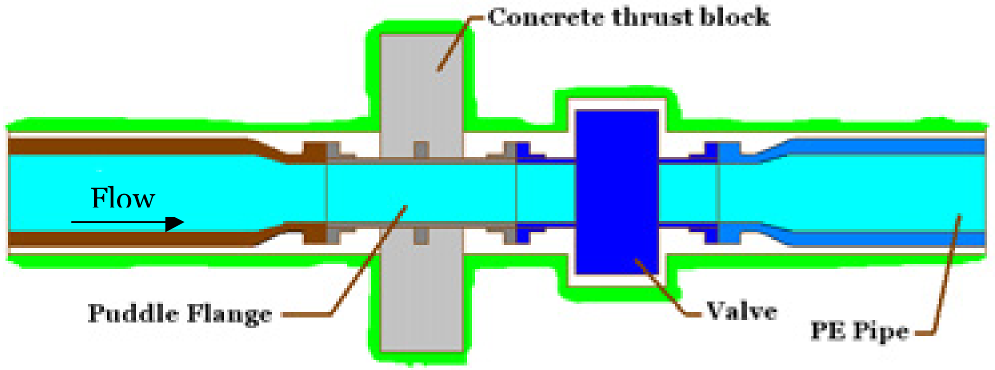


Figure 1.0; Thrust assembly for line valves

Puddle flanges would generally be of steel or cast iron construction to provide a rigid connection to one side of the line valve. Puddle flanges are generally treated as a fabrication by the suppliers but one, which is readily available.

The basic principle is that thrust developed by virtue of closing the valve is transferred either by a tensile or compressive force on the puddle flange (dependent on which way the water is flowing in the line). The puddle flange then transfers the thrust load to the concrete encasement block which is locked into and has a load bearing surface area onto the surrounding soil.

A simple example is detailed overleaf to illustrate typical dimensions to be expected for a concrete thrust block.

For Blank Ends and Tee's Thrust = **100 x A x P**

A = External Cross Section of Pipe
P = Maximum Internal Pressure (Bar)

Pipe nominal dimensions; 250 mm diameter (**A**=Πr^2 = 0.049 m^2)

Thrust developed per bar internal pressure, approximately 4.9kN

Nominal operating pressure; 10 Bar. *Note it is important to use the largest pressure seen by the system this is typically during initial testing*.

Total thrust developed **49** kN

For a range of soil types, typical safe bearing pressures are as follows (source, WRc PVC Pipes Manual, 2nd Edition 1994)

Soil type	Safe bearing pressure (kN/m^2)
Soft clay	24
Sand	48
Sandstone & gravel	72
Sand & gravel bonded with clay	96
Shale	240

The bearing area required for support is the total thrust divided by the safe bearing load of the soil type.

Assuming the worst-case ground condition, soft clay, the bearing surface for the block would therefore be (= 49/24) 2.04 m^2.

Assuming the soil type to be, sandstone & gravel, the bearing surface for the block would therefore be (= 49/72) 0.68 m^2

Best practice would indicate that the bearing surface should be against ground, which has not been disturbed by the excavation.

Polyethylene Pipe Bends and Bending

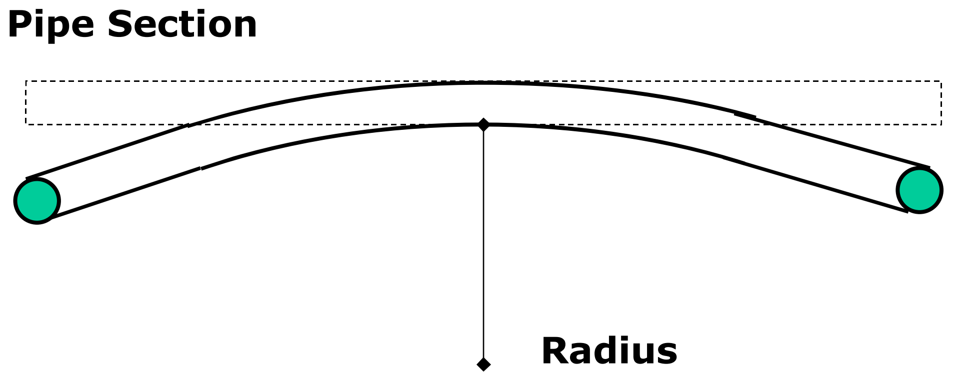
The bending of PE80 and PE100 is permissible, and the properties of fusion of a fusion-jointed system allows for changes in direction without the necessity for the installation of prefabricated bends. However, pipes should not normally be COLD bent to a radius less than 25 × outside diameter of the pipe, when the ambient temperature of the pipe is at 20ºC.

In special circumstances with smaller diameter service pipe the minimum bending radius can be reduced to 15 × outside diameter of the service pipe.

In winter conditions when the temperature drops to 0ºC it is recommended that the minimum cold bending radius be increased to 50 × outside diameter. The table below details the recommended minimum cold bending radius for both zero and twenty degrees centigrade.

