TECHNICAL GP-IT005/1

GPS
PE PIPE SYSTEMS

Innovation in polyethylene pipe systems for water, gas and other applications

Installation and Technical Guidelines

GPS PE PIPE SYSTEMS

Our Company

GPS PE Pipe Systems is a member of the international Aliaxis Group of Companies who manufacture and sell pipe systems and related products for residential and commercial construction, industrial and public utilities.

We specialise in the research, development and manufacture of polyethylene and multi-layer pipe systems including fittings for gas and water transportation in the utilities, offshore and industrial markets.

Resulting from the amalgamation of two market leading companies, GPS PE Pipe Systems brings together over one hundred years of experience and knowledge in plastic pipe systems.

The Environment

We actively and consistently strive to reduce our impact on the environment. We have measured our performance against various environmental indicators since 1997 and operated an environmental management system accredited to ISO 14001 since 1999. Our carbon footprint is independently verified under the Certified Emissions Measurement and Reduction Scheme (CEMARS).

Market Oriented

GPS PE Pipe Systems products have a broad range of applications in the industrial and utilities markets on a worldwide basis. The utilities of water and gas distribution are important sectors for high integrity products where the maintenance of water quality and the safe transport of gaseous fuels are of paramount importance. Industrial applications include: alternative energy installations in landfill gas systems; effluent transportation and mineral slurries.

Many of the brands in the GPS portfolio have a long record of innovation in meeting the needs of the water and gas utilities. One of the foremost pioneers in polyethylene pipe systems, GPS is continually improving and updating its offering to meet the ever growing needs of the distribution engineer, ensuring they stay at the forefront of world gas and water distribution/treatment systems.

Manufactured in the UK, our products are sold to more than 60 countries worldwide.

Customer Focus

The key to our success lies in the commitment we pledge to provide the highest quality service and support to our customers and industry end-users. We are a team of highly motivated and experienced individuals who are dedicated to helping our customers achieve their goals.

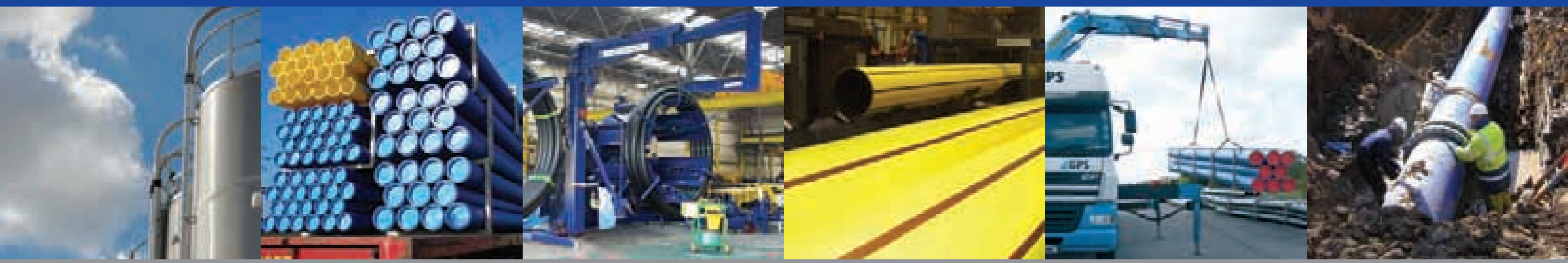
We place the utmost importance in meeting the needs of our customers, constantly evolving our extensive product portfolio to meet the ever changing demands of the water and gas utilities, industrial and offshore markets.

Quality

Designed, manufactured and supplied under a BS EN ISO 9001:2008 accredited Quality Management System, GPS products comply with relevant national, European and international product standards to ensure peace of mind for our customers.

Certificate No. FM 34819

Certificate No. E 51385



World leaders in the design, manufacture, marketing and sales of high performance, high integrity plastic and composite piping systems.

Contents

Products Overview

GPS PE piping products offer all the major advantages of polyethylene allowing considerably lower installation and whole life costs when compared to traditional pipeline materials:

- Lighter weight for reduced logistical costs and easier handling
- Great flexibility
- Homogeneous fully welded system is possible
- No corrosion and excellent chemical resistance
- No anchor or thrust blocks needed (fully end load bearing)
- Smooth, non-porous bore for better flow capacity
- Long system life (typically 100 years - as per IGN 4-32-18) with minimum maintenance

Manufactured to meet the exacting standards imposed by gas and water bodies, polyethylene pipe systems from GPS offer:

- High quality - designed, manufactured and supplied under a BS EN ISO 9001: 2008 accredited Quality Management System
- Wide choice of systems
- Up to 16bar rated at 20ºC when carrying water and certain other liquids
- Up to 10 bar (7 bar in the UK) rated at 20ºC when carrying natural gas
- Ease of use
- Four jointing methods - Electrofusion, Butt-fusion, Mechanical Fittings and Push-Fast (a mechanical integrated spigot and socket system)
- Full compliance with water & gas industry standards

Standard PE Pipes

GPS PE pipes are extruded in two standard materials - PE80 (MDPE) and Excel (PE100) in the following colours:

- Blue - for potable water supply below ground.
- Yellow/Orange - for gas supply below ground.
- Black - for global water and gas supplies, UK potable water supplies above the ground and industrial (sewage, mining and quarry) applications above and below ground.

Pipes are available in 6m and 12m straight lengths with other lengths available to order. Pipe up to 180mm OD is also available in coils of 50m, 100m and 150m and may be supplied in longer lengths by special order. Pipe can also be extruded with four co-axial stripes to identify the contents being conveyed or to identify the application.

Excel 3^c

Excel 3^c is a unique patented factory clean PE100 pipe coil that is approved by the Secretary of State for installation without pre-chlorination. It allows installers to proceed to immediate installation, significantly reducing the overall installation time and costs. Excel 3^c pipe may also be supplied complete with a factory fitted Towing Head, ready to be attached to a towing shackle for immediate installation, saving even more time.

Protecta-Line

Protecta-Line is an award winning fully integrated barrier pipe and fittings system for safely transporting water through contaminated land. With WRAS and Regulation 31/27 approvals, the system provides total peace of mind to the highest industry standards including the new WIS 4-32-19, meeting all the safety legislation demanded by water companies and customers alike.

Protecta-Line combines all of the advantages of conventional high quality PE pipe with an aluminium barrier layer to prevent permeation of ground contaminants and an additional PE outer protection layer. The Protecta-Line system is currently offered in pipe diameters from 25mm through to 355mm and incorporates a dedicated range of approved fittings:

- From 25mm to 63mm, a full range of Mechanical Compression Fittings requiring no scraping
- From 63mm to 180mm, a full range of Fluid Compression Fittings requiring no scraping
- From 90mm to 355mm, a full dedicated range of tapping ferrule off-takes with 25mm, 32mm and 63mm Mechanical Compression Fitting outlets
- From 90mm to 355mm, a dedicated range of electrofusion fittings. Sizes 90mm to 355mm of Protecta-Line can be also joined using butt-fusion.

Secura-Line

Secura-Line is Excel (PE100) pipe with an outer protective skin of peelable polypropylene, which provides extraordinary resistance to abrasion damage when used in techniques such as pipe bursting. Secura-Line pipe also gives significant benefits and cost savings for installers: the outer polypropylene skin may quickly and easily be removed to expose the perfect surface finish for jointing. The peeled pipe is immediately ready for electrofusion or butt-fusion without any additional requirement for scraping or cleaning. Secura-Line can be electrofused or butt-fused using the same parameters as standard PE pipe.

DuraFuse & Frialen® Electrofusion Fittings

DuraFuse electrofusion fittings are easy to use, offer superb performance and a rapid, convenient means of joining polyethylene pipes. Their design ensures optimum melt pressure because the energising coils of wire are precisely positioned to ensure uniformly consistent melting and to minimise the risk of accidental wire damage. Each fitting is bar coded to enable suitable electrofusion control units (ECUs) to scan the bar code in order to determine the fusion parameters. DuraFuse fittings are offered in PE80 (MDPE) Yellow or PE100 (HPPE) Black and in pipe sizes up to 500mm. GPS also offers a range of larger diameter electrofusion fittings. The FRIALEN range is offered in Black PE100 with bar code labelling to facilitate fusion and data logging.

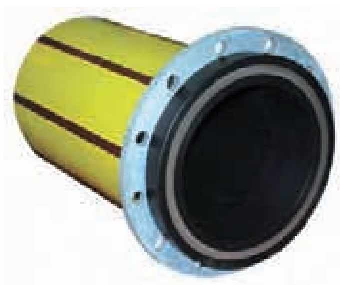
Long Spigot & Pupped Fittings

The GPS Long Spigot range offers a comprehensive choice of fittings suitable for butt-fusion without the need for pupping (provided that machines with narrow clamps are used). Products are offered in PE80 Yellow, as well as PE100 Blue and Black. To facilitate easier jointing on-site, a range of fittings is also offered with factory-fitted half-metre pups in pipe sizes up to 400mm and with one-metre pups for larger pipe sizes.

GPS recommend derating the pressure rating of large diameter mitred bends in sizes 355mm and above to 0.8 x the pipe rating from which they are made. Bends incorporating 30° mitres should also be de-rated in sizes below 355mm.

SlimFlange

SlimFlange is a unique product developed by GPS to allow size-for-size connection of PE pipeline to metal fittings or pipe without any change to the nominal bore. SlimFlange features a steel reinforced PE face which allows the PE shoulder height to be reduced significantly, while at the same time the strength of the joint is actually increased and is fully end-load bearing. SlimFlange offers reduced weight, maintains full-bore flow and offers considerable cost savings. SlimFlange is made from PE100 Black, comes complete with gasket and backing ring and may be pupped with all of the GPS pipe materials.



Push-Fast

The Push-Fast spigot and socket type jointing system has proven end load performance. Push-Fast enables fast, simple and efficient pipe jointing, without the need for welding and is unaffected by weather conditions. Unlike similar spigot and socket systems offered in other materials, Push-Fast resists the end thrust generated by the internal pressure, so anchors or thrust blocks are not usually required. The Push-Fast system has individual elastomeric sealing and internal grip rings, ready chamfered pipe ends and is offered in Blue or Black Excel (PE100) rated up to 16 bar. This product is not suitable for gas applications.

Quality

GPS operates a quality assurance system in accordance with the requirements of BS EN ISO 9001, which is audited on a regular basis by BSI.

The quality assurance system imposes stringent standards of control throughout design, development and subsequent manufacturing and inspection processes.

Products are subjected to a range of dimensional, mechanical and destructive tests carried out on a sample basis in accordance with the requirements of GPS Product Quality Plans. Upon agreement, these Quality Plans can be amended to incorporate specific Customer Inspection and Test requirements.

Detailed records are kept of dimensional and performance tests for each production batch. Each batch is given a unique identification number that is reproduced on every fitting and pipe. This enables traceability to be maintained from raw material to finished products and for the provision of Certificates of Conformity, if required.

Environment

GPS operates an environmental management system in accordance with the requirements of BS EN ISO 14001. The system is regularly audited by SGS to ensure conformance to the standard.

GPS continually monitors its business activities with the aim of minimising their impact on the environment. A number of on-going waste minimisation projects have been implemented in areas such as energy usage, product packaging and landfill waste.

A continual improvement culture is promoted within the company by setting environmental targets and objectives that are regularly monitored and reviewed.

Certificate No. FM 34819

Certificate No. E 51385

GPS polyethylene range is designed to comply with the requirements of one or more of the standards, specifications and guidance notes shown on this page.

General Standards

Standard	Title	Applicable to GPS Products
ISO 161-1:1996	Thermoplastic pipes - nominal outside diameters and nominal pressures	All pipes and fittings
ISO 4065:1996	Thermoplastic pipes - universal wall thickness tables	All pipes
BS ISO 11922-1:1997	Thermoplastic pipes for the conveyance of fluids dimensions and tolerances metric series	All pipes
BS EN 1092-1:2007	Flanges and their joints - circular flanges for pipes, valves, fittings and accessories, PN designated	All flange backing ring drillings, PN16 and PN10

Water Standards

Standard/Approval	Title	Applicable to GPS Products
Regulation 31 (England & Wales), Regulation 27 (Scotland), Regulation 30 (NI)	The Water Supply (Water Quality) Regulations 2000 - England The Water Supply (Water Quality) Regulations 2001 - Wales The Water Supply (Water Quality) Regulations 2001 - Scotland The Water Supply (Water Quality) Regulations 2007 - Northern Ireland	All pipes
The (Water) Regulators Specification & The Water Supply (Water Fittings) Regulations 1999	The (Water) Regulators Specification & The Water Supply (Water Fittings) Regulations 1999	All pipe materials. All fitting materials. All PE100 fittings and matching pipes. All Protecta-Line fittings and matching pipes
BS 6920 Part 1:2000	Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on water - Part 1: Specification	All pipe materials. All fitting materials. All PE100 fittings and matching pipes. All Protecta-Line fittings and matching pipes
BS 6920 Part 2:2008	Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on water - Part 2: Methods of test	All pipe materials. All fitting materials. All PE100 fittings and matching pipes. All Protecta-Line fittings and matching pipes
ISO 4427:2007	PE pipes for water supply	Blue and black PE80 and PE100 pipes and fittings
BS EN 15494:2003	Specifications for polyethylene components and systems	Blue and black PE80 and PE100 pipes and fittings up to 1600 mm
BS EN 12201:2003	Plastic piping systems for water supply – polyethylene	Blue and black PE80 and PE100 pipes and fittings in sizes up to 1600 mm
BS EN 805:2000	Water supply – requirements for systems and components outside buildings	External water supply installations
BS EN 681-2:2000	Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications. Thermoplastic elastomers.	Seals and flange gaskets
BS 5306:1990 - Part 2	Fire extinguishing installations and equipment on premises	Blue and black PE80 and PE100 for external buried fire mains
BS 6572:1985	Specification for blue polyethylene pipes up to nominal size 63mm for below ground use for potable water	Blue PE80 pipes up to and including 63mm

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Water Standards

Standard/Approval	Title	Applicable to GPS Products
WIS 4-08-02:1994	Specification for bedding and sidefill materials for buried pipelines	Backfill materials specification
WIS 4-22-02	Specification for ferrules and ferrule straps for underground use	Protecta-Line ferrules
WIS 4-24-01:1998	Specification for mechanical fittings and joints including flanges for polyethylene pipes for the conveyance of cold potable water for the size range 90 to 1000 including those made of metal or plastics or a combination of both	Stub flanges, Slimflange and fluid compression fittings in sizes 90mm to 1000mm
WIS 4-32-08:2002	Specification for the fusion jointing of polyethylene pressure pipeline systems using PE80 and PE100 materials	Butt fusion and electrofusion jointing of blue and black PE80 and PE100 pipes and fittings
WIS 4-32-16:1998	Specification for butt fusion jointing machines	Automatic, semi automatic and manual butt fusion machines
WIS 4-32-17:2001- Issue 2	Polyethylene pressure pipes for pressurised water supply and sewerage duties	Blue and black PE80 and PE100 pipes including Securaline in sizes up to and including 1600mm
WIS 4-32-19:2007	Polyethylene pressure pipe systems with an aluminium barrier layer for potable water supply in contaminated land sizes	25mm to 630mm – Protecta-Line pipe and fittings
IGN 4-08-01:1994	Bedding and sidefill materials for buried pipelines	Backfill materials selection
IGN 4-32-18:2003	The choice of pressure ratings for polyethylene pipe systems for water supply and sewerage duties	Blue and black PE80 and PE100 pipe systems
IGN 4-37-02:1999	Design against surge and fatigue conditions for thermoplastic pipes blue and black	PE80 and PE100 pipe systems
IGN 9-04-03:2002	The selection of materials for water supply pipes in contaminated land	Protecta-Line pipes and fittings
DIN 8074:1999	Pipes of high density polyethylene (HDPE) type 2 – dimensions	Black PE80 and PE100 pipes in sizes up to and including 1600 mm
DIN 8075:1999	Pipes of high density polyethylene (HDPE) type 2 – testing	Black PE80 and PE100 pipes in sizes up to and including 1600 mm
DIN 16963:1980	Part 1 – High density polyethylene (HDPE) fittings dimensions, type 2	Black PE80 and PE100 spigot and electrofusion fittings up to and including 1200mm

Gas Standards

Standard	Title	Applicable to GPS Products
ISO 4437:2007	Buried pipes for the supply of gaseous fuels	All yellow and black pipes and electrofusion and spigot fittings
BS ISO 8085-1	Polyethylene fittings for use with polyethylene pipes for the supply of gaseous fuels	All yellow and black electrofusion fittings up to and including 630mm
BS ISO 8085-2	Spigot fittings for butt fusion or socket fusion using heated tools and for the use with electrofusion fittings	All yellow and black spigot fittings up to and including 630mm
BS ISO 8085-3	Electrofusion fittings	All yellow and black electrofusion fittings up to and including 630mm
BS EN 682:2002	Elastomeric seals – materials for seals used in pipes and fittings carrying gas and hydrocarbon fluids	Seals and flange gaskets
BS EN 1555:2010	Plastic piping systems for supply of gaseous fuels	All yellow PE80 and black PE100 pipes and fittings up to and including 630mm
BS EN 12007-1:2000	Gas supply systems – pipelines for maximum operating pressure up to and including 16 bar	Pipeline recommendations
BS 2494G	Specification for elastomeric materials used in the manufacture of seals for gas mains and fittings up to 7 bar (BS EN 682)	Seals and flange gaskets
GIS/PL2:2006	Specification for polyethylene pipe and fittings for natural gas and suitable manufactured gas	Yellow PE80 and Secura-Line pipes up to 630mm
Part 1	General and polyethylene compounds for use in polyethylene pipe and fittings	Raw materials
Part 2	Pipes for use at pressures up to 5.5 bar	Yellow PE80 and Secura-Line pipes up to 630mm
Part 4	Fusion fittings with integral heating elements	Yellow PE80 and orange PE100 and black PE100 electrofusion fittings
Part 6	Spigot end fittings for electrofusion and/or butt fusion purposes	Yellow PE80 and orange PE100 and black PE100 spigot fittings
Part 8	Pipes for use at pressures up to 7 bar	Orange PE100 pipes up to 500mm
GIS/PL3:2006	Specification for self anchoring mechanical fittings/joints for polyethylene(PE) pipe for natural gas and suitable manufactured gas	Stub flanges and Slimflange
GIS ECE1	Specification for electrofusion control units	Electrofusion control boxes
GIS/EFV1:2000	Specification for flow limiters for PE services operating at pressures above 75 mbar and not exceeding 6m3/hr	Excess flow limiters – electrofusion couplers and reducers
GIS/F2	Mains sealing plugs and service connection fittings for use at pressures not greater than 2 bar	Purge Saddles

Health and Safety

GPS polyethylene products have been installed and used safely in large volumes over many years. However, good working practice is vital to ensure safety; our products should be handled and processed in accordance with the British Plastics Federation guidelines*. All PE80 and Excel® (PE100) pipe systems contain trace quantities of process residues and may also contain other materials such as pigments, antioxidants and UV stabilisers.

Chemically unreactive, PE is regarded as being biologically inert, though some pipe materials contain low levels of additives which may be toxic.

* (www.bpf.co.uk)

Ingestion

Ingestion of PE should be avoided. Some pipe materials may contain additives which are harmful if swallowed. Materials specified for purposes other than carrying water may contain pigments which are not suitable for use with potable water.
These materials may be hazardous if ingested in large quantities.

Inhalation

PE does not release harmful fumes at ambient temperature.
The threshold limit value for PE dust is $10mg/m^3$ (8-hour-time-weighted average in the working environment), but the generation of such levels when working with PE pipe and/or fittings is extremely unlikely.

Physical Contact

PE is not considered to be a skin irritant. Where PE dust is generated by cutting or machining pipe or fittings, powder particles of PE dust may cause eye irritation by abrasion.

Fire Characteristics

When PE is heated in air, melting will occur at 120-135°C and decomposition will commence at approximately 300°C. Above this temperature PE will pyrolise oxidatively to produce carbon dioxide, carbon monoxide, water and various hydrocarbons. These gases may ignite and provide heat which may accelerate the pyrolysis of more PE in the vicinity. In burning, molten droplets of material may be released which could ignite adjacent inflammable materials. Actual cooling conditions in a real fire will be influenced by many factors such as location and oxygen availability, which will determine the progress and combustion products of the fire.

Combustion of PE may release toxic materials. Avoid inhalation of smoke or fumes. Also, do not allow PE dust to accumulate, since there may be a risk in exceptional circumstances of dust explosion, and consider carefully the sitting of potential heat sources such as electrical equipment.

In case of fire with PE Pipes, any fire extinguisher may be used. Powder extinguishers are very effective in quenching flames. Water sprays are especially effective in rapid cooling and damping down a fire, but are not recommended in the early stages of a fire since they may help to spread the flames.

Other factors will also influence the selection of fire extinguishers eg. proximity of live electrical equipment. Please refer to specific classifications of fire fighting extinguishers.

Handling of Molten Material

During the fusion welding of PE pipe and fittings molten PE is formed. If allowed to have contact with skin it will adhere strongly and cause severe burns. Such molten material has a high heat content and will remain hot for some time. Gloves should be worn where there is any risk of skin contact.

Small quantities of fumes may be given off by molten PE – these are more pronounced at higher temperatures and greater care must be taken where there is a risk of PE adhering to heated surfaces, such as heating plates used for welding. Ventilation must be provided to ensure safe working conditions.

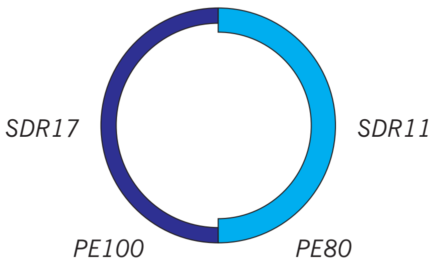
Materials

GPS manufactures polyethylene systems in both PE80 and Excel® (PE100). The numbers relate to the MRS (Minimum Required Strength) values of the material (see page 10).

PE80 – This is the term used to denote the polyethylene material which has been widely used for gas, water and industrial applications for many years. The terms MDPE and HDPE were commonly used to describe this material, although MDPE PE80, as historically supplied by GPS, has a much higher long term stress crack resistance than traditional HDPE PE80.

PE100 – This is a term used to denote high performance polyethylene, and PE100 pipes are sold by GPS under the brand name of Excel. PE100 is a higher performance material than PE80 and demonstrates exceptional resistance to rapid crack propagation as well as to long-term stress cracking.

Moreover, the higher strength of PE100 permits thinner pipe walls than PE80 for the same operating pressure. PE100 uses less polymer and provides for a larger bore and increased flow capacity for a given nominal pipe size. This can result in significant cost savings at certain sizes and pressure ratings.



PE80 and Excel® (PE100) are not recommended for continuous pressure operation at temperatures above 60°C for liquids, including sewerage and industrial effluents, or 40°C for gaseous fluids*. Excel® (PE100) has advantages over PE80 at low temperatures, since it is extremely crack resistant down to -20°C. When considering applications which exceed the limits stated above, please contact our Technical Support Department for further information.

* Please see page 10 for de-rating.

Property	Method of Test	Units	PE80 MDPE	PE100 HDPE
Melt flow rate - 2.16kg load	EN ISO 1133	g/10min	0.2	<0.15
5kg load	EN ISO 1133	g/10min	1.0	<0.5
Density (Mean Values)	EN ISO 1183	kg/m³	yellow 940 blue 943 black 950	orange 951 blue 951 black 957
Tensile strength at yield	EN ISO 6259	MPa	18	23
Elongation at break	EN ISO 6259	%	>600	>600
Flexural Modulus	ISO 527	MPa	700	1000
Vicat softening point	EN ISO 306	°C	116	124
Brittleness temperature	ASTM D746 ISO 9784	°C	<–70	<–100
Linear thermal expansion	ASTM D696	$°C^{-1}$	1.5×10^{-4}	1.3×10^{-4}
Thermal conductivity	BS874 DIN 52612	W/m°K	0.4	0.4

Further details may be obtained from GPS Technical Support Department.

These values are typical, actual value depends on exact material, pipe sizes etc.

Standard Dimensional Ratio (SDR)

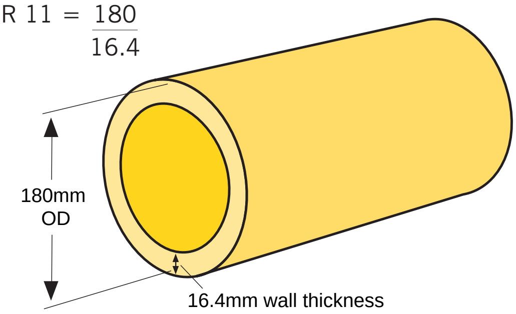
One of the items of information stated on both pipe and fittings is the *standard dimensional ratio*.

In all but the smallest sizes of PE pipe (< 25mm) the ratio between wall thickness and outside diameter remains constant for a given pressure rating of the pipe. This relationship, called the standard dimensional ratio or SDR, can be expressed as an equation:

$$\text{SDR} = \frac{\text{nominal (minimum) outside diameter}}{\text{minimum wall thickness}}$$

Example:

$$\text{SDR } 11 = \frac{180}{16.4}$$



Relationship between wall thickness and outside diameter (OD)

Pipe End Reversion and Ovality

Following manufacture, a slight taper effect occurs at the ends of a pipe length. This will also occur when pipes are cut at a later date, therefore the outside diameter should be measured at a distance of at least one diameter from the end of the pipe. This effect is not detrimental to either the pipe or joints, provided that site jointing is carried out in accordance with recognised fusion jointing procedures (WIS 4-32-08).

Extruded polyethylene pipe will normally exhibit a degree of ovality, with straight pipe up to 3.5% and coiled pipe up to 6% for SDR11 and 12% for SDR17/SDR17.6. Recent investment by GPS has allowed us to reduce SDR17 ovality to less than 5%.

It should be noted that coiled pipe in its restrained form may exhibit a higher degree of ovality before dispensing and this situation can be worsened by prolonged storage in the vertical plane, particularly if pre-chlorination is being carried out.

The ends of coiled pipe need to be aligned and re-rounded by the use of suitable equipment when fusion jointing. Please see page 33 for further details on Electrofusion Jointing of coiled pipe.

Coiled pipe being re-rounded

Pipe Bending Radii for PE

The minimum bend radius for GPS PE pipes is 15 times the pipe OD under optimum conditions (ie. warm ambient temperature and thick-wall/low SDR pipe). A more typical safe bending radius for SDR11 and SDR17 pipes is 25 times, increasing to 35 times the pipe OD in very cold weather. For thin-walled SDR26 and SDR33 pipes, these values should be increased by 50%. Electrofusion or mechanical joints and fittings should not normally be incorporated in sections of pipework which are to be bent. Instead a formed bend or elbow should be welded into the pipeline in order to prevent excessive stress. In the case of pipe supplied in coils, the above bend radius values apply only if pipe is bent in the same direction as it was previously coiled.

Expansion and Contraction

The average coefficients of linear thermal expansion between 20ºC - 60ºC are ($1.5 \times 10^{-4}\,{}^{o}C^{-1}$) for PE80 (MDPE) and ($1.3 \times 10^{-4}\,{}^{o}C^{-1}$) for Excel (PE100) are approximately ten times greater than for metal. Allowance must be made for this when designing polyethylene pipeline installations where significant temperature variation is expected (eg. above ground). If the above length change is re-stated as 8mm for PE80 and 9mm for Excel® (PE100) per 6m pipe length per 10ºC of temperature change, the magnitude of potential thermal movement can be better appreciated. In above-ground installations the natural flexibility of the pipe, coupled with judicious sitting of anchor and support brackets, will conveniently accommodate expansion and contraction at changes of direction, etc. In installations where fully end-load bearing joints are used, the compressive or tensile forces set up in the pipeline due to constraint of thermal movement will not detract from long-term performance, but the effects of these forces on pipe support, ancillary equipment and so on, must be considered and allowances made.

The potential for thermal movement is a particular issue where a (fully end-load bearing) PE system is connected to any non end-load bearing mechanically jointed system. It is essential that such transitions are securely anchored, to obviate the risk of any joints in the mechanically jointed system separating.

The use of a polyethylene puddle flange may be used to transmit end load to a concrete thrust block or alternatively, a double flanged iron “spool” piece can be fitted between the stub flange at the end of the polyethylene system and the corresponding flange on the pipework to which it is to be connected. A concrete thrust block can then be cast around this “spool” piece to provide anchorage.

A polyethylene pipe can be encased in concrete, however, protection should be afforded by first wrapping the pipe with a heavy duty polyethylene membrane, which should extend outside of the concreted area.

It is also prudent to allow a newly installed pipeline time to conform to ambient temperature before end connections are made.

Anchorage

One of the fundamental features of a fully integrated fusion welded polyethylene pipe system, is that it is end load resistant. Anchorage is not normally required at the junctions, bends and end connections provided that all associated fittings are themselves fully end load bearing. The need for restraint will be necessary, where connections are made to non end load resistant pipe systems, in order to resist axial stresses arising from thermal or pressurisation effects. Fusion welded joints will provide the necessary degree of end load resistance and where mechanical fittings are used, then these should be Type 1 (WIS 4-24-01).

When a restrained polyethylene pipeline is subjected to internal pressure and/or a temperature change, longitudinal stress will be produced. In the case of a pipe which is unrestrained, this stress will cause a simple contraction or expansion of the pipeline.

Pressurisation

The relationship between circumferential hoop stress and internal pressure is as follows:

$$\text{Hoop Stress (MPa)} = \frac{\text{Internal Pressure (bar) x (Pipe SDR} - 1)}{20}$$

The associated longitudinal stress generated in a restrained polyethylene pipeline is the product of the circumferential hoop stress and Poisson's ratio (0.48 for PE). This stress acts over the pipe cross sectional area to produce a tensile end load which is independent of the pipe length.

Temperature Change

The thermal strain resulting from a change in temperature is the product of the linear coefficient of expansion and the temperature change.

The resultant longitudinal thermally induced stress in a fully end restrained pipeline, is the product of the thermal strain and the elasticity modulus of the pipe (which is time/temperature dependent). This longitudinal thermal stress acts over the pipe cross sectional area resulting in either a tensile or compressive end load depending on the nature of the temperature change.

In an unrestrained pipeline, the change in length arising from a change in temperature, is the product of the thermal strain and the original pipe length.

Insulation

Polyethylene is a good insulator and will help prevent freezing of liquid pipe contents to an appreciable extent. Even if freezing does occur, the pipe will not fail since it can safely expand to accommodate increased volume. Nonetheless, the pipeline system may still need to be protected against freezing temperatures to prevent flow restriction.

An insulation calculator can be found at:
www.wras.co.uk/insulation.htm

Abrasion Resistance of Polyethylene

PE has significant advantages over other pipe materials where internal resistance to abrasion is required - for example if the pipe is intended for transporting abrasive media such as particulate slurry at low velocity. This resistance to abrasion, combined with flexibility, ruggedness and immunity from corrosion, makes PE ideal where traditional pipe materials would be unsuitable.
Abrasion resistance depends on slurry characteristics and flow parameters, but is predictable in many cases. Polyethylene pipe has been used successfully for pumped abrasive media such as fly ash, china clay slurry and various industrial effluents.
In addition, it has been proven that during installation, the abrasive elements of typical soils and backfills make a negligible impression on the external surface of PE pipe. However, in the unlikely event of a notch or groove being cut into the wall by more than 10 per cent of the wall thickness, the pipe section should be rejected.

Chemical Resistance - General

Polyethylene is renowned for its good resistance to chemical attack. The degree of resistance to a specific chemical will depend on concentration, temperature and working pressure, each of which will affect the long term life of any system. Polyethylene does not rot, rust, pit, corrode or lose wall thickness through chemical or electrical reaction with the surrounding soil. Polyethylene does not normally support the growth of, nor is affected by, algae, bacteria or fungi.

In broad terms the most common harmful chemicals can be grouped into oxidisers, cracking agents and certain solvents.

Chemical Resistance - Special Cases

Special care is required in industrial applications where effluents contain particular chemicals. Under certain conditions of pressure and temperature, the chemicals listed hereunder may be detrimental or permeate the pipe wall and taint water supplies.
If you are in any doubt, please contact our Technical Support Department for further information.

Oils:	animal; vegetable or mineral such as petrol, creosote, turpentine and silicone fluids.
Organic solvents:	petrol and diesel; solvent esters; acetaldehyde; benzene and its compounds; cellulose thinners; solvent naphtha; carbon disulphide; carbon tetrachloride; chloroform; dichlorethylene; trichlorethylene; ethers and turpenes; coal tar.
Halogens:	fluorine; chlorine; bromine in high concentrations; chlorine dioxide.
Acids:	glacial acetic acid; chlorosulphonic acid; cresylic acid; chromic acid; nitric acid (over 25%); phosphoric acid (over 50%) and sulphuric acid (over 70%).

Pressure Ratings & Flow Characteristics

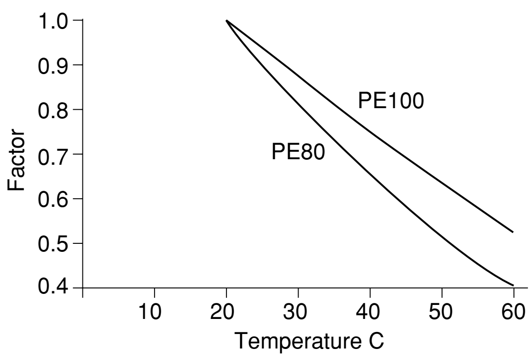
Various ISO/CEN working groups have considered the design factors that should be used to determine the maximum operating pressures of polyethylene water and gas systems. ISO/DIS 12162 classifies types of polyethylene, by the minimum required strength (MRS). This is the value of the lower prediction limit of the 50 year hoop stress in MPa obtained by extrapolation of data from stress rupture tests on completely water filled pipe samples under various internal pressures and temperatures.

In the UK MDPE is classified as MRS 8 and HPPE is classified as MRS10, but these two types of polyethylene are referred to as PE80 and PE100. Maximum working pressures for polyethylene pipes are determined by the application of safety factors to these MRS values in accordance with UK Gas and Water Industry Standards.

Maximum continuous operating pressures for GPS standard polyethylene pipes at 20ºC are given on page 11.

For water applications, GPS recommend derating the pressure rating of large diameter mitred bends to 0.8 x the pipe rating from which they are made. Bends incorporating 30° mitres should also be de-rated in sizes below 355mm. Thus 10 bar 30° mitres made into a mitred bend would be rated at 8 bar, and 16 bar 30° mitres would make a 12.8 bar fitting and so on. The fittings are fabricated from pipe complying with BS EN 12201-2 or BS EN 13244 or WIS 4-32-17.

The graph below shows the reduction factor, which should be applied to the recommended maximum continuous working pressure at 20ºC to obtain appropriate working pressures for elevated temperatures.



Reduction factor vs Temperature

The reduction graph has been calculated to give normal factors of safety after 50 years. It refers only to the conveyance of fluids to which the pipe material is completely resistant.

At temperatures lower than 20ºC, polyethylene becomes stiffer and stronger, with strength increasing by 1.3% per ºC reduction.

Velocity of Flow

The velocity of flow in polyethylene water distribution mains, does not normally exceed 1-2 metres per second and where higher velocities are expected, consideration needs to be given to the effects of surge.

BS EN 805 advises that “in practice it will be desirable to avoid unduly high or low velocities. The range 0.5 m/s to 2.0 m/s may be considered appropriate. However, in special circumstances velocities up to 3.5 m/s may be acceptable. For pumping mains a financial appraisal should be undertaken to determine the most economic diameter of pumping main to minimise the capital and discounted pumping cost. The resulting velocity will normally lie in the range of 0.8 m/s to 1.4 m/s”. For sewerage rising mains, a minimum velocity of 0.75 m/s should be maintained to satisfy the standard sedimentation criterion.

