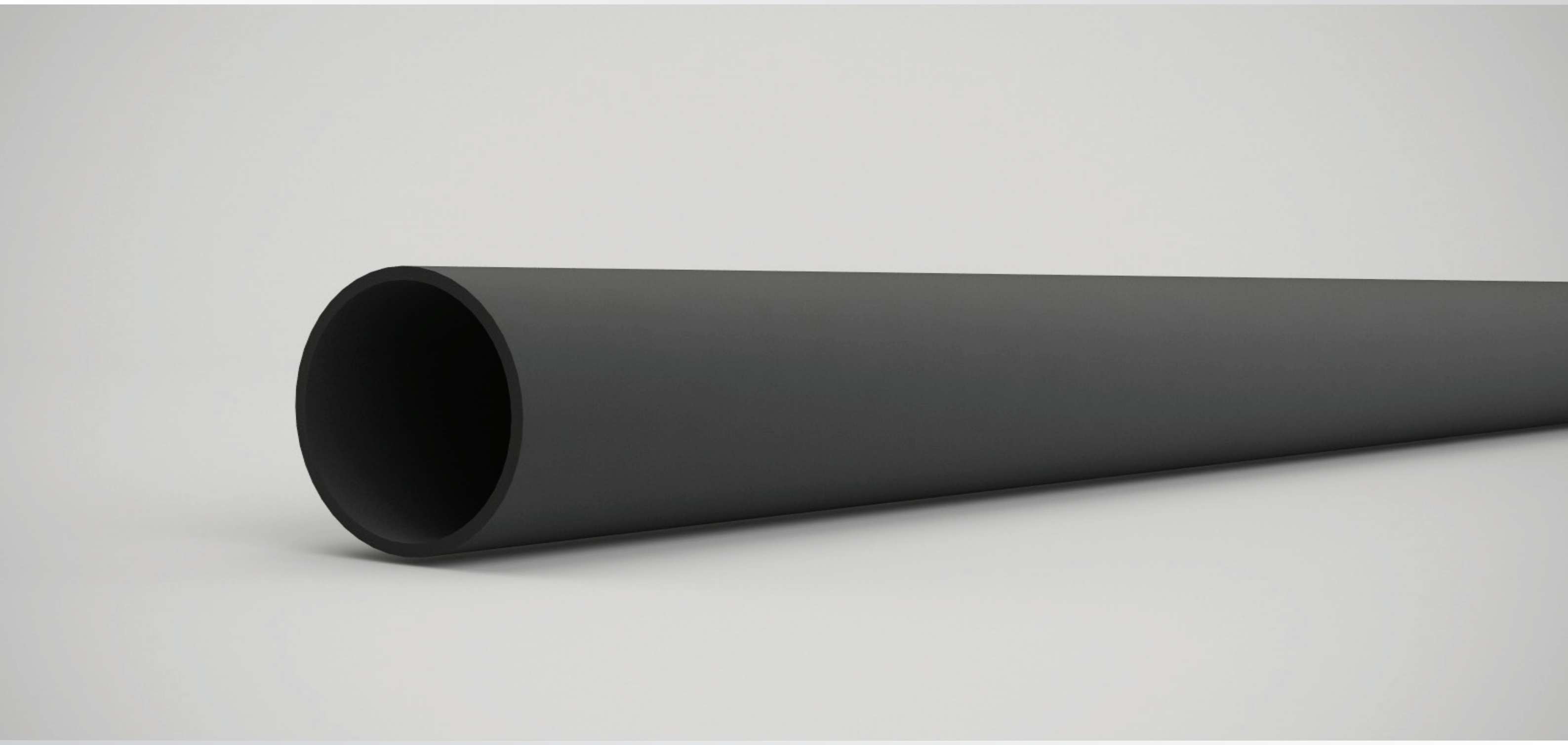
Abrah Dashte Markazi's
Engineering Manual for PE piping systems

Edition: 14 Aug 2017



innovation in Quality

Abrah Dashte Markazi

About this manual

Disclaimer

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Our General Terms of Sale apply.

This manual assisst you perform the planning and design and managing and work when the data has been compiled. It also clarify our manufacturing capabilities and fields of application of our exclusive quality piping systems in the range of PE-HD pipes

This data is based on the relevant international ISO and EN standards, on various national standards, DVS guidelines and additional data from piping manufacturers.

For further information please contact our technical support:
tech-info@ardm.ir
If you have questions
we are always happy to help.