Nominal Pipe Outside Diameter	Minimum Cold Bending Radius (Metres)	
	Pipe temperature 20ºC	Pipe temperature 0ºC
75	1.88	4.5
90	2.25	6.25
110	2.75	9.0
125	3.13	12.5
160	4.00	15.75
180	4.50	9.00
225	5.63	11.25
250	6.25	12.50
315	7.88	15.75
355	8.88	17.75
400	10.00	20.00
450	11.25	22.50
500	12.50	25.00
560	14.00	28.00
630	15.75	31.50

COLD BENDING OF PE



At 20ºC the bending radius should be less than 25 x Outside Diameter i.e for 250mm x 25 = 6.25 m

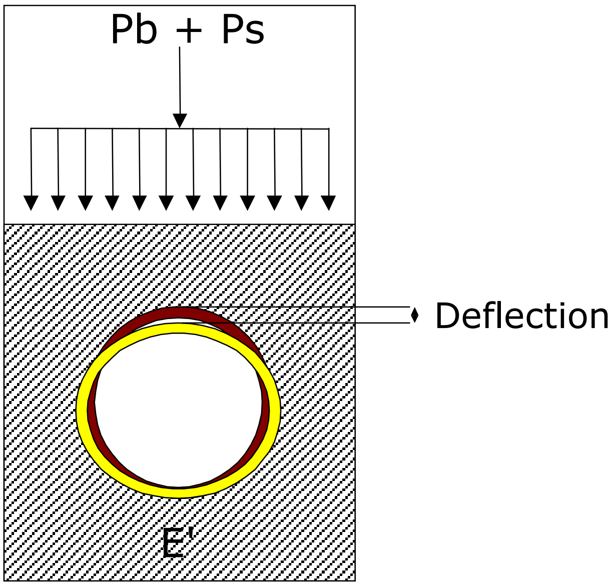
At 0ºC the bending radius should be less than 50 x Outside Diameter I.E for 250mm x 50 = 12.5 m

Spangler 'Iowa' Long Term Deflection Formula

$$\text{Deflection} = \frac{\text{Applied Loading}}{\text{Pipe stiffness} + \text{Soil stiffness}}$$

$$\text{Deflection} = \frac{K \cdot (DL \cdot Pb + Ps}{(8 \cdot S) + (0.061 \cdot E)}$$

- Ps = Vertical Pressure From Surcharge (Traffic)
- Pb = Vertical Pressure From Backfill
- K = Bedding Factor (Dimensionless)
- DL = Deflection Lag Factor
- E' = Pipe Zone Material Modulus
- S = Long Term Pipe Stiffness



Temperature De-rating of Polyethylene Pipelines

Polyethylene is a thermoplastic and the strength of Polyethylene materials is temperature dependent. As a Consequence the nominal documented operating pressures of polyethylene are for the pipelines operated at or below 20ºC.

At the lower end of the temperature scale the mechanical properties of polyethylene allow the pipe to be used successfully in very low temperature environments. At normal UK winter temperatures, the pipe will remain flexible and of itself will not impede installation operations.

Where Polyethylene is to be operated at temperatures above 20ºC for sustained periods then the maximum pressure rating of the pipeline must be reduced if a 50-year minimum life expectancy is to be maintained.

The table below details the corrected pressure ratings for Polyethylene operated at elevated temperatures, the derating factor used to calculate recommended pressure ratings for Polyethylene operating at temperatures above 20ºC is a reduction in pressure of 1.3% per Degree Centigrade above 20ºC. In general operating temperatures above 60% are not normally recommended.

	20ºC	25ºC	30ºC	35ºC	40ºC	45ºC	50ºC	55ºC	60ºC
PE 100 SDR 11	**16 bar**	**14.9**	**13.9**	**12.8**	**11.8**	**10.8**	**9.7**	**8.7**	**7.6**
PE 100 SDR 17	**10 bar**	**9.3**	**8.7**	**8.0**	**7.4**	**6.7**	**6.1**	**5.4**	**4.8**
PE 80 SDR 11	**12.5 bar**	**11.7**	**10.9**	**10**	**9.2**	**8.4**	**7.6**	**6.8**	**6.0**
PE 80 SDR 17	**8 bar**	**7.5**	**6.9**	**6.4**	**5.9**	**5.4**	**4.9**	**4.3**	**3.8**

Polyethylene pipe recommended maximum towing loads

The Maximum recommended towing load for polyethylene pipe is 50% of the ultimate tensile strength of the pipe, that is 50% of the load required to cause yielding of the PE material. This recommendation assumes that the tensile forces are applied for less that one hour. Where the loads are applied for periods up to an hour, it is recommended that a period of at least one hour be allowed post insertion to allow for the viscoelastic recovery of the material.