In low pressure self-scouring gas pipelines (<75 mbar) velocity is not generally a critical factor particularly where gas conditioning has been carried out and that dust problems are unlikely. In medium pressure systems, velocities are generally higher and the rolling and lifting velocities are lower so dust problems may be more acute. Where dust cannot be removed or satisfactorily filtered, then the velocity should be restricted. Further information may be obtained from the Institution of Gas Engineers and Managers ref. IGE/TD/3 Edition 4 (2003).

Surge and Fatigue in PE80 and Excel® (PE100) Pipes

The two phenomena of surge and fatigue may be treated separately, since they describe different potential effects on the pipe material. UK IGN 4-37-02, March 1999, can be summarised as follows with respect to PE pipe systems:

Surge

For systems where extreme transient conditions are unlikely, it may be safely assumed that the peak surge pressure will never have a value more than twice the rated steady state pressure. Occasional surge pressures of up to this value will not harm even low toughness PE pipes that have been rated for the steady state system pressure.

Fatigue

Fatigue is associated with repeated transient pressure variations occurring over an extended period of time. The fatigue resistance of PE pipes depends on the toughness of the material used, as well as on the magnitude of the pressure variations. Data from numerous laboratory and field test programmes have resulted in the table overleaf (see also the Notes) which can be used to re-rate PE pipes according to material toughness and the predicted frequency of pressure excursions in the system:

Daily number of Pressure Transients	Low Toughness PE80 & PE100 Re-rating factor	High Toughness GPS PE80 & PE100 Re-rating factor
4	1.1	0.5
24	1.5	0.5
48	1.7	0.5
120	2.0	0.5
240	2.3	0.5
1200	3.0	0.5

Notes

- The predicted pressure variation range for the system must be multiplied by the factors given in the table in order to establish the pipe PN necessary to avoid the risk of fatigue damage.
- High toughness PE80 & PE100 pipes (all GPS pipes) are able to resist a wall stress of 4.6MPa at 80°C for 1,000 hours in the EN 13479 Notched Pipe Test without any stress crack growth, and therefore need no re-rating for fatigue irrespective of the frequency of the surge events (as reflected in the final column).

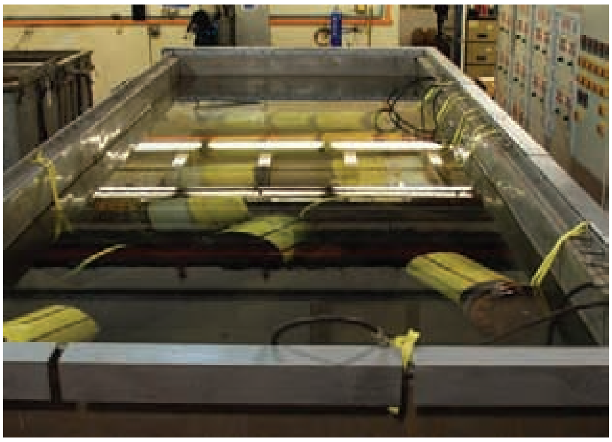
The pipe PN must always be at least equal to the maximum steady state pressure of the system, and the pipe must be structurally adequate for the given burial conditions.

Where a surge event creates a sub atmosphere pressure, resistance to collapse should be assessed in accordance with BS EN 1295 (see page 17).

Example

An Excel (PE100) system operating at a steady state pressure of 5 bar is expected to experience cyclic transient pressure variations between O bar and 16 bar 1200 times per day. From the table, a pipe pressure rating PN of at least 8 bar should be specified.

For above example, 16 (the pressure variation in bar) X 0.5 (the re-rating factor) = 8 (the minimum pipe pressure rating to be used).



MAXIMUM CONTINUOUS OPERATING PRESSURES AT 20ºC FOR GPS STANDARD PE PIPES.

PIPE OD * PIPES SPECIFICALLY SIZED FOR INSERTION LINING APPLICATIONS	SDR11				SDR17.6 (GAS) / SDR17 (WATER)		SDR17	SDR21 (GAS) / SDR21 (WATER)		SDR26 (GAS) / SDR26 (WATER)	
	PE80		Excel (PE100)		PE80		Excel (PE100)	Excel (PE100)		Excel (PE100)	
	GAS	WATER	GAS	WATER	GAS	WATER	WATER	GAS	WATER	GAS	WATER
20mm	5.5	12.5									
25mm	5.5	12.5									
32mm	5.5	12.5									
50mm	5.5	12.5									
63mm	5.5	12.5	7.0	16.0	3.0	8.0					
90mm	5.5	12.5	7.0	16.0	3.0	8.0	10.0				
110mm		12.5		16.0	3.0	8.0	10.0				
125mm	5.1	12.5	7.0	16.0	3.0	8.0	10.0				
160mm	5.1	12.5		16.0	3.0	8.0	10.0		8.0		6.0
180mm	4.1	12.5	7.0	16.0	3.0	8.0	10.0		8.0		6.0
213mm*											
225mm		12.5		16.0		8.0	10.0		8.0		6.0
250mm	4.0	12.5	7.0	16.0	3.0	8.0	10.0	2.0	8.0	2.0	6.0
268mm*											
280mm		12.5		16.0		8.0	10.0	2.0	8.0	2.0	6.0
315mm	3.4	12.5	7.0	16.0	2.7	8.0	10.0	2.0	8.0	2.0	6.0
355mm	3.1	12.5	7.0	16.0	2.5	8.0	10.0	2.0	8.0	2.0	6.0
400mm		12.5	7.0	16.0	2.3	8.0	10.0	2.0	8.0	2.0	6.0
450mm		12.5	7.0	16.0	2.2	8.0	10.0	2.0	8.0	2.0	6.0
469mm*											
500mm		12.5	7.0	16.0	2.1	8.0	10.0	2.0	8.0	2.0	6.0
560mm			7.0	16.0	2.0		10.0		8.0		6.0
630mm			7.0	16.0	1.8		10.0		8.0		6.0
710mm				16.0			10.0		8.0		6.0
800mm							10.0		8.0		6.0
900mm							10.0		8.0		6.0
1000mm							10.0		8.0		6.0
1200mm							10.0		8.0		6.0

- GPS can usually offer SDRs other than those shown in the table, e.g. for close fit lining applications
- UK gas operating pressures have historically been limited to 7 bar for PE100 pipe - this is the result of the UK rating system for charges on pipelines at higher pressure
- GPS recommend derating the pressure rating of large diameter mitred bends in sizes 355mm and above to 0.8 x the pipe rating from which they are made. Bends incorporating 30° mitres should also be de-rated in sizes below 355mm. Please contact our Technical Support Department for further information
- PE80 (MDPE) water pipelines 355mm and greater in diameter should be derated if significant amounts of air are present - see the UK Water Industry's IGN 4-32-18 March 2003
- PE80 (MDPE) gas pipe pressures must be further derated for temperatures below 0ºC.
- The values in the above table do not address any other safety-related issues associated with pipeline design.

Vacuum or Suction Pipelines

All pipes may be subjected to internal negative pressure. The amount of vacuum that a polyethylene pipeline can support on a short or long term basis will be determined by the pipe's material, SDR and installation conditions. The following table gives the approximate resistance to static differential pressure (in bar) by various SDRs.

Resistance to static differential pressure (Vacuum or External Fluid) for Unsupported PE100 Pipe

Term	SDR 11	SDR 17	SDR 21	SDR 26	SDR 33
1 Day	5.9	1.9	1.1	0.5	0.3
1 Month	4.4	1.0	0.8	0.3	0.1
1 Year	3.3	1.0	0.5	0.3	0.1
50 Years	2.9	0.9	0.5	0.3	0.1

Frictional Pressure Loss in Low Pressure Polyethylene Gas Pipelines

The flow charts on the following page are based on the Low Pressure Flow Equation derived from the General Flow Equation as referenced in Section 4.5 of the Institution of Gas Engineers and Managers publication:

Recommendations on Transmission and Distribution Practice - Distribution Mains (IGE/TD/3: Edition 4: 2003)

Note: An approximation for the pressure drop through fittings as an equivalent pipe length can be made using the methodology shown for water pipelines on page 14.

For Natural Gas assuming:

General Flow Equation Constant (C)	$= 7.57 \times 10^{-4}$
Average Compressibility Factor (Z)	= 1
Specific Gravity (S)	= 0.6
Average Gas temperature (Ta)	= 15°C
Standard Temperature (Ts)	= 15°C
Standard Pressure (Ps)	= 1.01325bar (absolute)

Low Pressure Flow Equation

$$(P1\text{-}P2) = \frac{Q^2 \times 1.841 \times 10^6 \times f \times L}{D^5}$$

where
- P1 = Upstream pressure — bar (absolute)
- P2 = Downstream pressure — bar (absolute)
- Q = Gas flow at base conditions — m^3/hr
- D = Internal pipe diameter — mm
- L = Pipe length — m
- f_{spl} = Friction factor (spl = smooth pipe law)

assuming Pipe Absolute roughness (k)
- for new pipework = 0.003mm
- Efficiency factor (e) = 0.97
- Friction factor (f) $= f_{spl}/e^2$

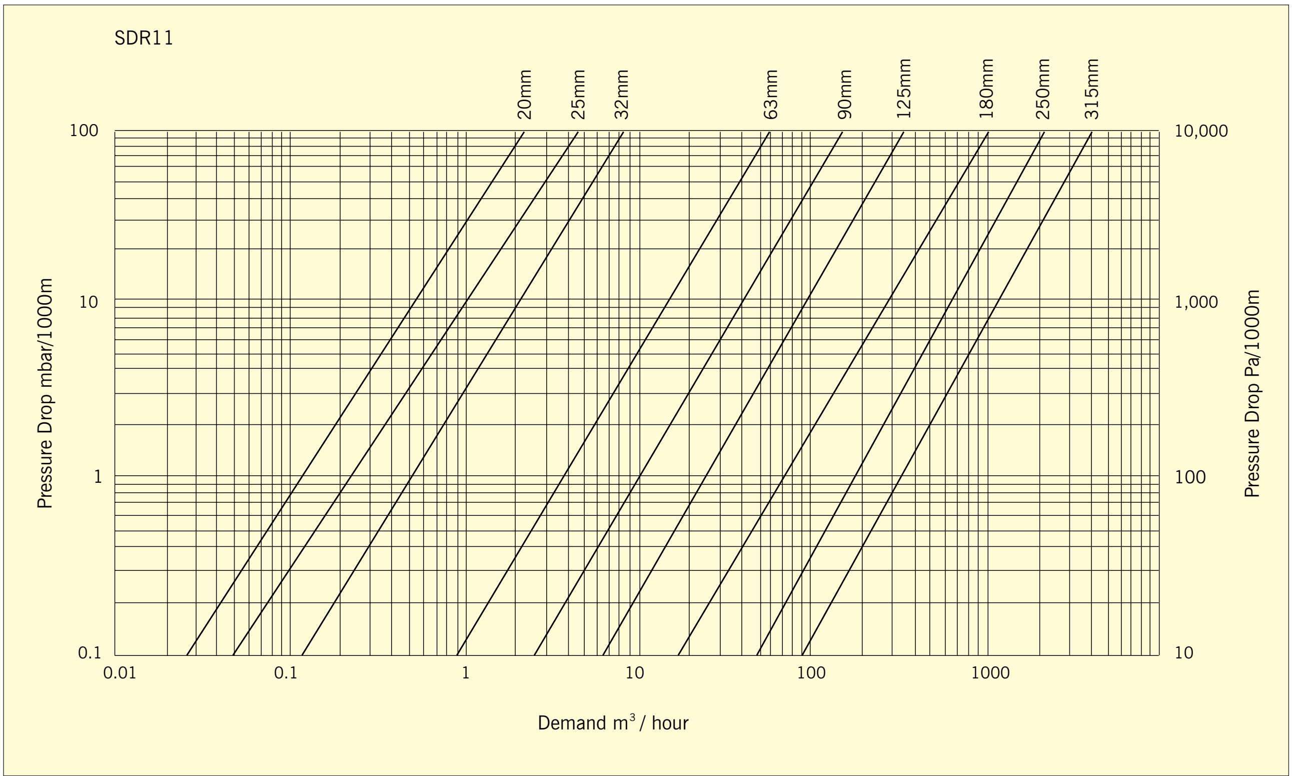
where $$\frac{1}{(f_{spl})^{0.5}} = 14.7519 + 3.5657X + 0.0362X^2$$

with $X = \log_{10}(Re) - 5$

and Re (Reynolds Number) $= 25043 \times \frac{Q}{D}$

The above is considered valid for pressures up to 75mbar.

Flow Charts for Low Pressure Polyethylene Gas Pipelines



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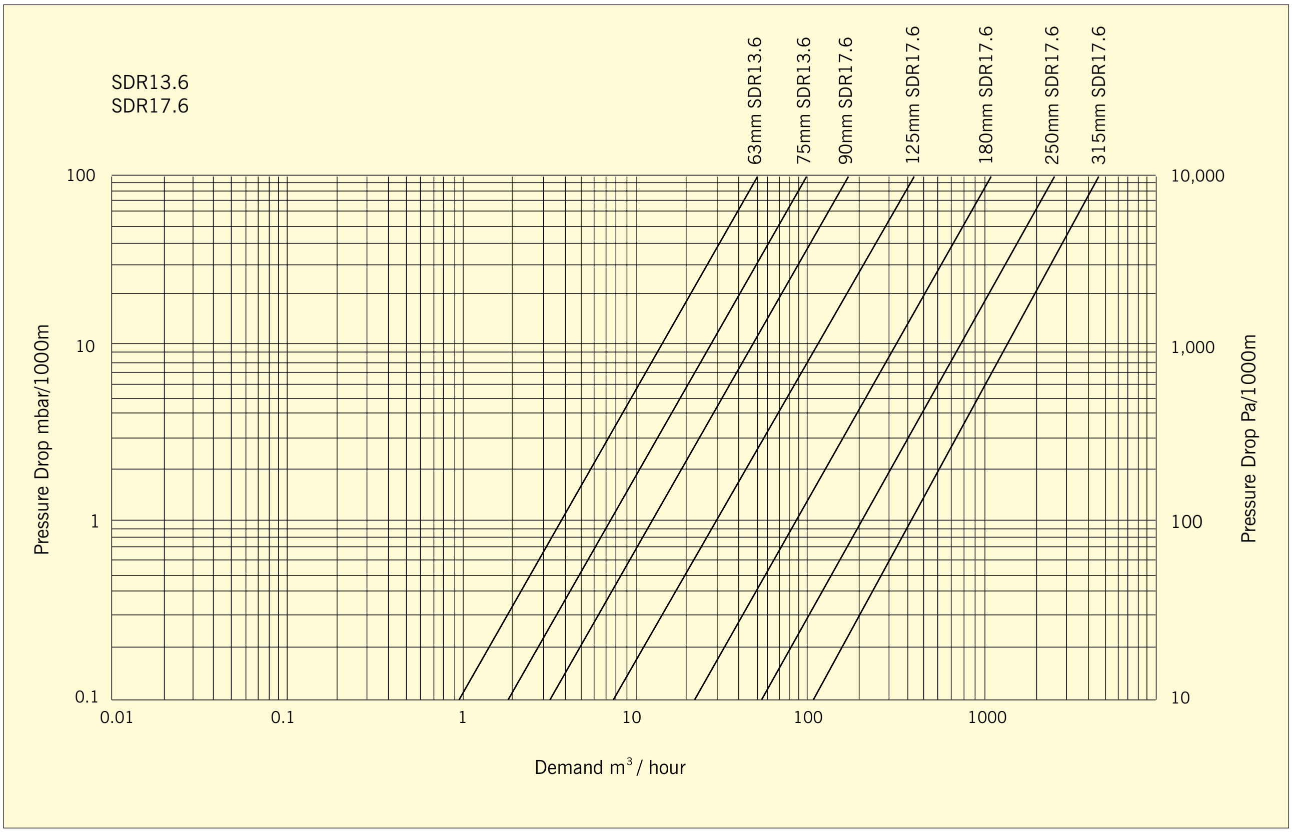
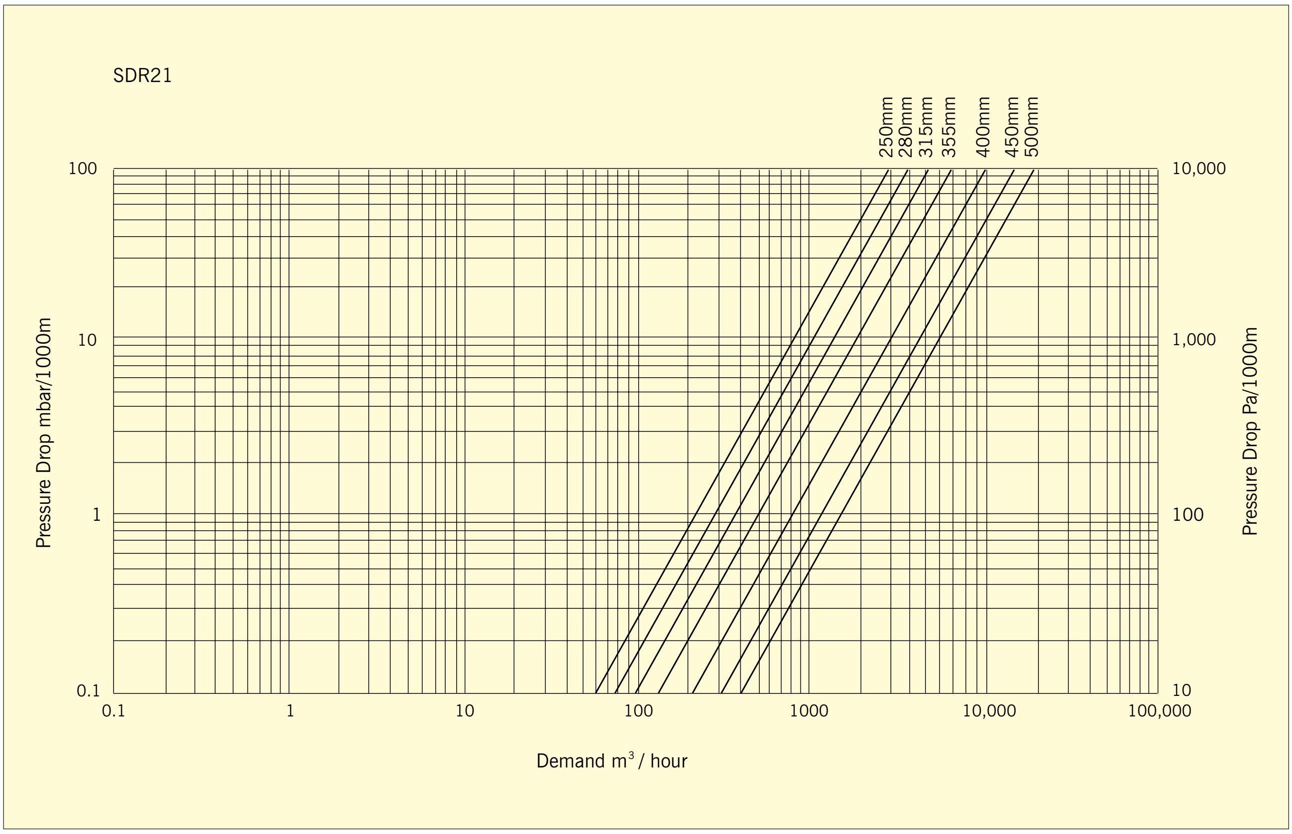

SDR13.6
SDR17.6
63mm SDR13.6
75mm SDR13.6
90mm SDR17.6
125mm SDR17.6
180mm SDR17.6
250mm SDR17.6
315mm SDR17.6
Pressure Drop mbar/1000m
100
10
1
0.1
Pressure Drop Pa/1000m
10,000
1,000
100
10
0.01
0.1
1
10
100
1000
Demand m³ / hour


SDR21
250mm
280mm
315mm
355mm
400mm
450mm
500mm
Pressure Drop mbar/1000m
100
10
1
0.1
Pressure Drop Pa/1000m
10,000
1,000
100
10
0.1
1
10
100
1000
10,000
100,000
Demand m³ / hour

Pressure Losses and Flows in Polyethylene Water Pipelines

Flow Calculations for Water

Pressure drop due to friction can be determined for practical purposes using a Head Loss Diagram, shown overleaf. This diagram is based on the Colebrook White formula for water at 10°C using the following values of hydraulic roughness factor k for PE pipework:

for pipe sizes up to 200mm, k=0.01mm

for pipe sizes above 200mm, k = 0.05mm

Head Loss Diagram - Example

This example shows how to use the Head Loss Diagram to find the approximate water flow rate through a 2,000 metre long 900mm SDR17 Excel (PE100) pipe, where the head loss over the entire pipeline is 10 metres.

- Obtain the mean bore of the pipe (it equals 791mm for a 900mm SDR17 Excel pipe).

  Mean internal diameters for pipes of various SDRs can be obtained from the GPS Product Guide/Price List Brochure (DP001).

- Drop a vertical line down from the point where the horizontal 5/1000 head loss line crosses the diagonal 800mm pipe bore line (10 metres head loss ÷ 2000 metres pipe length = 5/1000).

- The flow velocity in metres/sec can be determined from the velocity diagonals at this point (it equals approximately 2.5 metres/sec).

- The flow in litres/sec is given by where the vertical line crosses the bottom horizontal head loss line from this intersection and may be seen to be approximately 1,250 litres/sec.

The diagram can be used to estimate the required head loss along the pipeline for a given flow rate by reversing the above procedure. The estimated head loss will comprise the loss due to internal friction and the head loss or gain due to the elevation differences between the upstream and downstream ends of the pipeline.

Pressure Drop Through Fittings

The head loss caused by flow through fittings and valves is approximately proportional to the square of the velocity and can be derived from the following formula:

$$H = \frac{K \times v^2}{2 \times g}$$

Where H = Head loss
v = Fluid velocity
g = Acceleration due to gravity
K = Fittings coefficient

Fitting Type	**K value**
90° Elbow	1.0
45° Elbow	0.4
22.5° Elbow	0.2
90° Tee (in line)	0.35
90° Tee (through branch)	1.2
90° Bend	0.2
45° Bend	0.4
22.5° Elbow	0.2
Gate Valve (open)	0.12
Gate Valve (3/4 closed)	24.0

Alternatively, calculations can be made for equivalent lengths of straight pipe using the following formula:

$$E = F \times d$$

Where: E = equivalent pipe length (metres)
F = fittings constant (below)
d = fitting internal diameter (mm)

To calculate the total pressure drop in the system, the equivalent straight pipe lengths for fittings is then added to the total straight pipe length to obtain the total drop.

Fittings constant

Fitting	**F**
90° Elbow	0.030
45° Elbow	0.015
90° Tee – Straight through	0.020
90° Tee – Side branch	0.075
90° Long Radius Bend (4D)	0.020
45° Bend Long Radius Bend	0.010
Reducer (d/D= 3/4)	0.007

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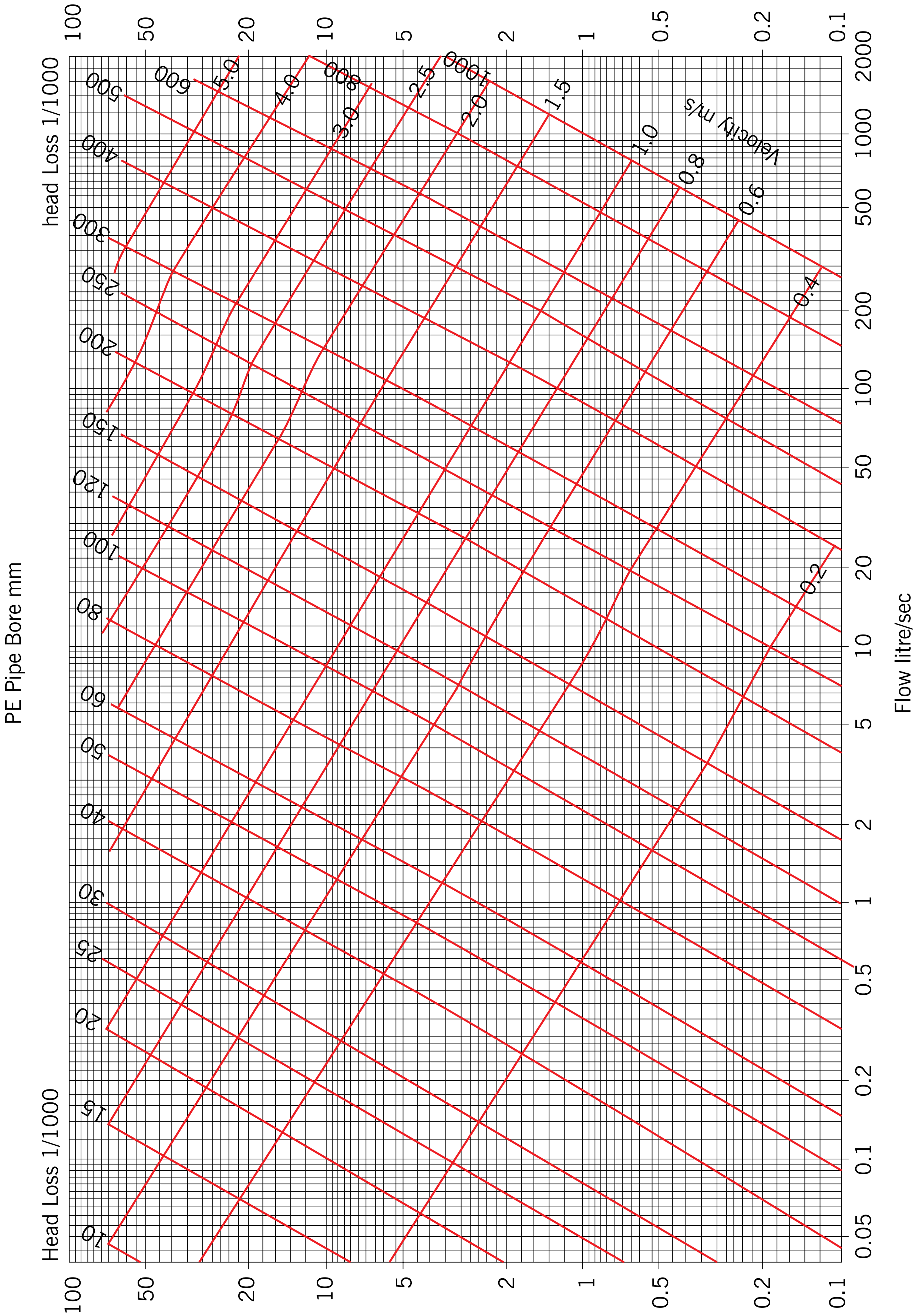
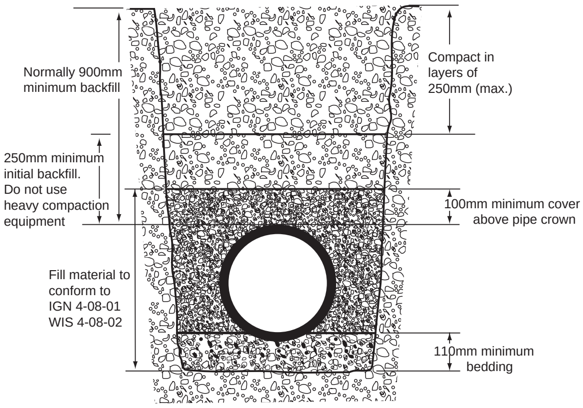


Head Loss Diagram

NOTE: For sizes not covered by the diagram please contact our Technical Support Department for further information.

Conventionally Buried Pipelines

The dimensions of a trenchline opening are normally governed by the pipe diameter, method of jointing and site conditions. Guidance is provided on the selection and use of materials suitable for providing structural support to buried pipelines in IGN 4-08-01 (Bedding and Sidefill Materials for Buried Pipelines) and WIS 4-08-02 (Specification for Bedding and Sidefill Materials for Buried Pipelines). Normal minimum depth of cover for mains should be 900mm from ground level to the crown of the pipe. Trench width should not normally be less than the outside diameter of the pipe plus 250mm to allow for adequate compaction of sidefill unless specialised narrow trenching techniques are used and/or specially free flowing and easily compacted side materials are employed (see advice on material selection below).



Considerable savings in the costs of imported backfill, reinstatement and waste spoil disposal can be made where needed if trench width is minimised. In many instances it may be acceptable to lay PE pipe directly on the bottom of the trench - especially where the soil is uniform, and there are no large flints, stones, or other large hard objects present. In rocky ground, the trench should be cut to a depth in isolation which will allow for the necessary thickness of selected bedding material below the bottom of the pipe. Where the finished top surface will subsequently be trafficked, and spoil from the excavation is unlikely to give the degree of ground stability required, (even after a degree of grading and compaction) granular material should be imported. Gravel or broken stone graded between 5 & 10mm in size provides suitable bedding, since it needs little compaction. Coarse sand, a sand and gravel mix, or gravel smaller than 20mm are also all acceptable straight from the quarry. The best granular material available from most modern quarries is designated 803X, and has been tested and approved by WRc. This has a maximum particle size of 12mm and very few fines and allows for trench widths only 50-100mm greater than the pipe irrespective of the excavation method. After lowering the pipe into position, the trench can be backfilled and the layers easily consolidated.

It is important to emphasise that the above requirements generally only apply when the PE pipe is buried in ground that will subsequently be trafficked, with or without a road pavement. The stated sidefill and backfill materials are required to give a stable top surface - the PE pipe itself will not be harmed if laid in much poorer surround provided there are no large sharp stones pressing against it, that are not surrounded by smaller stones.

Normal sidefill & backfill requirements

For minor roads, excavated material can often be returned to the trench and compacted in layer thicknesses specified by the Utility Company. Relevant Water Industry specifications. e.g. WIS 4-08-02, permit much coarser material for the side and backfill (uti 10% of pipe nominal size) for PE pipelines than is normally recommended for the bedding. However, heavy compaction equipment should not be used until the fill over the crown of the pipe is at least 300mm.

When GPS PE pipes are laid in fields it is preferable and most cost effective to use the originally excavated material all around the pipe provided that there are no large sharp isolated stones positioned underneath it. Large clay masses should be kept as dry as possible after excavation and broken up by rotovating (particle sizes should be no larger than 10% of pipe diameter).

By using as-dug material for bedding, surround and backfill, the drainage characteristics of the land are not altered, and any slight future soil movement as the ground re-stabilises is easily accommodated by the flexible and ductile nature of the PE pipes. It can rarely be justified to import granular fill in such cases and there are no particular benefits from using a geotextile wrap around the fill area.

External loading

If a pipeline to be rehabilitated by no-dig techniques, is deeply buried or passes under a river, the buckling loads produced by external ground water should be considered. Account should also be taken of PE ovality and whether grouting will be carried out. Long term safe external heads can vary between approximately 60 metres of water for a grouted installation using fully circular SDR11 PE80 pipe, down to about two metres for an ungrouted and loose SDR26 lining with six per cent ovality. These examples assume that the old main is structurally sound and that the PE lining OD is significantly less than the mains bore. If host pipe strength is doubtful, ground and water loading calculations must take into account probable soil support and grout stiffness (if used) and the known condition of the existing main.

Grouting

Where ground water loads are an issue in conventional slip-lining, annular grouting is usually more economical than using the heaviest possible grade of PE pipe guaranteed to give satisfactory resistance to ground water loads. The resistance of the inserted pipe to grouting

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The following table is reproduced from the WRc Sewerage Rehabilitation Manual, Vol III.

Permissible external pressures on PE pipes at grout curing temperatures.

Deformation SDR	0%	1%	3%	6%
	Permissible External Pressure (kN/m2)			
33	13	12	10	7
26	27	25	20	15
17	96	88	73	59
11	417	383	317	242

pressure will depend on SDR and on cross-sectional circularity (see below). This is a particularly important consideration for pipe taken off a coil or drum.
Grouting is irrelevant to close-fit lining systems of course, since the final annular gaps are negligible.

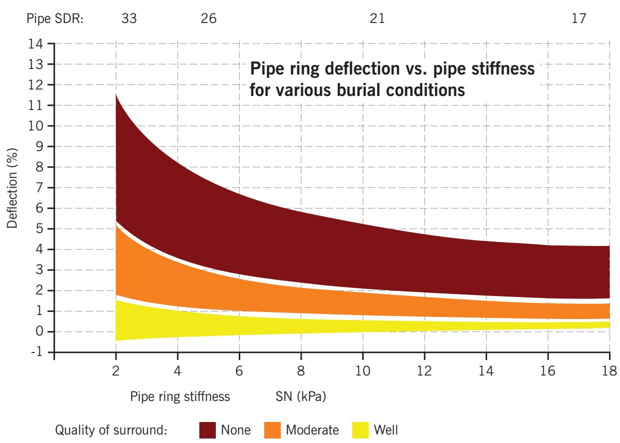
Structural Design of buried PE pipes

There is often a requirement to provide proof of design security for buried pipelines, and this may be done by using the calculation method in BS EN 1295-1:1997 UK Annex, which specifies the requirements for the structural design of water supply pipelines, drains, sewers and other water industry pipelines. In addition, this standard provides the guidance of nationally established methods of design.

The UK method was developed before PE was used extensively as a pipe material, and does not properly allow for the composite PE pipe/soil system. Values for long term safety factors against buckling and the total ('combined') stress equations are now recogrnised to be overly conservative. The latest version of the BS reflects this.

The European Plastic Pipes and Fittings Association (TEPPFA) and the Association of Plastics Manufacturers in Europe (APME) have sponsored extensive field trials from which an empirically based graph has been developed to aid PE pipe structural design (see below).

The graph gives the short term vertical pipe deflections that will occur for various burial conditions (materials used, plus degree of care taken) and pipe stiffness (SDRs), with long term deflection values determined by adding prescribed amounts.



TEPPFA design graph for pipe deflections immediately after installation

Assuming that the correct pressure rating of pipe is chosen for the specified duty, the total stress in the wall when the pipe is buried will always be less than the rated value (ref BS EN 1295-1:1997). The pipeline designer will simply need to decide how much deflection is acceptable in the particular circumstances (e.g. a higher value would be satisfactory in a field than under a road), and then select the PE pipe and type of surround accordingly. Note that long term deflections of up to 12.5% - 15% are completely safe for PE pipes (BS EN 12666-1, ISO TR 7073).

Long and short term pipe ring stiffness values are dependent upon the pipe's flexural modulus of elasticity, which is time, temperature and material dependent.

There is currently no international consensus about the best values of modulus to use in every situation, but the following are generally considered appropriate at ambient temperature (20ºC).

Type	Es (Short Term Modulus of Elasticity)	El (Long Term Modulus of Elasticity)
PE80 (MDPE)	900 MPa	130 MPa
PE100 (HPPE)	1100 MPa	160 MPa

Guidance on resistance to buckling where a surge event creates a sub atmospheric pressure in the pipeline is given in IGN 4-37-02 (Design Against Surge and Fatigue Conditions for Thermoplastic Pipes).

Entry to Structures

Polyethylene is unaffected by the constituents of concrete and the pipe can be partially or completely surrounded; however, protection should be afforded to the pipe surface to prevent the risk of fretting damage by wrapping the pipe in a heavy-duty polyethylene membrane prior to forming the concrete surround. The wrapping should extend beyond the concreted area. Should anchorage also be required, then a polyethylene 'puddle' flange may be incorporated (Figure 1 overleaf).

Achieving a water-tight seal where polyethylene pipes pass through concrete structures is difficult due to the materials natural flexibility; however provision may be made for external sealing (Figure 2).

The natural flexibility of a fully welded polyethylene pipeline can accommodate relatively large deflections. However, where a high degree of differential settlement is anticipated, consideration should be given to the use of support pads (Figure 3). The use of 'hinged' joints (rocker-pipes) is considered to be inappropriate for polyethylene pipeline installations.