Content

Abrah Dashte Markazi Company Profile

About Abrah Dashte Markazi

Abrah Dashte Markazi Company is a preimer manufacturer of solid wall polyethylene (PE-HD) pipe

Using engineered production methods

In recent years Abrah Dashte Markazi company has gained remarkable achievements by using its experienced employees in product hdpe pipes that have engineered step by step process in each field of production to deliver high performance pipes for toughest applications

Customers feedback as a part of the prodution and Development Process

As part of process of development Abrah Dashte Markazi always has been open to the customer's Feedback for rapidly moving forward in increasing quality of products and satisfaction of it's own customer

Using Advanced machinery and material

Abrah Dashte Markazi Company using new technology of production lines and best material in the row from inside Middle east and iran and Basell ,Solvay to produce the best performance HDPE PIPES

The holder of the national standard

Abrah Dashte Markazi Has this honor and merit to be holder of national standard and always will be an effort to preserve this trust

member of Iranian Association of Polyethylene Pipe & Fittings Producers

Abrah Dashte Markazi has this proud and deserve to join Iranian Association of Polyethylene Pipe & Fittings Producers always will be an effort to preserve this trust

PE80 and PE100 materials use

Abrah Dashte Markazi company using a wide range of PE80 and PE100 material performance and application for the customer according to the offers on demand

Quality Management

Abrah Dashte Markazi's Quality management is certified in accordance Din EN ISO 9001- 2008

Certificate of Registration

QUALITY MANAGEMENT SYSTEM

Abrah Dashte Markazi Co.

304 Ave.,Kheirabad Industrial Zone,Arak, Iran

Scope

Manufacturing of All Types Of HDPE Pipes.

This is to certify that the Quality Management System of the above mentioned organization meets the requirements of

ISO 9001:2008

MSIR : 44820615	15.June.2015
Certificate Number	Date of Initial Registration
15.June.2015	14.June.2016
Date of Last Issue	Date of Expiry

Signed on behalf of OSS Certification Services Pvt. Ltd.

◆ Certificate is Valid for 3 Years (15.June.2015 to 14.June.2018) From the Date of Initial Registration. Upon Successful Completion of Surveillance Audit a New Certificate with an Extended Validity will be issued.

OSS Certification Services Pvt. Ltd.

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www.osscertification.com

Accreditation by the Joint Accreditation System of Australia and New Zealand

www.jas-anz.org

Rev. 00, dt. 15.June.2015

Treacebaility Code

All the PE-HD PIPES has been manufacterd in Abrah Dashte Markazi Company have Treacebaility Code For Assureance of material used , data of producation and specifiction of MFR , Site , application , manufacturer of raw material

1 Material Properties and approval

1.1 Health and Safety

1.1.2 Contact with food and drinking water

Polyethylene pipeline systems have been used by our customers for drinking water supply since their introduction in the 1950s
The plastics industry has taken great responsibility in ensuring that the products used do not adversely affect water quality.

base on (BfR) report in Berlin determine acceptability of materials. and iranian Isiri standards Abrah Dashte markazi's
PE100/PE80 PE-HD and PE100 RC PIPE is suitable for contact with food and drining water.

PE-EL ,PPs are unsuitable for contact with food.

1.1.3 Resistance to rodents

rodents cannot easily get their teeth into smooth, rounded pipe surfaces. Rodent activity on pipes or on the surfaces of flat pieces is rare.

1.1.4 Resistance to micro-organisms

The pipe materials sold by Abrah Dashte markazi's are not suitable substrates for micro organisms (bacteria, fungus, spores) and are not affected by them. This is also true for sul fate-reducing bacteria.

1.1.5 Electrical conductivity

PE is an excellent insulator and does not conduct electricity. The typical electrical properties of PE are shown in Table
Abrah Dashte markazi's PE100/80 PE-HD and PE100 RC are, like all other plastics, electric insulators. Any material with a volume resistivity higher than 10^6 Ohm • cm is an insulator.
The resistivity of these plastics is in the order of 10^{15} Ohm • cm.
The surface resistance is important for the user. If it is higher than 10^9 Ohm, the material is classed as electrostatically chargeable.

In plastic pipeline construction, electrostatic charge is to be avoided when electrically non-conducting media are being transported or the pipeline is to be laid in places with risk of explosion. Transporting ignitable gases or liquids is without risk only if the system is closed and grounded. The static charge danger can be further reduced by reducing the transport speed.

