POLYETHYLENE PIPES SYSTEMS

Innovation in polyethylene pipe systems for water, cable ducts and other applications

DOSHI

Doshi Enterprise Ltd is part of the Doshi Group of companies, a manufacturer and supplier of quality pipeline solutions.

With a comprehensive choice of cost effective pipeline products and associated tooling, all of which conform to the highest British, European and International standards, Doshi provide total peace of mind solutions which will be reliable for years to come.

Benefits of PE

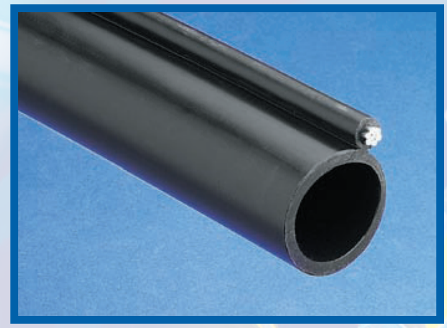
Polyethylene, unlike traditional materials, is able to offer a whole host of unique qualities that ot only save valuable time and money, but also ensure long-term reliability and efficiency:

- Light-weight – reduces health and safety risk of injury and cost of expensive equipment to handle heavy items.
- Non corrodible material provides long term reliability and offers an extended pipeline life span.
- 100 year design life provides overall life cost savings.
- Flexible material – Permits coiling, ideal for trenchless installation and reduces number of joints. Excellent surge resistance.
- Smooth internal bore ensured efficient supply capability is sustained.
- Ideal for areas where ground movement occurs such as earthquake regions
- Suitable for aggressive ground conditions – such as sharp objects and shingle
- Offers excellent chemical resistance.
- Fully end load bearing - No thrust blocks or anchors required.
- Good insulator – permits system design flexibility in low temperature climates.

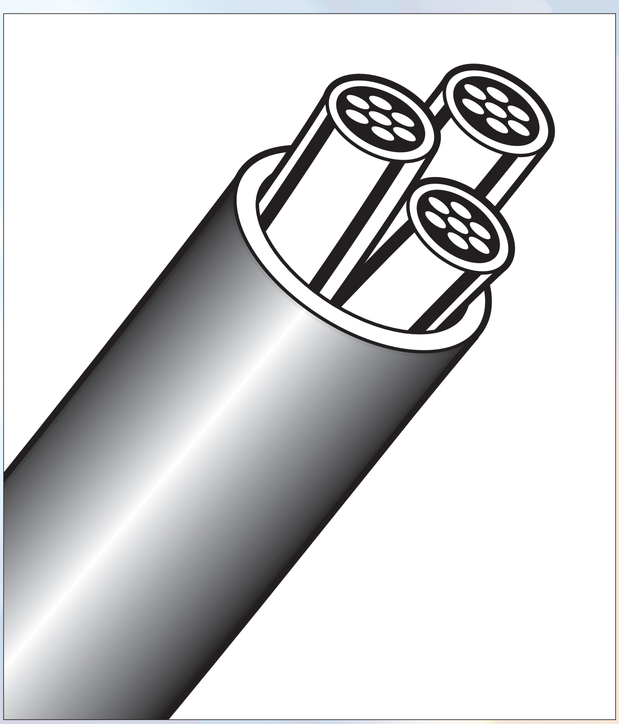
The flexibility and inherent longevity of PE means significant costs savings can be achieved through reduced maintenance and operational costs.

DOSHI PE products offer the most comprehensive and cost effective design solution for pipeline installations.

HIGH DENSITY POLYETHYLENE (HDPE) CONDUIT / DUCT



Telecommunication, Electrical, and Power Utility
Solutions: Smooth Wall Ribbed Wall Listed HDPE Aerial Aerial Figure 8 Corrugated Toneable Accessories



HDPE Duct is designed for the installation and protection of cables. It provides a channel for the cables to be installed into empty or occupied duct structures using jetting, blowing or pulling installation methods.

Features

- Manufactured from P3408 pressure resin rated at 3300 PSI.
- Sizes: 10 mm, 12 mm, and 16 mm
- Low sliding friction to aid in the pulling and jetting of Micro-Gard and micro-cables
- High tensile strength material for longer pulling distances
- Variety of colors/ stripes for identification - paralleling available
- Sequential marked footage
- Pre-installed pull line available (10 mm and larger)
- UV-formulated material for outside storage
- Complete line of fittings and accessories

