Selection of Polyethylene Pipes

Waters & Farr manufactures polyethylene pipes in a range of sizes up to 1200 mm. Pipes for pressure applications are manufactured in accordance with AS/NZS 4130:2009 in a variety of pressure classes.

Polyethylene compounds for production of pipes for pressure applications are classified in accordance with AS/NZS 4131:2010 as **PE 80** and **PE 100** based on the values of minimum required strength, **MRS**, which are derived from extrapolation of test data to a 50 years design life at 20°C (the test includes determination of failure times and failure modes for materials in pipe form being subjected to a series of values of hoop stress induced by application of internal hydrostatic pressure continuously at various temperatures).

Compound classification	MRS value, MPa
PE 80	**8.0**
PE 100	**10.0**

Polyethylene pipes for conveyance of water, wastewater, slurries, compressed air (and some other fluids) under pressure are specified in AS/NZS 4130:2009 as **Series 1** pipes, for conveyance of fuel gas - as **Series 2** (Nominal Outside Diameter Series) and **Series 3** (Nominal Inside Diameter Series) pipes. The pipes are referred to in the Standard in terms of standard dimension ratio, **SDR,** - a nominal ratio of the pipe outside diameter to its wall thickness.

Selection of polyethylene pipes is defined by maximum allowable operating pressure, **MAOP**, – the maximum pressure that can be sustained, with a design factor, by the type or class of pipe for its estimated useful life under the anticipated operating conditions, in MPa. Series 1 pipes are classified in terms of the nominal pressure rating, **PN**, – 10 times the value of MAOP at 20°C based on the overall service (design) coefficient, ***C***, equal to 1.25; correlation between PN, nominal working pressure and SDR is given in Table 1.

Table 1. Correlation between pressure rating and SDR for Series 1 polyethylene pipes to AS/NZS 4130:2009

Nominal working pressure						SDR	
PN	MPa	kPa	Bar	Head, m	P.S.I.	PE 80	PE 100
3.2	0.32	320	3.2	32	46	SDR 41	-
4	0.40	400	4.0	40	58	SDR 33	SDR 41
6.3	0.63	630	6.3	63	91	SDR 21	SDR 26
8	0.80	800	8.0	80	116	SDR 17	SDR 21
10	1.00	1000	10.0	100	145	SDR 13.6	SDR 17
12.5	1.25	1250	12.5	125	181	SDR 11	SDR 13.6
16	1.60	1600	16.0	160	232	SDR 9	SDR 11
20	2.00	2000	20.0	200	290	SDR 7.4	SDR 9
25	2.50	2500	25.0	250	362	-	SDR 7.4

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For Series 1 pipes, MAOP shall be calculated from the following equation (AS/NZS 4130:2009, App. B):

$$MAOP = \frac{0.125 \times PN}{C}$$

For water, sewerage and general pressure application pipes, ***C*** shall not be less than 1.25, and MAOP shall not be greater than the above listed nominal working pressure. Recommendations of AS/NZS 4130:2009, App. C, on the selection of appropriate design factors are given in Table 2.

For transmission of compressible fluids, such as compressed air, ***C*** shall not be less than 2.0 (design factors of AS/NZS 4645.3:2008 listed in Table 3 may be applied; f_0 = 2.0).