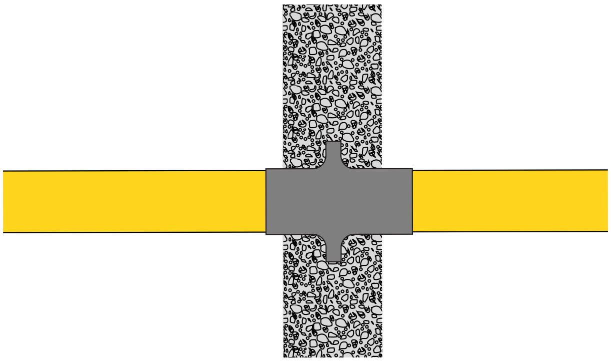


Figure 1.

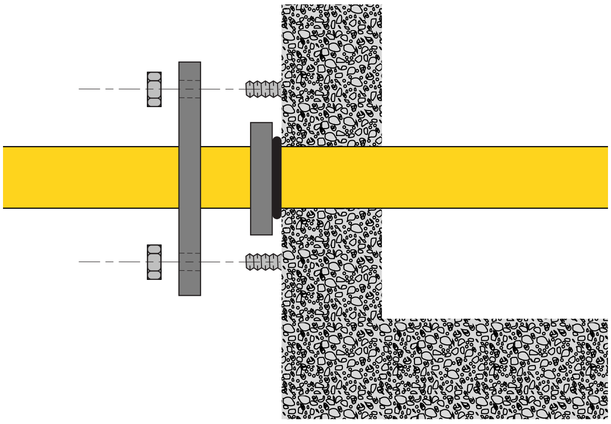


Figure 2.

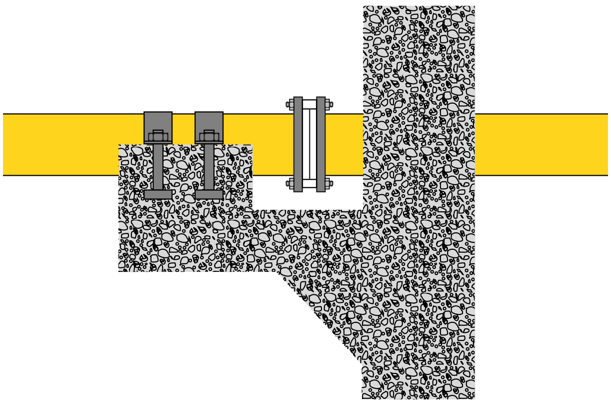


Figure 3.

Further information may be obtained from the WRc* 'Polyethylene Pipe Systems' manual.

*(www.wrcplc.co.uk)

Embankment Installation

Where pipes are to be installed above existing ground level and then covered, they should not be laid until the mound of made up ground has been built up and compacted to one metre above where the crown of the pipe is to be. A trench should then be cut into the mound and the pipes laid in the conventional way.

Above-ground Supported Installation

For exposed supported above ground pipework, proper anchorage is essential. The structure and anchorages must resist or accommodate thermal stresses or movement over the ambient temperature range to which the pipe system will be subjected. It is preferable that a polyethylene pipe is installed at or near the maximum operating temperature such that pipes are thermally expanded whereby at that point clamps or supports can be bolted into position thus restraining the pipe from further movement. As the pipeline cools, tensile stresses are developed and the pipeline will remain straight between supports. If the pipeline then warms to its original installation temperature, it returns to its installation condition and sag between pipe supports is minimised. Supported polyethylene pipe systems may also be designed using the traditional methods, employing 'flexible arms' and 'expansion loops'. For further information, please refer to BS EN 806 part 4 Annex B.

Support

Recommendations for maximum support spacing are given in the table below. They are based on a mid-span deflection of 6.5mm when the pipe is full of water and assume a long term flexural modulus of 200MPa at an ambient temperature of 20ºC. Pipe clips used for anchorage and support should have flat, non-abrasive contact faces, or be lined with rubber sheeting, and should not be over-tightened. The width of support brackets and hangers should normally be either 100mm or half the nominal pipe bore diameter, whichever is the greater.

Above Ground Pipework Maximum Support Spacing (metres)				
Pipe	SDR11	SDR17	SDR21	SDR26
20mm	0.6	N/A	N/A	N/A
25mm	0.7	N/A	N/A	N/A
32mm	0.9	N/A	N/A	N/A
63mm	1.1	N/A	N/A	N/A
90mm	1.3	1.2	N/A	N/A
110mm	1.5	1.3	N/A	N/A
125mm	1.6	1.4	N/A	N/A
160mm	1.8	1.6	1.6	1.5
180mm	1.9	1.7	1.7	1.6
200mm	2.0	1.8	1.8	1.7
225mm	2.1	1.9	1.9	1.8
250mm	2.2	2.0	2.0	1.9
280mm	2.3	2.1	2.1	2.0
315mm	2.5	2.3	2.2	2.1
355mm	2.6	2.4	2.3	2.2
400mm	2.8	2.5	2.4	2.3
450mm	2.9	2.7	2.6	2.5
500mm	3.1	2.8	2.7	2.6
560mm	3.3	3.0	2.9	2.8
630mm	3.5	3.2	3.1	2.9
710mm	N/A	3.4	3.3	3.1
800mm	N/A	3.6	3.5	3.3
900mm	N/A	3.8	3.7	3.5
1000mm	N/A	4.0	3.9	3.7
1200mm	N/A	4.4	4.2	4.0

Note: Figures given are for horizontal support spacings; and may be doubled for vertical support spacings.

Towing Loads

When towing pipe strings in average conditions, welded lengths up to 700 metres long of PE80 and 1000 metres of PE100 – can be pulled into place, irrespective of diameter or SDR and without excessive axial strain.

The maximum recommended towing loads at 20°C for various sizes of GPS PE80 and Excel (PE100) pipe are shown below.

The values given for maximum towing loads are based on a wall stress of 7.5MPa for PE80 and 10 MPa for PE100, which corresponds to 50% of the relative pipe yield stresses at 20°C.

These are applicable for straight pulling, and for a maximum period of half an hour at ambient temperature (20ºC). It is advisable to restrict frictional drag with the use of suitable pipe supports when pulling above ground.

When carrying out slip lining or insertion it is recommended that for long strings, a pipe relaxation period of at least 24 hours is allowed, before grouting or making permanent tie-in joints and lateral connections.

To further minimise residual tensile stresses, it is also desirable to carefully nudge in any accessible exposed pipe ends using a digger bucket. This is especially helpful in warmer weather.

Maximum towing loads at 20°C

Nominal PE Pipe Size (mm)	SDR	Max OD	PE80 20ºC load (tonnes)	Excel (PE100) 20ºC load (tonnes)
20	8.7	20.3	0.10	0.11
25	11	25.3	0.12	0.17
32	11	32.3	0.20	0.27
50	11	50.4	0.50	0.66
63	11	63.4	0.80	1.05
63	13.6	63.4	0.65	N/A
75	13.6	75.6	0.92	N/A
90	17	90.6	1.1	1.4
90	11	90.6	1.6	2.1
110	17	110.7	1.6	2.1
110	11	110.7	2.4	3.1
125	17	125.8	2.1	2.7
125	11	125.8	3.1	4.1
160	26	161.0	2.3	3.1
160	21	161.0	2.8	3.7
160	17	161.0	3.4	4.5
160	11	161.0	5.1	6.8
180	26	181.1	3.0	3.8
180	21	181.1	3.5	4.7
180	17	181.1	4.3	5.7
180	11	181.1	6.4	8.6
200	26	201.2	3.6	4.8
200	21	201.2	8.0	10.6
200	17	201.2	5.3	7.1
200	11	201.2	11	13
225	26	226.4	4.5	6.0
225	21	226.4	5.5	7.4
225	17	226.4	6.7	9.0
225	11	226.4	10.0	13.4
250	26	251.5	5.6	7.42
250	21	251.5	6.8	9.1
250	17	251.5	8.3	11.1
250	11	251.5	12.5	16.6
280	26	281.7	7.0	9.3
280	21	281.7	8.5	11.4
280	17	281.7	10.4	13.9
280	11	281.7	15.5	20.8
315	26	316.9	8.8	11.8
315	21	316.9	10.8	14.4
315	17	316.9	13.2	17.6
315	11	316.9	20.0	26.3

Nominal PE Pipe Size (mm)	SDR	Max OD	PE80 20ºC load (tonnes)	Excel (PE100) 20ºC load (tonnes)
355	26	357.2	11.2	15.0
355	21	357.2	13.7	18.3
355	17	357.2	16.8	22.4
355	11	357.2	25.0	33.4
400	26	402.4	14.2	19.0
400	21	402.4	17.4	23.3
400	17	402.4	21.3	28.4
400	11	402.4	32.0	42.4
450	26	452.7	18.0	24.0
450	21	452.7	22.1	29.5
450	17	452.7	26.9	35.9
450	11	452.7	40.0	53.6
500	26	503.0	22.2	29.6
500	21	503.0	27.2	36.3
500	17	503.0	33.2	44.4
500	11	503.0	50.0	66.2
560	26	563.4	27.9	37.2
560	21	563.4	34.2	45.6
560	17	563.4	41.7	55.6
560	11	563.4	62.5	83.0
630	26	633.8	35.3	47.1
630	21	633.8	43.2	57.7
630	17	633.8	52.8	70.4
630	11	633.8	79.0	105.2
710	26	716.4	44.8	59.8
710	21	716.4	54.9	73.3
710	17	716.4	67.0	89.5
800	26	807.2	56.9	75.9
800	21	807.2	69.7	93.0
800	17	807.2	85.1	113.6
900	26	908.1	72.0	96.0
900	21	908.1	88.2	117.8
900	17	908.1	107.8	143.7
1000	26	1009.0	88.8	118.5
1000	21	1009.0	108.9	145.4
1000	17	1009.0	132.0	177.5
1200	26	1210.8	127.9	170.7
1200	21	1210.8	156.8	209.3
1200	17	1210.8	191.5	255.5

OD = Outside Diameter
SDR = Standard Dimensional Ratio

Jointing PE to PE by Fusion

PE pipes of different SDRs

Butt-fusion
Butt-fusion should only be used for jointing pipes of the same OD and SDR value.

Electrofusion
Electrofusion fittings are able to weld pipes of the same OD but different wall thicknesses (SDRs). They are available in a choice of 10bar or 16bar (water) and 5.5bar or 7bar (gas) rating. Care should be taken to ensure that the pressure rating of the fittings is equal to or greater than that of the pipe.

SDR applications are marked on individual fittings. However, for the more unusual SDRs, specific advice should be sought from our Technical Support Department.

Jointing Different Types of PE

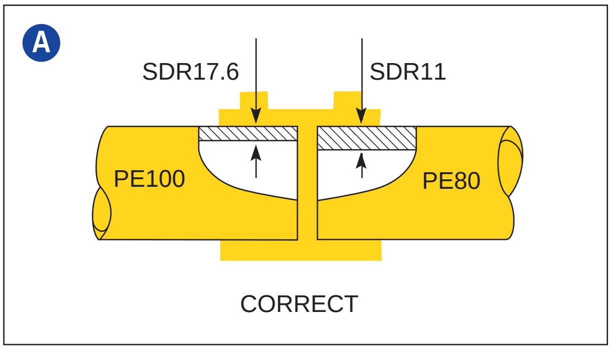
Different pipe producers may have alternative suppliers of preferred PE80 grades, but these are all intended to be joined by identical techniques. Similarly different grades of PE100 can be joined together with the same technique.

Material and SDR Compatibility Summary

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

NB. The maximum working pressure should not exceed the lower value for the two pipes.

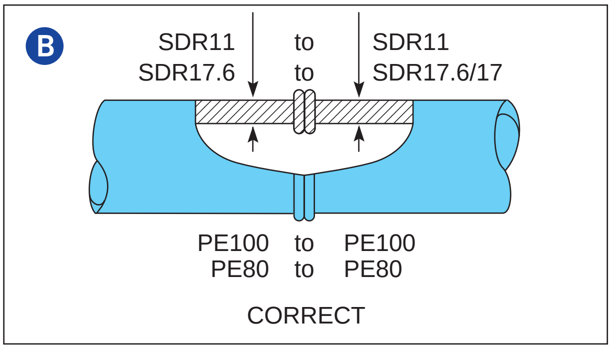
See Figure A.



(b) Similar materials and/or wall thicknesses may be jointed by butt fusion or electrofusion.

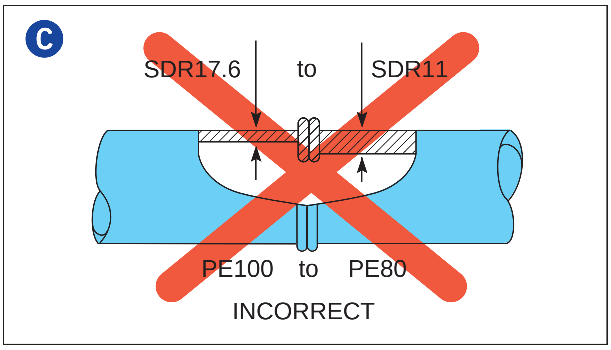
Note: SDR17 may be butt fused to SDR17.6.

See Figure B.



(c) Dissimilar wall thicknesses must **not** be jointed on site using butt-fusion. Note: PE80 should only be butt fused to PE100 under closely controlled factory conditions.

See Figure C.



GPS PE PIPE SYSTEMS **Tel:** +44 (0)1480 52121 **Fax:** +44 (0)1480 458829 **Technical Support:** +44 (0)1480 442620




General Handling

Although relatively lightweight, polyethylene pipe products should be treated with a similar level of caution as for heavier metallic pipe products. Whilst polyethylene is a robust and resilient material, care should be taken not to cause excessive scuffing or gouging of the surface. Surface damage may occur during handling, storage and installation, but providing the depth of any score is no greater than 10% of the wall thickness, then the service performance of the pipe or fitting will not be affected. Further guidance regarding handling and storage of PE pipes and fittings is given by various industry bodies, including the following:

HSE Guidance (best practice) - Avoidance of danger from overhead power lines (HS GS 6); Protect yourself, protect the load; The lifting operations and lifting equipment regulations (LOLER); The provision and use of work equipment regulations (PUEWER).

Department of Transport - Safety of loads on vehicles.
WRc - Polyethylene Pipe Systems For Water Supply (version 01/02).
IGEM /G/8 Handling, Transport and Storage of PE Pipes and Fittings.

In lifting operations, where either manual or mechanical effort is involved in moving a load, the following factors are common to all situations and provide the basis on which the selection of the appropriate type of lifting equipment can be made:

- The weight of the load
- The bulk, size or shape of the load
- The method of joining the load to the lifting system
- The centre of gravity of the load
- The method of security or stabilising the lifting equipment
- Training of personnel involved in lifting operations
- The environment i.e. ground conditions, weather etc.

Physical dimensions of products, the mean weights of pipes (per unit length), weights of coils and individual fittings can be obtained from the GPS Product Dimensions / Price List Brochure, reference GP-DP001.

The Rules on Handling and Storage

Never

- Drag or roll individual pipes or bundles.
- Throw or drop pipe/fittings from delivery vehicles.
- Use metal slings, hooks or chains when handling.
- Expose pipe/fittings to prolonged sunlight. (Protect with opaque sheeting or tarpaulin).
- Stack pipe bundles more than three metres or three bundles high.
- Place pipes or fittings in contact with lubricating or hydraulic oils, gasoline, solvents or other aggressive materials (see Chemical Resistance Safety section on page 9).
- Stack coils more than two metres high.

Always

- Store pipes/fittings on flat, firm ground, able to withstand the weight of the materials and lifting apparatus.
- Keep pipe/fittings well away from sharp objects, such as flints.
- Use wide non-metallic slings (eg. nylon or polypropylene).
- Exercise special care when handling pipes in wet or frosty conditions, since they may become slippery.
- Keep protective packaging (battens, shrinkwrap, pallets, strapping, etc.) intact until pipes/fittings are required for use.
- Keep pipes/fittings away from intense heat.
- Allow for some bending deflection when pipes are loaded and unloaded. Lifting points should be evenly spaced.

Delivery and Unloading at Customer Sites

The Plastic Pipe Industry - UK Best Practice - Recommended Guidelines for the Safe Delivery and Unloading of Plastics Pipes to Customers Site (Health & Safety Charter) has been developed by industry stakeholders to provide a risk-based framework to assist with the safe delivery and off-loading of plastics pipe products. This document has been commended by the HSE and GPS have formally adopted these guidelines.

Deliveries should not be made to unmanned sites.

Lengths and Bundles
It is the responsibility of the Site Responsible Person to ensure that the site is safe to accept pipe deliveries. The area where the delivery vehicle is to stop shall be safe and the location for storage shall be on firm level ground which is free from damaging material.

Polyethylene pipe products should be off-loaded in a controlled manner. All polyethylene pipe products shall be mechanically off-loaded and where there is no suitable mechanical off-loading equipment on site then an on-board crane vehicle shall be requested. It is the responsibility of the on-board crane operator to off-load polyethylene pipes and is the only person authorised to access the trailer for this purpose. It is important to maintain an exclusion zone with all personnel and vehicular traffic kept at a safe distance.

Coils
The delivery driver is responsible for undoing the load securing devices, which should only be removed from product that is to be imminently off-loaded. The driver is the only person authorised to access the trailer and if off-loading is to be carried out by fork-lift then the driver should be escorted to a safe zone away from the off-loading area by the Site Responsible Person.

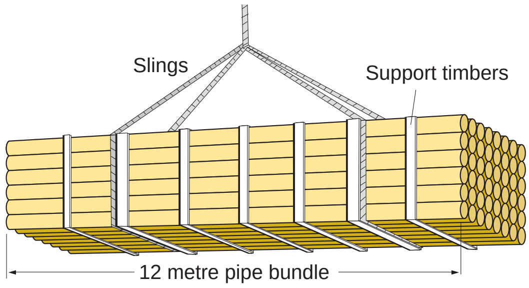
It is the responsibility of the person operating the fork-lift to ensure that the off-loading process is carried out safely. If off-loading is to be carried out by the driver using the on-board crane, then the procedures as for lengths and bundles should be followed.

Larger coils 90mm – 180mm pipe will require lifting by a fork-lift ensuring that the tines are covered to protect the coils from damage. It is recommended to use anti-slip protective fork covers, which are readily available.

Small coils of pipe, delivered on pallets, may be handled by forklift, but should remain secured to the pallet during transportation. Securing bands should only be broken at the time of use. Coils delivered in shrink-wrapped packs should be handled with care to avoid damage.

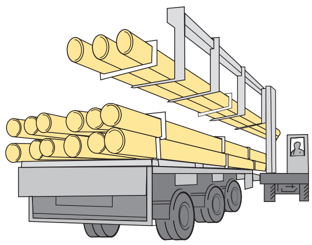
Site/Depot Handling

A flat-bed vehicle, free from sharp objects and projections should be used for transporting pipes. When lifting pipe bundles by crane, wideband slings of polypropylene, nylon or similar material are recommended. Do not use chains, hooks or hawsers.



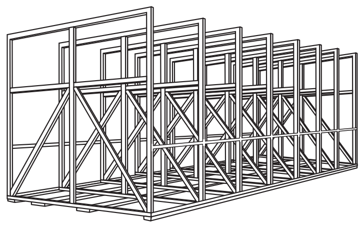
Good lifting practice

Allow for a certain amount of deflection or slight bending of pipe bundles when loading or unloading. Standard six metre bundles may be handled by forklift, but longer lengths should be moved by a side-loader with a minimum of four supporting forks or by a crane with a spreader beam.



Handling of long lengths

Where large diameter coils are to be stored vertically, as at depots, coils must be secured in purpose built racking with protective matting positioned underneath, and facilities for safe lifting, movement and loading must be available.



Example of racking for vertical storage of large diameter coils

Fittings

Boxed fittings and pre-fabricated fittings may be stacked on pallets for transport which should be adequately secured. They should be stacked, secured and transported such that no loads are imparted to the fittings. Never use hooks to lift fittings.

Storage

Pipes

The on site storage facilities will vary depending upon factors such as the available space, location, size and nature of the project etc.

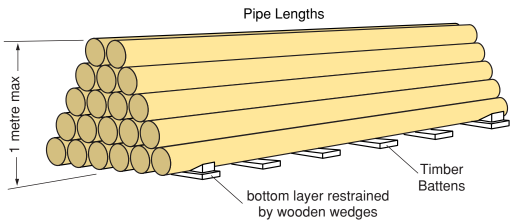
The storage may range from a secure central storage compound, localised storage points close to the laying operation, to stringing the pipes along the planned route.

In all cases careful consideration should be given to the following aspects:

- Security of all materials and equipment from theft, vandalism, accidental damage or contamination (Pipe-end caps, intended to prevent ingress of contamination, should be kept in place during storage).
- Safety of the general public, especially, the elderly and disabled.
- The movement of traffic, construction equipment, farm machinery and animals.
- All pipe store locations should be on suitably firm, level ground, free from damaging material with adequate access for construction vehicles and/or lifting equipment.
- Badly stacked pallets, coils or bundles may slip or collapse, causing injury to personnel or damage to the pipe.

Lengths

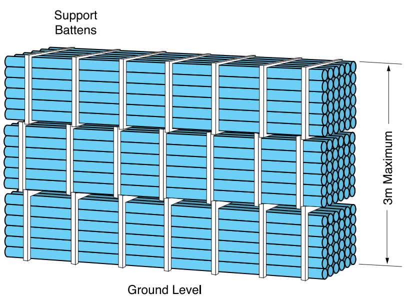
Pipe lengths stored individually should be stacked in a pyramid not more than one metre high, with the bottom layer fully restrained by wedges. Where possible, the bottom layer of pipes should be laid on timber battens. On site, pipes may be laid out individually in strings. (Where appropriate, protective barriers should be placed with adequate warning signs and lamps.)



Storage of loose pipes

Bundles

Bundled packs of pipe should be stored on clear, level ground, with the battens supported from the outside by timbers or concrete blocks. For safety, bundled packs should not be stacked more than three metres high.



Storage of bundles

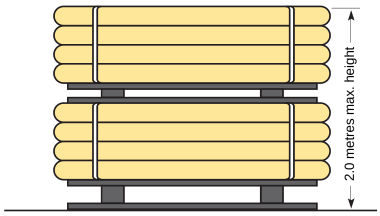
Large Coils

Coiled pipe should be stored flat, especially during periods of warm weather, and on firm level ground which has suitable protection for the bottom coil. Where space is limited and coils are to be stacked, the height of stacked coils should be such that the stack is stable and the uppermost coil can be safely handled. Under no circumstances should the stack exceed 2.0 metres in height.

Wooden battens placed below the bottom coil and used as spacers between each layer will facilitate easy access for slinging.

When the need for transportation is required, it should only be carried out by trained operatives.

Batches of coils delivered on pallets must remain secured to the pallet and only be broken at the time of use.



Storage of coils

Coil Dispensing

Safety first: Pipe held in coils, is under tension and is strapped accordingly. Coils may be hazardous if released in the incorrect manner – particularly if the end of the pipe is not kept restrained at all times. It is most important to read and understand the following guidelines before attempting to release coils.

Coils are secured by one of two methods depending on the pipe's diameter:

1. **Outer bands with additional strapping of individual layers (63mm and above).**
   Do not remove any of these bands until pipe is required for use. Remove them carefully, from the outermost layer first, so that only the length of pipe needed immediately is released. Successive layers can be released by removing banding as the pipe is drawn away from the coil.

   Coils of pipe above 32mm diameter should only be dispensed in the field from proprietary trailers.

2. **Wrapped coils**
   Pipe sizes in 32mm and below have external layers of filmwrap, enabling the free end of the pipe to be taken from inside the coil. Take only sufficient pipe for immediate use from the coil and on no account remove the outer wrapping until the coil is almost fully unwound.

Fittings

Electrofusion fittings should be stored under cover in dry conditions, preferably on racking. They should be kept in their boxes/packaging until ready for use. Fabricated fittings may be stored outdoors, as long as they are protected against damage and prolonged direct sunlight.

Storage Outside

Black polyethylene material contains ultraviolet stabiliser to provide excellent protection against degradation due to UV radiation.

Blue and yellow polyethylene is UV stabilised to resist degradations in storage only. The maximum recommended storage outside, in Northern Europe, is 12 months. Product to be stored outside for periods in excess of this, should be covered with black polyethylene sheeting or stored under cover.

Additional precautions may be required, where polyethylene pipes are stored outside in regions of the world with high solar radiation.

Cutting PE Pipes

When using any pipe cutting equipment, care should be taken to follow the manufacturers instructions and to wear the appropriate protective clothing. Any statutory regulations regarding cutting equipment must be adhered to and operation only carried out by appropriately trained personnel.

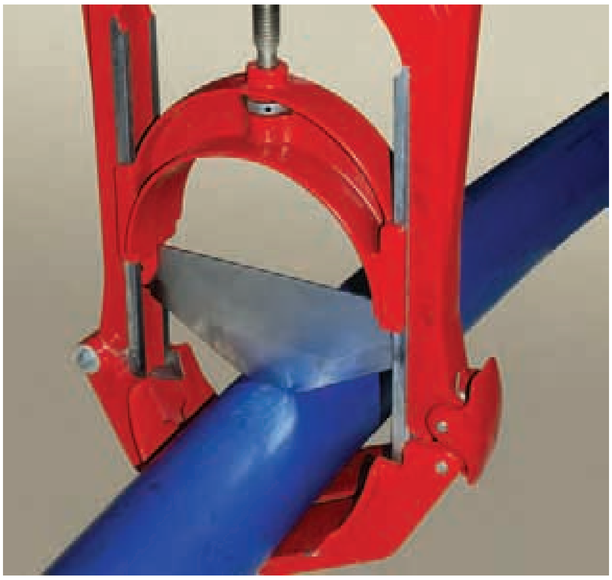
Service pipe sizes

It is recommended that proprietary pipe secateurs are employed for service pipes, since these produce a smooth square end ready for electrofusion jointing or mechanical fitting assembly. When using pipe secateurs care should be taken to keep fingers and loose clothing clear of the cutting blade. After use, the secateurs should be closed and the catch engaged in order not to leave the blade exposed.

Mains pipe sizes

The following can be used for cutting PE mains pipes. In all cases blunt, warped or cracked saw blades should be replaced immediately:-

1. Coarse toothed hand-saws can be used at quite large pipe sizes, and proprietary guides are available which are designed to fit onto electrofusion alignment clamps.
2. Guillotine cutters and motorised pipe cutters are available from specialist tool hire companies.



3. Jigsaws fitted with coarse toothed blades are a readily available option, however it is usually necessary to start from a suitably sized pre-drilled hole.
4. Alligator saws, which have reciprocating blades are a popular choice for cutting large PE pipes.

Specialist blades have been developed for use with petrol cut-off saws; however, operation and maintenance should only be undertaken by appropriately trained personnel.

When using any electrical equipment, the manufacturers' mechanical and electrical safety instructions should be adhered to.

Chainsaws should not be used to cut PE pipes, irrespective of the machine type and saw tooth pattern. There is a significant risk of snagging/snatching occurring with these saws and it is also probable that lubricating oil would find its way onto the pipe surface, impeding any subsequent fusion jointing.

Whatever cutting tool is employed, the pipe to be cut should be adequately held and supported.

Any swarf produced by cutting, should be disposed of safely and with environmental consideration.

Identification

All pipes and fittings should be used in order of delivery and to assist stock rotation, the following product identification guidance is provided.

Electrofusion Fitting Markings

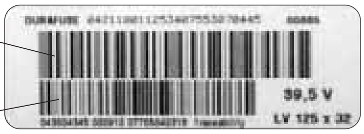
Where applicable, most fittings incorporate the following information on the outer surface, either moulded into the product or on the barcode label:

- Material Designation - PE100 or PE80
- Standard Dimensional Ratio (SDR) of Fitting
- SDR Fusion Range (maximum/minimum)
- Nominal Size (mm)
- Fusion Time (seconds)
- Cooling Time (minutes)
- Name and Trademark

Electrofusion fittings product labels also incorporate traceability barcodes to trace the relevant production records. These codes can be read by any ECU with a traceability option (see page 31 for further information).

Fusion Barcode

Traceability Barcode



Product Packaging

In addition to information marked directly on the products, the following information is supplied on the product packaging:

- Fitting Type
- Application Information (Gas or Water)
- Certifying Symbols and Standards
- System Voltage (if applicable)
- Pressure Rating
- Weight (kg)
- Product Code

Other Fitting Markings

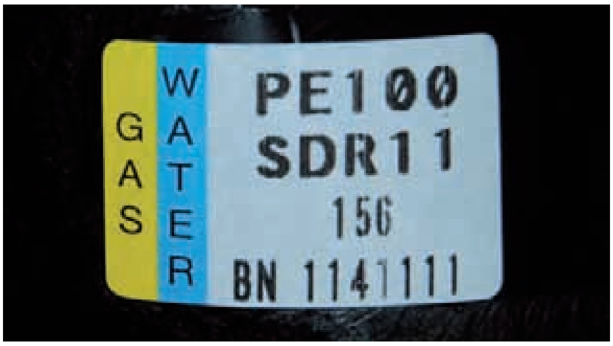
All GPS fittings manufactured within a specific batch are marked with an identification number, unique to that batch.

This unique number consists of either 5 or 7 digits, which can be interpreted as follows:

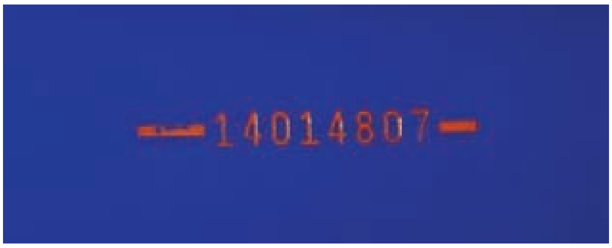
1 2 3 4/5 6/7

- 6/7 — The last two digits of the year
- 4/5 — International Standard week number
- 3 — The day of the week: 1 = Monday, 7 = Sunday
- 2 — Batch reference: the number of the batch in a particular shift, usually 1.
- 1 — Shift period: day = 1, night = 2

- Long Spigot fitting batch codes consist of the full 7 digits in the above format.
- DuraFuse fitting batch codes consist of digits 3 to 7.



Batch code (bottom) for a long spigot fitting



Shift code for a PE100 pipe

GPS Pipe Marking

As a minimum requirement, the following Information is marked indelibly and linearly at intervals along the pipe:

GPS 180mm SDR11 PE100 S 14143004

- 14143004 — Shift Code (an 8 Digit code denoting Machine, Shift, Week & Year - as shown on the photo above).
- S — Raw Material Code
- PE100 — Material designation (i.e.PE80 or PE100)
- SDR11 — Standard Dimensional Ratio (SDR) Value
- 180mm — Nominal Pipe Outside Diameter (OD) in mm
- GPS — Manufacturer

GPS pipe is also marked with the name of any industry standard to which it conforms.

Blue water pipe also carries reference to the bar rating of the pipe (usually after the OD) and is marked at three separate intervals within the coding with the word WATER for high visibility and identification purposes.

For identification purposes, Protecta-Line and Secura-Line pipes are also marked with four brown stripes to indicate that they are multi-layered pipes.

Polyethylene pipe systems from GPS are designed to make installation quicker, easier and more cost effective. Installation is as much a part of the costing equation as ease of maintenance and the cost of the pipe system itself. PE's great advantage in installation is its lightness and flexibility, coupled with its durability and totally secure jointing methods. For all modern pipelaying techniques, whether in rehabilitation work or the construction of new pipelines above or below ground level, PE80 (MDPE) and Excel (PE100) systems from GPS usually provide the simplest, most economic solution. Indeed, rehabilitation techniques have been developed which rely completely on polyethylene's unique properties.

A major advantage of PE is that pipe lengths can be butt-fused or electrofusion jointed to form a continuous string of pipe and there is rarely need for thrust blocks. This, together with the material's inherent flexibility, (see material properties section for bend radii on page 8) makes polyethylene ideally suited to a full range of new and innovative installation techniques. GPS PE Pipe Systems support all methods of installation used today including chain trenching, moleploughing, size-for-size moling, pipe bursting and slip-lining. Working practice and techniques for installing GPS products by a variety of pipelaying methods are as follows.

Low-Dig and No Dig New Lay Techniques for Buried Pipelines

Chain trenching

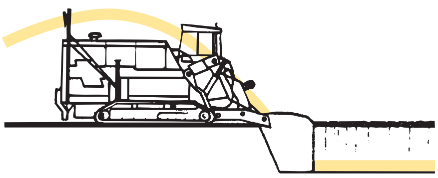
As previously noted, a major installation advantage of PE pipe is that lengths can be fused together by butt-fusion to form continuous strings. Since the need for in-trench jointing is virtually eliminated, the width of excavations can be minimised, resulting in reduced labour cost, less imported backfill and lower reinstatement costs. Modified mechanical diggers with oblique profiled buckets are ideal provided that the soil produced by the digging action is relatively fine. Chain excavators in particular will break up the original ground finely and permit trench widths only 50 to 100mm greater than the PE pipe outside diameter.

Profiled digger bucket

Suction Excavators
Suction excavators are special excavation machines which can excavate all kinds of both wet and dry material without damaging buried utility lines, cables and tree roots. High output volumes can be achieved even where there are unfavourable soil conditions.

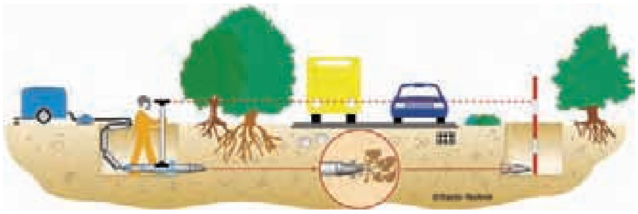
Suction excavator (courtesy of TT-UK Ltd.)

Moleploughing
This technique was originally developed for laying land drainage and adapted for installation of gas and water pipes in rural areas. It enables pipelines to be laid across rural landscapes with minimum disruption to agriculture, while the ground can also be reinstated virtually to prime condition. A new PE pipe string is literally ploughed into the ground to a prescribed depth and the ground restored immediately to its original condition.



Moleploughing

Impact moling
Impact moling is highly economic in instances such as road crossings, where considerable savings can be made over traditional open-cut excavation methods. Traffic control systems are often unnecessary, for example, and the cost of excavation, backfill and reinstatement is virtually eliminated. With this installation method, excavation is only necessary at the starting and finishing locations of the pipeline - in order to accommodate the mole and its ancillary equipment. The impact mole drives a borehole between launch and reception pits, leaving the ground surface undisturbed. A sacrificial liner is sometimes attached to the mole and pulled along behind it. The PE pipe is pulled directly behind the mole or into the pre-liner if present. Independent studies have indicated that only thin walled pipes e.g. thinner than SDR17, are at significant risk from excessive scoring during impact moling. However, for total security GPS's Secura-Line can be specified (see also pipe bursting on page 29).

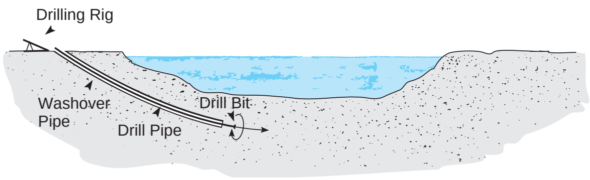


Impact moling (courtesy of TT-UK Ltd.)

Directional drilling
This is a pipe installation technique that was originally developed for oil and gas wells, however it is now increasingly used for PE pipe. It allows pipelines to be installed under roads and rivers etc. with minimal excavation work. The technique involves drilling a hole under an obstacle and then pulling the pipeline back through an enlarged hole from the far side.

Tensile loading measuring devices, fitted to the pipe which is to be installed, are available to ensure that the pipe is not overstressed when directional drilling or pipe cracking is carried out.