1

typical electrical properties of PE

Electrical Property	Units	Test Method	Value
Volume Resistivity	ohms-cm	ASTM D257	> 10^{16}
Surface Resistivity	ohms	ASTM D257	> 10^{13}
Arc Resistance	seconds	ASTM D495	200 to 250
Dielectric Strength	volts/mil	ASTM D149	450 to 1,000
Dielectric Constant	—	ASTM D150	2.25 to 2.35 @ 60 Hz
Dissipation Factor	—	ASTM D150	> 0.0005 @ 60 Hz

1.2.1 Chemical resistance

An integral part of any piping system design is the assessment of the chemical environment to which the piping will be exposed and the impact it may have on the design life of the pipe. Generally, PE is widely recognized for its unique chemical resistance. As such, this piping material has found extensive utilization in the transport of a variety of aggressive chemicals.

HDPE is one of the most chemically inert plastics and therefore is extremely resistant to chemical attack and corrosion. HDPE pipe can resist the corrosive effects of soils or effluents with pH range from a very acidic 1.5 to a very caustic 14. HDPE pipe is often specified where acidic or alkaline native soil conditions exist

In choosing the appropriate material for a specific project, the chemical resistance needs to be considered.

It depends on the:

- medium
- concentration
- temperature
- manufacturing conditions of the finished piece and the load.

1.3.1 Fire Characteristics

When PE is heated in air, melting will occur at 120- 135°C and decomposition will commence at approximately 300°C.

The DIN 4102 differentiates between
- non-combustible building materials (Class A), and
- combustible building materials (Class B).
Without exception, plastics are Class B. A further differentiation is:

- B1 flame retardant
- B2 ignites normally
- B3 ignites easily.

Further indication for fire behavior is the oxygen index (Table Fire behavior). This number gives the minimum oxygen concentration of the surrounding air required for steady combustion.

A value under 20.8 % means that the material can be ignited and continues to burn after the ignition source is removed.

1

Above 300°C 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.

Fire Behavior

Material	PE-HD
Fire behavior acc. to DIN 4102 Class	B2
External ignition temp. ASTM 1929 °C	340
Oxygen index ASTM 2863 %	18
Evaluation DIN 53438 Class	F2
	K2

1.4.1 Weathering stability

When used or stored outside, most natural and synthetic materials are damaged across the time by weathering, especially by solar UV radiation.

Discoloration and degeneration of mechanical properties can render the products less effective. This applies especially to natrual PE-HD Certain UV stabilizers (special order) may increase the light protection factor of coloured material to four times that of the uncoloured material. Adding some types of black carbon offers further increases. Together these effects produce excellent weathering stability for PE-HD black

1.5.1 Water absorption

PE-HD is a water-repellent. There is no swelling or change in dimensional stability. Tests according to DIN 53495 show a very slight water absorption. This is only from adsorption of traces of surface moisture.

1.6.1 Material Specifiction

Material	
PE	Polyethylene
PE RC	Polyethylene, resistant to crack

Material Specifiction	Standards/guidelines	PE 80	PE 100 RC	PE 100 RC Black
Density, g/cm3	ISO 1183	0.945	0.948	0.949
Yield stress, MPa	DIN EN ISO 527		23	25
Elongation at yield, %	DIN EN ISO 527		10	
Elongation at break, %	DIN EN ISO 527		>1000	600
Tensile modulus of elasticity, MPa	DIN EN ISO 527		850	1100
Impact strength, kJ/m2	DIN EN ISO 179	22	25	16
Notched impact strength, kJ/m2	DIN EN ISO 179	no break	no break	no break
Ball indentation hardness, MPa	DIN EN ISO 2039-1	40	40	40
Shore hardness, D	ISO 868		62	60
Thermal conductivity, W/m · K	DIN 52612	0.38	0.38	0.38
Surface resistance, Ohm	DIN IEC 167	1 · 10		
Combustibility	DIN 4102	B2	B2	B2
Physiological acceptability	as per BfR and isiri	yes	yes	yes
Chemical resistance	according to DIN 8075 Supple-ment	fulfilled	fulfilled	fulfilled
Temperature range, °C		– 40 to + 80	– 40 to + 80	– 40 to + 80
MRS, MPa	ISO/TR 9082	8	10	10
OIT, min	EN 728	30	30	30
S4 Test (RCP) , bar	ISO DIS 13477		> 20	>10
Resistance to Slow Crack Growth , h	ISO 13479		>1000	>1000