When the pipe is inserted using techniques such as swagelining or horizontal directional drilling, where the load is applied for substantially longer than an hour, often up to 24 hours, then it is recommended that the recommended maximum towing load should be derated to 40% of the ultimate tensile strength. A substantial period of time at least equal to the time under load, preferably five times the period the insertion length was under load should be applied to allow the PE material to recover.

The tables for PE 80 and PE100 detail recommendations for pipe material installation at less than 23ºC.

PE 80 PIPE DIAMETER mm	SDR	PE 80 Half Yield (MPa)	Maximum Towing/Winch Loads
90	17	7.5	1.08
90	11	7.5	1.61
110	17	7.5	1.61
110	11	7.5	2.40
125	17	7.5	2.08
125	11	7.5	3.10
160	17	7.5	3.41
160	11	7.5	5.08
180	17	7.5	4.31
180	11	7.5	6.43
250	17	7.5	8.31
250	11	7.5	12.41

PE 100 PIPE DIAMETER mm	SDR	PE 100 Half Yield (MPa)	Maximum Towing/Winch Loads
90	17	9.5	1.36
90	11	9.5	2.04
110	17	9.5	2.04
110	11	9.5	3.04
125	17	9.5	2.63
125	11	9.5	3.93
160	17	9.5	4.31
160	11	9.5	6.44
180	17	9.5	5.46
180	11	9.5	8.15
225	17	9.5	8.53
225	11	9.5	12.73
250	17	9.5	10.53
250	11	9.5	15.72
315	17	9.5	16.72
315	11	9.5	24.96
355	17	9.5	21.23
355	11	9.5	31.70
400	17	9.5	26.96
400	11	9.5	40.24
450	17	9.5	34.12
450	11	9.5	50.93
500	17	9.5	42.12
500	11	9.5	62.88
560	17	9.5	52.84
560	11	9.5	78.87
630	17	9.5	66.87
630	11	9.5	99.82

Weatherability of Black Polyethylene

Radius Systems' polyethylene pipe material has a generally good resistance to the effects of weathering and can readily withstand moderate climates without excessive degradation. Consideration should be given when installing a polyethylene pipeline above ground or when materials are to be stored for extended periods without protection.

The detrimental effects, which may be caused by ultraviolet radiation exposure on the pipe material, are controlled by the inclusion of suitable stabilisers in the polyethylene resin.

Blue pigmented polyethylene is intended for below ground potable water applications. Radius Systems' range of blue polyethylene material is protected by ultraviolet stabilizers which allow the pipes and fittings to be stored above ground in areas of moderate climates such as the U.K. for periods of up to twelve months. When longer storage times are required or when the materials are to be stored above ground in areas of the world with hotter climates then pipes and fittings should be protected from direct sunlight by covering the materials or storing them undercover.

Black pigmented polyethylene can be used for above ground applications. Radius Systems' black polyethylene pipe material is pigmented with carbon black which protects the polyethylene from ultraviolet radiation from the sun. The inclusion of carbon black within the materials formulation enables black polyethylene pipes and fittings to be both stored and used above ground without the need for further protection.

The levels of carbon black content are normally specified in the relevant manufacturing specifications to which the pipe is produced, but a common figure is the inclusion of 2 – 2.5% (measured in accordance with ISO 6964) of finely divided carbon black.

Carbon black is the single most effective additive capable of enhancing the weathering characteristics of Radius Systems' black polyethylene range of pipes. The protection that even relatively low levels of this material impart to polyethylene is so great that it allows black polyethylene pipes to be safely used outside in most climates for many years without danger of loss of physical properties from ultraviolet exposure.

TESTING & COMMISSIONING OF PE PIPE SYSTEMS

These requirements are in accordance with the procedures laid down by the undertaker. These standards will normally require, as a minimum, the adequate flushing of any service and the testing of all pipes and joints.

After being tested pipelines must be subjected to a disinfection process.

The commissioning of new or repaired mains is normally carried out in the following order:

- Cleaning and/or swabbing of the main.
- Filling and sterilisation
- Flushing and / or neutralisation.
- Refilling the main.
- Acceptance certification.
- Introduction of the main into service

Hydrostatic Pressure Testing

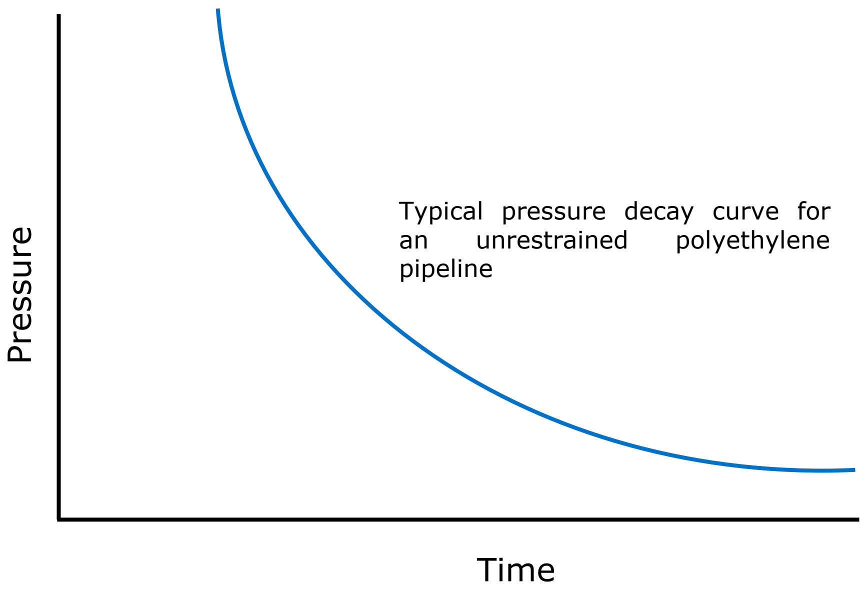
The testing procedure employed when testing most pipeline materials used in the Water Supply Industry has traditionally been the procedure given in BSI CP 312: Section 10.