The stages are as follows:



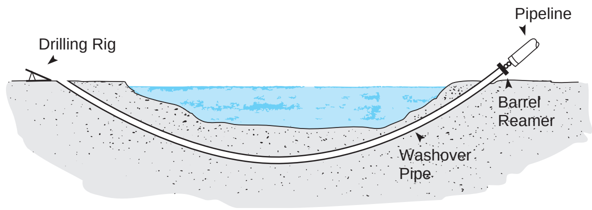
i) A small diameter 'pilot hole' is drilled from one side of the obstacle to the next by a drill head attached to the 'pilot string' which, in turn, may be connected to a 'washover' pipe which overdrills the hole and provides rigidity to the pilot string.

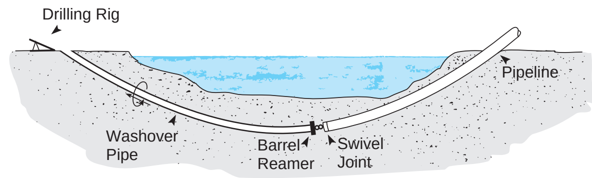
ii) An enlarged hole is bored by one of various means, which include high-pressure fluid jets for cutting (plus carbide cutting blades to cope with the more difficult soils), and drill bits which are driven by mud motors.

iii) The drill head is steered by using a flexible joint close to the head which is moved by manipulation of the jets or by thrust force on the end of the drill string. A transmitter in the head sends signals to the surface, and these are received by a hand-held locator which displays both the lateral position and depth of the head, allowing tracing and guidance of the drill head.

iv) When the drill head exits on the far side of the obstacle, the drill head is removed and a reverse barrel reamer is attached to the washover pipe followed by the PE pipe string. The reamer is used to increase the size of the hole to the final size required to enable the PE pipe string to be pulled back through.

In the case of large diameter pipes, a number of passes are made using reamers of progressively increasing sizes before the final pull-through of the PE pipe string is carried out.

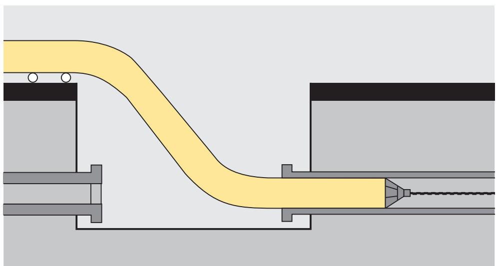




Rehabilitation and Renovation using No-Dig Techniques

Slip-lining / Insertion
In slip-lining or insertion, a replacement PE pipe string of smaller size is inserted into an existing decommissioned pipeline.
Although rarely necessary, pressure grouting (see page 16) of the annular gap can enable the existing pipeline to be rehabilitated structurally, whilst also reinforcing the hoop strength of the new PE pipe.

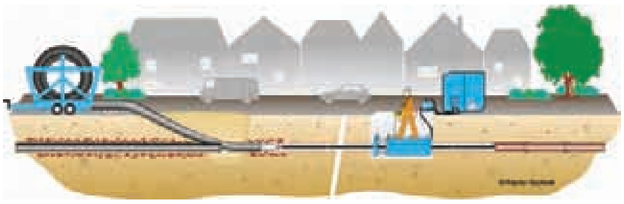
Though some reduction in flow capacity is inevitable, this can be minimised by careful preparation and cleaning of the old pipe so that the largest possible diameter of new PE pipe can be inserted. In many instances an average annular clearance of as little as five per cent of mains diameter - less still for sizes above 300mm - has proven adequate where pipelines are reasonably straight and of uniform bore. In pressure pipelines the reduction in carrying capacity can also be compensated for by an increase in internal pressure. In gravity applications any effect of bore reduction is minimised both by the exclusion of ground water entering the system and by the improved flow characteristics of PE.



Slip-lining

Pipe bursting

Size-for-size replacement or upsizing of existing iron pipelines can be achieved with significant savings by the pipe bursting method. With this technique an existing main is cracked open and the borehole simultaneously expanded by a mole. Modern pipe bursting moles - especially those with hydraulically expanding segments - can crack and open out an unserviceable pipeline, even if it has repair collars or concrete surrounds. Risk of damage to adjacent utility installations is minimised by using hydraulic moles, helping to maximise the cost advantages of using the existing 'hole in the ground'. The early practice was to use a sacrificial polyethylene sleeve which was drawn behind the mole and into the cleared borehole through which the new PE main could be inserted. Naturally the use of a sacrificial PE sleeve or liner increased both time and cost of the operation, but nowdays with suitable pipe bursting equipment and in favourable ground conditions, a standard PE pipe can be installed directly behind mole, saving time as no second insertion is to take place. Also there is no need for a second insertion for GPS's Secura-Line pipe (gas applications), as its peelable abrasion resistant outer coating protects the core pipe during installation.



Pipe bursting (courtesy of TT-UK Ltd.)

Pipe bursting in progress

Bursting head

Original pipe in service trench

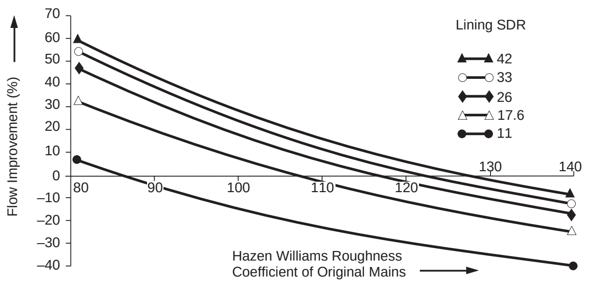
Exit of bursting head from service trench

Entry of bursting head to service trench

New pipe pulled into position

Close-fit insertion systems

Close-fit systems offer two major advantages. They never require grouting (see page 16) and, in most cases, even though there is a slight reduction in pipe diameter, the exceptional hydraulic smoothness of GPS pipe actually enables flow capacity to be increased. The following figure illustrates the point graphically. Quite clearly, Excel (PE100) pipe is the best choice where maximum flow capacity is required for a given pressure rating.



Flow capacity improvements for close-fit polyethylene lined mains, irrespective of head loss or mains size. (Assumes Hazen Williams Roughness Coefficient 'C' of Lining = 150 and 1% fit deficit)

If the old main is structurally unsound, close-fit PE linings can be SDR17/17.6 or SDR11, depending on ground cover and pressure requirements. For pipelines that are strong but leaking, PE lining thickness down to SDR33 or less should be considered. With a 50-year minimum life and exceptional gap-bridging performance, thin-walled PE linings provide a cost-effective sealing membrane that is totally reliable.

Rolldown

One of the first close-fit methods to be developed, was conceived and patented by the former Stewarts and Lloyds Plastics and is now operated by Subterra (subsidiary of Daniel Contractors Ltd). In this system pre-welded strings of PE pipe are reduced in diameter by approximately ten per cent - with very little extension by pushing them through rollers. The reduced diameter pipe string is then inserted, often as a separate operation, into the old pipeline and re-expanded by water pressure to take up a close fit.

Subline

Subline was also developed in conjunction with Subterra. This technique involves welded up strings of liner pipe ranging in diameter from 8” right up to 40”. They are deformed in the field into a “C” cross sectional shape by jacking them through a mechanical plough and trough. The C shape is retained by friction-welded plastic straps until these are intentionally snapped by internal water pressure after the Subline string has been winched into the old mains. The liner SDR is generally chosen to ensure that the reverted liner is pushed out into a tight fit against the host bore by the normal operational pressure of the mains.

Subline

Swagelining™/ Die Drawing

This works by pulling a pre-welded string through a reducing die and into the old pipeline in one operation. Re-expansion to a close-fit diameter occurs naturally within a few hours of the winching load being released.

Swagelining

Jointing

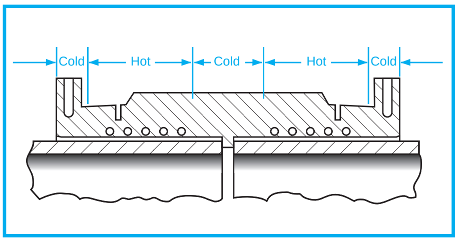
After installation by close-fit lining electrofusion jointing may be carried out, but first the polyethylene pipe requires expanding to the nearest standard pipe outside diameter and a stainless or coated steel insert (depending upon application) positioned inside the bore.
Alternatively, ‘stepped couplers’ may be adopted where available.

Principles of Electrofusion

Electrofusion fittings incorporate an electrical heating coil to which an Electrofusion Control Unit (ECU) supplies the electrical energy necessary to heat the coil. When the coil is energised the material adjacent to it melts and forms an expanding pool which comes into contact with the surface of the pipe. The continued introduction of heat energy causes the pipe surface also to melt and a mixing of pipe melt and fitting melt takes place; this is vital to produce a good weld. Following the termination of the heat cycle, the fitting and pipe are left to cool and the melted material solidifies to form a sound joint (see electrofusion sequence on page 32).

Preparation and assembly procedures are similar for all electrofusion systems. Some fittings require the fusion time to be entered into the ECU manually and are therefore described as manual. Some fittings incorporate auto-recognition aids and the ECUs are therefore described as automatic. The majority of fittings require a 39.5V supply but some larger couplers are designed to require a 79V supply.

Hot and cold zones sometimes called melt and freeze zones, are formed after energising the coil. The length of these zones is particularly important. Each zone ensures that fusion is controlled to a precise length of the socket of the fitting and that the melt pressure is also controlled throughout the entire jointing process. The precisely controlled pitch and positioning of the coil in relation to the inner surface of the socket ensures uniform heat distribution.



Electrofusion Control Units (ECUs)

Electrofusion Control Units are designed to operate from an electrical mains or field generator supply having an output of 110V and a rating of generally 3.5 to 7.5kVA for 39.5V fittings and 6 to 7kVA for 79V fittings.

ECUs can also be obtained combined with an integral generator. All ECUs manufactured after 1st January 1996 for sale into Europe should comply with the Electro-Magnetic Compatibility Directive and be CE marked.

Electrofusion fittings supplied by European manufacturers may have terminals which are 4.0mm in diameter and which are smaller than the 4.7mm diameter terminals on similar fittings manufactured in the UK. Adaptor pins are available from polyethylene pipe jointing equipment suppliers to ensure satisfactory connections are achieved.

Barcodes and ECUs

ECUs can be supplied with the ability to read a bar code when connected to an electrofusion fitting. The machines have a bar code reading device that the operator uses to scan the data contained within the bar code. Once the bar code data has been entered, the ECU will usually display a description of the fitting and its size, which should be checked by the operator before proceeding with the electrofusion process. The bar code system will automatically adjust the fusion time by small amounts to compensate for variations in ambient temperatures.

ECUs should contain data logging facilities to ensure traceability of welding parameters. An output socket allows this information to be downloaded onto a computer database or printer to obtain a complete record of the joints that have been made.

Electrofusion Control Unit

ECUs are now available, that can confirm the presence of clamping during the fusion cycle and provide photographic evidence and joint location data, based on satellite navigation systems technology. Additional control over joint quality can be achieved using ECUs that will lock out the unit in the event of any discrepancy in the jointing procedure. To reinstate the unit to full operation, it will be necessary to seek authorisation before the unit can be unblocked and jointing continued.

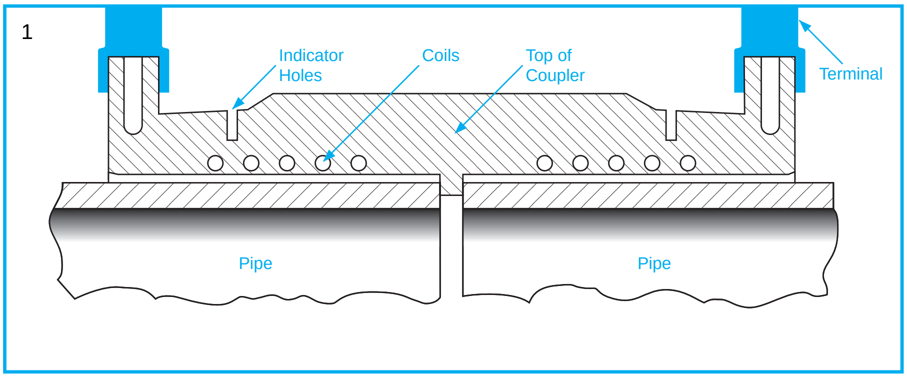
Multi Clamping Tool with Fitting Sensor

Traceability Barcodes

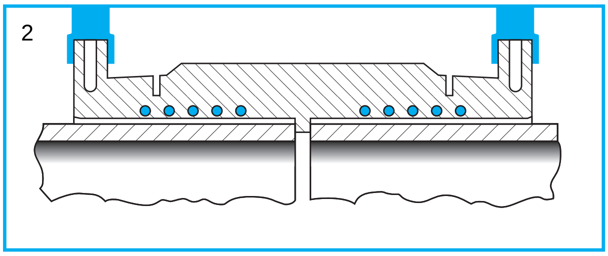
Most electrofusion fittings are fitted with traceability barcodes that can be read by any ECU with a traceability option. This barcode contains specific information regarding the manufacture of the product such as: the name of the fitting manufacturer, the type of fitting, the size of the fitting, the production batch number, the manufacturing location, the product SDR rating, the product raw material, the material status, the material MRS and the material melt flow index.

Electrofusion Sequence

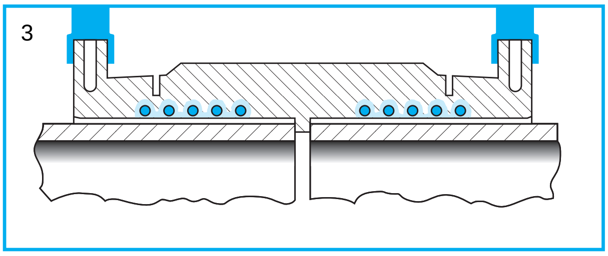
The sectional drawings show the jointing sequence from energising the coil until completion of fusion. The whole cycle is electronically monitored by the electrofusion control unit (ECU).



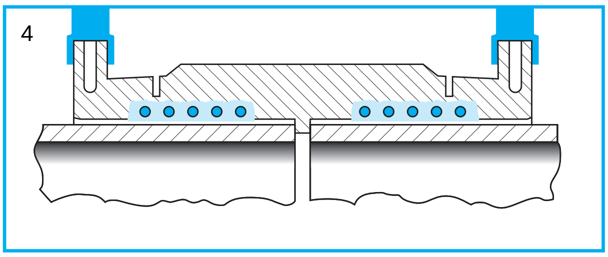
Pipe positioned in coupler prior to energising coil.



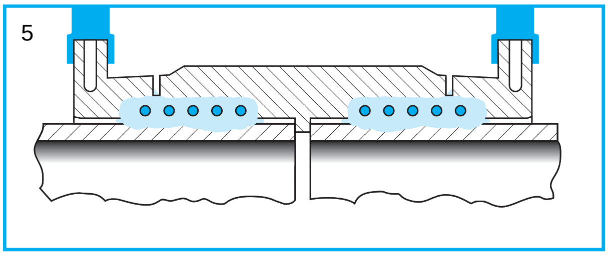
Coil energised.



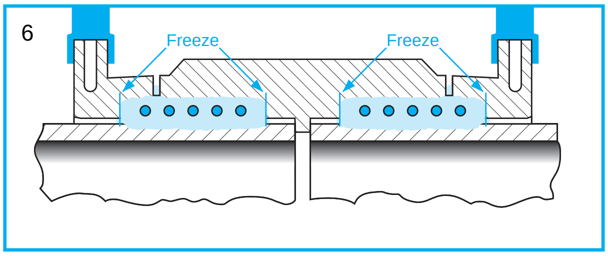
Material surrounding coils starts to melt.



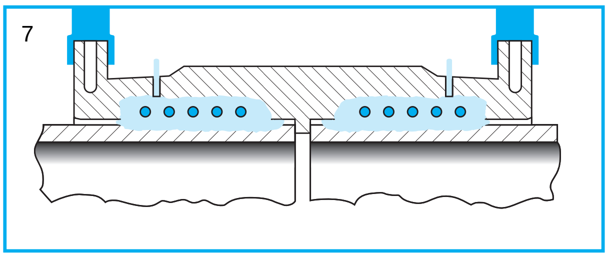
Area of melt extends leading to expansion towards pipe surface.



Heat transfers to pipe wall and pipe material starts to melt.



Melt solidifies at the start of the cold zones, thereby sealing the melt zone. Further input of energy causes increase in melt pressure.



Melt pressure reaches optimum value at end of energising cycle. Emergence of the melt at the indicator holes shows that fusion is complete.

Wet Wipes

It is preferred that electrofusion joints are made without the use of wet wipes. This is provided that the pipes are freshly scraped, the fitting has just been debagged and the assembly and fusion of the joint follows immediately (see Additional Notes).

If any deviation from the above occurs, which may result in contamination of either the scraped pipe or the debagged fitting then prescribed wet wipes shall be used, - (90% Iso-Propyl Alcohol 10% water mix). Separate fresh wet wipes shall be used for the scraped pipes and the debagged fitting if both are contaminated. The final application of the wipe should be done in axial direction. Whether wiping both scraped pipe or fitting or just one of them, wiped surfaces must be allowed to visibly dry (do not touch the wet surface), then the joint assembled and fused. Failure to allow the jointing surfaces to visually dry will increase the risk of voids at the weld interface.

Note: In butt-fusion jointing wet wipes are not used for cleaning pipes that have already been machined/trimmed.

The above was an agreed industry position between GPS PE Pipe Systems, Fusion Provida Ltd, Uponor Ltd and Bodycote.

Additional Notes

Wet wipes would not be required provided that:
- Pipe ends are cleaned to remove contamination caused by the installation process
- Pipe ends are mechanically scraped and inspected to ensure that they are free from contamination
- Pipe ends are inserted into the fitting immediately after scraping (within 1 minute)
- Fusion cycle is in accordance with WIS 4-32-08

When using wet wipes the following procedure should be adhered to:
- A pad of 4 - 5 wipes for each pipe or fitting to be joined should be used to create an effective barrier between the palm of the hand and pipe surface.
- Use pad to remove contamination and allow to evaporate completely from the pipe surface prior to insertion into the fitting
- The process should be repeated using 4 - 5 fresh wipes on each pipe/fitting end to be jointed.

Electrofusion Jointing of Coiled Pipe

Polyethylene pipe coils will tend to exhibit ovality, the extent of which is influenced by many things, but primarily the SDR of the pipe (up to 6% for SDR11 and 12% for SDR17). Recent investment by GPS has allowed us to reduce SDR17 ovality to less than 5%.

Consequently, pipe ends need to be re-rounded and aligned using suitable equipment prior to electrofusion jointing.

To electrofuse joint pipes up to and including 63mm, clamps must be used which align and restrain the pipe.

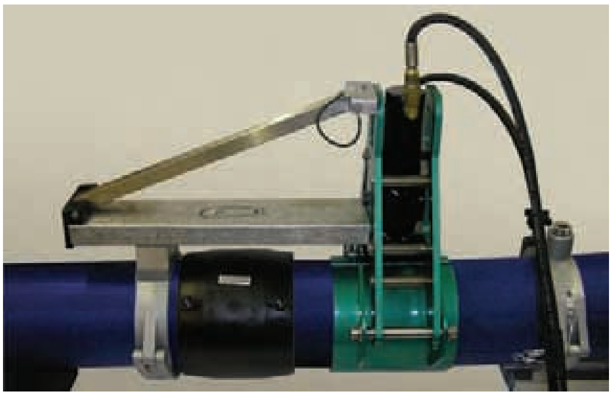
To electrofuse joint pipes greater than 63mm the equipment must have a re-rounding capability.

Re-rounding clamps are available, which consist of two half shells which are bolted together around the pipe in order to restore its circularity in preparation for jointing. These may be used in conjunction with suitable pipe inserts to maintain roundness during electrofusion jointing.

Pipe insert

Pipe jointing

When using insertion, mole ploughing or directional drilling techniques, a straight length of pipe may be butt-fusion jointed to the end of the coil to reduce the effects of curvature and ovality. More recently hydraulic re-rounding equipment has been developed to permit a straight length of pipe to be electrofusion jointed to the ends of the coil.



Hydraulic re-rounding equipment

Squeeze-off units may also be employed to introduce a hinge effect, however the need to re-round the pipe will still be necessary and care taken to adhere to industry requirements when using squeeze-off equipment.

Pipe straighteners, which are fitted to coil trailers, are available, which remove the curvature and ovality from the coiled pipe to facilitate main-laying and jointing.

Jointing Instructions for DuraFuse Electrofusion Fittings

The instructions that follow describe the procedures used to join DuraFuse electrofusion fittings to adjacent lengths of pipe and Long Spigot fittings. The procedures described must be read in conjunction with any Code of Practice affecting a particular industry, for example:

- National Gas Installation Codes and IGE/TD/3 Edition 4 (2003)
- WIS 4-32-08 Issue 3 April 2002
- WRc Polyethylene Pipe Systems For Water Supply.

Equipment

- Generator (110V for the UK and 220V for Europe). Generally 3.5kVA to 7.5kVA output for 39.5V fittings and 6 to 7kVA for 79V fittings.
- Electrofusion Control Unit (ECU).
- Clamping equipment.
- Pipe scraping preparation tool capable of removing 0.2 to 0.4mm from the outer surface of the pipe.
- Ancillary equipment such as marker pen, solvent wipes and lint free cloth/paper towel.
- Pipe cutter/saw.
- A shelter to protect the pipe, fittings and ancillary equipment against adverse weather conditions and contamination.
- Pipe end caps.

Temperature/Fusion Time Compensation

DuraFuse products are designed to work on a fixed fusion time for temperatures between -5ºC and +23ºC. Where the time is being entered manually then temperature compensation is not normally necessary within these parameters. The bar code system will automatically adjust the fusion time by small amounts to compensate for variations in ambient temperature.

Terminal Pin Sizes (DuraFuse)

DuraFuse electrofusion fittings adopt the UK standard for terminal pin sizes:

39.5 volt – 4.7mm
79 volt – 5.7mm

GPS PE PIPE SYSTEMS **Tel:** +44 (0)1480 52121 **Fax:** +44 (0)1480 458829 **Technical Support:** +44 (0)1480 442620

Power Supply Requirements

It is important to ensure that the fitting receives its optimum power requirements in order to effect a satisfactory electrofusion joint. To allow this to happen it is necessary, not only, to have available the correct specification electrofusion control box but also power supply/generator set. Ensure that the output of the power supply is adequate/appropriate for the job being undertaken.

The table shown below provides information as to the power supply/generator set power output requirements for each of the DuraFuse couplers, other manufacturers fittings may differ from this table.

In cases where a high current is required it may be necessary to have an adaptor available to allow connection from the 16 Amp plugs of the electrofusion control box to the 32 Amp socket of the generator set. These are normally available from your control box supplier.

If in any doubt, please seek advice before attempting to weld any fitting.

Fitting		Generator		
Dimension	Voltage	Socket (min) (Amps)	Socket (max) (Amps)	
20	39.5	2	2	16 Amp Generator Socket
25	39.5	4	4	16 Amp Generator Socket
32	39.5	4	4	16 Amp Generator Socket
40	39.5	6	7	16 Amp Generator Socket
50	39.5	7	8	16 Amp Generator Socket
63	39.5	7	9	16 Amp Generator Socket
75	39.5	7	9	16 Amp Generator Socket
90	39.5	11	13	16 Amp Generator Socket
110	39.5	12	14	16 Amp Generator Socket
125	39.5	15	17	16 Amp Generator Socket
140	39.5	14	16	16 Amp Generator Socket
160	39.5	20	23	32 Amp Generator Socket
180	39.5	18	21	32 Amp Generator Socket
200	39.5	23	26	32 Amp Generator Socket
225	39.5	26	29	32 Amp Generator Socket
250	39.5	26	30	32 Amp Generator Socket
280	39.5	26	30	32 Amp Generator Socket
315	39.5	26	29	32 Amp Generator Socket
355	39.5	28	32	32 Amp Generator Socket
400	39.5	26	31	32 Amp Generator Socket

Transition Fittings – Jointing Procedures

DuraFuse transition fittings, available from 25mm x $\frac{3}{4}$" to 63mm x 2" with both a male and female BSP taper, are made by fixing a short polyethylene spigot onto a machined DZR brass component. The brass component contains a knurled area, which prevents over-tightening and the spigot end is designed to be a light interference fit inside DuraFuse electrofusion fittings.

The transition fittings arrive unassembled in a kit allowing maximum flexibility. The spigot end of the transition fitting must be scraped prior to assembly with the DuraFuse electrofusion fitting, with normal electrofusion procedures being followed.

The brass component should be fully tightened, using a wrench, before the fusion cycle is started. PTFE tape should be used to seal the threads.

It is possible to make minor adjustments to the threaded component after fusion. Adjustment should be restricted to $\frac{1}{4}$ turn as excessive movement may damage component parts within the brass transition.

Recommended Torque Values for Transition Fitting Installation

Fitting	Recommended torque (Nm)
25 x $\frac{3}{4}$	50
32 x 1	60
40 x $1\frac{1}{4}$	80
50 x $1\frac{1}{2}$	90
63 x $1\frac{1}{2}$	90
63 x 2	105

Design

High integrity, consistently reproducible electrofusion joints will only be achieved if the following criteria are met:

- Heating coils are as close to the joint surfaces as possible.
- Wire position is accurately controlled during manufacture and during the subsequent fusion process.
- Heat distribution is uniform over the length of the hot zone.
- Melt pressure and temperature are both accurately controlled.
- Coils are protected from damage prior to, during and after fusion.

The design and unique manufacturing technique of the DuraFuse electrofusion system ensures positive compliance with all these criteria.

Procedure

1. Cut the pipe square and remove burrs.

2. Wipe loose dirt from pipe ends.

3. Without removing the protective wrap, place the centre of the electrofusion fitting alongside the pipe end and mark the pipe around the circumference, approximately 15mm beyond the extremity of the socket depth, using a suitable marker pen.

4. Using the pipe end preparation tool, remove the entire surface of the pipe over the marked area, preferably as a continuous ribbon or strip. Note: The use of mechanical end preparation tools is preferred as hand scraping requires great care and can be time-consuming especially on larger diameter pipes. It is essential that material is removed by scraping or peeling; scratching or abrading is not sufficient.

5. Remove the fitting from its packaging and check that the bore of the fitting is clean and dry.

6. For water applications, the scraped area of the pipes and fittings surface may be cleaned with Isopropanol wipes (see page 33).

   For gas applications, the peeled/scraped area of the pipe should not be wiped.

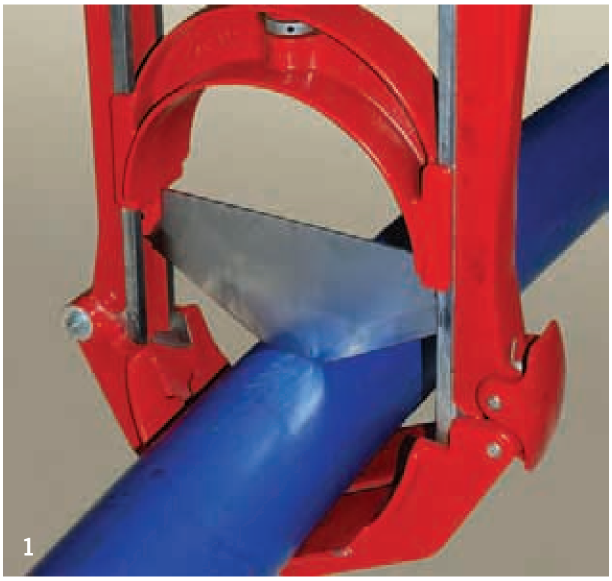
   Once wiped, peeled/scraped do not touch the cleaned ends of the pipe or the inside of the coupler with your hands or rags.

7. Insert the pipe ends into the fitting so that they are in contact with the centre stop. Mark the pipe around the circumference adjacent to the ends of the fitting.

8. For all socket electrofusion fittings (couplers, reducers, elbows and tees) clamps must be used. The clamps must be adjusted to suit the particular size and type of fitting being welded so the pipes cannot move during the fusion cycle. If possible, rotate the fitting to check that the pipe ends are correctly aligned.

9. Check that there is sufficient fuel in the generator to complete the joint. Start the generator and check for correct operation.

10. Connect the ECU output leads to the fitting terminals. It does not matter which lead is connected to each terminal. (The connections are not live and neutral). Refer to page 34 for terminal pin sizes.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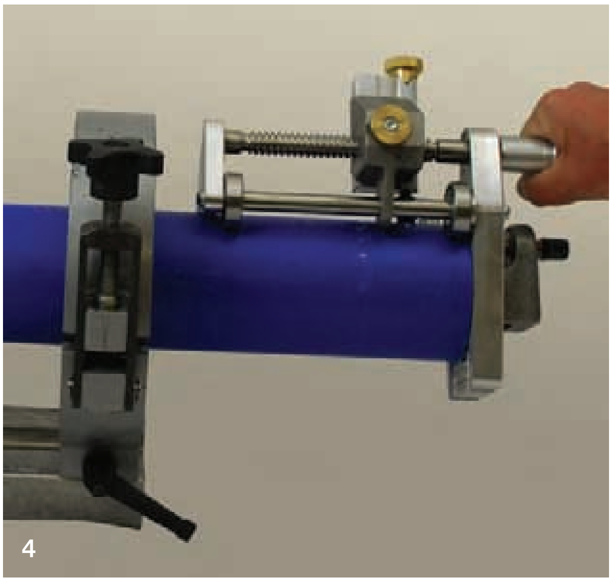
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GPS PE PIPE SYSTEMS **Tel:** +44 (0)1480 52121 **Fax:** +44 (0)1480 458829 **Technical Support:** +44 (0)1480 442620

11. Operate the ECU according to the instructions, which should have been thoroughly read and understood prior to any welding operations. The ECU will either have some form of automatic operating system or require manual operation. Whichever system the ECU uses, all DuraFuse fittings are marked with both fusion and cooling times plus the necessary input voltage.

12. During the fusion process, there will be some movement of the weld indicators. The level of movement is dependent on many factors including outside temperature, pipe diameter and ovality.

13. The joint must be left in the clamps for the cooling time specified on the fitting, although the terminal leads may be removed carefully without disturbing the joint.

If the fusion cycle terminates before completion of the count-down. Check that there is adequate fuel in the generator. Check for faults as indicated by the ECU display. If using a transformed supply, make sure that the supply lead to the ECU is not of excessive length.

NEVER extend the length of the leads from the ECU to the fitting.

Under no circumstances shall an attempt be made to carry out a second fusion cycle on any fitting. This is a WIS 4-32-08 Specification and shall be adhered to.

Do not pressurise the system until the joints have cooled to ambient temperature.

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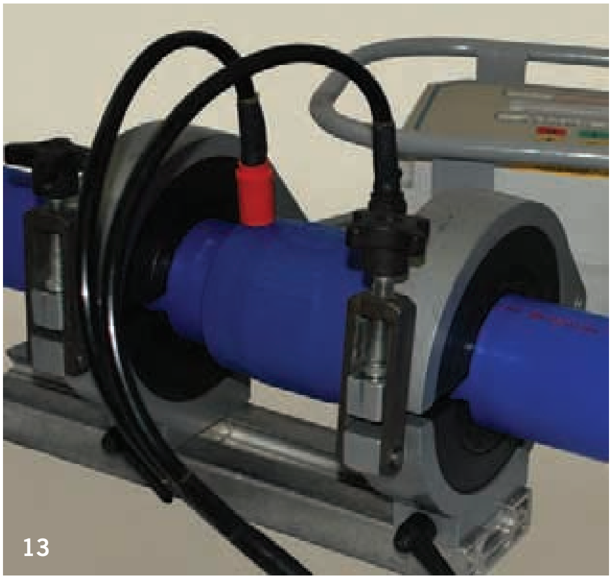
DuraFuse fittings are marked with both fusion and cooling times.



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Electrofusion Jointing Dos / Don'ts UTI 500mm

Pre Jointing Checks

- Use equipment that is clean, in good condition and regularly maintained.
- Mechanical pipe preparation tooling must be used wherever possible.
- Ensure that the cutters/blades of mechanical scrapers are clean and in good condition.
- Check that you have somewhere clean and dry to place tools and equipment during the electrofusion process, and enough access to the work area.

Dos

- DO WORK SAFELY
- Do understand the principals of electrofusion (refer to pipe manufacturers details if necessary).
- Do use a shelter and ground sheet, (a suitable anti-slip surface) in both dry and wet conditions to minimise contamination. Use end protection to pipes, (plugs or caps) to eliminate draughts.
- Do always use appropriate clamps for the true alignment, restraining and re-rounding of all pipes, both sticks and coils.
- Do ensure control box voltage is compatible with fitting.
- Do ensure pipe and fittings to be jointed are compatible with each other.
- Do cut pipe ends square for all electrofusion socket fittings.
- Do fully prepare pipe and/or spigot surfaces. (Secura-Line pipe ends need not be scraped prior to electrofusion if outer skin has been freshly peeled and the core pipe is pristine. Should the peeled pipe ends become contaminated then they should be prepared in the same way as standard PE pipe.)
- Do keep prepared pipe and/or spigot surfaces and fittings clean.
- Do assemble joint and fuse immediately following preparing the pipe.
- Do check that the fusion time displayed by the ECU (automatic or manual) matches the fusion time on the fitting. In the case of automatic recognition, if the time is different to that shown on the fitting, do not weld.
- Do ensure correct fusion and cooling times are observed and adhered to.
- Do always input the correct operator code and job code to allow for full traceability with Electrofusion Control Units with data retrieval facilities.
- Do mark finished joints with a joint number/data.
- Do ensure that the fusion indicators have risen, if there is no apparent movement of one or both of the indicators, the joint should be cut out and a new joint made (WIS 4-32-08).
- Do ensure that when jointing tapping tees the fitting is correctly positioned on the pipe before fusion. Following the required quality inspections and pressure testing of the welded saddle fitting, the pipe can then be tapped through.
- Do always enter your I.D. details should the ECU request it. Enter your operator and job code to allow full traceability.
- Do always ensure you mark/sign the completed joint with the number issued from the ECU, along with the date if given. This is imperative for full traceability.

Don'ts

- Do not start any electrofusion joint unless it can be completed without interruption.
- Under no circumstances shall an attempt be made to carry out a second fusion cycle on any fitting. This is a WIS 4-32-08 Specification and shall be adhered to.
- Do not use dirty or contaminated fittings.
- Do not use fittings from split or torn bags, all fittings should remain bagged until immediately prior to use.
- Do not ever touch prepared fusion/jointing surfaces.
- Do not allow prepared fusion/jointing surfaces to become wet or damp.
- Do not remove clamps from fitting until cooling time has elapsed.
- Do not remove integral cutter from the stack/saddle (contamination risk).

Health & Safety

GPS make every effort in the design and manufacture of their pipes and fittings to ensure safety whilst in use. The following precautions are however worth bearing in mind:

- Never allow hot polyethylene to come into contact with the skin. In such an event, cold water should be used to cool the affected area. Expert medical advice must be sought.
- **Under no circumstances should any attempt be made to remove any material that becomes stuck on the skin without medical supervision. This could result in a more serious injury.**
- Heavy pipes, fittings and equipment should not be handled without assistance or mechanical aid. The requirements of Manual Handling Operations Regulation 195 should be adhered to.
- GPS recommend the wearing of Personal Protective Equipment in compliance of statutory legislation such as gloves, safety glasses and safety boots whilst carrying out electrofusion joints.
- Care should be exercised by taking normal precautions when using electrical equipment on site, particularly in wet conditions. ECUs are not intrinsically safe and should not be taken into trenches.
- Normal precautions should be observed when handling electrical equipment and for safety reasons, all 110v portable generator sets should be 'Centre Tapped' for site use +55/0/-55 volts.