DOSHI POLYETHYLENE

PE Pressure Pipes

For water supply
- EN 12201
- ISO 4427

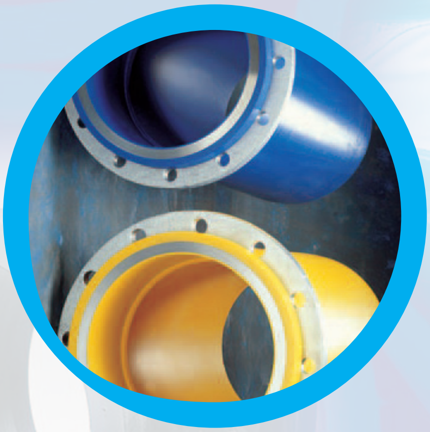
	SDR 33	SDR 26	SDR 21	SDR 17	SDR 13.6	SDR 11	SDR 9	SDR 7,4
	S 16	S 12,5	S 10	S 8	S 6,3	S 5	S 4	S 3,2
SN (kN/m^2)	SN 2	SN 4	SN 6	SN 16	SN 32	SN 64	SN 80	SN 128
PE 80 (c=1,6) MOP (bar)	**PN 3.2**	**PN 4**	PN 5	**PN 6***	PN 8	PN 10	PN 12.5	PN 16
PE 80 (c=1,25) MOP (bar)	PN 4	PN 5	PN 6*	PN 8	**PN 10**	PN 12.5	PN 16	PN 20
PE 100 (c=1.25) MOP (bar)	PN 5	PN 6*	PN 8	**PN 10**	PN 12.5	**PN 16**	**PN 20**	PN 25
Nominal outside diameter								
d_v	**en**	**en**	**en**	**en**	**en**	**en**	**en**	**en**
mm	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**
16							2.0	2.3
20						2.0	2.3	3.0
25					2.0	2.3	3.0	3.5
32				2.0	2.4	3.0	3.6	4.4
40			2.0	2.4	3.0	3.7	4.5	5.5
50		2.0	2.4	3.0	3.7	4.6	5.6	6.9
63		2.5	3.0	3.8	4.7	5.8	7.1	8.6
75		2.9	3.6	4.5	5.6	6.8	8.4	10.3
90		3.5	4.3	5.4	6.7	8.2	10.1	12.3
110		4.2	5.3	6.6	8.1	10.0	12.3	15.1
125		4.8	6.0	7.4	9.2	11.4	14.0	17.1
140		5.4	6.7	8.3	10.3	12.7	15.7	19.2
160		6.2	7.7	9.5	11.8	14.6	17.9	21.9
180		6.9	8.6	10.7	13.3	16.4	20.1	24.6
200		7.7	9.6	11.9	14.7	18.2	22.4	27.4
225		8.6	10.8	13.4	16.6	20.5	25.2	30.8
250		9.6	11.9	14.8	18.4	22.7	27.9	34.2
280		10.7	13.4	16.6	20.6	25.4	31.3	38.3
315	9.7	12.1	15.0	18.7	23.2	28.6	35.2	43.1
355	10.9	13.6	16.9	21.1	26.1	32.2	39.7	48.5
400	12.3	15.3	19.1	23.7	29.4	36.3	44.7	54.7
450	13.8	17.2	21.5	26.7	33.1	40.9	50.3	61.5
500	15.3	19.1	23.9	29.7	36.8	45.4	55.8	
560	17.2	21.4	26.7	33.2	41.2	50.8		
630	19.3	24.1	30.0	37.4	46.3	57.2		
710	21.8	27.2	33.9	42.1	52.2			
800	24.5	30.6	38.1	47.4	58.8			
900	27.6	34.4	42.9	53.3				
1000	30.6	38.2	47.7	59.3				
1200	36.7	45.9	57.2	70.6				
1400	42.9	53.5						
1600	49.0	61.2						

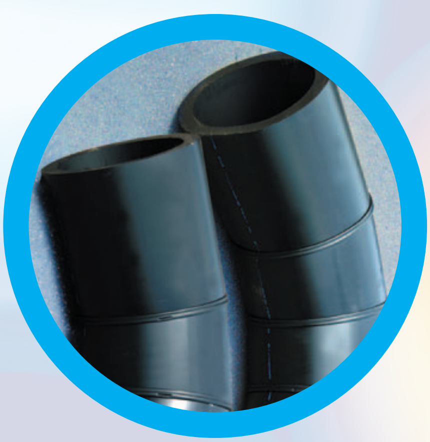
***The calculated value for PE 80 pipes is 6.3. bar and for PE 100 pipes 6.4 bar**

Definitions

d_n	mm	nominal outside diameter
en	mm	nominal wall thickness
SN	kN/m^2	ring stiffness
MOP	bar	max. operating pressure
PN	bar	nominal pressure
c		overall service coefficient
SDR		standard dimension ratio dn/en
S		pipe series

DOSHI POLYETHYLENE PRODUCTS





DOSHI offers complete piping systems manufactured primarily from polyethylene for pressure applications.

The advantages of polyethylene pressure pipe systems have been appreciated in the gas and water industries and by general industrial users for many years. Polyethylene's toughness, immunity from corrosion, excellent resistance to chemicals and light weight have contributed to its continued appeal for use in situations where cost-effective and reliable systems are required.

Polyethylene pipes from DOSHI offer the following advantages:

- *Wide choice of systems.*
- *Up to 16bar rated at 20ºC when carrying water and certain other liquids.*
- *Up to 10bar rated at 20ºC when carrying natural gas.*
- *Ease of use.*

Polyethylene systems from DOSHI are manufactured to meet the exacting tandards imposed by gas and water bodies.

DOSHI polyethylene systems are available in different colours and are offered in high quality PE80 polymer, formerly known as MDPE (Medium Density Polyethylene) and PE100 formerly known as HPPE (High Performance Polyethylene).

DOSHI POLYETHYLENE

MATERIAL PROPERTIES & COMPATIBILITY

Materials

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

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.

PE100 – This is a term used to denote high performance polyethylene, and is a higher density material than PE80 and demonstrates exceptional resistance to rapid crack propagation as well as to long-term stress cracking.