These procedures are not suitable for polyethylene materials, without modified analysis.

Polyethylene is a viscoelastic material; such materials exhibit creep and stress relaxation.

When a polyethylene pipeline is sealed and subjected to a test pressure, there will be a reduction in pressure over time in a leak free system due to the viscoelastic response (creep) in the material.

The Pressure decay seen in the diagram below of an unrestrained polyethylene pipeline is non-linear.



Type 1 Pressure Test

Although the type 1test is no longer recognised by relevant codes of practice for PE pipes, there are instances where it may be beneficial to employ the type 1 test over the general PE test. These instances are generally where the pipes on test are of a small diameter and have a relatively short length.

This test procedure is appropriate for detecting major leaks in short lengths of small diameter pipes

1. In this procedure, the creep in polyethylene is sustained by maintaining the selected test pressure for a period of 30 minutes. This is achieved by additional pumping during the initial 30 minute period.

2. The pressure should then be reduced rapidly from the system to a nominal pressure of approximately 2 bar at which point the control valve should be closed and the system isolated.

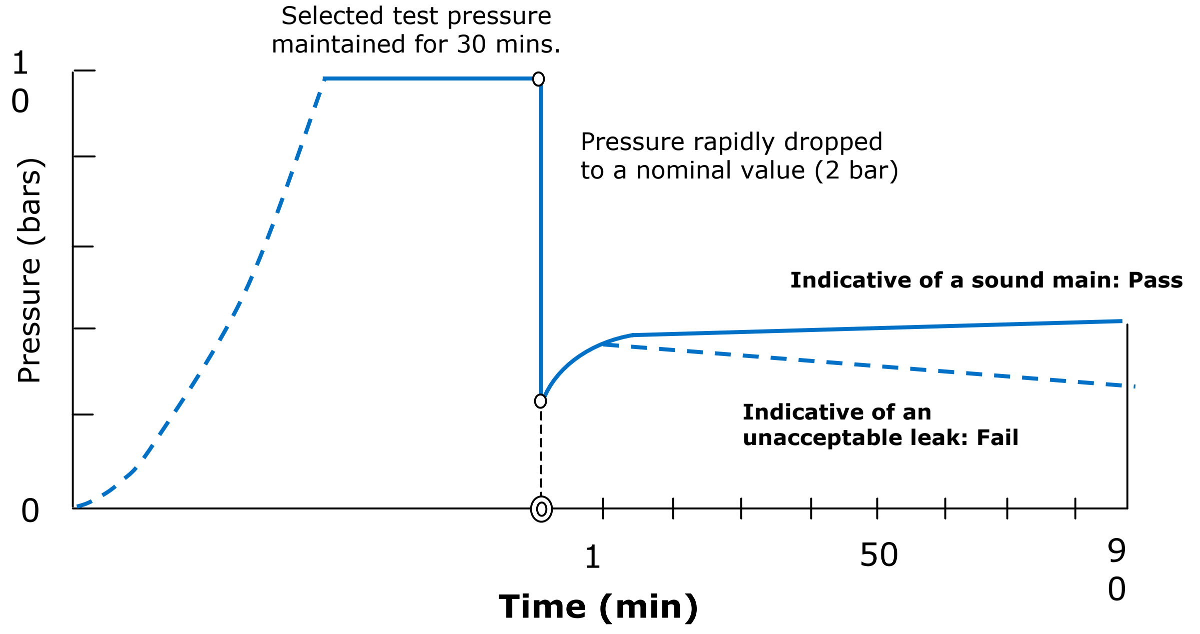
3. A record should be made of the pressure readings at the following intervals:

- Every 2 minutes for the first 10 minute period
- Every 5 minutes from 10 to 30 minutes
- Every 10 minutes from 30 to 90 minutes

Within a 90 minute period a good indication will normally be achieved as to the integrity of the pipe section. If during the 90 minute period there is a falling away of pressure, this would indicate a leak within the system.

4. The resulting graph for a leak-tight system should have a characteristic profile similar to that shown in the following diagram.