  Always remember that where joint records are automatically stored, these should be downloaded on a regular basis to allow full traceability and integrity of workmanship

Jointing Instructions For Frialen® Large Diameter Electrofusion Couplers

The installation of large diameter electrofusion fittings (400mm and above) is a specialist activity. To ensure full control over the quality of electrofusion jointing it is important that the following procedures are adhered to. Large diameter couplers must only be installed by contractors/operatives who have successfully achieved the standards required on the GPS training course. Successful candidates will possess a Frialen ECU operator control card and a completion certificate.

Friamat Electrofusion Control Units are supplied in the closed operating mode ensuring that they can only be activated by a trained operator's control card.

Training Certificate?
Have you got yours?
Telephone: 01480 442620

FRIALEN® 400, 450, 500, 560, 630 and 710mm Coupler Installation Procedure

For site representation or to arrange product installation training, please contact our Technical Support Department.

The fittings are 40 volt bi-filament and are bar code read with installation incorporating a pre-heat procedure requiring the Friamat ECU. FRIALEN® fittings have 4.0mm terminal pins.

Essential Equipment:

1) 7kVA Minimum petrol generator
2) FRIALEN® electrofusion control box
3) Mechanical pipe scraper FWSG630 (FWSG710 for 710mm)
4) Re-rounding clamps
5) Alcohol wipes
6) Packing tape
7) Hand scraper
8) Marker pen
9) Rubber/nylon hammer
10) Outside diameter tape

Additional Equipment:

1) Feeler gauge
2) 90° Set square

Equipment can be hired from Friatec's (GPS') approved hire centres:-

MCA - TEL: 01582 482 307

FRIALEN® Large Diameter Electrofusion Couplers Jointing Procedure

Electrofusion Coupler Electrical Check

1. Check that the coupler is OK by running the fusion cycle for 10-12 seconds. Before starting this process start the generator and leave to settle for approximately 1 minute. Ensure that the FRIALEN® ECU is switched OFF before connecting the power supply lead to the generator, then connect it to the generator and switch ON.
2. Before starting it will be necessary to first swipe your user card I.D. card and log on to the ECU. There are two barcode labels on each FRIALEN® fitting. There maybe two single barcode labels, one white and one yellow, or two white (see below), one with one barcode and one with two barcodes. Connect the leads of the ECU to one side of the coupler. Once connected swipe the WHITE bar code on the fitting and press START on the ECU. Where the fitting has two white barcode labels swipe the Fusion barcode on the “Double” barcode label (see diagram below) on the fitting. Once 10-12 seconds have elapsed press the Stop button. (This procedure checks the heating element).

Pre-Heat Barcode

Fusion Barcode

Traceability Barcode

Double Barcode Label

3. If the coupler cuts out during this 10-12 seconds, check the ECU for error messages and rectify accordingly after turning off and disconnecting the ECU from the generator. The most probable cause is a faulty generator or dirty connections/terminals. Should the coupler prove to be faulty then mark the coupler and return to supplier.

Preparing the pipe

1. Check the pipe for any abrasions or impact damage that may be detrimental to the performance of the coupler.
2. Ensure that the pipe end is cut square. It may be useful to use a set-square to be certain - the pipe should not be out of square. Use your outside diameter tape to measure the pipe dimension. The pipe diameter should be greater than the nominal (minimum) diameter specified. Knowing the outside diameter of the pipe will help you to assess how much of the pipe material needs to be scraped off from the outside diameter of the pipe.
3. The FRIALEN® Mechanical Scraper takes off approximately 0.25mm of the pipe surface per rotation. **Note: this equates to 0.5mm reduction of the pipe diameter.**
4. Once you have established how much material is required to be removed, you can now mark the pipe end for the couplers insertion depth.
5. Before scraping takes place, clean the surface of the pipe to remove as much grease, oil or surface dirt as possible.
6. Use your hand scraper to create a chamfer on the leading edge of the pipe and remove all swarf from the pipe. This will provide a smooth leading edge to assist with the installation of the coupler.
7. Mark the pipe end for the couplers insertion depth (½ coupler length plus 5mm). Use wavy lines to help identify the area that needs to be scraped. If the coupler is to be used for a repair, the whole length of the coupler should be scraped.
8. Check that the scraper blade is in good condition. Worn blades must be replaced. Scrape the surface of the pipe to remove any dirt and the oxidised layer the required number of times, but before the final scrape, try the coupler on the pipe and check the fit and establish any “pinch points”.
9. Scrape off any remaining line markings using hand scraper (grooves and scratches should not be present on the area to be fused) and then use the alcohol wipes to clean the outside surface of the pipe. Use separate wipes to clean the inside of the coupler. All traces of the cleaner should be allowed to **evaporate completely** prior to the fusion process continuing.
10. **Do not touch the cleaned ends of the pipe or the inside of the coupler with your hands or rags.**
11. Protect the end against the ingress of dirt, dust or water.

Final Preparation

1. We have now completed the final preparation before starting the fusion process. Fusion should be conducted immediately after scraping.

2. Measure ½ a coupler length on the end of each of the pipe ends to be joined and mark this onto the pipe using a marker pen. Set the hydraulic re-rounding clamp to the pipe behind the mark.

3. Place coupler onto the end of the pipe and establish where pipe ovality may interfere with placing the coupler onto the pipe. It may be necessary to mark the pipe end and hand scrape the affected area.

4. Deburr both the inner and outer end edges of the pipe using the hand scraper before proceeding. You are now ready to install the coupler onto the pipe. Frialen couplers are designed to be an interference fit and it may be necessary to tap the coupler with care onto the pipe using a nylon or rubber mallet. Care must be taken not to allow the coupler to 'tilt' on the pipe during this final phase. Knock the coupler on using the rerounding clamp as a stop.

5. Control localised gaps by using packing tape to close the annular gap between the pipe and coupler. This will help keep any warmth inside the coupler, thus aiding the preheat process to close any gaps caused by ovality or pipe tolerances.

6. **Before starting the fusion process ensure, that both the pipe and the coupler are adequately supported to stop any 'sagging' during the fusion process and avoid any tension on the coupler.**

Please Note: Additional Points to Remember

1. Handle couplers and fittings with care. Do not drop or throw.
2. Always store in a clean dry place. Never outside.
3. All fittings must be pre-heated prior to the main electrofusion weld. Take care to adhere to the minimum and maximum times between pre-heat and final electrofusion.
4. Always ensure that the generator has sufficient fuel and does not run out during fusion as this could lead to a failed joint.
5. The weld indicators do not always fully protrude from the fitting; this does not indicate a weld failure.

Electrofusion Process

1. Now connect up the Frialen ECU as previously described. Connect the terminal leads to the coupler and swipe the yellow bar code this initiates the preheat cycle of the coupler. Confirm the details on the Frialen ECU display and press Start button. Once completed allow the electrofused side to warm (heat soak) for a minimum of 15 minutes and a maximum of 20 minutes, this will allow the pipe enough time to expand inside the coupler. It may be necessary to preheat more than once. Up to a maximum of three times is permissible (depending on wall thickness/SDR).

2. Each preheat cycle should bridge a gap of approximately 1mm between the pipe and coupler.

3. Check that all adequate precautions to reduce any gaps to acceptable limits have been taken. The maximum air gap between the pipe and the electrofusion fitting should be no more than 2mm. Particular care should be taken if a feeler gauge is used as these can be a source of contamination to the previously cleaned surfaces and can damage the wires of the electrofusion fitting.

   You can now proceed with fusion process. To begin fusion, return to the first side and reconnect leads to the terminal and swipe the white bar code. Confirm the details on ECU display and press the green Start button.

4. Repeat steps 1 to 3 for the other side. Precaution **must** be made to prevent any movement bending or pulling on the coupler to avoid tension on the joint during the fusion cycle.

5. It is also important **not to disturb the joint during its fusion or cooling period.**

   Frialen fittings are equipped with a swell indicator on each side, adjacent to the terminals. The swell indicator signalises the fusion process by changing its colour to red and increasing its volume.

6. Pipes and fittings may be joined between -10ºC and +45ºC for sizes up to and including 630mm and between 0ºC and +45ºC - for sizes 710mm and above.

7. To ensure the correct sequence of operation during jointing, note the completed stages on the pipe surface.

Datalogging/Fusion Completion

1 Download joint data from the electrofusion control unit for trace ability.

2 Swipe I.D card - log off.

The DuraFuse system includes a range of stack loading/ top loading tapping tees and branching saddles designed to fit pipes with outside diameters up to 315mm (see the Friatec section for larger sizes).

Stack/Top Loading Tapping Tees & Saddles

These fittings are designed for use with either the strap type, or the pedestal type stack loading tools. Both tools perform the same function of clamping the saddle to the pipe with a predetermined force.

Tapping tees can be electrofusion welded to a live main, the specially designed cutter being used to make a hole in the pipe once the service connection has been made.

Strap Type Stack Loading Tool

The procedures described within this section must be read in conjunction with any Code of Practice affecting a particular industry for example:

National Gas Industries Codes of Practice
IGE/TD/3 Edition 4 2003
WIS 4-32-08 Issue 3 April 2002
WRc Polyethylene Pipe Sytems For Water Supply

Tapping Tees - Installation Procedure Using the Strap Type Stack Loading Tool

1. Place the fitting still in its packaging on the mains pipe in the position it should be welded. Mark the outline of the unit on the pipe using a suitable marker pen.
2. Remove the fitting and place somewhere clean and dry. Thoroughly scrape the pipe within the marked area to completely remove the surface layer.

Mechanical Scraper Tools are available to facilitate pipe preparation for Top Loading Tees and Branching Saddle connections.

3. Rotate the handwheel of the top loading tool anti-clockwise until the stop is reached.
4. Remove the fitting from its packaging and the threaded cap from the top of the tee and check that the cutter head is flush with or slightly proud of the threaded stack.
5. Place the fitting on top of the prepared area on the main pipe.
6. Press the nose of the loading tool into the aperture in the top of the tapping tee cutter and push fully home.
7. Holding the loading tool and the tee in position with one hand, push the straps under the main pipe and up through the slots in the tool. Ensure that the straps are not twisted or kinked. Clamp the straps in place using the lever locks. It is not necessary, at this stage, to pre-tension the straps to a taut condition.
8. Still holding the tool and tee with the one hand, rotate the handwheel of the loading tool in a clockwise direction until the central indicator is flush with the top face of the handwheel.

The clamping assembly is now at the required loading pressure for fusion to commence, however ensure that the saddle base fits squarely on the pipe, particularly in the case of range fittings.

Tapping Tees - Installation Procedure Using a Pedestal Type Stack Loading Tool

1. Place the fitting still in its packaging on the mains pipe in the position in which it is to be welded. Mark the outline of the cardboard protector on the pipe using a suitable marker pen.
2. Remove the fitting and place somewhere clean and dry. Thoroughly scrape the pipe within the marked area to completely remove the surface layer.
3. Rotate the handwheel of the top loading tool anti-clockwise until the stop is reached.
4. Remove the fitting from its packaging and the threaded cap from the top of the tee and check that the cutter head is flush or slightly proud of the threaded stack.
5. Press the nose of the top loading tool into the cutter head.
6. Place the base plate underneath the pipe and lower the tapping tee onto the scraped pipe surface.
7. Rotate the handwheel in a clockwise direction until the indicator is flush with the top face of the handle or spring carrier.

The clamping assembly is now at the required loading pressure for fusion to commence, however ensure that the saddle base fits squarely on the pipe, particularly in the case of range fittings

Electrofusion Procedure

1. Connect the electrofusion control unit (ECU) leads to the tapping tee and key in the correct fusion time, as shown on the fitting.
2. Check the loading pressure is correct by ensuring that the central indicator is still flush with the top face of the spring carrier.
3. Press the fusion start button.
4. On completion of the cycle remove the leads and allow the joint to cool for the required time, as shown on the fitting, before removing the tool.
5. **Replace the threaded cap ensuring that the 'O' ring seal is in position.**

Service Connections - Tapping Tee to Service Pipe

The service connections between the tapping tee and the service pipes are made using either service couplers or service reducers in conjunction with a suitable alignment clamp.

The procedure for making a service connection is as described for the electrofusion couplers.

Any hydrostatic pressure tests should be carried out on the service pipe before the hole is cut through the wall of the mains pipe using the integral cutter.

Pedestal Type Stack Loading Tool

Service Connections - Tapping into a Water Main

Tapping into the water main should not be carried out until at least 30 minutes have elapsed following the end of the cooling cycle. After this time period the tapping procedure is as follows:

1. Insert the tapping key into the recess in the top of the metal cutter and turn in a clockwise direction. Continue until the pipe wall is completely cut through (indicated by a reduction in the force necessary to turn the key).
2. Retract the cutter by turning the key in an anti-clockwise direction until the top of the cutter is flush with the top of the threaded stack, showing that the cutter is clear of the branch.

The coupon of material cut from the pipe wall will be retained in the end of the cutter.

- Check that the 'O' ring seal is in place in the cap and screw it down hand tight onto the threaded stack of the tee.

Note: Thread Followers - The torque may be high when cutting through the wall of large diameter pipes. Thread followers are available to enable the load to be spread over a greater number of threads, minimising the risk of stripping the moulded threads inside the stack of the tapping tee.

Jointing Procedures for DuraFuse Top Loading Branching Saddles

The procedure for branching saddles is very similar to that previously outlined except that a hole cutter will be required to cut a hole in the pipe wall after fusing on the saddle. It is also necessary to use an adaptor plate to replace the 'nose' of the stack loading tools in order to clamp the fitting onto the pipe surface during the fusion cycle.

Under pressure connections can be made through a gate valve fitted to a flange adaptor on the saddle branch.

Jointing Procedure for DuraFuse and Inno 3 Under Clamp Tapping Tees

DuraFuse under clamp tapping tees are supplied complete with 2 types of under clamps as shown below.

DuraFuse tapping tees can be electrofusion welded to a live main, the specially designed cutter being used to make the hole in the pipe once the service has been connected and tested.

Type A Under Clamp Tapping Tee

Type B Under Clamp Tapping Tee

Inno 3 Under Clamp Tapping Tee

Installation Procedure for Type A Under Clamp Tapping Tees

1. Place the fitting still in its packaging on the mains pipe in the position in which it is to be welded. Mark the outline of the fitting on to the pipe using a suitable marker pen.
2. Remove the fitting and place somewhere clean and dry. **Thoroughly** scrape the marked area to completely remove the surface layer.
3. Place the fitting back on top of the prepared area of the main pipe. Fit the under clamp piece in to place under the fitting body and push into place whilst holding the fitting from the top. The under clamp piece should be fully pushed on to the fitting wings. A mallet should be used to carefully tap the under clamp piece in to place if it cannot be fully pushed by hand.
4. The tapping tee is now at the required pressure for electrofusion to commence.

Installation Procedure for Type B Under Clamp Tapping Tees

1. Place the fitting still in its packaging on the mains pipe in the position in which it is to be welded. Mark the outline of the fitting on to the pipe using a suitable marker pen
2. Remove the fitting and place somewhere clean and dry. **Thoroughly** scrape the marked area to completely remove the surface layer.
3. Place the fitting back on top of the prepared area of the main pipe.
4. Place the fitting without screws, onto one of the tapping tee wings. The strap piece will only fit in one particular orientation to ensure the correct loading is applied.
5. Thread the strap under the pipe and place the strap under clamp piece, with screws, onto the tapping tee wing at the other side of the tapping tee. Whilst holding the tapping tee in position screw the screws up until they are fully tightened and the 2 bars of the strap under clamp piece are pulled together.
6. The tapping tee is now at the required pressure for electrofusion to commence.

Installation Procedure for Inno-3 Under Clamp Tapping Tees

The procedure for Inno 3 Under Clamp Tapping Tees is very similar to the installation procedure outlined above, except that straps locating pins and screws will need to be slotted into the tapping tee lugs on the fitting before screwing the screws up until they are fully tightened and the bar of the strap is in contact with the tapping tee lugs.

Electrofusion Procedure

1. Connect the electrofusion control unit (ECU) leads to the tapping tee. Start the generator and key the correct fusion time into the ECU. The fusion time is moulded onto the fitting.
2. Press the fusion start button
3. On completion remove the ECU leads and allow the fitting to cool for the stated time. The cooling time is moulded onto the fitting.
4. The under clamp pieces can be either left in place or removed.

See page 43 for instructions on tapping into a main or service pipe.

Installation Procedure for Using Under Clamp Branch Saddles

Under clamp branch saddles incorporate a bore restriction in the saddle base to allow for the correct internal cold zone for the fusion cycle. Following electrofusion jointing, which is performed in the same way as for the under clamp tapping tees, drill sizes during the cutting operation should be restricted to the hole diameters shown below for the various branch sizes.

Branch Saddle Outlet Diameter (mm)	20	25	32	40	50	63	63 x 63
Maximum Drill Size (mm)	13	18	23	29	36	46	42

Assembly and Operating Instructions for Friatop Top Loading Clamping Unit when used on Frialen Multi Branch Saddles (250 - 630mm)

Frialen Multi Branch Saddles are not suitable for use with pipes with wall thicknesses less than 19mm.

Assembling the FRIATOP Clamping Unit on 250 - 560mm pipe

1. The adaptor is fitted into the clamping unit before this is tensioned and forms the connection with the FRIALEN® component. It has various steps, depending on the type of saddle fitting being fused on. If a FRIALEN® SPA-TL is being fused on, the screw cap of the fitting is located directly into the unit without the adaptor. The same applies to the VSC-TL.
2. The preparation of the area being fused is carried out in a similar manner to the descriptions given in the assembly instructions for FRIALEN® safety fittings.
3. Place the saddle component onto the pipe.
4. Fit the adaptor and the clamping unit onto the saddle component. The different steps in the adaptor fit the various types of saddle component. Lay the tensioning belt around the pipe (do not twist it!)
5. Thread the loose end of the tensioning belt into the rollers on the twist grip. Pull the belt taut by turning the twist grip clockwise.
6. Check that the clamping unit is in the untensioned state (no air pressure at the valve) and then connect the air pump to the valve. In the unpressurised state the tensioning figures (1 or 2) are visible in the window on the rim of the housing.
7. If necessary make a final correction to the seating of the saddle on the pipe.
8. Pump up the clamping unit. (The pressure gauge on the pump should indicate between 3 and 4bar). The expansion of the cylinder will press the saddle onto the pipe. The gap between the pipe and the saddle must be completely closed by the pressure applied. **A visual check must be made by the user!**

9. In the pressurised state the tension number is read off in the window next to the handle and marked for safety on the piece of pipe. This will give a check on any fall off in pressure during fusion. If this drop in pressure is no greater than one scale graduation then the fusion has been carried out in accordance with the standard. If the pressure drop is greater than this the fusion process must be broken off and the reason investigated. Afterwards, and when the proper cooling time has elapsed, a second fusion can be carried out.

Assembling the FRIATOP Clamping Unit for SA-TL on 630mm Pipe

1. The adaptor is fitted into the clamping unit before this is tensioned and forms the connection with the FRIALEN® component. The required steps vary, depending on the type of saddle fitting to be fused. If a FRIALEN® SPA-TL is being fused, the screw cap of the fitting is located directly into the unit without the adaptor. The same applies to the VSC-TL.
2. The preparation of the area being fused is carried out in a similar manner to the description given in the assembly instructions for FRIALEN® Safety fittings.
3. Place the saddle component onto the pipe.
4. The different steps in the adaptor fit the various types of saddle component. Lay the tensioning belt around the pipe (do not twist it).
5. Thread the loose end of the tensioning ring belt into the rollers on the twist grip. Remove the slack in the belt by turning the twist grip clockwise.
6. Check that the clamping unit is in the untensioned state (no air pressure at the valve) and then connect the air pump to the valve. In the unpressurised state, the tensioning figures (1 or 2) are visible in the window on the rim of the housing.
7. If necessary make a final correction to the seating of the saddle on the pipe.
8. **Check that fitting is loaded fully square to the pipe, failure to do so will mean the fitting will not fully load at one side on the spigot. If excessive movement is experienced it is acceptable to pack around the spigot top between the fitting and the top loading tool with a packing collar made from metal or plastic.**

9. Pump up the clamping unit slowly. Once the unit pressure gauge shows 1Bar. Stop the pumping for a minimum of 40 seconds. Again pump the clamping unit until the pressure gauge shows 2Bar. Stop the pumping for a minimum of 40 seconds.

10. Ventilate the system. The indicator on the clamping unit should fall between 1 and 2. Pull the belt again and turn the twist clockwise (see 5). Pump up as described in steps 6 to 9.

    The pressure should stay constant and the gap between the saddle and the pipe should be completely closed. The maximum allowable gap between pipe and fitting should be no more than 0.5mm (this can be checked with a feeler gauge). If this is not the case, the final part of the procedure (8) should be repeated. **A visual check must be made by a user!**

11. In the pressured state the tension number is read off in the window next to the handle and marked for safety on the piece of pipe. This will give a check on any fall off in pressure during fusion. If this drop in pressure is no greater than one scale graduation, then the fusion has been carried out in accordance with the standard. If the pressure drop is greater than this, the fusion process must be stopped and the reason investigated. Afterwards, and when the proper cooling time has elapsed, second fusion can be carried out.

Fusion

Connect the fusion cable from the fusion unit to the contacts on the saddle and start the fusion process.

During the fusion process the tension number should be checked.

For general safety reasons always stay at a distance of one metre from the point of fusion during the fusion process.

Removing the FRIATOP Clamping Unit

After fusion has finished, always maintain the joint pressure in accordance with point 9 on page 45 for a 10 minute cooling period. After this, the pressure can be taken off by venting the unit to air and the unit dismantled.

Before drilling, please allow to cool down for 60min (for sizes 250mm to 630mm). If the cooling down time is not adhered to, the saddle can come away from the pipe in the area of the fused joint, therefore a permanently safe fused joint cannot be guaranteed.

Warranty

The warranty is six months. It will not apply if there are signs of force or inappropriate usage, you must keep in accordance with the operating instructions.

Functional Safety

The FRIATOP clamping unit has been checked for safe operation before being shipped. The equipment requires very little maintenance. We recommend a half yearly check on all functional parts. The unit should be protected from dirt.

Assembly and Operating Instructions for Friatop Top Loading Clamping Unit when used on Frialen Tapping Tees (250 - 315mm)

FRIALEN® Saddle Components are used with pipes from SDR17 to SDR11 from 250mm diameter. They are held in place during fusion by the FRIATOP clamping device.

FL615339 Pressure Tapping Fitting - Top Loading 250mm - 315mm diameter suitable for using as branch connectors onto non-pressurised or pressurised pipelines.

Frialen Top Loading Tapping Tee

For technical reasons FRIALEN® Pressure Tapping Fittings cannot be used with SDR7 pipes.

1. Mark out the area of the fusion zone on the pipe (and the side outlet spigot) and remove the oxide skin by scraping. The fusion zone is the area of pipe covered by the saddle; for a side outlet, it is the insertion depth on the smooth pipe spigot. The oxide skin in the area of the fusion zone, which has formed on the surface of the pipes during storage, must be totally removed before assembly.

   If the oxide skin is not completely removed this can lead to an unsatisfactory fused joint which may leak.

   A single unbroken removal of the surface is adequate (min. 0.15mm). There should not be any pipe surface damage such as grooves or scratches within the fusion zone.

Filing or using an emery cloth is not acceptable as this can lead to impurities being embedded in the surface. As a check that the removal of material from the surface is unbroken and covers the full area, we recommend the use of marked lines to check. If during the scraping process areas of the surface are not scraped (e.g. if the pipe is oval) these must be reworked. Protect the cleaned up zone from dirt, soap, grease, water running back and unfavourable weather (e.g. from effects of moisture, the formation of frost).

2. The surfaces of the pipe being fused and the internal surfaces of the fittings must be absolutely clean, dry and free from grease. Immediately before assembly, and after scraping, clean these surfaces with a suitable cleaning fluid, using only absorbent non-fibrous, non-coloured paper. We recommend the use of special PE cleaning fluid.

   When using alcohol based cleaners the alcohol content must be a minimum of 99.8%. The cleaner must have evaporated completely before using.

   Now, using a marker pen, redraw the line to show the perimeter of the fusion zone on the pipe since previous markings will have been removed by scraping and cleaning. Take care to ensure that the fusion zone remains clean whilst doing this.

   The areas to be fused must be clean and dry prior to the fitting being mounted. Avoid touching the cleaned fusion area. Any moisture caused by dew or condensation in the area to be fused must be removed using appropriate means.

3. To assemble the joint, place the saddle onto the prepared surface of the pipe. Fit the clamping device as directed in the operating instructions for Friatop.

   Do not take the fitting to be fused from its packaging until just before processing. The packaging protects the component from external damage during transport and storage.

   On FRIALEN® Pressure Tapping Fittings the drill setting made at the factory must not be altered before fusing.

   After the fusion process has finished always maintain the jointing pressure for a 10 minute cooling period.

4. When using FRIALEN® Pressure Tapping Fittings onto pipes carrying a fluid or gas the following maximum permissible operating pressures must not be exceeded during the fusion process and until cooling down is complete.

Maximum permissible working pressure in bar

Pipe Material SDR	PE80 17.6/17	 11	Excel® (PE100) 17	 11
Gas pipe	1	4	4	10
Water pipe	8	12.5	10	16

Only use ECUs which are designed and authorised by their manufacturer to process FRIALEN® Safety Fittings. The fusion parameters are contained in a bar code which is affixed to the FRIALEN® Safety Fitting. The parameters are entered into the ECU using the reader wand.

The ECU automatically monitors the progress of the fusion process and regulates the electrical energy input to within specified limits.

The fitting fusion indicator only gives an indication that fusion has taken place. The proper progress of the fusion process, however, is only shown by the ECU.

For the sake of general safety always maintain a distance of one metre from the fusion point during the fusion process.

5. The cooling time (CT) given on the components are the cooling times before drilling can commence.

Diameter in mm	Cooling down time for FRIALEN® Multi Saddle components before pressurising through the outlet	Before drilling (CT)
250-500	50 mins	60 mins

If the waiting times are not complied with, there is a risk of an unsatisfactory fused joint which may leak. Before drilling, the general installation guidelines must be observed.

Frialen Under Clamp Branch and Spigot Saddles

Preparation and fusion procedures are the same as for Frialen Tapping Tees. Tapping is done with commercially available tapping units, incorporating shut-off valves. Please contact our Technical Support Department for further information.

Butt-Fusion Jointing Procedures

General

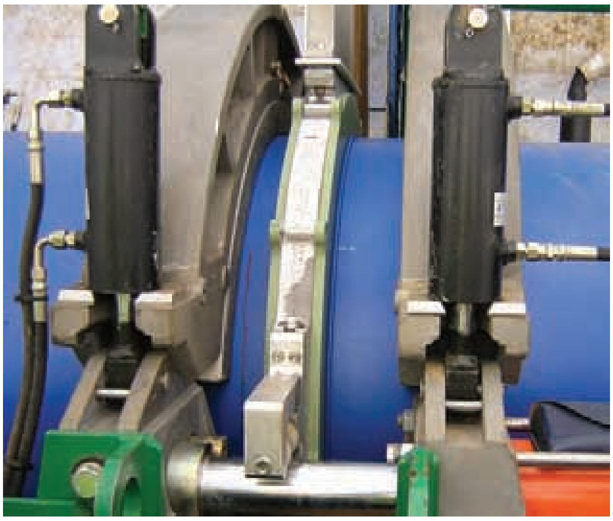
Butt-Fusion is a jointing method which allows on-site jointing of pipes 90mm and above. It is a thermofusion process which involves the simultaneous heating of the ends of two components which are to be joined, until a melt state is attained at each contact surface. The two surfaces are then brought together under controlled pressure for a specific fusion/cooling time and homogeneous fusion takes place.

The resultant joint is fully resistant to end thrust and has identical performance under pressure to the pipe.

This method of jointing requires an electrically heated plate to raise the temperature of the pipe ends to the required fusion temperature. It is used for both PE80 and PE100 grades of material for pipes of size 90mm and above of the same Standard Dimension Ratio (SDR).

Automatic butt-fusion machines are to be preferred, however particularly when jointing the larger pipe sizes, semi-automatic machines with full data retrieval may be considered.

Note: The Site Fusion Jointing Specification WIS 4-32-08 Issue 3, April 2002 emphasises the importance for the butt-fusion machine to be able to control properly the reduced secondary ram pressures that are now required for 'dual pressure' butt-fusion jointing.



For SDR11 pipes of sizes 250mm, 280mm and 315mm and for all pipe (SDRs 11, 17, 17.6, 26) of size 355mm and above, i.e. all pipes with a wall thickness greater than approximately 20mm, the butt-fusion pressures should be reduced to $^1/_6$ of its initial value after 10 seconds and therefore fully automatic butt-fusion machines are preferred as these will give greater control over the fusion parameters.

- Traditionally for manual machines a data plate, coloured blue for water and yellow for gas have been permanently attached to the machine indicating the necessary fusion parameters.
- Automatic machines have the jointing data programmed with respect to the pipe material and pressure rating to be jointed.

For gas applications, the UK Gas Industry recommends to use only fully automated butt-fusion equipment. See the tables on page 50 for butt-fusion jointing parameters for water applications.

Peelable gas pipes (Secura-Line) can be joined using a standard butt-fusion machine. There is no requirement to remove the skin in order to clamp the pipe in the machine. A pipe exposure tool should be used to remove a circumferential strip a minimum length of 25mm from the pipe end.

When jointing water pipes using butt-fusion techniques, the heater plate temperatures are the same for both PE80 and PE100 - 225ºC to 240ºC (average in the case of low ambient temperatures) as given in WIS 4-32-08 Issue 3, April 2002.

A UK Water Industry guidance note, published by Bodycote in February 2003, allows an extra one minute soak time for PE100 pipe sizes above 500mm SDR11. This is designed to ensure that fully ductile welds are always obtained under all field conditions to comply with stringent UK requirements in this respect.

Butt-Fusion Jointing Parameters for Water (WIS 4-32-08 issue 3 April 2002)
Heater Plate Surface Temperature: 225°C to 240°C.

Table 1 Single pressure butt-fusion jointing conditions for PE80 and Excel® (PE100)

Outside diameter	SDR	Wall thickness (minimum)	Bead up interface stress	Initial bead size (approx)	Soak time	Min soak interface stress	Max plate removal time	Fusion and cooling interface stress	Cooling time in clamps	Cooling time out of clamps	Cooling time for coiled pipe in clamps	Typical final overall bead width min	max
mm		mm	MPa	mm	seconds	MPa	seconds	MPa	minutes	minutes	minutes	mm	mm
90	26	3.5	0.15	2	95	0	10	0.15	10	5	15	8	15
90	17.6	5.1	0.15	2	110	0	10	0.15	10	5	15	8	15
90	11	8.2	0.15	2	140	0	10	0.15	10	5	15	9	16
110	26	4.2	0.15	2	100	0	10	0.15	10	5	15	8	15
110	17.6	6.3	0.15	2	125	0	10	0.15	10	5	15	9	16
110	11	10.0	0.15	2	160	0	10	0.15	10	5	15	10	17
125	26	4.8	0.15	2	110	0	10	0.15	10	5	15	8	15
125	17.6	7.1	0.15	2	130	0	10	0.15	10	5	15	9	16
125	11	11.4	0.15	2	175	0	10	0.15	10	5	15	10	17
160	26	6.2	0.15	2	120	0	10	0.15	10	5	15	9	16
160	17.6	9.1	0.15	2	150	0	10	0.15	10	5	15	9	16
160	11	14.6	0.15	2	205	0	10	0.15	10	5	15	11	18
180	26	6.9	0.15	2	130	0	10	0.15	10	5	15	9	16
180	17.6	10.2	0.15	2	160	0	10	0.15	10	5	15	10	17
180	11	16.4	0.15	2	225	0	10	0.15	10	5	15	11	18
225	26	8.6	0.15	2	145	0	10	0.15	10	5	–	9	16
225	17.6	12.8	0.15	2	190	0	10	0.15	10	5	–	10	17
225	11	20.5	0.15	2	265	0	10	0.15	10	5	–	12	19
250	26	9.6	0.15	2	155	0	10	0.15	10	5	–	9	16
250	17.6	14.2	0.15	2	200	0	10	0.15	10	5	–	10	17
280	26	10.7	0.15	3	170	0	10	0.15	10	5	–	13	22
280	17.6	15.9	0.15	3	220	0	10	0.15	10	5	–	14	23
315	26	12.1	0.15	3	180	0	10	0.15	10	5	–	13	22
315	17.6	17.9	0.15	3	240	0	10	0.15	10	5	–	14	23
	Tolerance		±0.02		±3			±0.02					

Table 2 Dual pressure butt-fusion jointing conditions for PE80 and Excel® (PE100)

Outside diameter	SDR	Wall thickness (minimum)	Bead up interface stress	Initial bead size (approx)	Soak time	Min soak interface stress	Max plate removal time	Fusion interface stress (1st 10 secs)	Cooling interface stress (after 10 secs)	Cooling time in clamps	Cooling time out of clamps	Typical final overall bead width min	max
mm		mm	MPa	mm	seconds	MPa	seconds	MPa	MPa	minutes	minutes	mm	mm
250	11	22.7	0.15	2	285	0	10	0.15	0.025	15	7.5	15	24
280	11	25.4	0.15	3	315	0	10	0.15	0.025	15	7.5	16	25
315	11	28.6	0.15	3	345	0	10	0.15	0.025	15	7.5	17	26
355	26	13.6	0.15	3	195	0	10	0.15	0.025	10	5	13	22
355	17.6	20.1	0.15	3	260	0	10	0.15	0.025	15	7.5	15	24
355	11	32.3	0.15	3	385	0	10	0.15	0.025	15	7.5	18	27
400	26	15.3	0.15	3	215	0	10	0.15	0.025	10	5	14	23
400	17.6	22.7	0.15	3	285	0	10	0.15	0.025	15	7.5	15	24
400	11	36.4	0.15	3	425	0	10	0.15	0.025	20	10	18	27
450	26	17.2	0.15	3	235	0	10	0.15	0.025	10	5	14	23
450	17.6	25.6	0.15	3	315	0	10	0.15	0.025	15	7.5	16	25
450	11	41.0	0.15	3	470	0	10	0.15	0.025	20	10	19	28
500	26	19.1	0.15	3	250	0	10	0.15	0.025	10	5	15	24
500	17.6	28.3	0.15	3	345	0	10	0.15	0.025	15	7.5	16	25
500	11	45.5	0.15	3	515	0	10	0.15	0.025	20	10	20	29
560	26	21.4	0.15	3	275	0	10	0.15	0.025	15	7.5	15	24
560	17.6	31.7	0.15	3	380	0	10	0.15	0.025	15	7.5	17	26
560	11	50.8	0.15	3	570	0	10	0.15	0.025	20	10	22	31
630	26	24.1	0.15	3	300	0	10	0.15	0.025	15	7.5	16	25
630	17.6	35.7	0.15	3	420	0	10	0.15	0.025	15	7.5	18	27
630	11	57.2	0.15	3	635	0	10	0.15	0.025	25	12.5	23	32
710	26	27.2	0.15	3	335	0	10	0.15	0.025	15	7.5	16	25
710	17.6	40.2	0.15	3	465	0	10	0.15	0.025	20	10	19	28
800	26	30.6	0.15	3	370	0	10	0.15	0.025	15	7.5	17	26
800	17.6	45.3	0.15	3	515	0	10	0.15	0.025	20	10	20	29
900	26	34.6	0.15	3	405	0	10	0.15	0.025	20	10	18	27
900	17.6	50.9	0.15	3	570	0	10	0.15	0.025	20	10	22	31
1000	26	38.4	0.15	3	445	0	10	0.15	0.025	20	10	19	28
1000	17.6	56.6	0.15	3	630	0	10	0.15	0.025	25	12.5	23	32
	Tolerance		±0.02		±3			±0.02	±0.01				

NB All jointing pressures must be calculated by using the effective ram area of the machine in relation to the cross-sectional area of the pipe wall. Effective ram area varies with manufacturer and models. Effective ram area should be marked on each model.