1.7.1 Approvals /standards

Approvals /standards

PIPE	Dimensions, general quality requirements and tests	Standards and guidelines also applicable
PE 80 / PE 100 pressure pipes	DIN 8074/8075 2011-12	ISIRI 14427
PE 80/PE 100 waste-water pressure pipes	DIN 8074/8075 2011-12	DIN EN 13244 , ISIRI 14427
PE 80/PE 100 drinking water pipes	DIN 8074/8075 2011-12	DIN EN 12201 , ISIRI 14427
Marking	Product will be marked on one side with characters at least 5mm high in a constrasting color	
Identification marking	The following identification and traceability marks will be printed once every meter; • Manufacturers identification: Abrah Dashte markazi • Standard number: DIN 8074 • Material designation: PE100 or PE80 • SDR • Outside diameter: 250mm (example) • Manufacturing Code (contains Date) (see note 2) Note 1: The use of this mark is Abrah Dashte Markazi's claim that the product has been manufactured in accordance with DIN 8074: 2011-12 Note 2: The shift code denotes the extruder, shift week and year of manufacture plus the plant identification code. Each item being allocated a maximum of 2 digits. Where the codes numerical value is less than 10 a 0 is inserted. Or a simple date code may be used DD/MM/YY	
Description	PE-HD pipe Base on (DIN 8074 - DIN 8075) (63-250mm)	
SDR	All manufactured products will be in SDR Series base on DIN 8074-8075	
Color	Black	
Specification	DIN 8074:2011-12 Polyethylene (PE) - Pipes PE 80, PE 100 – Dimensions DIN 8075:2011-12 Polyethylene (PE) - Pipes PE 80, PE 100 – General Quality Requirements, Testing	
Weights	All weights (Equivalent pipe) are published in Abrah Dashte Markazi Product Guide.	
Dimensions	All dimensions are in accordance with DIN 8074:2011-12.	
Lengths	Pipes ≤ 125 mm diameter will be supplied in lengths of 6 or 12m or coil lengths of 50m, 75m, 100, 150m , 200m Pipes ≥ 125mm diameter will be supplied in standard lengths of 6m, 12m (Other lengths maybe produced at customer's request).	
The following materials will be used in accordance With the manufacturer's technical specification: PE80 and PE100 Pressure pipe materials		

1

2 Standard PE Piping Material Designation Code

2.1.0 Standard PE Piping Material Designation Code

2.1.0 Standard PE Piping Material Designation Code

While all PE piping standards specify minimum material requirements based the on the cell requirements of ASTM D3350, a simpler, short-hand, ASTM recognized material designation code is commonly used for quickly identifying the most significant engineering properties of a PE pipe material.

An important feature of this designation code is that it identifies the maximum recommended hydrostatic design stress (HDS) for water, at 73°F(23°C). Originally, this designation code was devised to only apply to materials intended for pressure piping. However, there is a recognition that even in non-pressure applications stresses are generated which makes it prudent to use a stress rated material.

This has led to the common practice of using this material designation code for quickly identifying all PE piping materials intended for pipes of solid wall or, of profile wall construction.

This code is defined in ASTM F412, "Standard Terminology Relating to Plastic Piping Systems", under the definition for the term code, thermoplastic pipe materials designation.

It consists of the ASTM approved abbreviation for the pipe material followed by four digits (e.g., PE4710). The information delivered by this code is as follows:

• The ASTM recognized abbreviation for the piping material. PE, in the case of polyethylene materials.

• The first digit identifies the density range of the base PE resin, in accordance with ASTM D3350, that is used in the material. (discussed in Chapter 3 , SECOND EDITION HANDBOOK OF PE PIPE - PPI Publication), the density of a PE polymer reflects the polymer's crystallinity which, in turn, is the principal determinant of the final material's strength and stiffness properties.

• The second digit identifies the compound's resistance to slow crack growth (SCG), also in accordance with ASTM D3350. A material's resistance to SCG relates very strongly to its long-term ductility, a property that defines the material's capacity for safely resisting the effects of localized stress intensifications.

2

• The last two numbers identify the compound's maximum recommended hydrostatic design stress (HDS) category (1) for water, at 73°F(23°C). This recommendation is established in consideration of various factors but, primarily the following: The capacity for safely resisting the relatively well distributed stresses that are generated only by internal pressure, and, the capacity for safely resisting add-on effects caused by localized stress intensifications. The Standard Designation Codes for materials which are recognized as of this writing by current ASTM, AWWA, CSA and other standards are listed in Table 4.

This table gives a brief explanation of the significance of the code digits. It should be recognized that a new material may be commercialized which qualifies for a code designation that has not been recognized as of this writing. For a listing of the most current recognized code designations the reader is invited to consult the periodically updated PPI publication TR-4. Contact PPI via their website, www.plasticpipe.org

* From SECOND EDITION HANDBOOK OF PE PIPE - PPI Publication

TABLE 1
Cell Classification System from ASTM D 3350-06 [1,2]