Type 1 Pressure Test Pressure Graph



Type 2 Pressure Test

A pressure test procedure has been developed by the WRC to enable interpretation of polyethylene's viscoelastic properties when hydrostatically pressure tested

Polyethylene should be tested in reasonable lengths, appropriate to the site conditions and pipe diameter, up to 1000 metres in length. Longer lengths have been tested, but particular care is needed in the test preparation and interpretation of the data gathered to minimise errors over longer sections. It may be required that longer pipelines are tested in sections.

If possible, locate the filling and test position at the lowest point on the main, this will aid in the expulsion of air as the main is filled. Charging the pipeline should be at a rate that allows the air within the main to discharge freely. Remove as much air as possible from the system.

Testing should always take place between blank flanges or full end load resistant end caps. Polyethylene pipelines should not be tested in this manner unless the pipe temperature can be kept below 30ºC.

Once the main has been charged it should be allowed to stabilise for a minimum of 2-3 hours. It is common for the main to be left overnight before commencing testing.

The use of potable water should be employed when charging potable water pipelines, unless otherwise specified by the undertaker.

Recommended Test Pressure

Rated Pressure	Test Pressure
Up to 10 bar	1.5 x rated pressure
12 to 16 bar	1.5 x working pressure (or 5 bar + working pressure, whichever is the lesser)

Applying the Test Pressure

Apply the pressure by pumping continuously at a sensible constant rate. The rise can be recorded and used as an aid in identifying if air is present within the main and if so, the amount of air. Should the pipeline require re-testing, this should **NEVER** be attempted until the pipelines has had sufficient time to recover. The recovery time is determined by the length of time the main has been pressurised. The pipeline should be left in an unpressurised state for 5 times the period it had been under pressure, i.e if a pipeline had been pressurised for 1 hour, it would need to be left for 5 hours before re-pressurising.

On reaching the required test pressure and satisfying the condition for minimal air entrapment, the pipeline should be isolated and the pressure allowed to decay. The time to achieve test pressure is used as a reference. The pressure loading time is ($\mathbf{t_L}$). The natural pressure decay readings are noted at predetermined times (multiples of $\mathbf{t_L}$).

As the pipeline will begin to relax pressurisation, a correction factor of 0.4$\mathbf{t_L}$ is applied to the results.

The diagram below illustrates a typical sequence of pressure readings taken during a three-point analysis

Sequence of operations to analyse the pressure test data

1. Take the first pressure reading (**Pressure1**) at time (**$time_1$**)

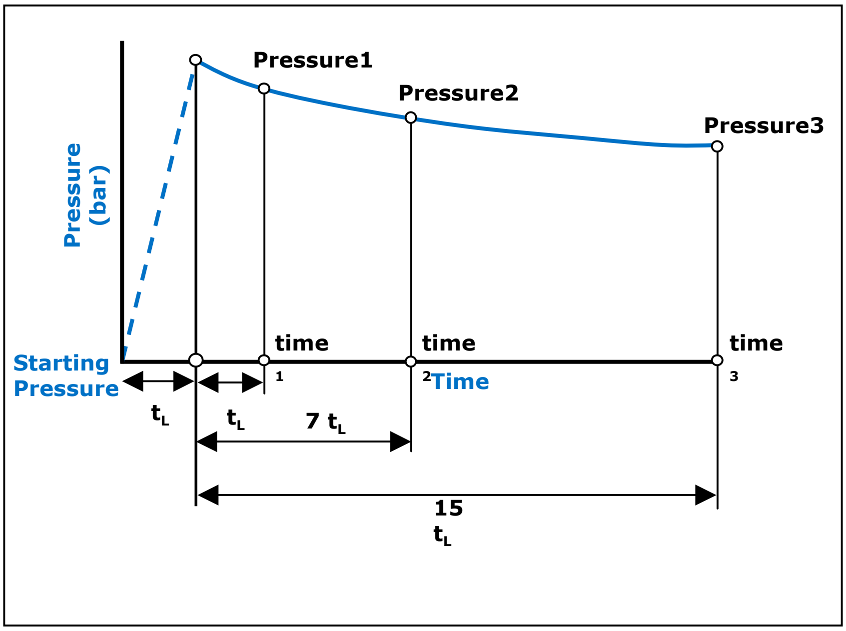
   time1 = $\mathbf{t_L}$

2. Take the second pressure reading (**Pressure2**) at time (**$time_2$**)

   time2 = 7 x $\mathbf{t_L}$

3. Take the third pressure reading (**pressure3**) at time (**$time_3$**)

   time3 = 15 x $\mathbf{t_L}$



- Calculate corrected **$time_1$**
  $time_{1c} = time_1 + 0.4t_L$
- Calculate corrected **$time_2$**
  $time_{2c} = time_2 + 0.4t_L$
- Calculate corrected **$time_3$**
  $time_{3c} = time_3 + 0.4t_L$

4. It is now possible to calculate the slope of the pressure decay curve expressed as (**n**). The first part is to measure the curve between **$time_1$** and **$time_2$** which we will refer to as (**n_1**).