Please refer to page 49 regarding soak time for thick walled pipe.

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Training Courses

It is essential that all installers of polyethylene pipe systems have received thorough training. Training leading to nationally recognised qualifications can be done at a number of organisations:

Develop Training	0800 876 6708
Water Skills	01733 246 415
Utilise T.D.S.	01942 260 697

In addition, GPS offers a specialist training course on the installation of FRIALEN® Large Diameter Couplers.

Training concerning other product and installation techniques are available and enquiries should be addressed to our Technical Support Department.

Butt-Fusion Jointing Principles

Butt-Fusion machines can be capable of welding moulded fittings directly onto pipe but not in all circumstances as it can depend on the design and make of the equipment. GPS offers two ranges of fittings to provide the greatest flexibility.

Long Spigot Fittings

These unpupped fittings are long enough to be gripped for butt-fusion in some types of machines.

Pupped Fittings

Pupped fittings are fabricated in our factory by butt-fusing lengths of pipe (pups) to each leg of a spigot fitting. The pup can be gripped by clamps of site butt-fusion machines.

GPS standard pupped fittings have a 0.5m length pup for sizes up to 400mm and a 1.0m length pup for sizes of 450mm and above.

Welding in Cold Weather

When butt fusion jointing at temperatures below 0ºC, a space heater should be provided for the welding shelter to raise the local temperature above 0ºC.

Equipment

- Generator to supply the heater plate, trimmer and hydraulic pump
- Butt-Fusion machine fitted with the correct size clamp shells, trimmer, heater plate, hydraulic pump and timer
- Pipe support rollers
- Welding tent
- Cleaning material, lint-free cotton cloth or paper towel
- External/internal debeading tool
- Bead gauge
- Digital thermometer with surface probe to check heater plate
- Pipe end caps
- Baseboard
- Pipe cutters
- Air temperature thermometer
- Indelible marker pen
- Timer

Jointing Method

Pre-jointing checks

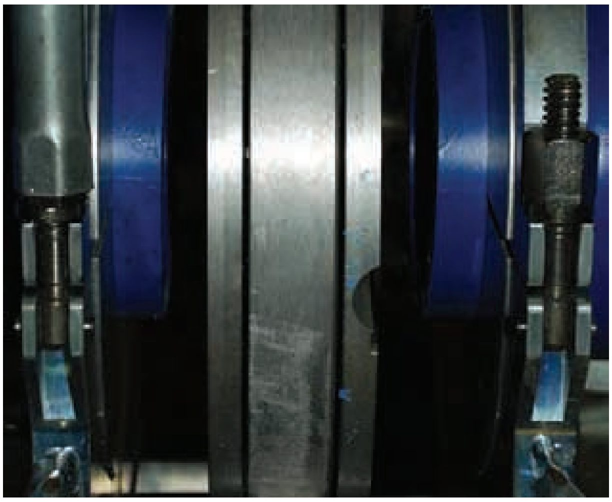
Before commencing a welding operation:

- Ensure that equipment used is clean, in good condition and regularly maintained
- Ensure that the correct jointing parameters for the machine type and pipe are known
- Check that the heater plate is clean and dry
- Check that the trimmer is clean and that the blades are not damaged and in the correct position for required pipe size
- Ensure clamp liners and securing screws are of the correct size
- Ensure that the generator is in good condition and has sufficient fuel
- A tent is available to provide shelter during welding and end caps are available.
- The pipes and/or fittings to be jointed are of the same size, SDR and material.

Dummy Welds

Even though washing of the heater plate may remove large deposits of dirt, very fine particles of dust may still remain on the heater plate. To remove such dust it is necessary to make a dummy joint at the start of each jointing session, whenever the plate has been allowed to cool below 180°C, or at a change of pipe size. Two dummy joints must be made if the pipe size is greater than 180mm.

A dummy joint can be made using pipe off-cuts of the same size, SDR and material as the pipe being installed however, it is not necessary to actually make a joint as the procedure can be discontinued after the full heat cycle has been completed. In the case of Automatic machines the abort button can be used to stop the process after the heat soak period has elapsed.



Welding Procedure

1. With the machine in the open position place the pipes in the clamps with the ends adjacent to the trimming tool and with the pipe markings aligned.

2. Align and level the components using external support rollers.

3. Tighten the pipe clamps to grip and re-round the pipes.

4. Cover the free ends of the pipes to prevent cooling of the plate by internal draughts.

5. Switch on the trimming tool and bring the clamps slowly together so that the pipe ends are moved against the trimming tool until continuous shavings are cut from each surface.

6. Keep the trimming tool turning whilst separating the clamps to avoid steps on the trimmed surfaces.

7. Remove the trimming tool taking care not to touch the trimmed ends.

8. Remove loose shavings from the machine and component ends. Do not touch the prepared surfaces or place hands between the pipe ends.

9. Check that both surfaces are completely planed. If they are not then repeat the trimming process.

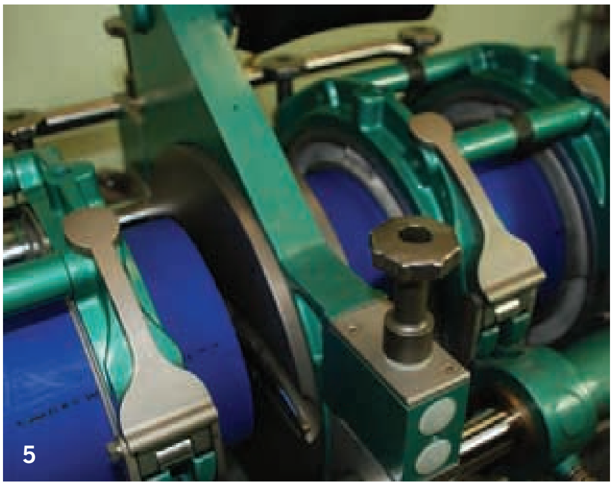
10. Bring the clamps together and check that there is no visible gap between the trimmed faces.

11. There should be no discernible mis-match on the outside diameter up to and including 180mm and less than 10% of the wall thickness for pipes greater than 180mm. If the mismatch is greater than these values then the pipe must be realigned and re-trimmed.

12. Automatic machines will measure the drag pressure and compensate for this but with the earlier manual machines, there was a need for this to be assessed accurately prior to making each fusion joint and added to the basic ram pressure values shown on the machine.

13. With the machine in the open position place the heater plate assembly on the machine, checking that it is up to the correct temperature.

14. The automatic butt-fusion cyle can now be commenced whereupon the required interface pressure will be maintained until a uniform bead of the correct size is formed on each pipe.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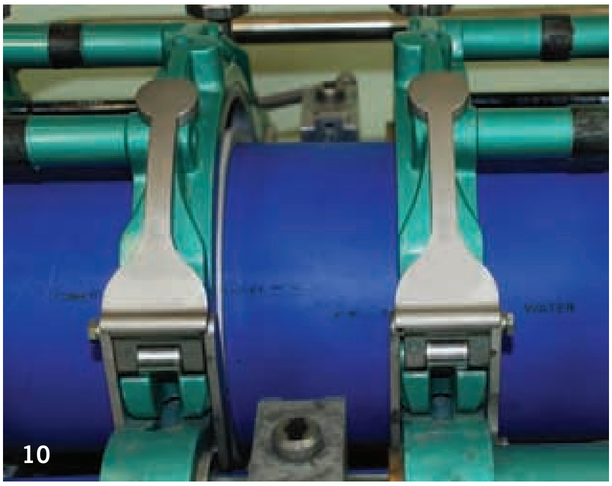

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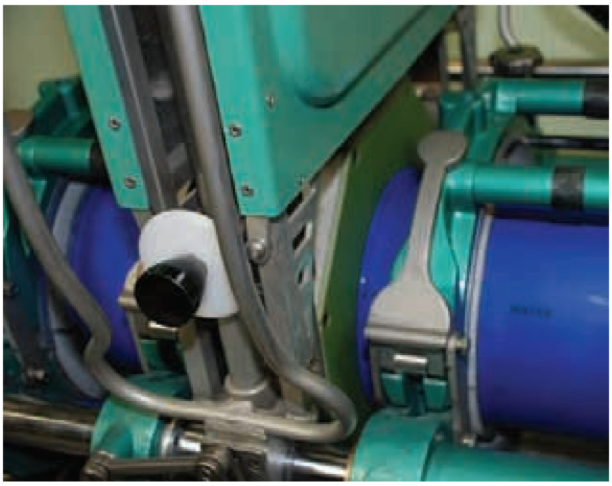
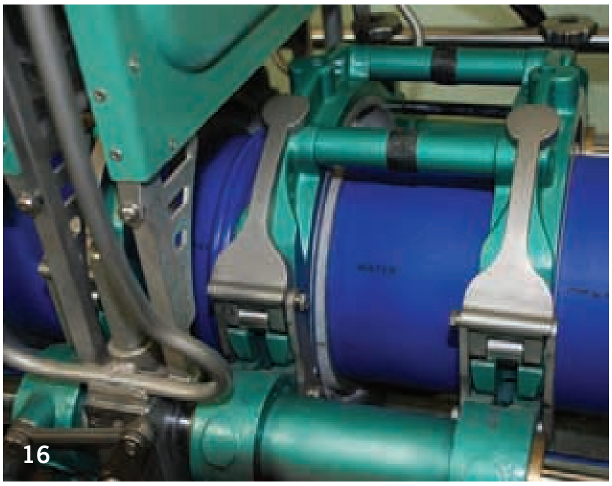


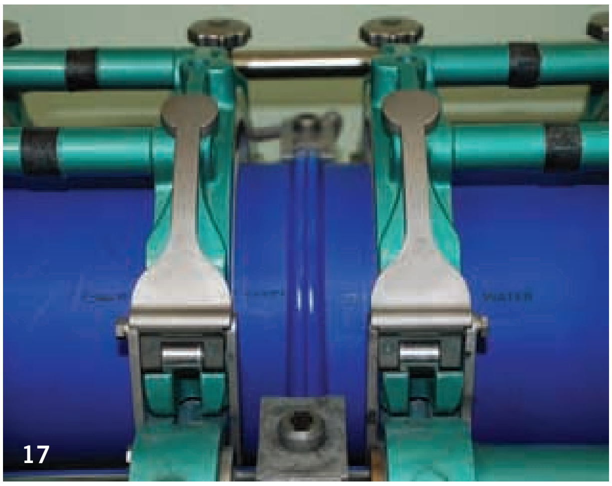
15. After the initial bead up, the pressure in the hydraulic system will be reduced to between zero and the drag pressure, so as to control the bead growth during the heat soak time.

16. When the heat soak time is completed, the machine will automatically open and remove the heater plate before bringing the pipe ends together under the prescribed interface pressure.

17. The prescribed pressure must be maintained for the required minimum cooling time.

18. After this time the assembly can be removed from the machine but should not be handled excessively for the required period.





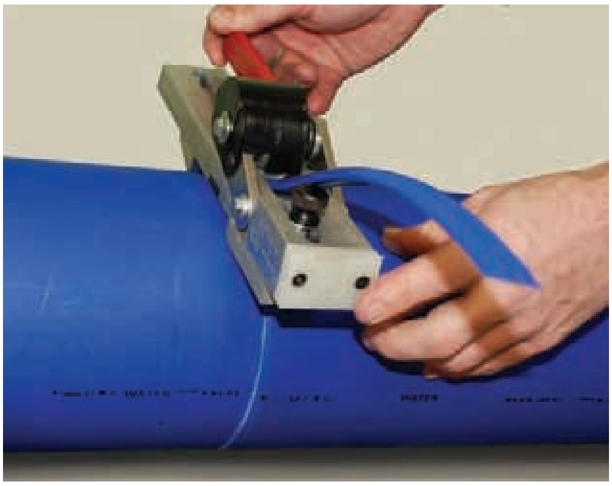
Post Welding Checks

1. Examine the joint for cleanliness and uniformity and check that the bead width is within the specified limits.

2. Remove the external bead and if required the internal bead using suitable debeading tools.

3. The beads and joint should be numbered/coded using an indelible marker pen to correspond with the joint details entered into the butt fusion machine data retrieval system.

4. The beads should be twisted at several positions and if a bead is seen to split at any point or deformities are present on the underside, then the joint should be cut out from the pipeline and remade. If a similar defect reoccurs, all further jointing should cease until the equipment has been thoroughly cleaned, examined and new trial joints made which are shown to be satisfactory.



An assessment of butt-fusion joint integrity can also be established by destructive tensile testing in accordance with Appendix B of Water Industry Standard (WIS) 4-32-08. All tensile test samples taken from a joint shall fail in a ductile manner.

Butt-Fusion Jointing Dos / Don'ts

Pre-Jointing Checks

- Use equipment that is clean, in good condition and regularly maintained.
- Ensure the correct jointing parameters for the machine type and pipe are known.
- Check that the heater plate is clean and dry.
- Check that the trimmer is clean and that the blades are not damaged and in the correct position for the required pipe size.
- Ensure clamp liners and securing screws are of the correct size.
- Ensure the generator is in good condition and has sufficient fuel.

Dos

- DO WORK SAFELY
- Do understand the principals of butt fusion (refer to pipe manufacturers/machine suppliers guidelines if necessary).
- Do always input **correct operator** code and **job code** to allow for **full traceability** with Automatic Butt Fusion machines.
- Do mark finished joint with joint number.
- Do use a shelter and ground sheet (a suitable anti-slip surface*), both in dry and wet conditions, to minimise contamination, and fit end protection to pipes, (plugs or caps) to eliminate draughts.
- Do ensure pipes are aligned correctly and supported on pipe rollers to minimise drag.
- Do position pipes in clamps with pipe markings aligned and to the top.
- Do perform dummy welds at the start of every welding session, when changing pipe size or if the heater plate has been allowed to cool (one dummy weld on pipe size 180mm and below and two on larger pipe sizes).
- Do ensure that when trimming, a continuous ribbon of material is produced from both pipe ends before commencing feathering operation.
- Do always use trimmer and heater plate stands provided.
- Do always remove swarf from underneath pipe ends and machine chassis following trimming.
- Do visually check that both pipe ends are completely trimmed.
- Do always check pipes for alignment and gaps around the entire circumference of the abutted pipes.
- Do always remove external bead from completed joint, inspect for slit defects/bead uniformity then bag and label with corresponding joint number for full traceability.

Don'ts

- Do not attempt to use equipment unless trained to do so.
- Do not attempt to weld pipes of different wall thickness.
- Do not touch trimmer blades when cleaning and especially when in motion, blades are very sharp and can cause serious injury.
- Do not touch heater plate (unless to clean when cold).
- Do not leave swarf inside pipe or on machine chassis.
- Do not introduce dirt onto trimmed pipe ends at any time, particularly when removing swarf.
- Do not remove pipes from machine until cooling time has elapsed.
- Do not attempt to install pipe until fully cooled.
- Do not attempt to operate the trimmer whilst it is out of the machine or attempt to by-pass the safety switch.
- **Do not attempt to cut corners in any part of the welding cycle.**

Health & Safety

GPS make every effort in the design and manufacture of their pipes and fittings to ensure safety in use. The following precautions are however worth bearing in mind:

- Never allow hot polyethylene to come into contact with the skin. In such an event cold water should be used to cool the affected area. Expert medical advice must be sought.
- **Under no circumstances should any attempt be made to remove any material that becomes stuck on the skin without medical supervision, as this would risk more serious injury**.
- Heavy pipes, fittings and equipment should not be handled without assistance or mechanical aid. The requirements of Manual Handling Operations Regulation 1992 should be adhered to.
- GPS recommend the wearing of Personal Protective Equipment in compliance with statutory legislation such as gloves, safety glasses and safety boots whilst carrying out butt-fusion.
- Care should be exercised by taking normal precautions when using electrical equipment on site, particularly in wet conditions.
- Normal precautions should be observed when handling electrical equipment. For safety reasons, all 110v portable generator sets should be 'Centre Tapped' for site use +55/0/-55 volts.
- Remember an audible alarm is fitted to automatic butt-fusion machines to warn of impending movement.

Always remember that where joint records are automatically stored, these should be downloaded on a regular basis to allow full traceability and integrity of workmanship

* Consideration should be given to a firm level base such as 19mm Marine Ply which is our minimum recommendation.

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Connecting PE to Iron Flanges

It is not possible to join polyethylene pipe to pipe made from other materials by fusion welding. In the case of mains pipe sizes it is necessary to use PE flange adaptors, including SlimFlange®, or specialist fabricated metal fittings eg. from Viking Johnson or WASK, that grip the pipe.

Since polyethylene systems are end-load bearing, precautions must be taken when a connection is made to pipe of another material. To prevent pull-out of any non end-load bearing joints, the transition may need to be externally harnessed or anchored/thrust blocked.

In larger pipe sizes there can be a discrepancy (in bore size and bolting) when jointing polyethylene pipe to iron pipe, as PE pipe has much thicker walls. When considering multi-material piping systems it is important to remember that PE pipe is always sized by its OD, whereas iron pipe is sized by its nominal bore, referred to as its DN (Diameter Nominal).

For example, a 450mm OD Excel (PE100) SDR17 pipe (with a bore of 400mm) can be jointed to a 450mm PN16 valve using a traditional 450mm x 450mm PE flange adaptor (see figure (i)). But this means that the bore size between a pipe and a valve changes from 400mm (PE) to 450mm (iron) with a significant extra cost.

SlimFlange® addresses this problem and is a fully end-loaded bearing (Type 1) fitting for most SDRs and under tensile loading, the pipe will yield well before the SlimFlange®.

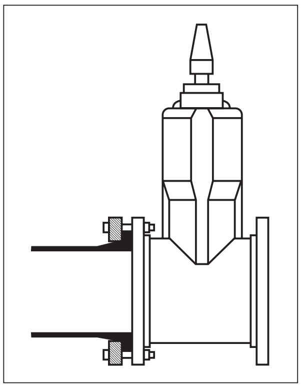


Figure (i) 450mm Excel (PE100) pipe and conventional PE flange adaptor bolted to a DN450 valve.

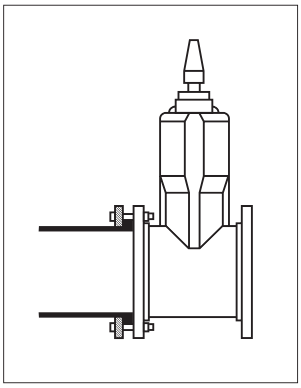


Figure (ii) 450mm Excel (PE100) pipe and SlimFlange® PE flange adaptor bolted to a DN400 valve.

SlimFlange®

This unique PE flange adaptor is currently available for PE sizes from 250mm to 560mm and permits actual or near bore-size-for-size jointing of a PE pipe to the flange of an iron fitting or pipe. This considerable benefit is achieved by incorporating a steel hoop in the PE flange stub face to provide a reinforcing effect. This allows the PE stub shoulder height and backing ring size to be reduced dramatically, with increased joint strength and improved sealing performance, including in those cases where SlimFlanges are bolted back to back. Unlike traditional PE flanges, SlimFlange® eliminates the need to upsize the connected valve or other metal component or to downsize the PE pipe (see figure ii).

At the same time, the backing ring is free to rotate in the normal way to permit easy bolting-up to valves and other fittings in the field.

GPS can also supply Special PE Flange Adaptors for sizes greater than 560mm, that employ bolting which pass through the PE stub shoulder and in this way approach bore-size-for-size connectivity. As for SlimFlanges, the backing rings have bolting circles that are the next size down compared to that of backing rings fitted to conventional PE stub flange adaptors.

Flange adaptor incorporating a polyethylene reducer

For the sizes where a SlimFlange® cannot be offered (ie. 630mm and above), another possible alternative is a fabricated fitting incorporating a reduced size PE flange (figure iii overleaf). There is clearly an associated reduction in strength and the arrangement is not permitted in the UK gas industry. Due to the temporary reduction in bore with this fitting, it may be desirable to incorporate a metal reinforcing plate between the PE flange and the metal flange to help stabilise the assembly. Please consult our Technical Support Department before specifying one of these ‘combination’ flanges.

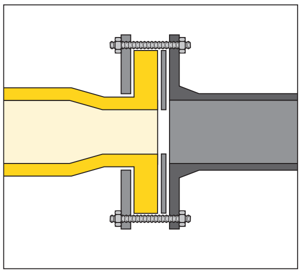


Figure (iii) 450mm x 400 PN16 'combination' flange adaptor

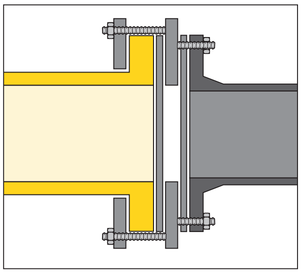


Figure (iv) 630mm x 600 PN16 flange adaptor with 600 PN16 x 500 PN16 steel flange converter

Steel flange converter

Where the PE and iron sizes cannot be accomodated by a SlimFlange® and a rotatable backing ring is desired, a better solution is to employ a two-way steel converter plate. In the diagram above (figure iv), a converter plate is drilled/studded to allow a direct connection between a 630mm PE x 600 PN16 flange adaptor and a DN500 PN16 ductile iron flange.

Connecting PE to Other Pipe Materials

PE can be jointed to other pipe materials (e.g. PVC-U, asbestos cement) in the same manner as outlined above for iron. If further assistance is required, please contact our Technical Support Department.

Mechanical Joints: Recommended Procedure for Bolting Up Flange Adaptors

Flanged joints should be made using a single full face or Corrugasket® rubber gasket or for more critical applications, steel reinforced gaskets. All four mating surfaces must be undamaged, clean and free from contamination.

Steel reinforced gaskets have the advantage of increased compliance without any risk of extrusion under pressure. For applications where significant transient pressures are possible, specification of profiled steel reinforced gaskets will give the maximum possible long term security. Details are available on request.

A jointing compound should not be used.

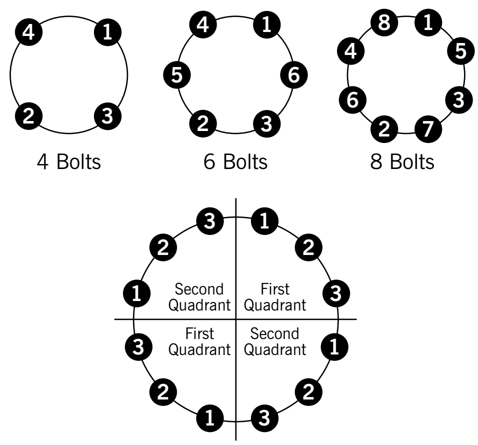
Wherever possible, flange joints should be made before other joints are completed. If not, the pipework should be configured so that mating faces are aligned and butted squarely to each other with a maximum separation of 5mm prior to bolting up, irrespective of pipe diameter.

Only clean undamaged nuts and bolts of the correct size should be employed, with lightly oiled threads and standard thick (Form A) washers at both ends, also of the correct size.

Care must be taken to ensure that the gasket is centred properly between the two flanges before tightening commences. The nuts and bolts must be tightened as uniformly as possible using a torque wrench, in diagonally opposite sequence, progressively from a finger tight start. The recommended bolting sequences are shown below.

Fingertight • 5% of final torque • 20% of final torque • 50% of final torque • 75% of final torque • 100% of final torque.

Bolting Sequences



4 Bolts 6 Bolts 8 Bolts

12 Bolts or more

For PE diameters above 180mm, it is recommended that two operators work simultaneously on diametrically opposite bolts where possible. To guarantee subsequent leak tightness, final torquing up should be repeated after the assembly has been allowed to relax for an hour or so.

Evenness of tightening is as important as final torque values - see the table below. The torques shown are for SDR11 and SDR17 pipe, in both PE80 and Excel® (PE100).

Typical bolting torques for flanges (PE to PE or PE to metal flanges)

	Standard Flanges			SlimFlanges or Special Flanges		
Nominal PE size (mm)	Nominal Iron size (mm)	Bolting	Torque (Nm) ±10%	Nominal Iron size (mm)	Bolting	Torque (Nm) ±10%
63	50	M16x4	35		n/a	
90	80	M16x8	35		n/a	
125	100	M16x8	35		n/a	
180	150	M20x8	60		n/a	
200	200	M20x12	80		n/a	
225	200	M20x12	80		n/a	
250	250	M24x12	100	200	M20x12	60
280	250	M24x12	100		n/a	
315	300	M24x12	120	250	*M20x12	70
355	350	M24x16	150	300	M24x12	120
400	400	M27x16	200	350	M24x16	150
450	450	M27x20	250	400	M27x16	200
500	500	M30x20	300	450	M27x20	250
560	600	M33x20	350	500	M30x20	300
630	600	M33x20	400	500	M30x20	300
710	700	M33x24	400	600	M33x20	400
800	800	M36x24	450	700	M33x24	400
900	900	M36x28	450	800	M36x24	450
1000	1000	M39x28	500	900	M36x28	450
1200	1200	M45x32	550	1000	M39x28	500

*non standard bolt size

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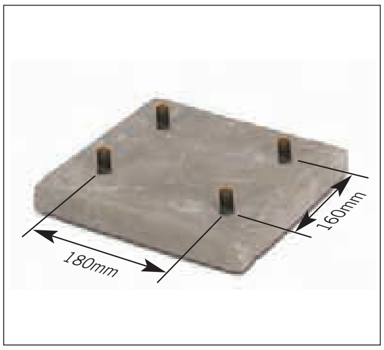
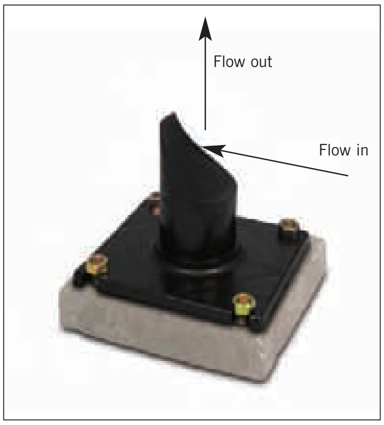
Duck Foot Bend Assembly

Assembly Instructions

1. Secure a concrete base into the ground and fit 4 x M16 bolts at 180 x 160mm centres. (Bolts not included in kit)

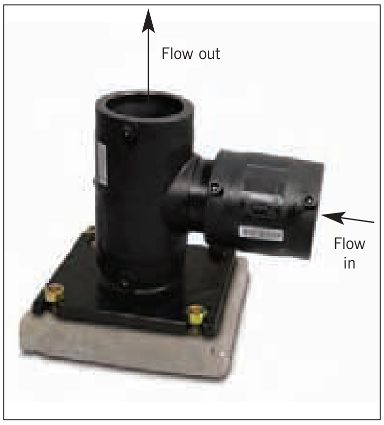


2. Fix and bolt the Duck Foot Bend base piece to the concrete base. Note that the orientation of the base should be such that the incoming flow meets the face of the Duck Foot Bend base.



3. Remove the lower pipe stop from the electrofusion tee and push firmly onto the base. As for part 2, the orientation of the electrofusion equal tee should be such that the incoming flow meets the face of the Duck Foot Bend base.

   Note:- Ensure that the bare spigot has been adequately scraped.



4. Cut the length of the pupped stub flange as required. Note that the total height (h) should include the Fire Hydrant height. Scrape the stub flange pipe end and place in the top of the electrofusion tee. Electrofuse the tee, securing the base and stub into place.

5. Electrofuse the coupler, reducer or spigot reducer into place and electrofuse to the incoming pipe.

   Note:- Ensure that the bare spigot has been adequately scraped.

6. Connect the hydrant to the stub flange assembly following the stub flange bolting procedure.

Jointing Instructions for Protecta-Line

Protecta-Line pipelines can be jointed using any of the following methods:

- Protecta-Line Mechanical Compression fittings (25mm - 63mm)
- Protecta-Line Fluid Compression fittings (63mm -180mm)
- Electrofusion fittings (90mm - 355mm)
- Butt-Fusion (90mm - 355mm)
- Dedicated Ferrule Off-Takes in mains sizes 63mm to 355m

Where electrofusion and butt fusion methods are to be employed, this should first be cleared with the local water utility. In both cases, the integrity of these joints has been proven by permeability testing to WIS 4-32-19 to ensure long term safety, some water utilities have stipulated that completed joints should be wrapped with Protecta-Line aluminium tape followed by a proprietary waterproof petrolatum tape (equivalent to Denso™).

Protecta-Line is an approved system. Only Protecta-Line fittings shall be used with Protecta-Line pipe. The use of alternative fittings will have the following effects on your Protecta-Line system:

USE ONLY PROTECTA-LINE APPROVED FITTINGS

- Invalidation of WRAS approval and manufacturers system performance warranty.
- Compromised permeation resistance (causing non-compliance with WIS 4-32-19 and possible risks to health).
- Danger of pipe-layer delamination, compromising system performance integrity and risking pipe bursts. It would be illegal to install non-WRAS approved fittings.

When made in accordance with GPS PE Pipe Systems' recommended procedures, butt-fusion and electrofusion joints of the Protecta-Line system have been independently shown to meet the requirements of WIS 4-32-19 without any need for subsequent wrapping. This does not exempt installers from local regulations and the local Water Company preferences must be adhered to.

Testing and Commissioning

The sequence of events for Protecta-Line includes the same basic testing procedures as for conventional PE pipes, but taking extra care appropriate for a contaminated environment as set out by the Local Water Undertaking.

As for normal PE pipes these procedures will normally require, as a minimum, the adequate flushing of the services and the testing of all pipes and joints to the maximum head to which the system is to be subjected.

Connecting to Alternative Barrier Pipe Systems

To connect Protecta-Line to alternative barrier pipe systems, a mechanical connection should be used: either a threaded connection in the case of the service pipe sizes or a flange connection in the case of larger sizes.

Approvals

- Regulation 31 (England & Wales), Regulation 27 (Scotland), Regulation 30 (NI)
- WRAS **(complete system approved)**
- WIS 4-32-19 **(complete system is Kitemarked)**
- BS 6572 (25mm - 63mm pipes)
- WIS 4-32-17 (25mm - 355mm pipes)
- BS EN 12201 (90mm - 355mm pipes)
- System permeation tests independently verified

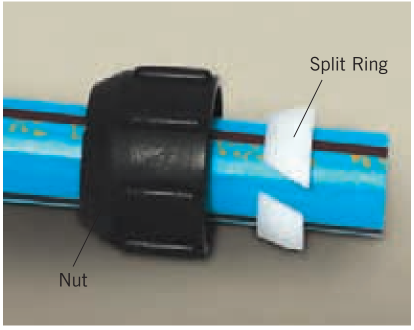
WRAS
0609132
0702502
0902519
0902515
0703510

07472
56151
508224

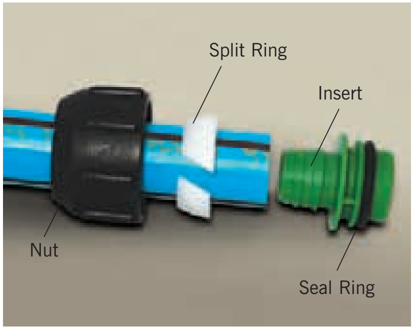
WIS 4-32-19
KM 514626

Jointing Instructions for 25mm-63mm Protecta-Line Mechanical Compression Fittings (Service Pipes)

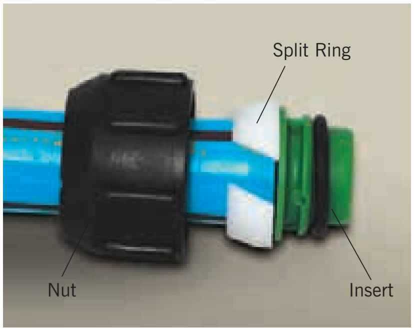
For use on GPS Protecta-Line Pipe only



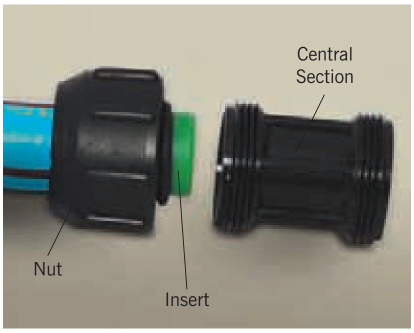
1. Cut the pipe square. Unscrew the Protecta-Line fitting and remove the nut and white split ring. Slide these on to the Protecta-Line pipe, nut first ensuring that the taper of the split ring faces towards the nut.



2. Tap the insert into the end of the Protecta-Line pipe with a flat wooden object. Ensure that the seal ring is correctly positioned on the pipe insert.



3. Slide the split ring along the Protecta-Line pipe until it is up against the insert. Snap the nut over the split ring.

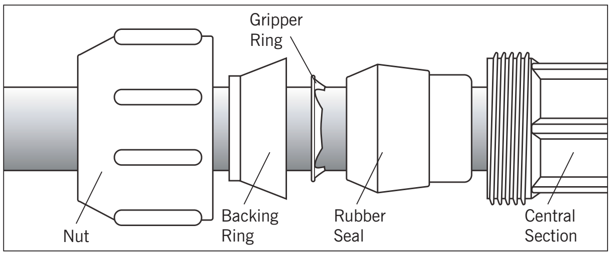


4. Offer the body of the fitting to the Protecta-Line pipe end and screw the nut on to the fitting body. Continue to tighten the nut until the thread on the body is no longer visible.

Note: Connecting to Alternative Barrier Pipe Systems

To connect Protecta-Line to alternative barrier pipe systems, a mechanical connection should be used: either a threaded connection in the case of the service pipe sizes or a flange connection in the case of larger sizes. Specific advice should be sought from our Technical Support Department.

Protecta-Line to copper joint (incorporates insert set for Copper Type A for above ground use on Table X tube).



1. Cut copper pipe square, preferably with cutters, and deburr.
2. Degrease pipe and roughen with wire wool or similar.
3. Unscrew nut from copper side of Protecta-Line fitting and slide this nut and plastic backing ring along copper pipe – with taper of backing ring towards nut.
4. Then slide metal gripper ring on to pipe and position it 10–15mm from end, ensuring flat face of gripper ring is facing towards backing ring/nut (i.e. slots in the gripper ring must face towards fitting body).
5. Next slide rubber seal on to copper pipe all the way up to internal stop - taper facing towards other parts already on pipe.
6. This will make certain that the metal gripper ring is pushed to correct location along pipe.
7. Slide backing ring forward to meet gripper ring/rubber seal.
8. Push assembly into body of Protecta-Line fitting and engage nut.
9. Tighten nut firmly with a wrench.
10. Ensure all pipework is securely anchored to counteract end loading.

Caution: Do not use heat near plastics and do not re-use gripper ring.

Connecting Protecta-Line mechanical compression fittings to iron fittings

When screwing Protecta-Line Mechanical Compression Fittings onto iron fittings it is important not to use excessive amounts of **thread** sealing tape or other material **because** this can result in unreasonable force needed to complete the joint. Thread sealing tape should be WRc approved.

Installation Instructions for 25mm and 32mm Protecta-Line Gunmetal Self-Tapping Ferrule Straps

For use on GPS Protecta-Line pipe only.

Gloves and safety glasses must be worn during the whole assembly process.

The ferrule strap cutter includes a sealing sleeve that prevents water contact with the aluminium barrier layer.

1. Fit the Protecta-Line end connector compression fitting to the ferrule strap male outlet, employing sufficient PTFE tape to ensure a good seal. (It is advisable to rotate the ferrule outlet having first slackened the securing collar).

2. Clean the surface of the Protecta-Line main where the self-tapping ferrule strap is to be installed, avoiding areas which appear damaged.

3. Ensuring that the sealing “O” ring is in place under the upper ferrule strap (and taking care not to damage this on the protruding sleeve), fit the self-tapping ferrule squarely around the main and tighten the two strap bolts evenly and symmetrically.

4. Fit the Protecta-Line service pipe into the compression fitting on the outlet, as described in the separate instructions. After aligning the outlet to the desired position, tighten the securing collar.