Moreover, the higher performance of **PE100** permits thinner pipe walls than **PE80** for the same operating pressure. It therefore 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 PE100 are not recommended for continuous pressure operation at temperatures above 60°C for liquids, including sewerage and industrial effluents, or 30°C for gaseous fluids. PE100 (Excel) has advantages over PE80 at low temperatures, since it is extremely crack resistant down to -30°C.

Property	Method of Test	Units	PE80	PE100
Melt flow rate - 2.16kg load	BS2782 ISO 1133	g/10min	0.2	<0.15
5kg load	BS2782 ISO 1133	g/10min	1.0	<0.5
Density (Mean Values)	BS3412 ISO 1872	kg/m^3	yellow 940 blue 943 black 950	orange 951 blue 951 black 957
Tensile strength at yield	BS2782 ISO R527	MPa	18	23
Elongation at break	BS2782 ISO 527	%	>600	>600
Flexural Modulus	BS2782 ISO R527	MPa	700	1000
Vicat softening point	BS2782	°C	116	124
Brittleness Temperature	ASTM D746 ISO 9784	°C	<–70	<–100
Linear thermal expansion	ASTM D696	°C	1.5 x 10^{-4}	1.3 x 10^{-4}
Thermal conductivity	BS874 DIN 52612	W/m°K	0.4	0.4

MATERIAL PROPERTIES & COMPATIBILITY

Standard Dimensional Ratio (SDR)

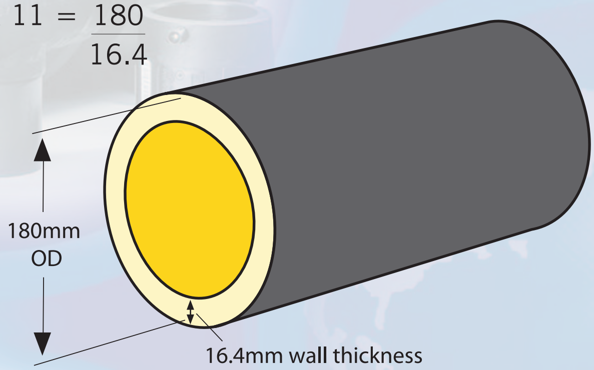
One of the items of information contained on both pipe and fittings is the standard dimensional ratio.

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:

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

Example:

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



Relationship between wall thickness and outside diameter (OD)

Expansion and Contraction

The average coefficients of linear thermal expansion between 20°C and 60°C for PE80 (1.3 x 10-4 ºC-1) and PE100 (1.5 x 10-4 ºC1) 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 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 allowance 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.

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

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**	**SDR26**
32mm	0.9		
63mm	1.1		
90mm	1.3	1.2	
110mm	1.5	1.3	
125mm	1.6	1.4	
160mm	1.8	1.6	1.5
180mm	1.9	1.7	1.6
200mm	2.0	1.8	1.7
225mm	2.1	1.9	1.8
250mm	2.2	2.0	1.9
280mm	2.3	2.1	2.0
315mm	2.5	2.3	2.1
355mm	2.6	2.4	2.2
400mm	2.8	2.5	2.3
450mm	2.9	2.7	2.5
500mm	3.1	2.8	2.6
560mm	3.3	3.0	2.8
630mm	3.5	3.2	2.9
710mm		3.4	3.1
800mm		3.6	3.3
900mm		3.8	3.5
1000mm		4.0	3.7

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

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 or drums, the above bend radius values apply only if pipe is bent in the same direction as it was previously coiled.

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.

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. 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 PE pipe. However in the unlikely event of a notch or groove being cut into the external surface by more than 10 per cent of the wall thickness, the pipe section should be rejected.

Chemical Resistance - General

Polyethylene material 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.

Oils: animal; vegetable or mineral such as petrol, creosote, turpentine and silicone fluids.

Organic solvents: petrol and diesel; amylacetate and other esters; acetaldehyde; benzene and its compounds; carbon disulphide; carbon tetrachloride; chloroform; dichlorethylene; trichlorethylene; ethers and turpenes; coal tar.

Halogens: fluorine; chlorine; bromine in high concentrations.

Acids: glacial acetic acid; chlorosulphonic acid; cresylic acid; chromic acid; nitric acid (over 25%); phosphoric acid (over 50%) and sulphuric acid (over 70%).

CHEMICAL RESISTANCE OF HIGH DENSITY POLYETHYLENE PIPE REAGENTS A THROUGH Z

S - Satisfactory
U - Unsatisfactory
M - Marginal
N - Not known

All concentrations are 100% unless noted otherwise. On reagents marked marginal, chemical attack will be recognized by a loss of physical properties of the pipe which may require a change in design factors.