$$n_1 = \frac{\text{Log } \mathbf{Pressure1} - \text{Log } \mathbf{Pressure2}}{\text{Log } \mathbf{time_{2c}} - \text{Log } \mathbf{time_{1c}}}$$

5. Now calculate the second part of the pressure decay curve (**n_2**)

$$n_2 = \frac{\text{Log } \mathbf{Pressure2} - \text{Log } \mathbf{Pressure3}}{\text{Log } \mathbf{time_{3c}} - \text{Log } \mathbf{time_{2c}}}$$

For a leak free pipeline the expected value of (**n_1** and **n_2**) should be found to be:

(a) 0.08 – 0.10 for pipelines without compacted backfill material (e.g. pipelines that have been sliplined or pipelines tested above ground).

(b) 0.04 – 0.05 for pipelines with compacted backfill.

The above test method was developed to enable a trained operative on site with standard testing equipment and a calculator to undertake this test procedure. It is strongly recommended that more than three, time and pressure readings are taken during the test period.

Simplification of the above test procedure has been accomplished by the use of data logging equipment. These devices are strongly recommended as the inbuilt data processing facilities on the market can facilitate early leak detection and clearer understanding of the test's pressure decay, which assists in identifying the cause of any leakage within a test section.

Further guidance may be found in BS EN 805 'Water supply requirements for systems and components outside buildings' or alternatively in the WRc handbook 'A guide to testing of water supply pipelines and sewer rising mains'.

Selection of as-dug pipe embedment materials for thermoplastic pipelines

Comprehensive guidance on this subject is contained within the following water industry publications. It is suggested that this document is read in conjunction with the relevant documents listed below.

- Information & Guidance Note 4-08-01, *Bedding and sidefill materials for buried pipelines.*
- Water Industry Specification 4-08-02, *Specification for bedding and sidefill materials for buried pipelines.*
- BS EN 1610 : 1998, *Construction and testing of drains and sewers*.
- Sewers for Adoption 6th Edition
- Civil Engineering Specification for the Water Industry 6th Edition
- British Standard EuroNorm 1295 Part 1: Structural design of buried pipelines under various conditions of loading – General requirements.

The information contained in this document should be used for guidance purposes. To enable a complete understanding of this subject this document should be read in conjunction with the afore listed water industry publications.

Note : Acceptance and the suitability of the materials used for pipe embedment must be sought from the adopting or overseeing authority prior to the pipe's installation.

Selection of as-dug pipe embedment materials.

Where as-dug materials are selected for use as pipe embedment should have the following properties:

1) In order to minimise the effects of point loading, the maximum particle size should not exceed those values specified within Table (1) of this guide.
2) They should be free flowing and easily worked to form a uniform level bedding to support the pipe and should be easily distributed into the haunching zones of the pipe.
3) They should not break up when wet or when compacted.
4) The material grading distribution should be such that it will not allow material fines that are supporting the pipe to be washed away see Table (1).
5) Materials contaminated with domestic, building or industrial waste must not be used.
6) Materials should be free from organic matter and should be non-combustible.
7) Pipe embedment materials should not be used in a frozen state.
8) Ideally materials will require minimal compactive effort to enable their design density to be reached.
9) They should offer adequate support to the pipe without applying point loading or stress concentrations into the wall of the pipe.

NOTE

Acceptance and the suitability of the materials used for pipe embedment must be sourced from the adopting or overseeing authority prior to the pipe's installation.

Table 1

Pipe nominal bore mm	Nominal maximum particle size (mm)	Maximum CF value for acceptability	Maximum CF value for acceptability
		Non–pressure pipe	Pressure pipe
100	10	0.15	0.3
Over 100 to 150	15	0.15	0.3
Over 150 to 300	20	0.15	0.3
Over 300 to 550	20	0.15	0.3
Over 550	40	0.15	0.3

Notes

The minimum particle size for all pipe diameters should not be smaller than 5mm.

Nominal bore is used in preference to DN because of the different nominal size classifications for flexible pipes.

Compaction fraction test to determine the CF value

As-dug material, is defined as "*excavated material which is suitable for use as bedding and sidefill without processing*".

As-dug non-cohesive bedding and sidefill materials on which the structural performance of the pipeline does depend should be evaluated using the compaction fraction test. Materials are suitable if the values obtained do not exceed those given in Table (1).

Equipment required

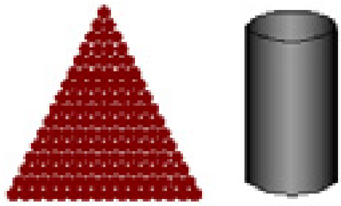
- Open ended test cylinder, approximately 250mm in length and having an internal diameter of 150mm (+10mm –5mm).
- Metal rammer weighing between 0.8 and 1.3kg and having a striking face of approximately 40mm.
- Rule, 300mm in length.