Table 2. Design factors for water and sewerage pipe systems

Condition	Installation	Factor	Index
Fluid	Water Domestic sewage Industrial sewage	1.25 1.25 1.25	f_0
Soil, fluid or pipe temperature (average *t*, °C)	$-20 < t \le -10$ $-10 < t \le 0$ $0 < t \le 20$ $20 < t \le 30$ $30 < t \le 35$ $35 < t$	Contact Waters & Farr 0.6 1.0 1.1 1.25 Contact Waters & Farr	f_1
Location based on minimum depth of cover specified in AS/NZS 2566.1	Open field Minor country road shoulder Major country road shoulder Minor country road – under pavement Major country road – under pavement Residential – paved and unpaved nature strip (footpath) Residential roadway - under pavement Major urban road – under pavement Commercial/Industrial paved and unpaved nature strip (footpath) Commercial/Industrial roadway - under pavement Central Business District Private land – easement Above ground Submarine crossings	1.0 1.0 1.0 1.1 1.2 1.0 1.1 1.2 1.1 1.2 1.4 1.0 1.0 1.4	f_2
Installation method	Standard trenching Plough-in Directional drilling Slip line with back grouting Slip line without back grouting Pipe cracking – with liner pipe in situ Pipe cracking – with liner pipe removed	1.0 1.1 1.2 1.0 1.2 1.0 1.2	f_3

NOTES:
1. Choose only one factor from each condition.
2. This table applies to PE 80B and PE 100 pipe with a life expectancy of >100 years.
3. Pumped installations require further design consideration.
4. Design factor $C = f_0 \times f_1 \times f_2 \times f_3$.
5. Where fluid carries contaminants capable of damaging PE compounds, consult Waters & Farr.

For Series 2 and Series 3 pipes, MAOP shall be calculated from the following equations (AS/NZS 4130:2009):

for Series 2 pipes, $$\text{MAOP} = \frac{2 \times \text{MRS}}{C(\text{SDR} - 1)}$$

for Series 3 pipes, $$\text{MAOP} = \frac{2 \times \text{MRS} \times T_{min}}{C(D_{m\,min} - T_{min})}$$

where $D_{m\,min.}$ – minimum mean outside diameter of pipe, in millimetres,
$T_{min.}$ – minimum wall thickness of pipe, in millimetres.
C – design factor (requirements are given in Table 3); shall not be less than 2.0.

Polyethylene pipes intended for the transmission of fuel gas shall be operated up to a MAOP of 1050 kPa gauge (AS/NZS 4130:2009).

According to NZS 5258:2003, PE80 pipes shall not be operated above 420 kPa.

Table 3. Minimum design factors for gas pipe systems to NZS 5258:2003 and AS/NZS 4645.3:2008

Condition	Installation	NZS 5258:2003		AS/NZS 4645.3:2008	
		Factor	Index	Factor	Index
Fluid	Natural gas LPG Manufactured gas	2.0 2.2 (see Note 1)	f_0	2.0 (minimum) 2.2 (minimum) (see Note 1)	f_0
Pipe form	Straight Coiled from factory	1.0 1.2	f_1	-	-
Soil temperature (average t°C)	$-20 < t \leq -10$ $-10 < t \leq 0$ $0 < t \leq 20$ $20 < t \leq 30$ $30 < t \leq 35$	(see Note 2) 1.2 1.0 1.1 1.3	f_2	(see Note 2) 1.2 1.0 1.1 1.3	f_1
Designation	Distribution	1.0	f_3	-	-
Installation method	Open trench with padding Other	-	-	1.0 1.1	f_2
Resistance to rapid crack propagation	All	1.0	f_4	-	-
Population density and area loading	Open field area Less trafficked roads in built-up areas Heavily trafficked roads in built-up areas Roads in populated areas Roads in industrial areas Residential area High density community use Industrial area Central business district	0.9 1.05 1.15 1.20 1.25 1.05 - 1.2 1.4	f_5	0.9 - - - - 1.05 1.2 / 1.4* 1.2* -	f_3

NOTES:
1. To be evaluated in each case taking into account the various constituents of that gas with special reference to liquefiable hydrocarbons and aromatics.
2. Value is greater than 1.2. Consult with Waters & Farr.
3. Design factor $C = f_0 \times f_1 \times f_2 \times f_3 \times f_4 \times f_5$ or $C = f_0 \times f_1 \times f_2 \times f_3$ correspondingly.

* AS/NZS 4548.1:2008 NZ-only Amendment A requirements for PE100 systems operated at 700-1050 kPa.