5. Remove the plug from the top of the ferrule cap, and, using an 8 or 11mm (depending on service pipe size) square section key, wind down the cutter assembly all the way until hard and solid resistance is felt. Note that before the solid resistance is felt there may be a temporary drop in resistance, followed by an increase as the sleeve around the cutter enters the main.

6. Withdraw the cutter all the way up to the top of the stem, employing a final counter-clockwise torque of approximately 15Nm to ensure a good seal and replace the plug. Some leakage through the plughole is normal before the cutter has been fully unscrewed.

Caution: Do not remove cutter or sleeve from this product before use.

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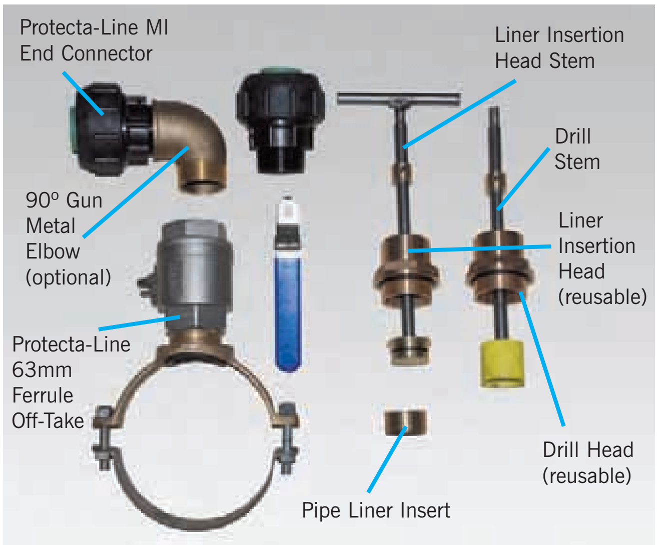
Installation Instructions for 63mm Protecta-Line Gunmetal Ferrule Off-Takes



Accessory	Code
* Protecta-Line 2" Drill Head	44 794 003
**Protecta-Line 2" Liner Head	44 794 004
***Protecta-Line Drill/Liner Head O-Ring Kit	44 996 062

*Drill Head setting: fix stop at 230mm from base to drill tip
**Drill Liner setting: fix stop at 180mm from stop base to bottom of tip on liner head
*** Includes four O-rings for replacement in either Drill Head or Liner Head

1. Ensuring that the sealing O-ring is in place under the upper ferrule strap, fit the ferrule squarely around the main in the required position and tighten the two strap bolts evenly and symmetrically. Ensure that ball valve operates correctly before fitting.

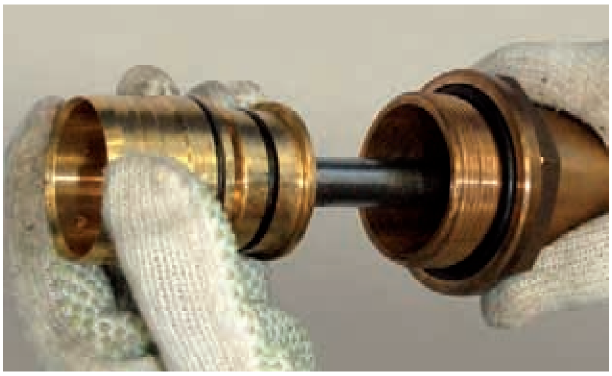
2. After assembling the drill stem with a 48mm hole cutter, withdraw the drill stem fully into the drill head.

3. Ensure that the ball valve is in the fully open position (anti-clockwise rotation). Fit the drill head to the outlet of the ferrule.

4. Attach the chuck of an electric drill to the top of the drill stem (ensuring that the power supply is disconnected). Re-connect the power supply to the electric drill and operate the drill with downward pressure until the stop on the drill stem contacts the top of the drill head.

5. Disconnect the power supply to the electric drill and remove the drill from the drill stem. Withdraw the drill stem, until the cutter is fully returned into the drill head and fully close the ball valve (clockwise rotation) before removing the drill head from the outlet of the ferrule.

6. Position the liner insert onto the carrier of the liner insertion head.



7. Fully withdraw the carrier and pipe liner insert into the liner insert head (indicated by the lower depth mark on the stem).

8. Fit the liner insertion head to the outlet of the ferrule. Open the ball valve (anti-clockwise rotation) and fully insert the liner insert, by applying downward pressure on the tee-bar handle on the shaft of the liner insertion head until the stop on the liner insertion head stem contacts the top of the liner insertion head.

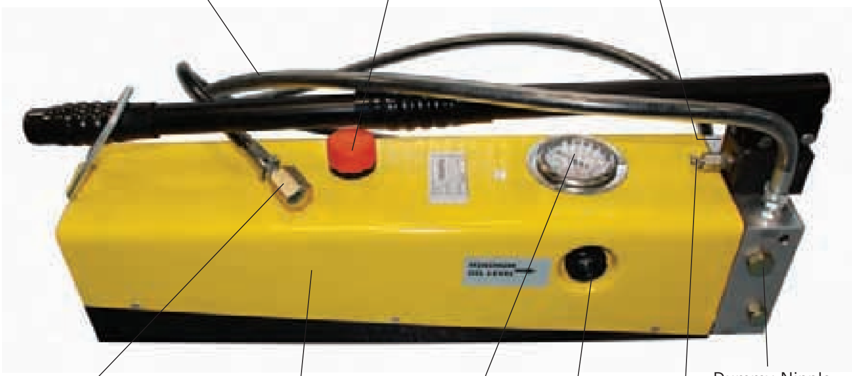
9. Withdraw the liner insertion head stem until the carrier is fully withdrawn into the liner insert head (indicated by the lower depth mark on the stem). Close the ball valve (clockwise rotation) and remove the liner insertion head.

10. The communication pipe can now be fitted to the outlet of the ferrule utilising a Protecta-Line 63mm x 2" MI mechanical end connector, either directly to the ferrule outlet (side connection) or in conjunction with 2" MI/FI 90° elbow (top connection).

11. Open the ball valve (anti-clockwise rotation).

Installation Instructions for Protecta-Line Fluid Compression Fittings - Pressurising the Joint

Gloves and safety glasses must be worn during the whole assembly process. Residual pressure within the fitting may be released while removing the connector, causing a momentary spurt of fluid.



1. A calibrated hydraulic pump must be used for all pressurisation of the Protecta-Line fluid compression fitting range. The pump must be filled with Protecta-Line hydraulic fluid.

2. Slide the nipple connector over the nipple on the Protecta-Line fluid compression fitting. Please note that the nipple connector is a slide fit over the nipple, not a push fit. An alternative nipple connector, secured in position by a knurled nut may be fitted. Care should be taken not to overtighten the connector and damage the seal.

3. Gently raise and lower the pump handle, watching the pressure gauge. As the pressure gauge approaches 260 bar, the pressure breaker valve will activate. This indicates that the required pressure has been achieved. Wait 10 seconds and repeat the pumping action until the pressure breaker valve activates. Wait 10 seconds and repeat again. The pressure gauge should now show a steady reading of approximately 260 bar. The joint is now made.

4. **The pressure must be released before removing the slide-on fitting connector from the Protecta-Line Fluid Compression shell.** Depress the manual relief valve on the pump for 2 seconds then slide off the nipple connector from the Protecta-Line fluid compression fitting.
5. If for any reason the nipple needs to be removed, the pressure in the fitting **must** be released first by using the pressure release tool, i.e. depressing the centre part of the fitting nipple. (Note: Care should be taken as a momentary spurt of fluid may occur).

6. Check that the marks on the pipe still line up with the end of the fitting.

7. The joint is now complete.

Fluid Quantities

Approximate fluid quantities to pressure the fitting shell (full shell):

Shell Size	Fluid Quantity (cc)	Number of Shells/Litre
63	40	25 Approx
90	90	11 Approx
110	150	6 Approx
125	190	5 Approx
160	320	3 Approx
180	375	2 Approx

Only Protecta-Line hydraulic fluid should be used with the pump as any other type of fluid can damage it.

Alternative Nipple Connector

1. An alternative style nipple connector is fitted to some hydraulic pumps.

2. The nipple connector slides over the nipple of the Protecta-Line Fluid Compression fitting and is secured in position by screwing the knurled nut at the top. Care should be taken not to overtighten the connector and damage the seal.

3. After the pressure is released (Stage 4) the nipple connector is removed by first unscrewing the knurled nut at the top of the connector sufficiently to slide the connector off of the nipple.

How to Bleed the Pump

Gloves and safety glasses must be worn during the whole assembly process.

Pumps fitted with a bleed screw

1. The bleed screw is positioned below the pump handle at the rear of the block.
2. Park the nipple connector onto the dummy nipple positioned on the pump block.
3. Raise handle to fullest extent.
4. Turn bleed screw anti-clockwise approximately one quarter of a turn.
5. Lower handle applying gentle pressure, oil will dribble out of the bleed valve.
6. Once the handle has reached the end of its stroke turn the bleed valve clockwise until solid.
7. Wipe any excess oil from around the bleed valve.
8. Check for pressurisation and repeat the bleed operation sequence if necessary.

   Note: Residual pressure within the system may be released while removing the nipple connector, causing a momentary spurt of fluid.

9. If unit still fails to pressurise after bleeding, return to supplier.

Pumps not fitted with a bleed screw

1. Park the nipple connector onto the dummy nipple positioned on the pump block.
2. Activate the manual relief valve and hold down.
3. Raise and lower the pump handle ten times, in each case achieving maximum stroke.
4. Release the manual relief valve.
5. Check for pressurisation and repeat bleed operation sequence if necessary.
6. Operate the manual relief valve and remove the nipple connector from the dummy nipple.

   Note: Residual pressure within the system may be released while removing the nipple connector, causing a momentary spurt of fluid.

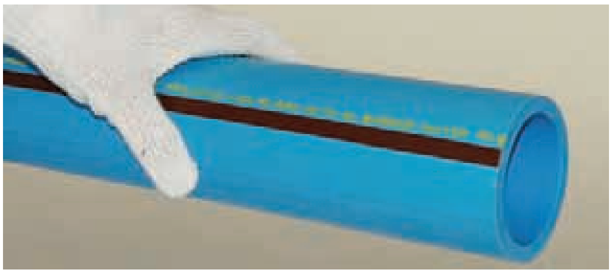
7. If unit still fails to pressurise after bleeding, then return to supplier.

Jointing Instructions for 63mm-180mm Protecta-Line Fluid Compression Fittings (Mains Pipes)

For use on GPS Protecta-Line pipe only.

Gloves and safety glasses must be worn during the whole assembly process.

1. Inspect the end of the pipes to be joined for any obstruction, removing any large burrs or ridges. Check the pipe ends are reasonably square.



2. Using a tape measure and a suitable marker pen mark the appropriate dimension "X" from the ends of the pipes to be joined.

63 - 47mm	110 - 71mm	160 - 91mm
90 - 64mm	125 - 81mm	180 - 106mm

3. Slide the outer shell over the pipe end (where there is evidence that the pipe has some degree of ovality then the pipe end should be re-rounded).
   Push the insert into the pipe end making sure that the pipe end is firmly against the shoulder of the insert.

For all fittings other than the coupler and repair coupler, the marking dimensions are as follows:

63 – 102mm	110 – 125mm	160 – 150mm
90 – 111mm	125 – 125mm	180 – 172mm

Note: The insert should be pushed into the pipe spigot until the stop is reached. The outer shell should be positioned so that one edge is aligned with the mark on the pipe and the other aligned with the end of the pipe. The spigots of stub flanges should be fully inserted into the pipe end upto the flange.

See page 81 for repairs using fluid compression fittings.

4. Connect the pipe and insert on to the free pipe end and push home fully, ensuring that both pipe spigot ends are in contact with the central stop of the insert.

5. Slide the outer shell over the assembly until the two marks on each end of the pipe are visible at each end of the outer shell.

6. The joint is now ready to be pressurised. Follow the pressurisation procedure.

Procedures for Butt-Fusion and Electrofusion of Protecta-Line Pipes in Sizes 90mm and Above

Standard butt-fusion and electrofusion procedures must be adhered to, but please note the following additional points:

Butt-Fusion

Where this is permitted by the local water company, it is important that the outer PE and aluminium layers are removed far enough back, using the Protecta-Line Surprep tool (see next pages), to prevent the aluminium from coming into contact with the butt-fusion machine trimmer or heater plates.

In addition, the outer PE and aluminium layers should be removed far enough back to permit normal debeading of the completed joint for normal quality control purposes.

It is recommended that the layers should be removed to a length equal to the width of the debeading tool on the end of each pipe. This should be increased by 50% when carrying out dummy weld procedures prior to final jointing.

Butt-fusion clamps should be checked for suitability before commencing work, particularly in larger sizes. Care should be taken not to damage the outer layers of Protecta-Line pipe when clamping it in the butt-fusion machine. In the case of some machines this may necessitate gently radiusing the edges of the jaw shutlines.

Electrofusion

It is essential that the Protecta-Line pipe is properly prepared prior to electrofusion jointing. It is necessary first to remove the outer PE layer, aluminium layer and any residual adhesive layer material.

Note: It is potentially dangerous to carry out electrofusion jointing where the aluminium layer is still in place.

The Protecta-Line Surprep Scraper must be used for pipe end preparation, as it not only removes the outer layers, but it also prepares the core pipe for electrofusion jointing.

Electrofusion clamps should be checked for suitability before commencing work, particularly in larger sizes. All electrofusion joint assemblies must be held in clamps throughout the fusion and cooling periods.

Protecta-Line Jointing End Preparation for Electrofusion Procedures

Pipe Size (mm)	Min preparation insertion depth (mm)	Max preparation depth (mm)
90	62	67
110	66	71
125	72	77
160	81	86
180	82	87
225	106	111
250	108	113
280	124	129
315	142	147
355	144	149

Wrapping

When made in accordance with GPS PE Pipe Systems' recommended procedures, butt-fusion and electrofusion joints of the Protecta-Line system have been independently shown to meet the requirements of WIS 4-32-19 without any need for subsequent wrapping. This does not exempt installers from local regulations and the local Water Company preferences must be adhered to.

Should wrapping be required, the following table can be used for guidance.

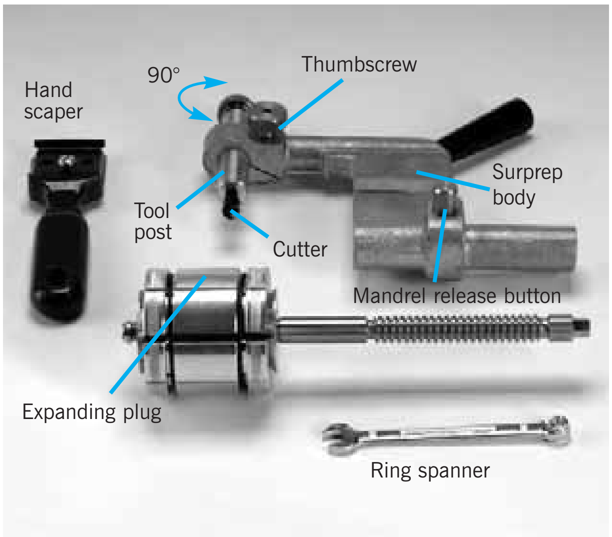
Aluminium Foil Wrapping Lengths - Foil width 50mm

Size (mm)	E/F fitting length (mm)	Amount of foil required (metres)	Joints per roll
25	76	0.38	132
32	83	0.69	72
63	111	2.04	25
90	130	3.37	15
110	135	4.46	11
125	150	5.06	10
160	165	7.41	7
180	165	8.22	6
225	220	14.05	4
250	225	15.71	3
280	260	19.58	3
315	290	25.42	2
355	300	27.12	2

Only Protecta-Line fittings shall be used with Protecta-Line pipe. The use of alternative fittings will have the following effects on your Protecta-Line system:

- Invalidation of WRAS approval and manufacturers system performance warranty.
- Compromised permeation resistance (causing non-compliance with WIS 4-32-19 and possible risks to health).
- Danger of pipe-layer delamination, compromising system performance integrity and risking pipe bursts.
- It would be illegal to install non-WRAS approved fittings.

Procedure for Using the Protecta-Line Surprep Scraper (90mm-180mm)



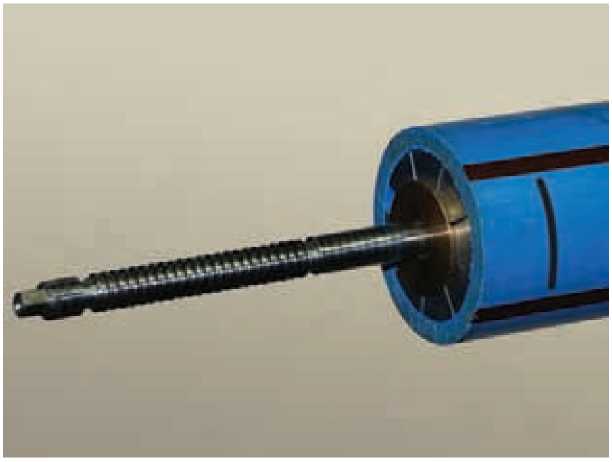
The Protecta-Line Surprep Kit has been designed to allow the correct scraping of Protecta-Line barrier pipe prior to electrofusion jointing.

Code	90mm	110mm	125mm	160mm	180mm
01-07-081	●	●			
01-07-083			●	●	●

To order, please contact Caldervale directly on 01924 469571 or sales@caldertech.co.uk

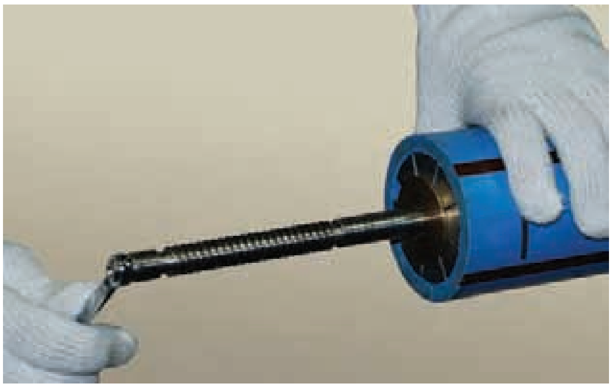
The Surprep Kit is available for hire through MCA Hire Services www.mcahire.com and Plant & Site Services Ltd www.psshire.com

1. Measure the insertion depth of the electrofusion fitting to be used (see table on page 64). Place a mark on both pipes to show the position where the edge of the fitting will be.
2. Clamp the pipe to be prepared taking care to avoid damage to the pipe's outer covering.
3. Separate the mandrel from the body of the Protecta-Line Surprep Scraper.

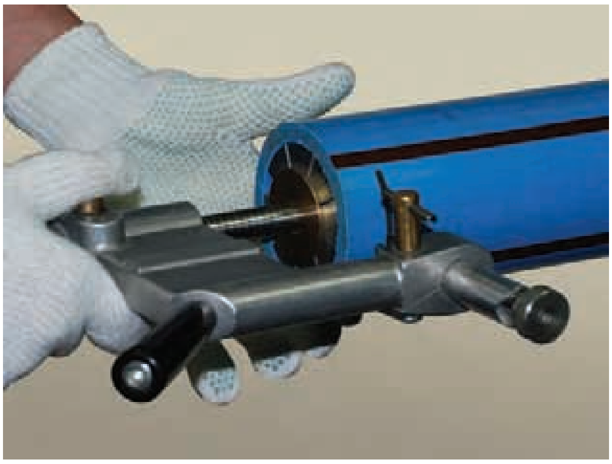


4. Hold the expanding plug and rotate the mandrel anti-clockwise until the plug is a light interference fit in the pipe bore.
5. Push into pipe until edge of plug is level with edge of pipe. Expand plug further using the 10mm ring spanner.

   Do not over-tighten in order to avoid pipe distortion.



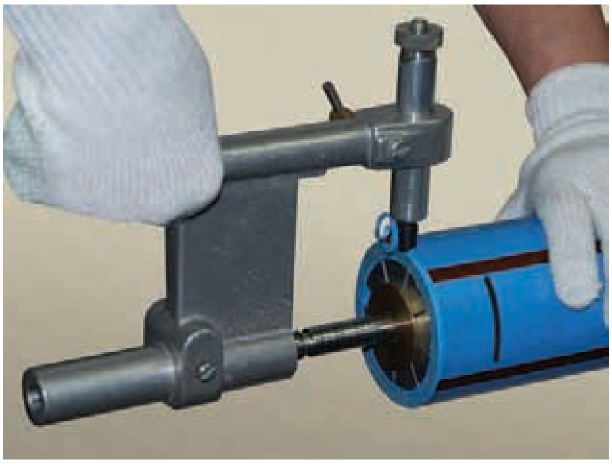
6. Slide the body of the Protecta-Line Surprep Scraper onto the mandrel, depress the release button and position the cutter close to the edge of the pipe.



Note: Protecta-Line Surprep Scraper cuts in an anti-clockwise direction, beginning at the end of the pipe.

7. Rotate the knob on the top of the tool post through 90°, against the spring tension, such that the cutter is in its raised position.

8. Loosen the body thumbscrew and position the cutter shoe on the edge of the pipe. Tighten the thumbscrew.



9. Rotate the knob on top of the post through 90° so that spring pressure is applied to the cutter.

10. Rotate the tool anti-clockwise in a smooth continuous motion to remove the outer layers in a continuous strip.

11. Stop cutting when the socket depth mark is reached.

12. Rotate the knob on top of the tool post so that the spring pressure is released.

13. Use the hand scraper to remove the peeled strip from the pipe.

    Caution: Do not attempt to break the peeled strip by pulling with bare hands, it has a sharp edge!

    Remove the tool in the reverse order of assembly (steps 3-6).

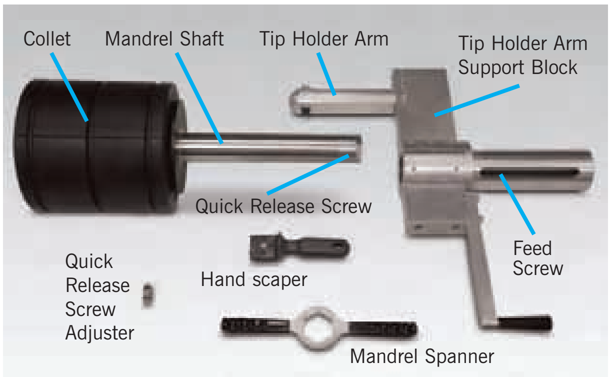
14. Inspect the prepared surface to ensure:
    i) All of the metallic layer has been removed.
    ii) All of the adhesive which bonds the metallic layer to the blue core has been removed.

15. If, for any reason, the prepared surface is not a uniform blue colour all over, use the hand scraper to complete the preparation process.

    Never attempt a second pass with the Protecta-Line Surprep Scraper.

When made in accordance with GPS PE Pipe Systems' recommended procedures, butt-fusion and electrofusion joints of the Protecta-Line system have been independently shown to meet the requirements of WIS 4-32-19 without any need for subsequent wrapping. This does not exempt installers from local regulations and the local Water Company preferences must be adhered to.

Procedure for Using the Large Diameter Protecta-Line Scraper (above 180mm)



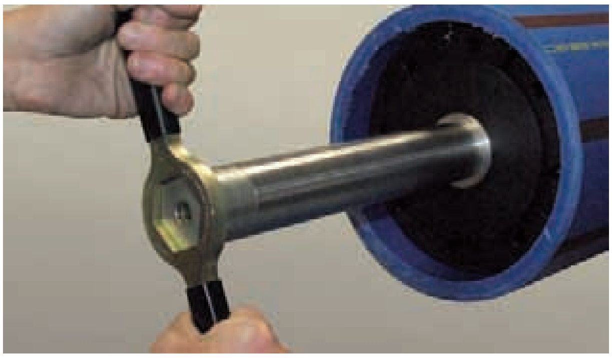
For Protecta-Line sizes above 180mm, the Surprep Scraper is a dedicated tool for each pipe size, with the cutter set to produce the required outside diameter. Adjustments must be done by a competent person and should not be carried out on site.

1. First mark the required length of pipe to be scraped (see table on page 64).

   Ensure that the correct size collet for the pipe to be scraped is fitted to the mandrel.

   Adjust the collet by twisting the mandrel shaft anti-clockwise until it achieves its smallest outside diameter.

   Slide the collet into the bore of the pipe, allowing 20mm of pipe to show after the collet, to allow for the barrelling effect found at the end of the pipe.



2. Adjust the collet by twisting the mandrel shaft clockwise until the mandrel becomes secure in the bore of the pipe and tighten with the mandrel spanner.

   To achieve the correct alignment parallel to the pipe bore, a joggling action in all directions is required.

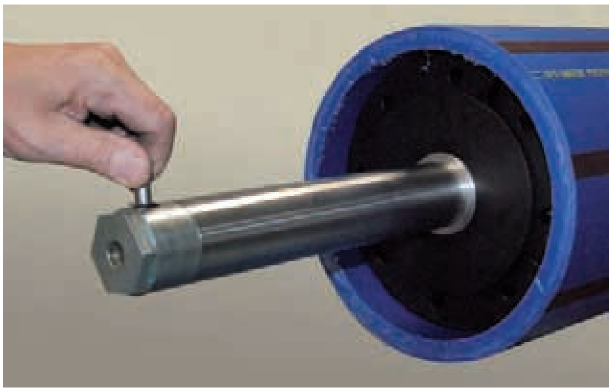
   The collet also acts to re-round the pipe so check for gaps between the collet and the bore of the pipe.

	225mm	250mm	280mm	315mm	355mm
Pipe insert collet					
01-07-255	●				
01-07-256		●			
01-07-257			●		
01-07-258				●	
01-07-259					●
Rotary tool c/w mandrill shaft*					
01-07-251	●	●	●	●	●

* Includes 2 collet expanding cones

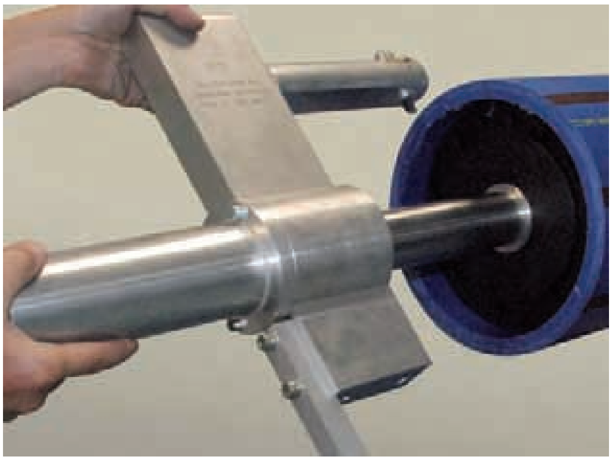
To order, please contact Caldervale directly on 01924 469571 or sales@caldertech.co.uk

The Large Diameter Scraper is available for hire through MCA Hire Services www.mcahire.com and Plant & Site Services Ltd www.psshire.com



3. Once the mandrel is secure and is parallel with the pipe bore, screw down the quick release screw to its full extent (about one and a half turns) using the adjuster, which is stored at the base of the tip arm support block.

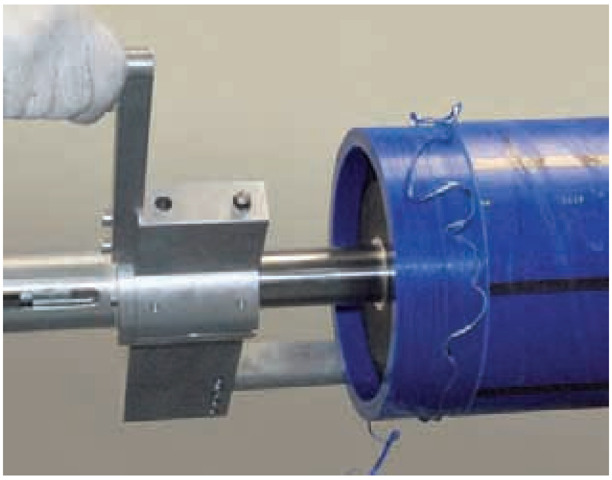
   Note: Remember the position of the quick release screw.



4. Ensure that the tip holder arm has been located in the hole corresponding to the pipe size in the tip holder support block.

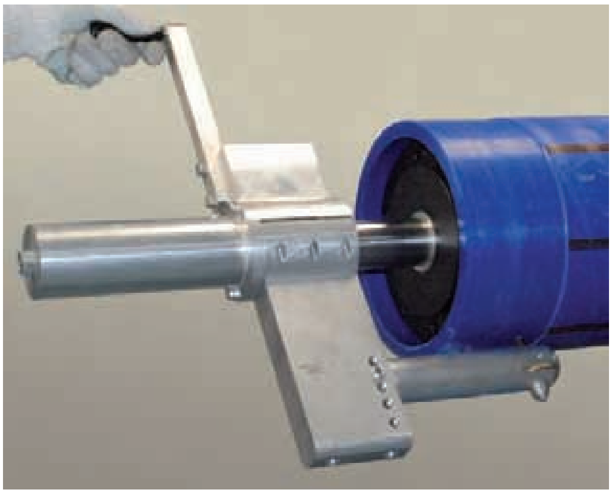
   Locate the tool onto the mandrel shaft taking care not to damage the bore of the tool.

   Slowly slide the tool along the mandrel shaft using a twisting action, until the feed screw touches the quick release feed screw nut.



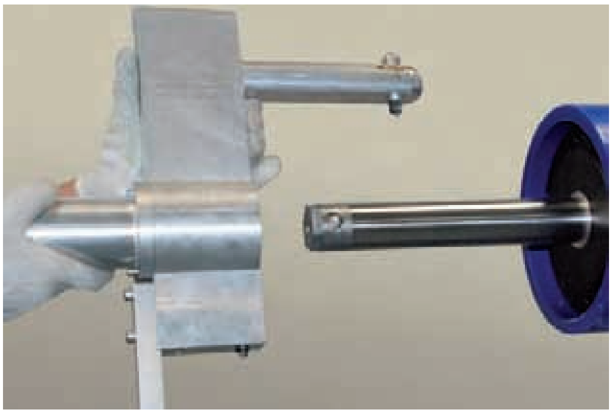
5. Taking care to avoid damaging the quick release nut and feed screw, rotate the tool in a clockwise direction with a slight force pushing forward.

   Once the feed screw has engaged with the quick release nut, it will now proceed to travel along the length of the mandrel shaft, removing the outer barrier layers and preparing the pipe for electrofusion jointing.



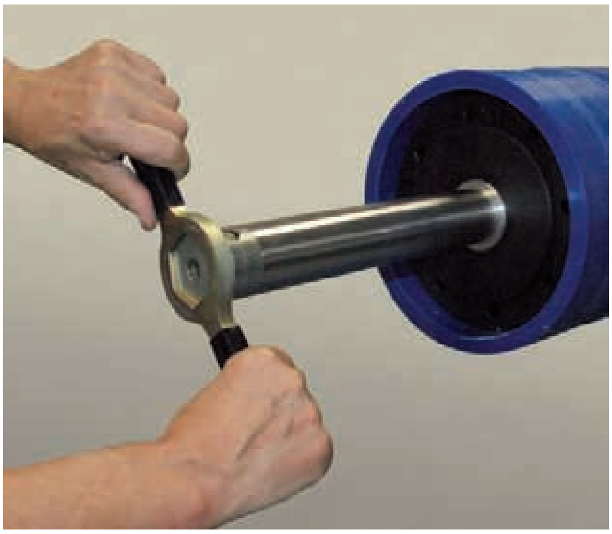
6. When the required length of pipe has been prepared, raise the quick release screw to its top position (about one and a half turns).

   The quick release screw can be accessed through the slot in the feed screw housing tube.



7. The tool can now be removed from the mandrel shaft.

   Note: The tool should be removed to a clean dry and safe area.



8. Loosen the collet using the mandrel spanner on the mandrel shaft in an anti-clockwise direction until free.

9. Remove the collet and mandrel from the pipe.

   The collet should be removed to a clean dry and safe area.

   If there are any areas of pipe that have not been prepared properly, then the hand scraper should be used to complete the preparation process.

   Note: The barrelling effect found at the end of the pipe may result in the barrier layers remaining on the pipe surface for a short distance in from the end of the pipe.

Basic Principles of Skin Removal for Electrofusion

The outer pipe skin should be removed by a pipe exposure tool, which comprises of a guidance platform/body, cutter and head. The cutter features an anvil to limit the depth of cut and avoid damage to Secura-Line's core pipe. The tool is supplied with full operating and maintainance instructions, but the basic principles are set out below. It is necessary in the first instance to use a downward pushing action to penetrate the pipe skin, followed by a pulling action for cutting. The guidance platform is omnidirectional (works in all directions), but the cutter may be readily rotated to facilitate a change in direction of cut, without lifting from the pipe – however, always rotate the cutter and handle in a clockwise direction to maintain position of the cutter under the skin.

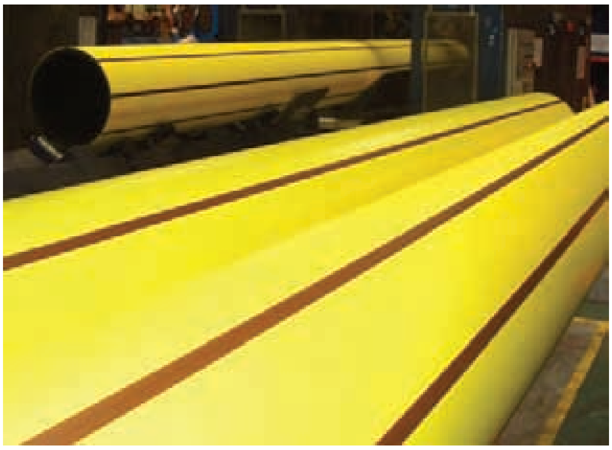
Preparation method for pipe ends prior to jointing

1. Hold the fitting against pipe end and mark the Secura-Line skin at a distance from the pipe end equal to the half of the coupler length plus 10mm.
2. Align the pointed side of the handle in a circumferential direction and press the blade into the Secura-Line skin where marked. Pull the tool around the pipe circumference keeping the cutting distance from the end of the pipe constant (a guide is provided with the tool).
3. When the cutter meets up with its starting position turn through 90 degrees and push or pull to the end of the pipe.
4. Lift, peel back and discard skin without touching the pipe surface underneath.
5. Do not touch the exposed pipe surface with your hands or with any rags.
6. Continue the jointing procedure in the normal way as for standard PE pipes (from paragraph 5 on page 36).
7. Should the exposed pipe become contaminated, continue the jointing procedure in the normal way as for standard PE pipes (from paragraph 4 on page 36).

Preparation method for installation of Electrofusion Tees and Branching Saddles.

1. With the fitting still in its bag, place the fitting on top of the pipe in the desired position.
2. Mark north, south, east and west positions around the fitting on the pipe, using a suitable marker pen.
3. Remove the fitting and extend the lines to draw a square on the pipe where the fitting will be joined.
4. Using the Pipe Exposure Tool, push the cutter head into the pipe skin.
5. Once the PP skin has been pierced, pull the tool (by holding the platform) towards you along the full length of the line marked.
6. At the end of the line, rotate the tool to the right (by holding the platform) always working clockwise around the marked area.
7. Repeat along all marked lines.
8. Upon completion, remove the polypropylene skin. Do not touch the exposed pipe surface with your hands or with any rags.
9. Continue the jointing procedure for standard PE pipes (see page 43/44).

Note: It is recommended that for complete joint security the saddle fusion area should be thoroughly scraped.



Push-Fast System

General

The Water Industry has traditionally used spigot and socket joints for buried mains, the pressure tight seal being affected by a rubber ring seal contained within the socket. Such methods are employed for ductile iron and PVC-U pipework.

Notwithstanding the reliable methods of welding polyethylene pipe and fittings, the need still exists for a pipework system which offers the advantages of polyethylene material but which still employs conventional spigot and socket jointing techniques.