Method

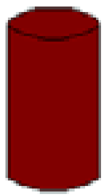
1. Obtain a representative sample* of material that is more than sufficient to fill the test cylinder when it is placed on a flat clean surface. Ensure that the moisture content of the sample material does not differ to that of the material used in for bedding and sidefill purposes at the time of its use in the trench.
2. Ensure that the maximum particle size limitations of Table (1) are adhered to
3. Stand the test cylinder vertically upright on a firm flat surface and gently pour the sample material into it, without any compactive effort such as tamping or vibrating.
4. Strike off sample material, flush with the surface of the test cylinder. Remove all surplus material.
5. Lift the test cylinder clear of its contents and place on a firm flat surface.
6. Pour approximately 25% of the sample material into the test cylinder and tamp with the metal rammer until no further compaction can be obtained. Repeat with the second, third and forth quarter of material and ensure that the finished tamped surface is level. Care should be taken to ensure the sample material being compacted does not break during compaction.
7. Using a rule, measure from the finished tamped surface to the top of the test cylinder. This measured distance divided by the test cylinder length will give the compaction fraction of the sample material being tested.
8. The maximum acceptable compaction fraction value to be used with non pressure flexible pipelines is 0.15, (therefore for a test cylinder 250mm in length, the depth of sample material in the test cylinder after compaction should not be less than 212.5mm). The maximum acceptable compaction fraction value for pressurised flexible pipelines is 0.3, (therefore for a test cylinder 250mm in length, the depth of the sample material in the cylinder after compaction should not be less than 175mm).

* To ensure that a representative sample of material is obtained, select approximately 50 kg of material. Using a shovel, turn this material 3 times and heap into a cone shape. Split this material into quarters by slicing vertically down the centre of the cone. Two of the opposite quarters should be discarded leaving one half of the original 50kg of material (approximately 25kg). This halving of material should be repeated until the required volume of sample material remains for the compaction fraction test.

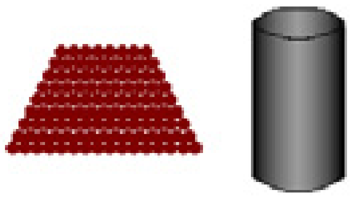
Compaction fraction test, graphical representation of procedure.



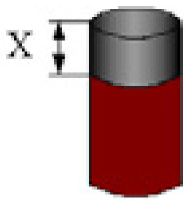
Step 1. Representative soil sample and open ended test cylinder, approximately 250mm in length and having an internal diameter of 150mm (+10mm –5mm).



Step 2. Test Cylinder filled with representative sample of soil and struck off flush with the test cylinder surface.



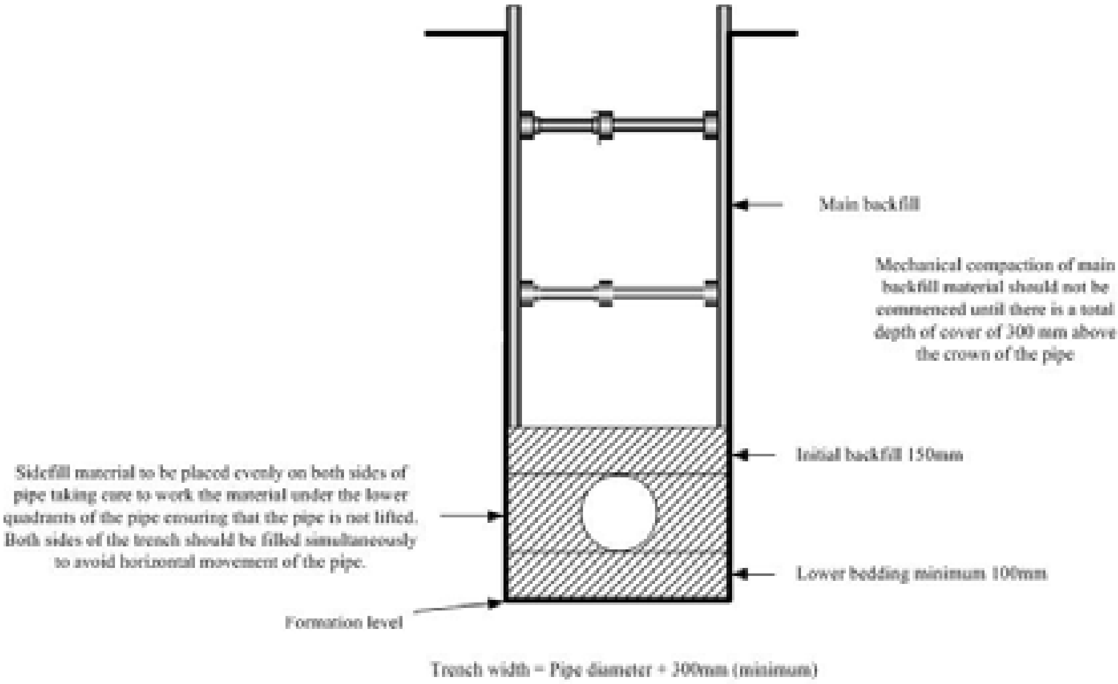
Step 3. Empty contents of test cylinder



Step 4. Pour approximately 25% of the sample material into the test cylinder, tamp with a metal rammer until no further compaction can be obtained. Repeat with the second, third and forth quarter of material and ensure that the finished tamped surface is level. Care should be taken to ensure the sample material being compacted does not break during compaction. Using a rule, measure from the finished tamped surface of the tamped material to the top of the cylinder (X). This measured distance (X) divided by the test cylinder length will give the compaction fraction of the sample material being tested