Property	Test Method	0	1	2	3	4	5	6	7	8
Density, g/cm3	D 1505	un-specified	0.925 or lower	>0.925 - 0.940	>0.940 - 0.947	>0.947 - 0.955	>0.955	--	specify value	--
Melt Index	D 1238	un-specified	>1.0	1.0 to 0.4	<0.4 to 0.15	<0.15	A	--	specify value	--
Flexural Modulus MPA (psi), 2% Secant	D790	un-specified	<138 (<20,000)	138-<276 (20,000 to <40,000(	276-<552 (40,000 to <80,000)	552-<758 (80,000 to <110,000)	758-<1103 (110,000 to <160,000)	>1103 (>160,000)	specify value	--
Tensile Stength at yield, MPa (psi)	D638	un-specified	<15 (<2000)	15- < 18 (2200-<2600)	18- < 21 (2600-<3000)	21- < 24 3000-<3500)	24- <28 (3500-<4000)	>28 (>4000)	specify value	--
Slow Crack Growth Resistance I. ESCR	D1693	un-specified								
a. Test Condition **b.Test Duration, hours** **c. Failure, max %**			A 48 50	B 24 50	C 192 20	C 600 20	-- -- --	-- -- --	-- -- --	specify value
Slow Crack Growth Resistance II.PENT (hours) Molded Plaque, 80°C, 2.4 MPa, notch depth Table1	F1473	un-specified	--	--	--	10	30	100	500	specify value
Hydrostatic Strength Classifiction I. hydrostatic design basis, MPa, (psi), (23°C)	D2837	NPR[B]	5.52 (800)	6.89 (1000)	8.62 (1250)	11.03 (1600)	--	--	--	--
Hydrostatic Strength Classification II. Minimum Required Strength, MPa (psi), (20°C)	ISO 12162	--	--	--	--	--	8 (1160)	10 (1450)	--	--

Notes to Table 1-A: Refer to 10.1.4.1 (ASTM D 3350) B: NPR = Not Pressure Rated, 1.) D 3350 is subject to periodic revisions, contact ASTM to obtain the latest version, 2.) The property and density are measured on the PE base resin; all the other property values are measured on the final compound

Table 2
Code Letter Representation

Code letter	Color and UV Stabilizer
A	*Natural*
B	*Colored*
C	*Black with 2% minimum carbon black*
D	*natural With UV stabilizer*
E	*Colored with UV stabilizer*

For designating a PE material in accordance with ASTM D 3350 the cell number for each cellproperty is identified, and this is done in the same order as shown in Table 1. This is then followed by an appropriate Code letter to indicate color and stabilization as shown in Table 2. An example of this material designation system is presented in Table 3 for the case of a PE material having designation code PE445574C.

Table 3
Properties of a Cell Number PE445574 Material

Digit Designating the Applicable property Cell (1)	Class Number or Code Latter	Corresponding Value of Property (from Table1)
1st Digit - Density of PE base Resin, gm/cm^3	4	>0.947 - 0.955
2nd Digit - Melt Index of compound, gm/10 min	4	<0.15
3rd Digit - Flexural Modulus of compound, psi (MPa)	5	110,000 - < 160,000 (758 - <1103)
4th Digit - Tensile Strength at Yield of compound, psi (MPa)	5	3,500 - <4,000 (24 - <28)
5th Digit - Resistance to Slow Crack Growth of compound (SCG)	7	500 Minimum based on PENT Test
6th Digit - Hydrostatic Design Basis for water at 73°F (23°C), psi of compound (MPa)	4	1600 (11.03)
Code Letter	C	Black with 2% minimum Carbon black

(1) The density is that of the PE resin. All the other properties are determined on the final compounded material.

A PE material that complies with the Table 3 cell designation i.e. PE445574C would be a higher density (higher crystallinity), lower melt index (higher molecular weight) material that exhibits exceptionally high resistance to slow crack growth. In addition, it offers a hydrostatic design basis (HDB) for water at 73°F (23°C) of 1600 psi (11.03 MPa). Finally, it would be black and contain a minimum of 2% carbon black. The cell classification system provides the design engineer with a very useful tool in specifying the requirements of PE materials for piping projects.

TABLE 4
Standard Designation Codes for Current Commercially Available PE Piping Compositions

Standard Designation Code	What the Digits in the Code Denote		
	the 1st Digit	*The 2nd Digit*	*The last two Digits*[1]
	Cell Number Based on the Density Cell In accordance with ASTM D3350 (See Table 1)	*Cell Number Based on the Resistance to SCG Cell In accordance with ASTM D3350* [2] *(See Table 1)*	*Recommended Standard Hydrostatic Design Stress (HDS) Category, for water, at 73°F (23°C) (psi)*
PE2406	*Cell number 2*	*Cell number 4*	630
PE2708		Cell number 7	800
PE3408	*Cell number 3*	*Cell number 4*	*800*
PE3608		*Cell number 6*	
PE3708		*Cell number 7*	*800*
PE3710			*1,000*
PE4708	*Cell number 4*	*Cell number 7*	*800*
PE4710			*1,000*

(1) The last two digits code the Standard HDS Category in units of 100psi. For example, 06 is the code for 630psi and 10 is the code for 1,000psi.