Recognising this need, GPS offers the Push-Fast System in blue and black Excel® (PE100) material and in PE sizes from 90mm to 250mm. Unlike most of the conventional spigot and socket systems Push-Fast incorporates a 'grip' ring. Made from a hard thermoplastic material the 'grip' ring enables the Push-Fast joint under most circumstances to withstand the end-loads induced, initially by the test pressure, and subsequently by the continuous working pressure, up to a maximum of 16bar. This largely eliminates the need for thrust blocks, while still allowing simple low force jointing. This system is covered by a GPS patent. Please consult our technical support department for advice when Push-Fast is to be installed above ground or might be pressure tested before back filling, especially where there are changes in direction or when pressures above 10 bar are likely for diameters above 180mm.

Section through Push-Fast assembled joint showing grab ring in taper and elastromeric seal.

The System

The basic element of the Push-Fast system is the specially designed patented socket. Standard 6m lengths of pipe are supplied with a factory welded socket on one end.

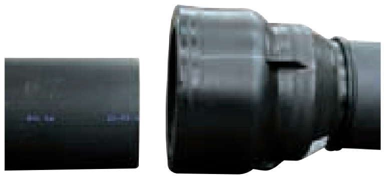
A range of complementary fittings is available with plain, socketed or flanged ends, based on Long Spigot fittings.

Jointing Procedure

It is important to remember that the performance of the Push-Fast joint depends on the efficiency of the seal between the elastomeric sealing ring, the pipe and the socket. Damage to the pipe or fitting or the presence of dirt or grit will adversely affect the performance of the joint.

Factory fitted protective packaging should be left in position until the components are ready for use.

1. Remove protectors from spigots and sockets and inspect for damage. Particular attention should be given to any scoring of the spigot. Scored spigots must be cut back to an undamaged section.



2. Push-Fast pipes are supplied with a factory machined chamfer. Any site cut pipes should be cut square and similarly chamfered.

3. Inspect the elastomeric sealing ring, and the respective locating grooves for any damage and replace if necessary. If dirt or grit is present, the seal must be removed and the seal groove and socket thoroughly cleaned of all foreign matter before refitting the components.
4. Similarly inspect the 'grip' ring and groove. Clean as necessary to remove any foreign matter but do not remove the 'grip' ring from the socket groove.
5. When all components are clean, care must be taken to ensure that they remain clean by replacing protectors or plastic bags over the ends unless jointing is to be carried out immediately.
6. The spigot ends of any site cut pipes should be marked with the insertion depth, using a suitable marker pen, as follows:

Pipe size mm	Insertion depth mm
90	155
110	130
125	145
160	195
180	200
225	230
250	250

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7. Apply the GPS Push-Fast lubricant, spray or gel, to the spigot, and to the grip ring and the elastomeric sealing ring in the socket. Typical usage of lubricant is as follows:

Pipe size mm	No. of joints per 400g spray/500g gel
90	100
110	80
125	60
160	30
180	30
225	25
250	20

8. Align the pipe and fitting and enter the spigot into the mouth of the socket. Apply sufficient force to the end of the pipe/fitting remote from the joint so that the spigot enters the socket up to the marked insertion depth. Smaller sizes should be entered using hand applied force, whereas assistance of a crowbar purchasing on a wooden block may be necessary for the larger sizes.
9. Under no circumstances must joints be pushed home using mechanical equipment, ie. a digger bucket.
10. The final stage of the installation is to activate the Push-Fast joint. This is easily done following insertion by sharply withdrawing the inserted pipe end from the socket to ensure the grip ring engages with the pipe surface and locks in position.

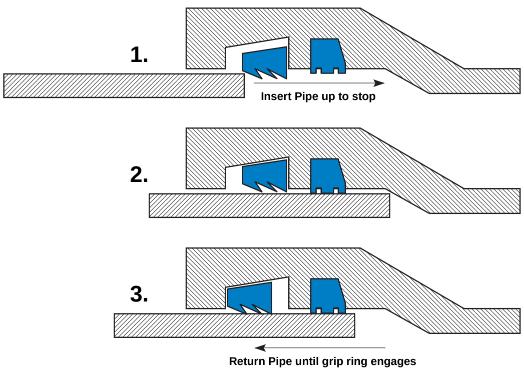


Figure 1. Push-Fast Insertion Procedure

11. Once the pipe has been inserted and locked the pipe and socket should not be disturbed.

Installation Notes

1. The action of inserting the pipe into the socket can cause the grip ring to “float” in its groove without locking onto the pipe therefore it may not engage fully unless subject to manual tensile loading or rapid slight axial movement during pressurisation.
2. Excessive use of lubricant on the joint may prevent the joint from locking correctly, particularly if the lubricant is highly viscous in texture. GPS PE Pipe Systems supply a recommended silicon lubricant and silicon gel for this application.
3. Once the pipe has been inserted and locked, the pipe and socket should not be disturbed. Particular care should be taken not to move previously locked joints when progressively jointing pipe to socket along a pipe run. If any back-to-back Push-Fast sockets are employed this is especially important and a suitable fixing point must be applied to the fitting or the second pipe insertion will disturb the first pipe insertion. If this happens it should be possible to re-lock both pipes by sharply withdrawing the pipe from the second end. It is very important that the joint should not be further disturbed.

Pressurisation

During pressurisation the pipe is ejected, piston like from the fitting (up to 30mm of displacement pre fitting is normal). This initial displacement serves to lock the grip ring, which will then resist further movement. Depending on the characteristics of each installation, the cumulative movement of pipe over a long run during pressurisation will always be less than the sum of the individual socket displacements. This is due to incremental pipe length reduction on pressurisation (otherwise known as creep).

Large Diameter Push-Fast Installation

With large diameter Push-Fast (200mm, 225mm and 250mm), one or both of the following strategies must be used to ensure joint integrity. In either case pressurisation of one short section of pipe

at a time is recommended.

1. Ensure that the pipe cannot deviate from the line of the pipe run during pressurisation. Sideways movement or bending enables the pipe to be ejected from the socket with low resistance. If the pipe run is not straight, bends should be fixed in position.
2. Pressurise as quickly as possible to encourage locking of the grip ring. A long slow pressurisation can cause the pipe to be ejected past the grip ring without being locked into position.

Above Ground Installation

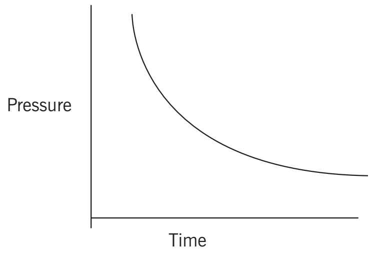
It is imperative that sufficient pipe supports of the correct type are used in above ground installations to prevent pipe sagging. These should be positioned as to generally permit axial movement. Changes in pipe direction require sufficiently strong fixings to prevent any lateral movements. Resistance to axial movement may also be required depending on the system layout. Pipe termination (generally at a fixed point) requires high end-load resistance.

Water Mains

The traditional testing procedures used for most pipeline materials, which are generally satisfactory for linearly elastic materials, are not suitable, without modified analysis procedures, for visco elastic materials such as polyethylene.

Pipe made from such visco elastic materials exhibit creep and stress relaxation.

When a polyethylene pipeline is sealed off under a test pressure there will be a reduction in pressure (pressure decay), EVEN in a leak free system, due to the visco elastic (creep) response of the material. This pressure decay is non-linear in an unconstrained pipe.



Typical pressure decay curve for an unrestrained PE pipeline

BS EN 805 gives advice on different pressure test methods, which may be used to assess pipelines for leakage. A review of these methods has resulted in the publication of IGN 4-01-03 – "Pressure Testing of Pressure Pipes and Fittings for Use by Public Water Suppliers" for the Water UK Standards Board, which adopts a single test methodology for both PE and PVC pipelines. Note: This IGN is only applicable to pipe systems which form part of a water supplier's distribution network.

Test Pressure

As recommended in BS EN 805, standard test pressure (STP) should always be 1.5 times the rated pressure of the lowest rated component of the system or the rated pressure of the lowest rated component plus 5 bar, whichever is the least. Where mechanical fittings are incorporated into the system the test pressure should be limited to 20 barg.

STP should apply at the lowest elevation of the pipeline under test. The pipeline should not initially be subjected to any pressure when filling from the mains supply as this may affect the test result. Polyethylene pipelines must not be pressure tested unless the wall temperature is kept to below 30°C; this includes open trench situations.

For charging the pipeline it should be ensured that the pump is of sufficient capacity to raise the pressure to STP (rise time) within 10 – 20 minutes, since the total test time is related to the rise time. To enable a precise analysis of the pressure test data, pressure transducers with a logging facility and display should be used.

Test Section

There is no technical reason for the length of pipeline under test to be limited. Successful pressure decay tests have been performed on a 5km length of 1400mm PE pipe.

The length of test section is usually governed primarily by mains elevation, test duration, number of fittings in the system, availability of water for charging the pipeline and facilities for subsequent disposal after testing.

BS EN 805 recommends a preliminary test phase to stabilize the pipeline and allow for saturation where water absorbing pipeline materials are concerned. However, IGN 4-01-03 advises that no preliminary test is either required or desired for PE pipes.

Pressure Test Method

On reaching the test pressure (STP), and satisfying the conditions for minimal air entrapment, the pipeline is isolated and the pressure allowed to decay. Experience shows that retesting can be more difficult to carry out because the pipe has already stretched due to creep from the pressure originally applied. It is therefore of extreme importance to ensure that air is removed prior to testing.

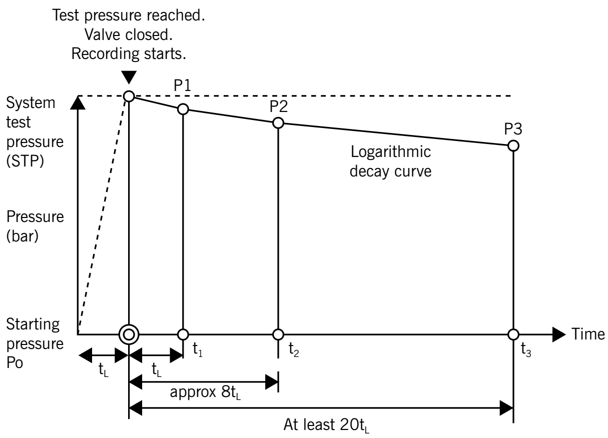
To enable an assessment of air entrapment to be made, equipment used for charging the pipeline should incorporate a suitably calibrated flowmeter with data logging capability.

A minimum test duration of one hour or twenty times the rise time, whichever is the greater, should be allowed.

Test Procedure - IGN 4-01-03

The pressure loading time or rise time to achieve test pressure (t_L) is used as a reference and the natural pressure decay readings are recorded at pre-determined times (multiples of t_L).

These time intervals are between t_L and 8 t_L (t_1 to t_2) and between 8t_L and 20t_L (t_2 to t_3).



Diagrammatic illustration of a sequence of pressure readings

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Take a first reading of pressure P_1 at t_1, where t_1 is equal to the pressure loading time t_L.

Take a second reading of pressure P_2, at a decay time of approximately $8t_L$ this is time t_2.

Take a third reading of pressure P_3 at a decay time of not less than 20 t_L this time is t_3.

Where there is a significant static head on the pipeline, then this can affect the results of the test and consequently pressure values used in the following calculations, should be those referenced to the initial start pressure (P_0).

PA = Current Pressure (P) – Start Pressure (P_0)

$$PA_1 = P_1 - P_0$$
$$PA_2 = P_2 - P_0$$
$$PA_3 = P_3 - P_0$$

Also a correction to the decay times is required to account for the time spent raising the pressure.

Where t_1 corrected $t_{1C} = t_1 + 0.4t_L$

t_2 corrected $t_{2C} = t_2 + 0.4t_L$

t_3 corrected $t_{3C} = t_3 + 0.4t_L$

Calculate the slopes (n) of the decay curve between the two time intervals. As the pressure decay is of exponential form the use of logarithms is necessary when comparing readings but the use of a pocket calculator is all that is required for 'on site' calculations.

$$n_1\ (t_1 - t_2) = \frac{\log PA_1 - \log PA_2}{\log t_{2C} - \log t_{1C}}$$

$$n_2\ (t_2 - t_3) = \frac{\log PA_2 - \log PA_3}{\log t_{3C} - \log t_{2C}}$$

It is to be expected that the pressure decay (n) values should be between 0.07 and 0.09. Values of (n) may sometimes range between 0.06 and 0.10 influenced to some degree by backfill compaction and air content. Values of (n) below 0.06 could indicate excessive pre-charging. Where there is an increase of slope with time, then leakage is indicated and if the longer term slope exceeds 0.13 then the decay rate is exceptionally high.

No great significance should be given to the values for (n) stated above which are given as a guide. Pipeline leak-tightness may only be confirmed by assessment of the decay profile. For a secure pipeline the pressure will decay with a constant logarithmic slope and any consistent increase in slope during the test would indicate leakage.

If the values are significantly less than the minimum identified, then there is too great a volume of air in the pipeline. This air will have to be removed before a satisfactory test can be performed.

If at any stage during this pressure test an unacceptable leak is indicated, it is advisable to check all mechanical fittings before visually inspecting the welded joints. Any defect in the installation revealed by the test should, of course, be rectified and the test repeated.

On completion of a test sequence the remaining pressure should be released slowly until the pipeline is under its pre-test conditions.

In the event of a further test being required on the pipeline, such a test should NOT be attempted before sufficient time has elapsed for the pipeline to recover from the previously imposed conditions. This recovery time will depend upon individual circumstance but a period equivalent to 5 times the previous test period may be taken as a guide.

Commissioning

The commissioning of new or repaired supply and distribution mains is normally carried out in the following sequence:

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

The sequence for PE should include these basic procedures but may be adapted to meet particular conditions (eg. pre-chlorination of sliplined mains). In all cases the procedures must comply with the requirement of the local Water Undertaking.

Service pipes should be tested with the ferrule connected to the main but before the cutter taps into the main.

After being tested, all service pipes must be subjected to a final disinfection process before being introduced into the water supply system. Guidance is given in the Water UK publication, "Principles of water supply hygiene and technical guidance notes". The water utility should be consulted with regard to their disinfection policy for service connections.

Special attention should be paid to the proper sterilisation of those services laid to hospitals and renaldialysis machines.

For further support concerning specific installations, please contact our Technical Support Department.

Pressure Testing - Gas

Pressure testing procedures vary according to utility; it is advisable that the regulations of the relevant body are referred to. The following general guidelines are based on the procedures of the Institute of Gas Engineers.

All new mains and services should be pressure tested before being commissioned. This includes any part of the pipeline which has been renewed or altered. It is important that the same test instrument is used for initial, intermediate and final pressure readings.

Any pressure testing of a polyethylene pipeline has to allow for 'creep'. This is the phenomenon whereby a PE pipe will relax when pressurised leading to a small increase in volume and a decrease in internal pressure.

There are two types of pressure test; hydrostatic and pneumatic. For mains and services which will operate above 2bar a hydrostatic pressure test should be followed by a pneumatic test, for mains and services with an operating pressure less than 2bar a pneumatic test only should be sufficient.

Hydrostatic Pressure Testing

This is carried out before a pneumatic pressure test. The mechanical integrity of a main or service is determined by completely filling the pipeline to be tested with water which is then pressurised.

When using this technique the engineer should avoid excessive test pressures which may occur due to hydrostatic head at low lying points.

An initial test pressure of 350mbar should be applied prior to the main test in order to ensure the general integrity of the system.

If the main is being filled by gravity, thought should be given to the need to vent air at high points and to allow water removal at low points. Also, excessively aerated water should not be used. Wherever possible water should be introduced into the pipeline at the lowest point.

An uninterrupted, even flow of water should be used to completely fill the pipe. This should not take place if the air temperature is 2°C or less or likely to drop to such a level.

Once water has been pumped into the pipe, the temperature should be allowed to stabilise prior to pressurising to the test level (refer to relevant governing body). This test pressure should be applied to the highest point of the pipe and checked with a gauge.

Regular re-pressurisation is necessary before the start of the test period in order to permit creep to take place. Once this has elapsed the test period can begin.

Pressure and ground temperature should be recorded at regular intervals (e.g. every 15 minutes) during the test period.

The pressure test is passed if there is no pressure loss recorded or if there is a constant or declining pressure decay rate which does not exceed 5% of the test pressure per hour.

If the results do not meet the above criteria, it is advisable to extend the test period to allow more data to be collected.

Following the test, the water must be removed, usually by the use of air propelled pigs. Dry pigs should then be put through the system until the pipe is deemed dry enough by the engineer.

Pneumatic Pressure Testing

This is a leakage test that simulates the system at its maximum operating pressure under gas conditions. When conducting this type of test account must be taken of barometric pressure.

For pipes greater than 63mm, stand pipes and gauges, should be connected at the ends of the new main and include a pressure relief valve (see figure 1). Air should be introduced into the main until the correct test pressure is attained.

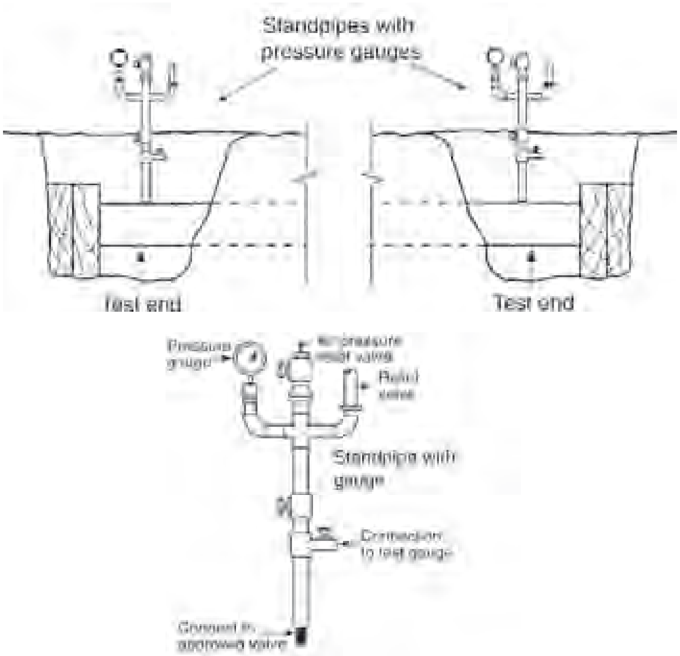


Figure 1. Pneumatic pressure testing of gas mains

Before the start of the test period, the temperature of the air should be allowed to stabilise.

At the start of the test period a pressure reading should be taken followed by another reading at the end. If the period is long, it may be wise to take several readings during the test. In this way, any early indication of probable test failure avoids the need to run for the full period.

When completed, air should be vented in a controlled manner until the main is at atmospheric pressure.

For pipes of a diameter not greater than 63mm, and of low pressure (not greater than 75 mbar), air is introduced into the service through the meter control valve, which is left open whilst the opposite end of the service, at the electrofusion tapping tee, is securely blanked off. For medium pressure (greater than 75 mbar not greater than 2 bar) and intermediate pressure (greater than 2 bar, but not greater than 7 bar) the test is from the main to the inlet valve of the service governor.

The pressure in the service should be increased to the relevant value.

The test period should be as recommended by the relevant governing body. No pressure loss is permissible.

For low pressure services, once a successful test has been completed, the meter control valve should be closed, the test apparatus detached and the integrity of the meter control valve tested. The pressure can then be released from the electrofusion tapping tee end.

Leakage Detection

The pipeline should be dosed with a suitable tracing agent (eg. sulphur hexafluoride or ethyl mercaptan – usage instructions must be followed carefully) and pressurised to 350mbar. The length of the pipe should then be checked using a suitable detection device. Once the leak(s) has/have been located, the pipe should be repaired and all pressure tests repeated.

Temperature Effects

Pressure changes with temperature and any calculations must consider this. To reduce temperature variations as much as possible the pipe trench should be backfilled.

Test Equipment Availability

For further details of pressure testing, please contact our Technical Support Department.

Repair Section Including Squeeze-Off

Where a repair is required remote from valves or where it would be too expensive to empty the pipe line, the flow of the contents in a polyethylene pipe can be arrested by using equipment that squeezes the pipe walls together. This method was developed by the UK Gas Industry in the early 1980s. The squeeze-off equipment comprises of two tangential bars to apply pressure to the outside of the pipe. The bars are moved together, manually or hydraulically, squeezing the pipe material until a seal is formed where the upper and lower walls meet. Manual tools are used up to and including 90mm, with Hydraulic jacks used to provide the necessary force to compress the pipe wall for sizes 110mm and above. Hydraulic tools have a spring return for the jack and locking pins to prevent accidental release of pressure during operation. Built in rotatable ‘check plates’ protect the pipe from damage from over compression. These plates can be exchanged to allow the tool to be used with the many sizes of metric and imperial pipe that exist.

Testing has shown that all types of polyethylene pipes can split during squeeze-off, if there is damage in the region of the pinch points, therefore prior to squeeze off it is absolutely essential that the pipe surfaces in the region of the pinch points are carefully inspected and are completely free of any surface damage before squeeze off commences.

Polyethylene pipes with peelable skins must have the skin removed with the appropriate peeling tool, to a distance of 0.5 pipe diameters either side of the squeeze off location prior to commencing squeeze off.

Protecta-Line pipe can be squeezed off, however, as a precaution GPS recommends that after re-rounding, in addition to any reinforcement bands that might be fitted (depending on diameter), previously squeezed off areas should be wrapped with Protecta-Line aluminium tape followed by a proprietary waterproof petrolatum tape (equivalent to Denso™).

Where the pipe wall is compressed the polyethylene pipe will be severely deformed in the regions of maximum compression. PE100 polyethylene material will also discolour due to stress whitening.

Following squeeze-off, the pipe will eventually regain its original shape after the release of the squeeze-off equipment, however re-rounding equipment is available to assist restoring pipe circularity. It is recommended not to force the pipe back to a round shape more quickly than necessary, especially in cold weather.

The following important points should be noted

- Specifically designed equipment fitted with the correct ‘check plates’ should be used to avoid over compression of the pipe.

For SDR 13.6 pipe the following check plates should be used:

63mm pipe - 55mm SDR 11 or 90mm SDR17.6 stop

75mm pipe - 63mm SDR11 stop

- The procedure must not be carried out within 3 pipe diameters of a fitting, a fusion joint or a previous squeeze-off operation.
- The squeeze-off procedure should not normally be used on pipes larger than 500mm diameter.
- The pipe surfaces in the region of the pinch points, should be carefully inspected for any damage prior to squeeze-off.
- Peelable pipes must also first have the skin removed as detailed above.

After the squeeze-off procedure is complete the pipe must be

- Inspected and re-rounded if necessary
- Renewed if there are any signs that the pipe is damaged ie splitting or cracking
- Recorded and marked as having been squeezed-off.

Tests which have been carried out by external test laboratories have indicated that satisfactory long-term performance can be achieved on previously squeezed-off and re-rounded pipes of various wall thicknesses.

Individual Utility Companies may limit the maximum diameter of pipe that can be squeezed-off and/or may require the use of stainless steel reinforcement bands above certain diameters.

Further details are given in IGE/TD/3 Ed4:2003 or the WRc Polyethlene Pipe Systems for Water Supply Manual.

Push-Fast Repairs/Alterations

The most satisfactory and safest method of effecting alterations or repairs to a Push-Fast system is to follow the procedure previously described using the GPS DuraFuse electrofusion techniques.

A repair or slip coupler is included in the Push-Fast range, however, the design of the coupler is such that it will not withstand end thrust loadings. This may therefore cause complications where a system has initially been installed without the provision of anchors or thrust blocks.

In addition, repair or slip couplers **must not** be used to repair long runs of polyethylene pipes as the joint is unlikely to accommodate the axial movement that may occur.

There is also the possibility that the pipe outer surface may have been damaged or scored to the extent that positive sealing cannot be achieved.

However, having checked that the above situations do not or will not arise, the following procedure should be followed:

1. Cut out the damaged section over a sufficient length to ensure that the remaining pipe surface is not damaged but in any event to a minimum of 600mm.
2. Ensure the pipe ends are square and chamfer the ends.
3. Clean the outer surfaces of pipe on each exposed end of the main being repaired for at lest the equivalent length of the slip coupler.
4. Using a suitable marker pen, mark each pipe end to half the depth of the coupler.
5. Lubricate these two ends and push a slip coupler over each end until the pipe ends touch the second elastromeric sealing ring.
6. Cut a new length of pipe to fit between the ends of the repair coupler. Again check that the ends of this pipe are also cut square and are chamfered.
7. Lubricate the ends of the new pipe and place in position.
8. Pull the slip couplers back over the new length of pipe until the insertion depth marks are just visible.

Push-Fast fittings are not available in service sizes. DuraFuse electrofusion fittings have to be used as do DuraFuse electrofusion tapping tees to achieve service connections to the main.

Repair Using Electrofusion

The pipe stops incorporated in the DuraFuse couplers are shearable and have been provided for the specific purpose of using the fittings for making repairs or breaking into existing pipelines.

Standard PE Pipes Repairs

The procedure, shown diagrammatically in fig.1: is as follows:

1. Cut out the damaged section of pipe and ensure the pipe is cut square.
2. Measure the distance (L) between the exposed pipe ends and cut the pipe length to be inserted equal to the measured distance less 10mm.
3. Clean the pipe ends for a distance slightly greater than the overall length of the coupler.
4. Scrape the pipe ends, as previously described, but for the overall length of the coupler.

Note: The use of mechanical end preparation tools is preferred as hand scraping requires great care and can be time-consuming especially on larger diameter pipes. It is essential that material is removed by scraping or peeling: scratching or abrading is not sufficient.

5. Remove the pipe stops in the coupler. This can be most satisfactorily achieved by placing one end of a **thoroughly cleaned** short length of pipe into the coupler and striking the other end onto a hard surface. The pipe stops can also be removed using a sharp knife, but care must be taken not to damage the bore of the fitting.
6. Using a suitable marker pen, draw a mark on each end of the pipe to be inserted which will be used to indicate where the mouth of each socket of the coupler should be positioned prior to fusion.
7. Check the jointing areas are clean and dry, use isopropanol wipes if necessary.
8. Care should be taken to ensure any of the residual water in the mains is not allowed to come into contact with the electrofusion area. It may not be possible to maintain a clean dry area, in such cases the couplings should be mechanical such as Push-Fast fittings.
9. Place the repair couplers over the exposed length of the installed main and slide these away from each other to allow the new pipe to be inserted between the exposed ends.
10. Insert the new pipe and align.
11. Slide the couplers towards each other as shown in the diagrams ensuring that the socket mouths line up with the marks on the pipe.
12. Carry out the normal jointing procedure as described in the previous section.

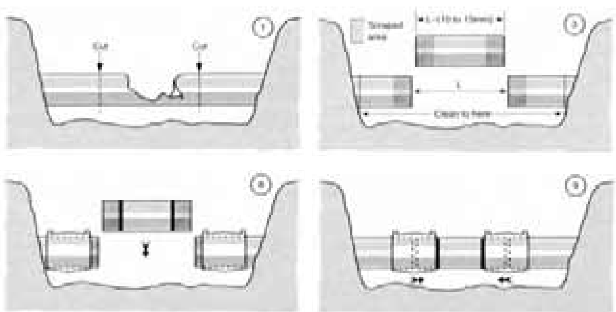


Figure 1.

Note: Stub Flange Assemblies may be used where there is a risk of water in the pipe contaminating joints during installation (see page 80).

Protecta-Line Repairs (225mm-355mm)

The pipe stops incorporated in the Protecta-Line or DuraFuse couplers are shearable and have been provided for the specific purpose of using the fittings for making repairs or breaking into existing pipelines.

1. Cut out the damaged section of the Protecta-Line pipe at least four times the length of the electrofusion repair couplers and ensure the pipe ends are cut square.
2. Measure the distance between the exposed pipe ends and cut a length of plain PE100 pipe of the same diameter and wall thickness as the existing Protecta-Line pipe, equal to the measured distance less 10mm ensuring that the pipe ends are cut square
3. Clean the ends of the cut section of plain pipe, for a distance slightly greater than the overall length of the repair couplers.
4. Using the pipe end preparation tool, remove the entire surface of the pipe over the marked area, preferably as a continuous ribbon or strip. **Note: The use of mechanical end preparation tools is preferred as hand scraping requires great care and can be time-consuming especially on larger diameter pipes. It is essential that material is removed by scraping or peeling; scratching or abrading is not sufficient.**
5. Remove the pipe stops in the coupler. This can be most satisfactorily achieved by placing one end of a **thoroughly cleaned** short length of pipe into the coupler and striking the other end onto a hard surface. The pipe stops can also be removed using a sharp knife, but care must be taken not to damage the bore of the fitting.
6. Clean the ends of the Protecta-Line pipe for repair and prepare for electrofusion jointing using the Protecta-Line Suprep Scraper as described on pages 67 and 68.
7. Using a suitable marker pen, draw circumferential lines half the length of the repair coupler on the prepared Protecta-line pipe ends which will be used to indicate the location of each repair coupler prior to fusion.
8. Care should be taken to ensure any residual water in the mains is not allowed to come into contact with the electrofusion area.
9. Insert the new plain section of pipe with repair couplers and then slide the repair couplers onto the Protecta-Line pipe ends, ensuring that they are positioned up to the marks on the prepared Protecta-Line pipe ends. Ensure that the surfaces are clean and dry.
10. Carry out the electrofusion jointing procedure as described in the GPS Installation & Technical Guidelines brochure - GP-IT005.

Repairs to Protecta-Line Using Stub Flange Assemblies

Alternatively, stub flange assemblies may be fitted to the ends of the Protecta-Line pipe (after preparation with the Protecta-Line Surprep Scraper) and then connected with a double flanged ductile iron spacer.

This method may be used where there is a risk of water in the pipe contaminating electrofusion joints during installation. Foam pigs can be used to temporarily seal the pipe bore. When electrofusion jointing of the stub flange assemblies has been completed, they can be removed before installation of the double flanged ductile iron spacer.

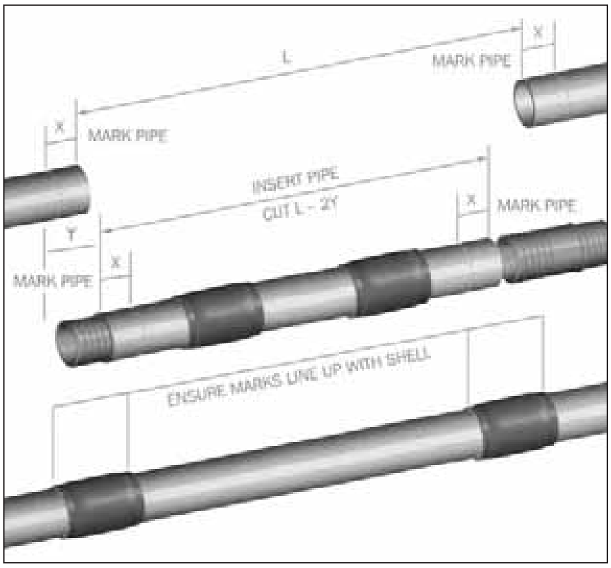
Squeeze-off of Protecta-Line pipe
Protecta-Line pipe can be squeezed off in the industry-approved way, as summarised in the GPS Installation and Technical Guidelines. However, as a precaution after re-rounding previously squeezed off areas should be wrapped with Protecta-Line aluminium tape followed by a proprietary waterproof petrolatum tape (equivalent to Denso™), in addition to any reinforcement bands that may be required to be fitted. For information on acceptable usage conditions refer to Table 9.2 in the WRc PE Pipe Systems Manual version 01/02.

When made in accordance with GPS PE Pipe Systems' recommended procedures, butt-fusion and electrofusion joints of the Protecta-Line system have been independently shown to meet the requirements of WIS 4-32-19 without any need for subsequent wrapping. This does not exempt installers from local regulations and the local Water Company preferences must be adhered to.

Jointing Instructions for Protecta-Line Fluid Compression Repair Fittings

63mm Repair Couplers

Gloves and Safety Glasses must be worn during the whole assembly process



Pipe Diameter	X	2Y	Min 'L'
63	47	108	400

- Remove damaged Protecta-Line pipe section. The length removed, L, must be at least as long as stated in the table.
- Mark pipe ends left in the ground 'X' mm from ends using the repair gauge and marker pen.
- Cut length of new Protecta-Line pipe L - 2Y long and also mark 'X' mm in from each end. Note Y = insert liner spigot shorter length + shoulder.
- Slide 2 repair shells over the new pipe section and push the longer spigots of the associated insert liners into both ends of this section.
- Position the new pipe section in line with the existing pipe in the ground and move both the insert liners outwards until their shoulders are hard against the cut ends of the existing pipe.
- Slide the two repair shells outwards so that the four marks previously made line up with the ends of the shells.
- Both repair fittings are now ready to be pressurised as per above.

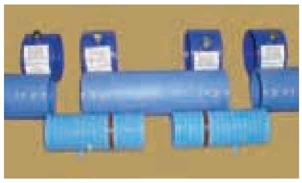
90–180mm Repair Couplers

Gloves and Safety Glasses must be worn during the whole assembly process

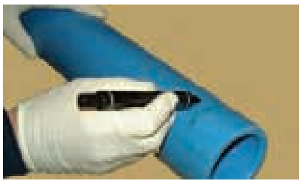
1. Cut out the damaged pipe section. The minimum length of the cut is shown in the table below.

2. The pipe should be internally deburred with a polyethylene deburring tool.

3. Where there is evidence that the pipe spigot has some degree of ovality, then the pipe spigot should be re-rounded.



4. From an undamaged pipe length cut out a repair piece. The length of the repair piece should be equal to the length of the cut out less the dimension 'Y' (see table below).



5. Clearly mark the penetration depth (dimension 'Z') on spigot ends (see table below).

6. Clearly mark dimensions on the new pipe.

7. Push the repair coupler inserts into the pipe with the short end of the repair couplers protruding. Ensure that the pipe ends are firmly against the stops on the inserts. Slide the repair coupler half shells on to the new pipe.

8. Slide the remaining half shells onto the pipe where the repair coupler inserts are to be fitted and insert the repair section with inserts into the pipeline. Slide the repair couplers and shells into position.

9. Ensure that the shells line up with the marks on the pipe. The joint is now ready to be pressurised. Please follow pressurisation procedure.

Pipe Diameter	Cut out Length (Min)	Dimension Y	Dimension Z
90	390	128	66
110	440	145	75
125	525	168	85
160	570	182	92
180	690	235	117

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Acknowledgement
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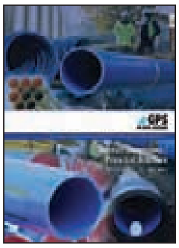

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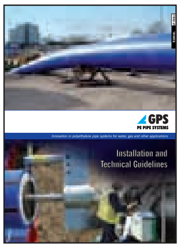

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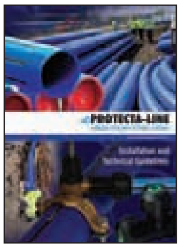
Installation and Technical Guidlines



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Protecta-Line Installation and Technical Guidlines

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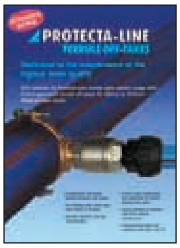

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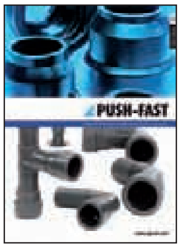

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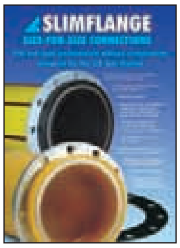

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SlimFlanges for Gas

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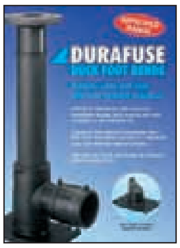

G0010

DuraFuse Duck Foot Bends

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