Reagent	70 deg. F (21 deg. C)	140 deg. F (60 deg. C)
Acetic Acid 1-10%	S	S
Acetic Acid 10-60%	S	M
Acetic Acid 80-100%	S	M
Acetone	M	U
Acrylic Emulsions	S	S
Aluminum Chloride-Dilute	S	S
Aluminum Chloride Conc.	S	S
Aluminum Fluoride Conc.	S	S
Aluminum Sulfate Conc.	S	S
Alums (All Types) Conc.	S	S
Ammonia 100% Dry Gas	S	S
Ammonium Carbonate	S	S
Ammonium Chloride Sat'd	S	S
Ammonium Fluoride 20%	S	S
Ammonium Hydroxide 0.8S S.G.	S	S
Ammonium Metaphosphate Sat'd	S	S
Ammonium Nitrate Sat'd	S	S
Ammonium Persulfate Sat'd	S	S
Ammonium Sulfate Sat'd	S	S
Ammonium Sulfide Sat'd	S	S
Ammonium Thiocyanate Sat'd	S	S
Amyl Acetate	M	U
Amyl Alcohol 100%	S	S
Amyl Chloride 100%	N	U
Aniline 100%	S	N
Antimony Chloride	S	S
Aqua Regia	U	U
Barium Carbonate Sat'd	S	S
Barium Chloride	S	S
Barium Hydroxide	S	S
Barium Sulfate Sat'd	S	S
Barium Sulfide Sat'd	S	S
Beer	S	S
Benzene	M	U
Benzene Suffonic Acid	S	S
Bismuth Carbonate Sat'd	S	S
Bleach Lye 10%	S	S
Black Liquor	S	S
Borax Cold Sat'd	S	S
Boric Acid Dilute	S	S
Boric Acid Conc.	S	S
Bromic Acid 10%	S	S
Bromine Liquid 100%	M	U

CHEMICAL RESISTANCE OF HIGH DENSITY POLYETHYLENE PIPE REAGENTS A THROUGH Z

Reagent	70 deg. F (21 deg. C)	140 deg. F (60 deg. C)
butanediol 10%	S	S
butanediol 60%	S	S
butanediol 100%	S	S
butyl Alcohol 100%	S	S
Calcium Bisulfide	S	S
Calcium Carbonate Sat'd	S	S
Calcium Chlorate Sat'd	S	S
Calcium Chloride Sat'd	S	S
Calcium Hydroxide	S	S
Calcium Hypochlorite RRGH	S	S
Calcium Nitrate 50%	S	S
Calcium Sulfate	S	S
Camphor Oil	N	U
Carbon Dioxide 100% Dry	S	S
Carbon Dioxide 100%Wet	S	S
Carbon Dioxide Cold Sat'd	S	S
Carbon Disulfide	N	U
Carbon Monoxide	S	S
Carbon Tetrachloride	M	U
Carbonic Acid	S	S
Castor Oil Conc.	S	S
Chlorine Dry Gas 100%	S	M
Chlorine Moist Gas	M	U
Chlorine Liquid	M	U
Chlorobenzene	M	U
Chloroform	M	U
Chlorosulfonic Acid 100%	M	U
Chrome Alum Sat'd	S	S
Chromic Acid 20%	S	S
Chromic Acid Up to 50%	S	S
Chromic Acid and Sulfuric Acid	S	M
Cider	S	S
Citric Acid Sat'd	S	S
Coconut Oil Alcohols	S	S
Cola Concentrates	S	S
Copper Chloride Sat'd	S	S
Copper Cyanide Sat'd	S	S
Copper Fluoride 2%	S	S
Copper Nitrate Sat'd	S	S
Copper Sulfate Dilute	S	S
Copper Sulfate Sat'd	S	S
Cottonseed Oil	S	S
Crude Oil	S	M
Cuprous Chloride Sat'd	S	S
Cychohexanol	S	S
Cyclohexanone	M	U
Detergents Synthetic	S	S
Developers, Photographic	S	S
Dextrin Sat'd	S	S
Dextrose Sat'd	S	S
Dibutylphthalate	S	M
Disodium Phosphate	S	S
Diazo Salts	S	S
Diethylene Glycol	S	S
Diglycolic Acid	S	S

Reagent	70 deg. F (21 deg. C)	140 deg. F (60 deg. C)
Dimethylamine	M	U
Emulsions, Photographic	S	S
Ethyl Acetate 100%	M	U
Ethyl Alcohol 100%	S	S
Ethyl Alcohol 35%	S	S
Ethyl butyrate	M	U
Ethyl Chloride	M	U
Ethyl Ether	U	U
Ethylene Chloride	U	U
Ethylene Chlorohydrin	U	U
Ethylene Dichloride	M	U
Ethylene Glycol	S	S
Ferric Chloride Sat'd	S	S
Ferric Nitrate Sat'd	S	S
Ferrous Chloride Sat'd	S	S
Ferrous Sulfate	S	S
Fish Solubles	S	S
Fluoboric Acid	S	S
Fluorine	S	U
Fluosilicic Acid 32%	S	S
Fluosilicic Acid Conc.	S	S
Formaldehyde 40%	S	N
Formic Acid 0-20%	S	S
Formic Acid 20-50%	S	S
Formic Acid 100%	S	S
Fructose Sat'd	S	S
Fruit Pulp	S	S
Fuel Oil	S	U
Furfural 100%	M	U
Furfuryl Alcohol	M	U
Gallic Acid Sat'd	S	S
Gas Liquids	S	M
Gasoline	M	U
Gin	S	U
Glucose	S	S
Glycerine	S	S
Glycol	S	S
Glycolic Acid 30%	S	S
Grape Sugar Sat'd Aq.	S	S
Hexanol, Tert.	S	S
Hydrobromic Acid 50i/O	S	S
Hydrocyanic Acid Sat'd	S	S
HydrochloricAcld 10%	S	S
Hydrochloric Acid 30%	S	S
Hydrochloric Acid 35%	S	S
Hydrochloric Acid Conc.	S	S
Hydrofluoric Acid 40%	S	S
Hydrofluoric Acid 60%	S	S
Hydrofluoric Acid 75%	S	S
Hydrogen 100%	S	S
Hydrogen Bromide 10%	S	S
Hydrogen Chloride Gas Dry	S	S
Hydrogen Peroxide 30%	S	S
Hydrogen Peroxide 90%	S	M
Hydrogen Phosphide 100%	S	S