(2) It should be noted that the lowest Cell number for SCG resistance for pipe is 4. Based on research and experience a rating of at least 4 has been determined as sufficient for the safe absorption of localized stresses for properly installed PE pipe.

3 Designing Diagrams of PE pipes

NOTE : This situation is always to be considered when performing a pipeline verification calculation that cannot be replaced by using the Abrah Dashte markazi's Diagrams.

3.1.0 Creep Muduls for PE80 / PE100 pipes

3.2.0 Internal Pressure Creep Curves for PE80 pipes

3.3.0 Internal Pressure Creep Curves for PE100 pipes

3.4.0 Anchor Foreces in Axially Constrained Plastic Pipelines

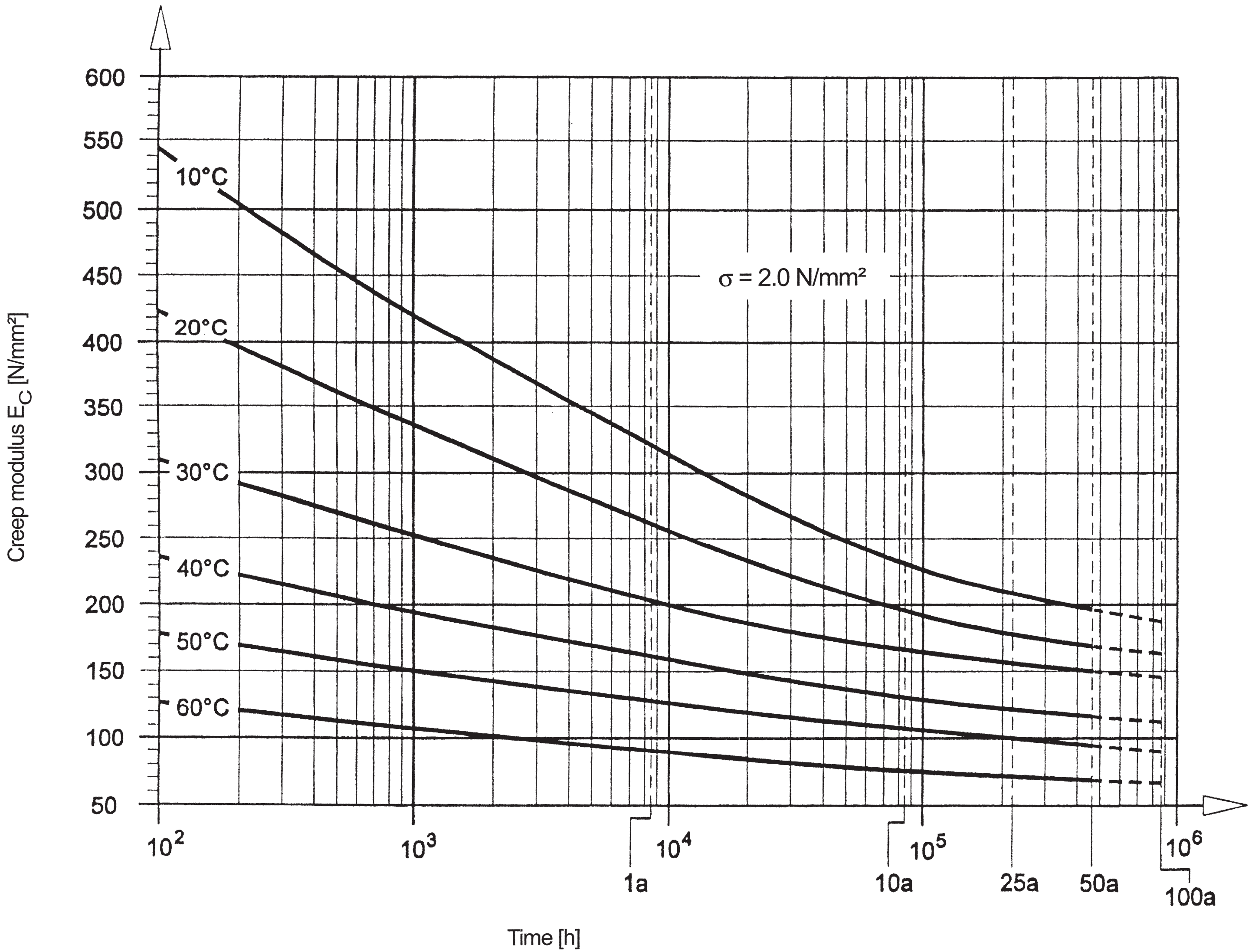
3.5.0 Permissible loads for Plastic pipelines under internal overpressure