For special applications (including a required working pressure value not listed above), the polyethylene pipe wall thickness requirements are calculated from the following equations (AS/NZS 4130:2009, App. D):

$$T_{min} = \frac{P \times D_{m\,min}}{2S + P}$$

where $T_{min.}$ – minimum wall thickness of pipe, in millimetres,
$D_{m\ min.}$ – minimum mean outside diameter of pipe (from Tables 2, 3 or 4 of AS/NZS 4130:2009), in millimetres,
P – maximum design operating pressure of pipe, in MPa,
S = MRS / C.

$T_{max.} = 1.10\ T_{min.} + 0.1$

where $T_{max.}$ – maximum wall thickness of pipe, in millimetres.

Requirements to pressure re-rating of PE pressure pipe due to thermal effects are given in AS/NZS 2033:2008 – see Table 4 and Table 5 for PE80B and PE100 pipes respectively. Life expectancy of the pipe working at elevated temperatures may also reduce with increase of the average wall temperature. PE80B and PE100 pipes should not be used where wall temperature is exceeding 60°C.

Table 4. MAOP for Series 1 PE80B pipes to AS/NZS 4130:2009 at elevated wall temperature

Temperature, °C	**MAOP**, bar							
	PN 3.2	PN 4	PN 6.3	PN 8	PN 10	PN 12.5	PN 16	PN 20
20	3.2	4.0	6.3	8.0	10.0	12.5	16.0	20.0
25	3.2	4.0	6.3	8.0	10.0	12.5	16.0	20.0
30	2.8	3.5	5.5	7.0	8.8	10.9	14.0	17.5
35	2.6	3.2	5.0	6.4	8.0	10.0	12.8	16.0
40	2.4	3.0	4.7	6.0	7.5	9.4	12.0	15.0
45	2.2	2.8	4.4	5.6	7.0	8.8	11.2	14.0
50*	2.1	2.6	4.1	5.2	6.5	8.1	10.4	13.0
55*	1.9	2.4	3.8	4.8	6.0	7.5	9.6	12.0

* At 50°C and 55°C the extrapolated performance of the pipe cannot be predicted beyond 36 and 24 years respectively based on the current data.

Table 5. MAOP for Series 1 PE100 pipes to AS/NZS 4130:2009 at elevated wall temperature

Temperature, °C	**MAOP**, bar								
	PN 3.2	PN 4	PN 6.3	PN 8	PN 10	PN 12.5	PN 16	PN 20	PN 25
20	3.2	4.0	6.3	8.0	10.0	12.5	16.0	20.0	25.0
25	3.2	4.0	6.3	8.0	10.0	12.5	16.0	20.0	25.0
30	3.0	3.8	5.9	7.5	9.4	11.8	15.0	18.8	23.5
35	2.9	3.6	5.6	7.1	8.9	11.2	14.3	17.9	22.4
40	2.7	3.4	5.3	6.8	8.4	10.6	13.5	16.9	22.1
45	2.5	3.2	5.0	6.4	8.0	10.0	12.7	15.9	19.9
50*	2.4	3.0	4.8	6.0	7.6	9.5	12.1	15.1	18.9
55*	2.3	2.9	4.5	5.7	7.2	8.9	11.5	14.3	17.9

* At 50°C and 55°C the extrapolated performance of the pipe cannot be predicted beyond 36 and 24 years respectively based on the current data.

Across the wall of the pipe, the material temperature is taken as the mean of the internal and external pipe surface temperatures. In general, the internal pipe surface temperature may be taken as equal to the temperature of the fluid inside the pipe unless flow is stopped for prolonged periods.

Polyethylene pipe systems may convey a variety of chemicals and additives, sometimes with certain restrictions, or with provisions for pressure re-rating. Contact Waters & Farr for more information about chemical resistance of polyethylene.

Normal ground water, storm water, sanitary sewerage, soils either with low or high pH level, common fertilisers, salt water, do not harm polyethylene pipe, and typically do not affect performance of the pipe.

Polyethylene pipe systems are not suitable as an electrical conductor, or in any fire related applications.