CHEMICAL RESISTANCE OF HIGH DENSITY POLYETHYLENE PIPE REAGENTS A THROUGH Z

Reagent	70 deg. F (21 deg. C)	140 deg. F (60 deg. C)
Hydroquinone	S	S
Hydrogen Sulfide	S	S
Hypochlorus Acid Conc.	S	S
Inks	S	S
Lodine (Alc. Sol.) Conc.	S	U
Lactic Acid 10%	S	S
Lactic Acid 90i/0	S	S
Latex	S	S
Lead Acetate Sat'd	S	S
Lube Oil	S	M
Magnesium Carbonate Sat'd	S	S
Magnesium Chloride Sat'd	S	S
Magnesium Hydroxide Sat'd	S	S
Magnesium Nitrate Sat'd	S	S
Magnesium Sulfate Sat'd	S	S
Mercuric Chloride Sat'd	S	S
Mercuric Cyanide Sat'd	S	S
Mercurous Nitrate Sat'd	S	S
Mercury	S	S
Methyl Alcohol 100%	S	S
Methyl Bromide	M	U
Methyl Chloride	M	U
Methyl Ethyl Ketone 100%	M	U
Methylsulfuric Acid	S	S
Methylene Chloride 100%	M	U
Milk	S	S
Mineral Oils	S	U
Molasses Comm.	S	S
Nickel Chloride Sat'd	S	S
Nickel Nitrate Conc.	S	S
Nickel Sulfate Sat'd	S	S
Nicotine Dilute	S	S
Nicotinic Acid	S	S
Nitric Acid 0-30%	S	S
Nitric Acid 30-50%	S	M
Nitric Acid 70%	S	M
Nitric Acid 95-98%	U	U
Nitrobenzene 100%	U	U
Octyl Cresol	S	U
Oils and Fats	S	M
Oleic Acid Conc.	S	U
Oleum Conc.	U	U
Orange Extract	S	S
Oxalic Acid Dilute	S	S
Oxalic Acid Sat'd	S	S
Ozone 100%	S	U
PerchloncAcid 10%	S	S
Petroleum Ether	U	U
Phenol 90%	U	U
Phosphoric Acid Up to 30%	S	S
Phosphoric Acid Over 30%	S	S
Phosphoric Acid 90%	S	S
Phosphorous (Yellow) 100%	S	N
Phosphorus Pentoxide 100%	S	N
Photographic Solutions	S	S

Reagent	70 deg. F (21 deg. C)	140 deg. F (60 deg. C)
Pickling Baths		
• Sulfuric Acid	S	S
• Hydrochloric Acid	S	S
• Sulfuric-Nitric	S	U
Plating Solutions		
• Brass	S	S
• Cadmium	S	S
• Chromium	N	N
• Copper	S	S
• Gold	S	S
• Indium	S	S
• Lead	S	S
• Nickel	S	S
• Rhodium	S	S
• Silver	S	S
• Tin	S	S
• Zinc	S	S
Potassium Bicarbonate Sat'd	S	S
Potassium Borate 1%	S	S
Potassium Bromate 10%	S	S
Potassium Bromide Sat'd	S	S
Potassium Carbonate	S	S
Potassium Chlorate Sat'd	S	S
Potassium Chloride Sat'd	S	S
Potassium Chromate 40%	S	S
Potassium Cyanide Sat'd	S	S
Potassium Dichromate 40%	S	S
Potassium Ferri/Ferro Cyanide Sat'd	S	S
Potassium Fluoride	S	S
Potassium Hydroxide 20%	S	S
Potassium Hydroxide Conc.	S	S
Potassium Nitrate Sat'd	S	S
Potassium Perborate Sat'd	S	S
Potassium Perchlorate 10%	S	S
Potassium Sulfate Conc.	S	S
Potassium Sulfide Conc.	S	S
Potassium Sulfite Conc.	S	S
Potassium Persulfate Satd	S	S
Propargyl Alcohol	S	S
Propyl Alcohol	S	S
Propylene Dichloride 100%	U	U
Propylene Glycol	S	S
Rayon Coagulating Bath	S	S
Sea Water	S	S
Selenic Acid	S	S
Shortening	S	S
Silicic Acid	S	S
Silver Nitrate Sol.	S	S
Soap Solution Any Conc'n	S	S
Sodium Acetate Sat'd	S	S
Sodium Benzoate 35%	S	S
Sodium Bicarbonate Sat'd	S	S
Sodium Bisulfate Sat'd	S	S
Sodium Bisulfite Sat'd	S	S
Sodium Borate	S	S