3.6.0 Permissible loads for Plastic pipelines under internal overpressure

3.7.0 load Capacity for Plastic pipelines under negative pressure

3.8.0 load Capacity for Plastic pipelines under negative pressure

3.1.0 Creep Muduls for PE80 / PE100 pipes

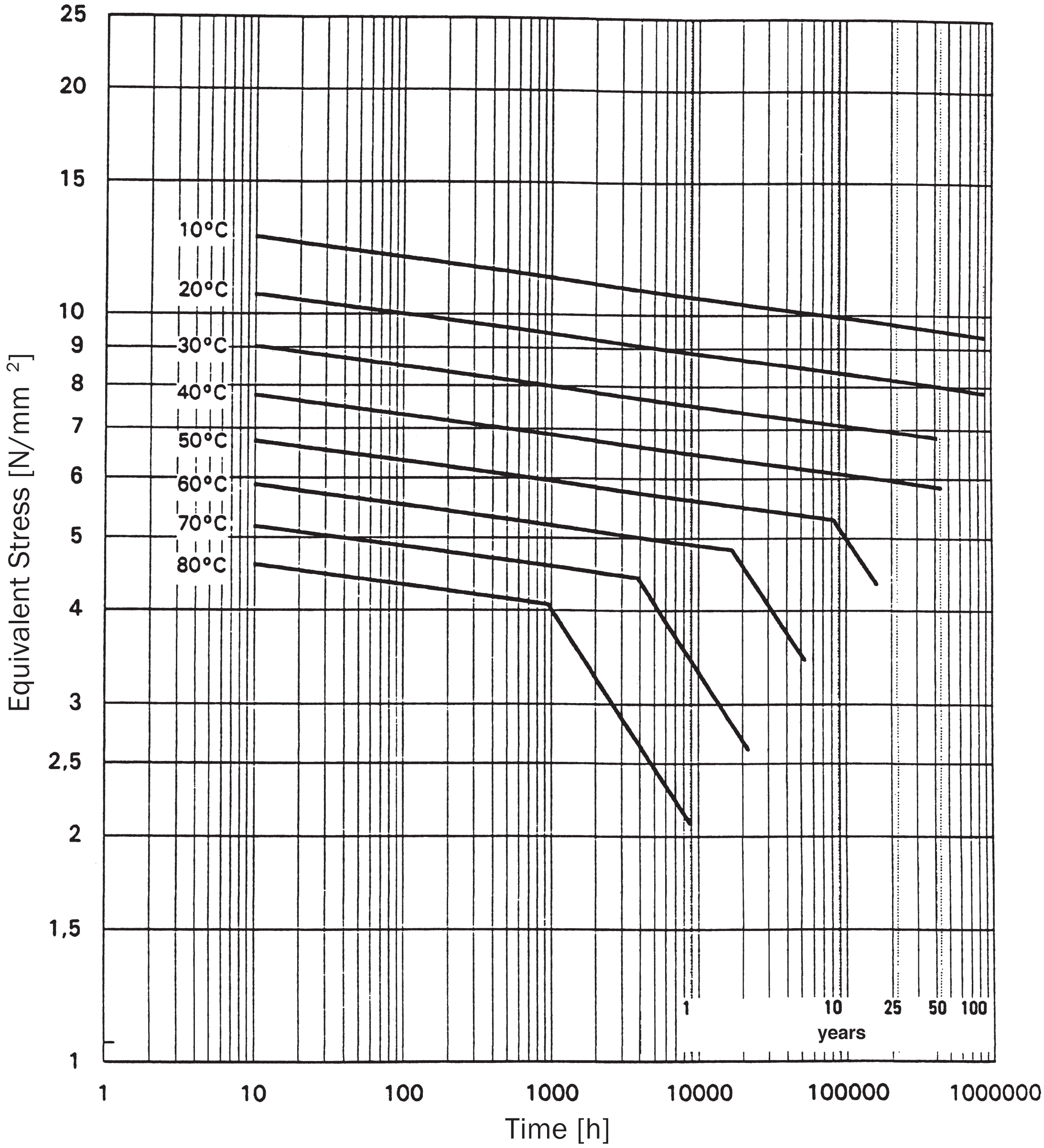


Calculation factors for the stress range	
σ = 0.5 N/mm²	1.20
σ = 1.0 N/mm²	1.08
σ = 2.0 N/mm²	▶ 1.00 ◀
σ = 3.0 N/mm²	0.78
σ = 4.0 N/mm²	0.70
σ = 5.0 N/mm²	0.60