Step 5. Divide the value of 'X' by the cylinder length to obtain the compaction fraction, CF value, the value of CF should not exceed the values quoted in Table (1).

Figure 1. Typical trench detail



As-dug materials that are to be used for pipe embedment should be selected from the material excavated from the trench, the moisture content of the material to be tested should be equivalent to that of the as-dug material which is to be used for the pipe embedment.

It is recommended that a compaction fraction value of as-dug materials should be undertaken at least once per day where the as-dug material is uniform and does not change, however where the soil type, particle size or moisture content changes then a compaction fraction test must be undertaken to determine the suitability of the as-dug material.

Recording of compaction fraction tests.

To ensure that accurate records of the materials used for pipe embedment are maintained, it is recommended that the following information is recorded as a minimum for each compaction fraction test:

- Date of test
- Linear position along the pipeline length
- Visual description of soil type
- Depth at which soil sample is taken
- Calculated value of the compaction fraction

Definitions

As-dug materials, Those materials generally derived from the soil excavated from the trench that is deemed suitable for use as pipe embedment without processing.

Pipe embedment, The zone around the pipe comprising the lower bedding, sidefill and initial backfill as shown in Figure 1.

Compaction fraction, the value calculated by dividing the length of the depth of compacted soil in test cylinder by the overall test cylinder length.

ENQUIRY FORM

STRUCTURAL DESIGN OF POLYETHYLENE AND PVC-O PIPE INSTALLATIONS

The structural design of polyethylene and PVC-O pipe installations is a specialist activity and should only be performed by a civil engineer who has an appropriate background and training in the application of the UK method documented in BS EN 1295-1.

Please note that it is not possible to provide structural design guidance at this time for installations other than those made by open cut trenching. For all other techniques used to install polyethylene, particularly horizontal directional drilling, the status of current design guidelines should be obtained in the first instance from the specialist technique provider.

Radius Systems can provide guidance on the likely values to be obtained from a structural analysis involving Polyethylene and PVC-O pipes. The information required is set out in the table below. A report will be generated using the method set out in BS EN 1295-1 and returned based on the information provided.

Information required for analysis (all boxes must be completed unless stated otherwise).

Parameter	Value	Units
Pipe outside diameter		mm
Pipe Standard Dimensional Ratio or Pressure Rating		
Pipe material[1]		
Trench width		mm
Trench Detail. Single, Dual or Stepped pipe configuration		
Class of pipe bedding & surround materials (embedment) **Class S1**: Gravel (Single size), **Class S2**: Gravel (graded), **Class S3**: Sand and coarse grained soil with more than 12% fines, **Class S4**: Coarse grained soil with more than 12% fines or fine grained soil with a liquid limit less than 50%, **Class S5**: Fine grained soil, liquid limit less than 50%, medium to no plasticity		
Degree of compaction to pipe embedment materials		%MPd

Parameter	Value	Units
Depth of cover above pipe		mm
Water table height above pipe. If the water table is below the pipe then indicate, *Water below pipe*		mm
Internal pressure in the pipe		bar
Time delay in pressurization from installation		months
Will the pipeline be subjected to internal transient vacuum, if so what is the magnitude of this transient vacuum?		bar
Traffic loading. Main, Light or Field etc.		
Description of native soil surround. Gravel, Sand, Clayey silty Sand, Clay. The density of the native soil for all materials other than Clay should be estimated from the following: very dense, dense, medium dense, loose and very loose. Should clay be the native soil then the density should be described as very hard, hard, very stiff, stiff, firm, soft and very soft.		
Contact name		
Contact telephone number		
Contact fax or email for reply		

Expected designation of the pipe material would be **PE80, PE100, PVC-O or ProFuse**

- Expected value for trench width, depth of cover and water table height would be ………..**millimeters**
- Expected value for internal pressure would be …………. **Bar**
- Expected value for traffic load would be **minor road, main road, construction or rail class**
- Density indicates modified Proctor density.
- Expected value for diameter would be ………. **mm**.

Radius Systems Ltd
Hilcote Plant, PO Box 1
Blackwell, Nr Alfreton
Derbyshire, DE55 5JD
United Kingdom

T: +44 (0)1773 811112
F: +44 (0)1773 812343
E: sales@radius-systems.co.uk
W: www.radius-systems.com

RADIUS Systems