CHEMICAL RESISTANCE OF HIGH DENSITY POLYETHYLENE PIPE REAGENTS A THROUGH Z

Reagent	70 deg. F (21 deg. C)	140 deg. F (60 deg. C)
Sodium Bromide Dilute Sol.	S	S
Sodium Carbonate Con.	S	S
Sodium Carbonate	S	S
Sodium Chlorate Sat'd.	S	S
Sodium Chkoride Sat'd	S	S
Sodium Cyanide	S	S
Sodium Dichromate Sat'd	S	S
Sodium Ferncyanide	S	S
Sodium Ferrocyanide Sat'd	S	S
Sodium Fluoride Sat'd	S	S
Sodium Hydroxide Conc.	S	S
Sodium Hypochlorite	S	S
Sodium Nitrate	S	S
Sodium Sulfate	S	S
Sodium Sulfide 25%	S	S
Sodium Sulfide Sat'd Sol.	S	S
Sodium Sulfite Sat'd	S	S
Stannous Chloride Sat'd	S	S
Stannic Chloride Sat'd	S	S
Starch Solution SaUd	S	S
Steanc Acid 100%	S	S
Sulfuric Acid 0-50%	S	S
Sulfuric Acid 70%	S	M
Sulfuric Acid 80%	S	U
Sulfuric Acid 96%	M	U
Sulfuric Acid 98%	M	U
Sulfuric Acid, Fuming	U	U
Sulfurous Acid	S	S
Tallow	S	M
Tannic Acid 10%	S	S
Tanning Extracts Comm.	S	S
Tartaric Acid Sat'd	N	N
Tetrahydrofurane	N	U
Titanium Tetrachloride Sat'd	N	U
Toluene	M	U
Transformer Oil	S	M
Trisodium Phosphate Sat'd	S	S
Trichloroethylene	U	U
Urea Up to 30%	S	S
Urine	S	S
Vinegar Comm.	S	S
Vanilla Extract	S	S
Wetting Agents	S	S
Whiskey	S	N
Wines	S	S
Xylene	M	U
Yeast	S	S
Zinc Chloride Sat'd	S	S
Zinc Sulfate Sat'd	S	S

Jointing PE to PE by Fusion
PE pipes of different SDRs

Butt-welding
Butt-welding should only be used for jointing pipes of the same SDR value.

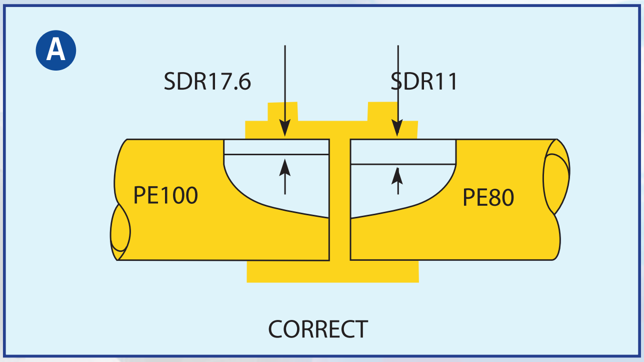
Electrofusion
Electrofusion fittings are able to weld pipes having differing wall thicknesses (SDRs). They are available in a choice of 10bar or 16bar (water) and 5.5bar or 7bar (gas) rating. Care should be taken to ensure that the pressure rating of the fittings is equal to or greater than that of the 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
Any medium density PE80 can be joined to any other medium density PE80 either by butt-welding or electrofusion. 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 in like fashion. Butt-welding different pipe materials - for example, PE80 to PE100 - is not recommended on site (see below).

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.

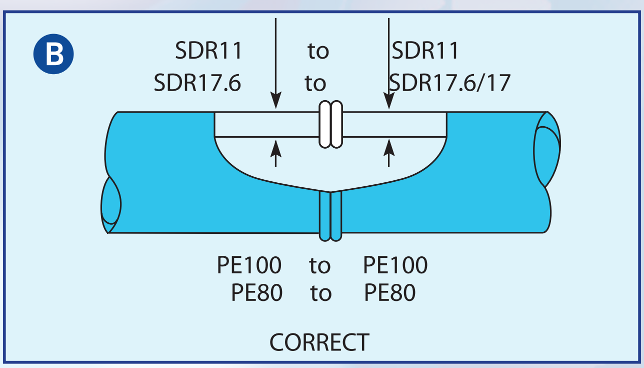
See Figure A.



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

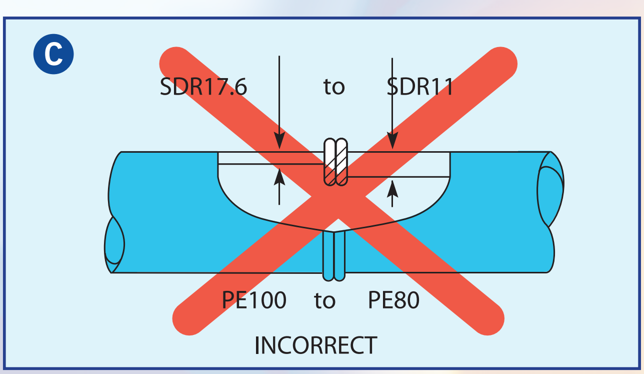
NB. SDR17 may be butt-fused to SDR17.6.

See Figure B.



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

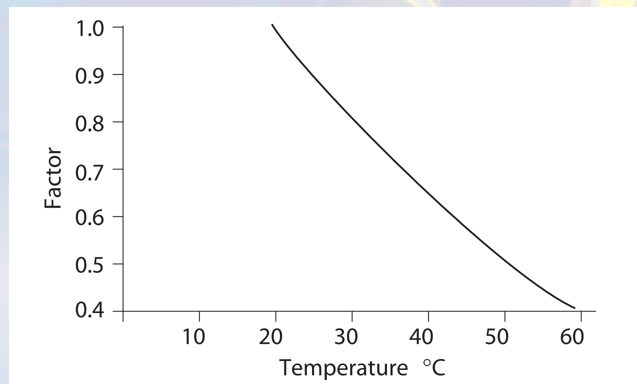
See Figure C.



PRESSURE RATINGS AND 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. These factors will account for any additional loadings or environmental conditions, eg. elevated temperature or exceptionaly poor ground conditions.

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.

Surge and fatigue in PE80 and PE100 pipes

The two phenomena of surge and fatigue may be treated separately, since they describe different potential effects on the pipe material.

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 below (see also the Notes) which can be used to re-rate PE pipes according to material toughness and the predicted frequency excursions in the system:

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

PIPE OD * PIPES SPECIFICALLY SIZED FOR INSERTION LINING APPLICATIONS	SDR11				SDR17.6(GAS) / SDR17 (WATER)		SDR17	SDR21	SDR27
	PE80		PE100		PE80		PE100	PE100	PE100
	GAS	WATER	GAS	WATER	GAS	WATER	WATER	WATER	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	8.0	6.0
268mm*									
280mm		12.5		16.0		8.0	10.0	8.0	6.0
315mm	3.4	12.5	7.0	16.0	2.7	8.0	10.0	8.0	6.0
355mm	3.1	12.5	7.0	16.0	2.5	8.0	10.0	8.0	6.0
400mm		12.5	7.0	16.0	2.3	8.0	10.0	8.0	6.0
450mm		12.5	7.0	16.0	2.2	8.0	10.0	8.0	6.0
469mm*									
500mm		12.5	7.0	16.0	2.1	8.0	10.0	8.0	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

- DOSHI CAN USUALLY OFFER SDRs OTHER THAN THOSE SHOWN IN THE TABLE, E.G. FOR CLOSE FIT LINING APPLICATIONS
- THERE MAY BE A REQUIREMENT TO DE-RATE MITRED BENDS FOR WATER APPLICATIONS
- PE80 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 GAS PIPE PRESSURES MUST BE FURTHER DERATED FOR TEMPERATURES BELOW 0 DEGREES C.
- THE VALUES IN THE ABOVE TABLE DO NOT ADDRESS ANY OTHER SAFETY-RELATED ISSUES ASSOCIATED WITH PIPELINE DESIGN.

Daily number of Pressure Transients	Low Toughness PE80 & 100 Re-rating factor	High Toughness GPS PE80 & 100 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.
- GPS PE80 and PEI00 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).

N.B. 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.

Example

A PE100 system operating at a steady state pressure of 5bar is expected to experience cyclic transient pressure variations between Obar and 16bar 1200 times per day. From the table, a pipe pressure rating PN of at least 8bar should be specified [i.e. 16 (=the pressure variation in bar) X 0.5 (=the re-rating factor)].

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 flow nomogram. The GPS nomogram is based on the Colebrook White formula for water at 10°C using a hydraulic roughness factor K for new pipework of 0.003mm.

The pressure drop at a given flow rate can be determined as follows:

1. Obtain the internal bore diameter of the pipe to be used by referring to the dimensions tables.
2. Mark this diameter on Scale A.
3. Mark the required flow rate on Scale B.
4. Draw a straight line connecting the points on Scales A and B and extend the line to cross Scales C and D.
5. The velocity of flow in metres per second is determined from the intersection with Scale C.
6. The frictional head loss in metres per 100 metres of pipe can then be read off Scale D.

Fittings

The calculation of pressure drop in fittings is more complex, but calculations can be made for equivalent lengths of straight pipe using the Formula E = Fxd where:

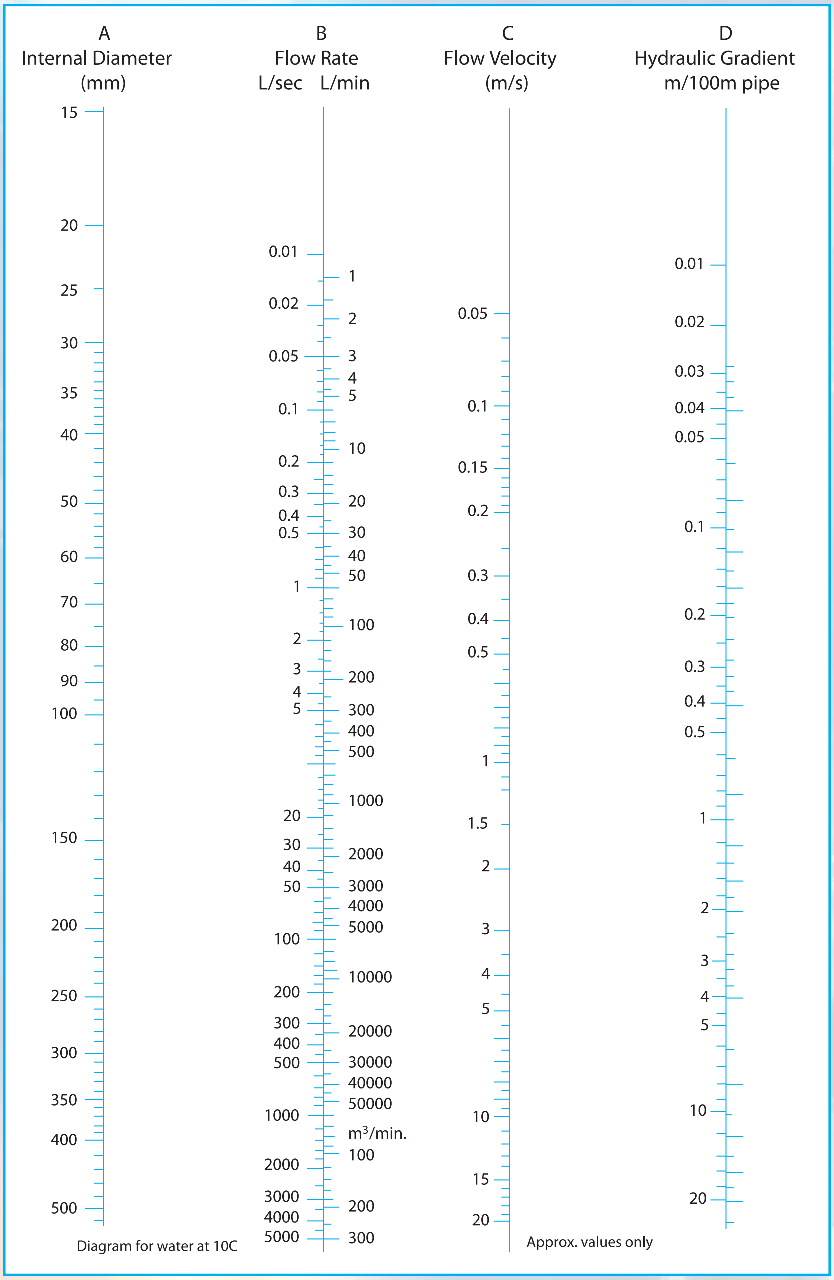
E = equivalent pipe length (metres)
F = fittings constant (See below)
d = fitting internal diameter (mm)

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

Flow Nomogram



NOTE: For sizes not covered by the nomogram, please contact Technical Support Department

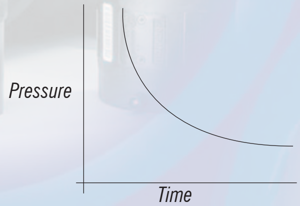
PRESSUER TESTING - WATER

Water mains

The traditional testing procedures used for most pipeline materials hroughout the Water Supply Industry is given in BSI CP 312:Part 3:1973: Section 10.

These procedures, 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 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

A pressure test procedure has been developed by WRc to enable interpretation of the effects of creep and stress relaxation.

For PE pipe systems the test pressures should always be a maximum of 1.5 times the rated pressure of the lowest rated component and/or 20bar maximum if any mechanical fittings are present. With these provisos the test pressure should be 1.5 times the pipe rated pressure when this is up to 10bar, and 1.5 times the mean working pressure of the system for pipes rated at 12.5 bar and above.

Pressure Test

On reaching the test pressure, and satisfying the conditions for minimal air entrapment, the pipeline is isolated and the pressure allowed to decay. The pressure loading time (t1) to achieve test pressure is used as a reference. The natural pressure decay readings at predetermined times (multiples of t1) are recorded.

A correction of t1 is then used to calculate ratios (N), the values of which indicated either the soundness of the main or the presence of an unacceptable leak. 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.

PE pipes should be tested in reasonable lengths appropriate to the pipe diameter, pressurising pump capacity, and the prevailing site conditions. Pipelines longer than 1000 metres may require testing in sections. The pipeline should not initially be subjected to any pressure when filling from the mains supply or from standing heads, 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. To enable a precise analysis of the pressure test data, pressure transducers with a logging facility and display should be used. The detailed procedure is as follows: Note: this represents a slight modification of the procedure detailed in the first printing of the WRc Manual for Polyethylene Pipe Systems for Water Supply – 1986.

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

Note $t_{1c} = t_1$ corrected $= t_1 + 0.4t_L$

Take a second reading of pressure P_2, at a decay time of approximately $7t_L$ this is time t_2.

Note $t_{2c} = t_2$ corrected $= t_2 + 0.4t_L$

$$\text{Calculate } N_1 = \frac{\log P_1 - \log P_2}{\log t_{2c} - \log t_{1c}}$$

For a sound main this ratio N1 should be:

a) 0.08 to 0.10 for pipes without constraint (eg. sliplined or not backfilled)

b) 0.04 to 0.05 for pipes with compacted backfill.

If the values are significantly less than the minimum identified, then there is too great a volume of air in the pipework. This air will have to be removed before a satisfactory test can be performed. 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. Take a further reading of pressure P_3 at a decay time not less than $15t_L$. Let this time be t_3.

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

$$\text{Calculate } N_2 = \frac{\log P_2 - \log P_3}{\log t_{3c} - \log t_{2c}}$$

The ratio for N_2 should be a) 0.08 to 0.10 for pipes without soil constraint b) 0.04 to 0.05 for pipes with compacted backfill.

The sensitivity of the test can be increased by extending the value of t3. 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.

HEALTH AND SAFETY

Our polyethylene products have been installed and used safely in large volumes over many years.

All PE80 and 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.

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/m3 (8-hourtime- 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 PE80 or PE100, 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.

Handling of molten material

During the fusion welding of PE pipe and fittings molten PE is formed which, if allowed to contact the skin, 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.