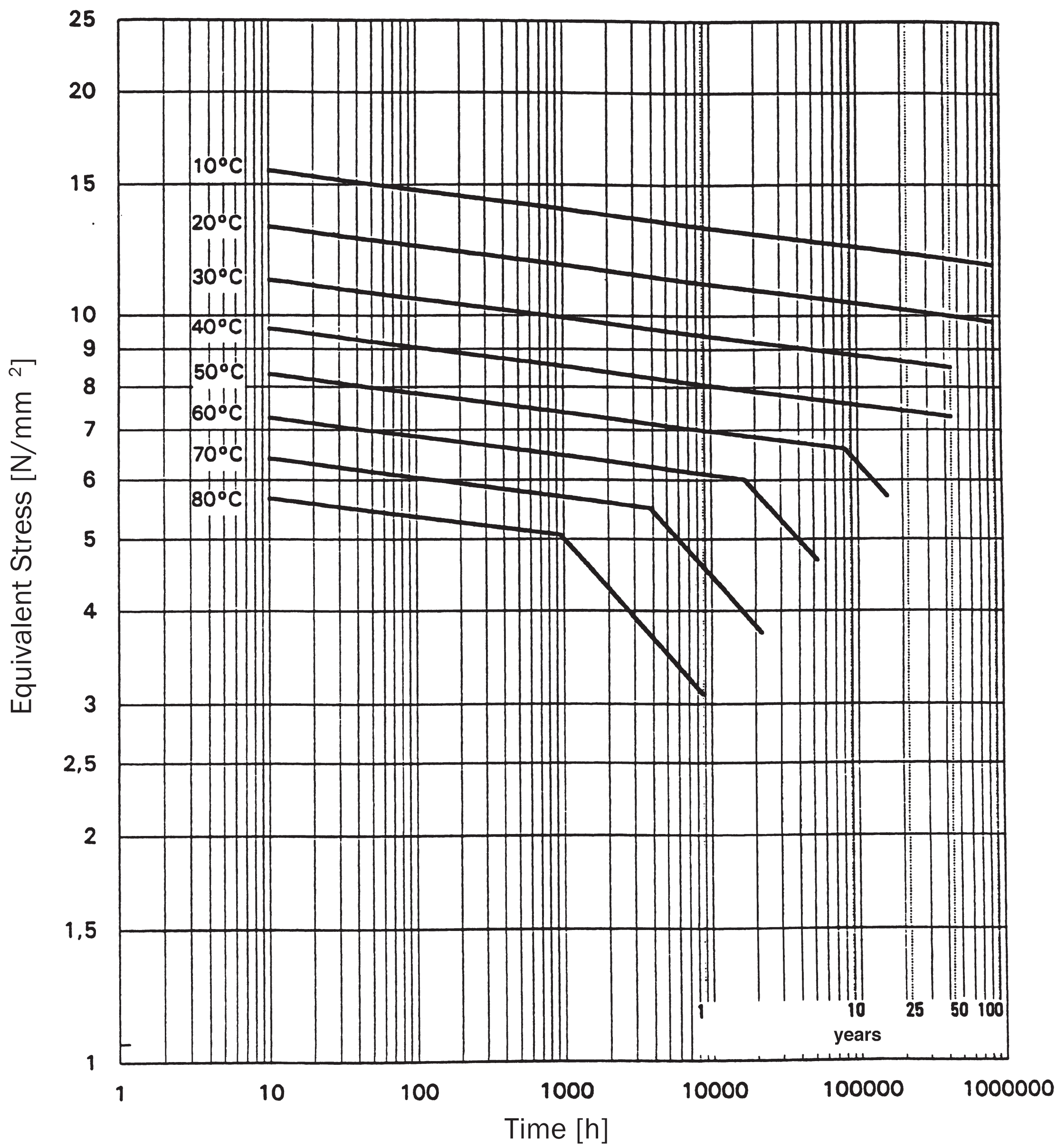
Modulus of elasticity [N/mm²]		
	1	2
Temperature	E_{KZ} 10^{-1}h	E_C 100min
≤ 10°C	1100	850
20°C	800	630
30°C	550	450
40°C	390	325
50°C	270	230
60°C	190	160

Note:
Values up to 80°C in Column 1 are from DVS 2205-2 Tab. 6. Numbers in Column 2 are interpolated between E_{ST} (10^{-1} h) and E_{LT} (1 year) according to DVS 2205-1.

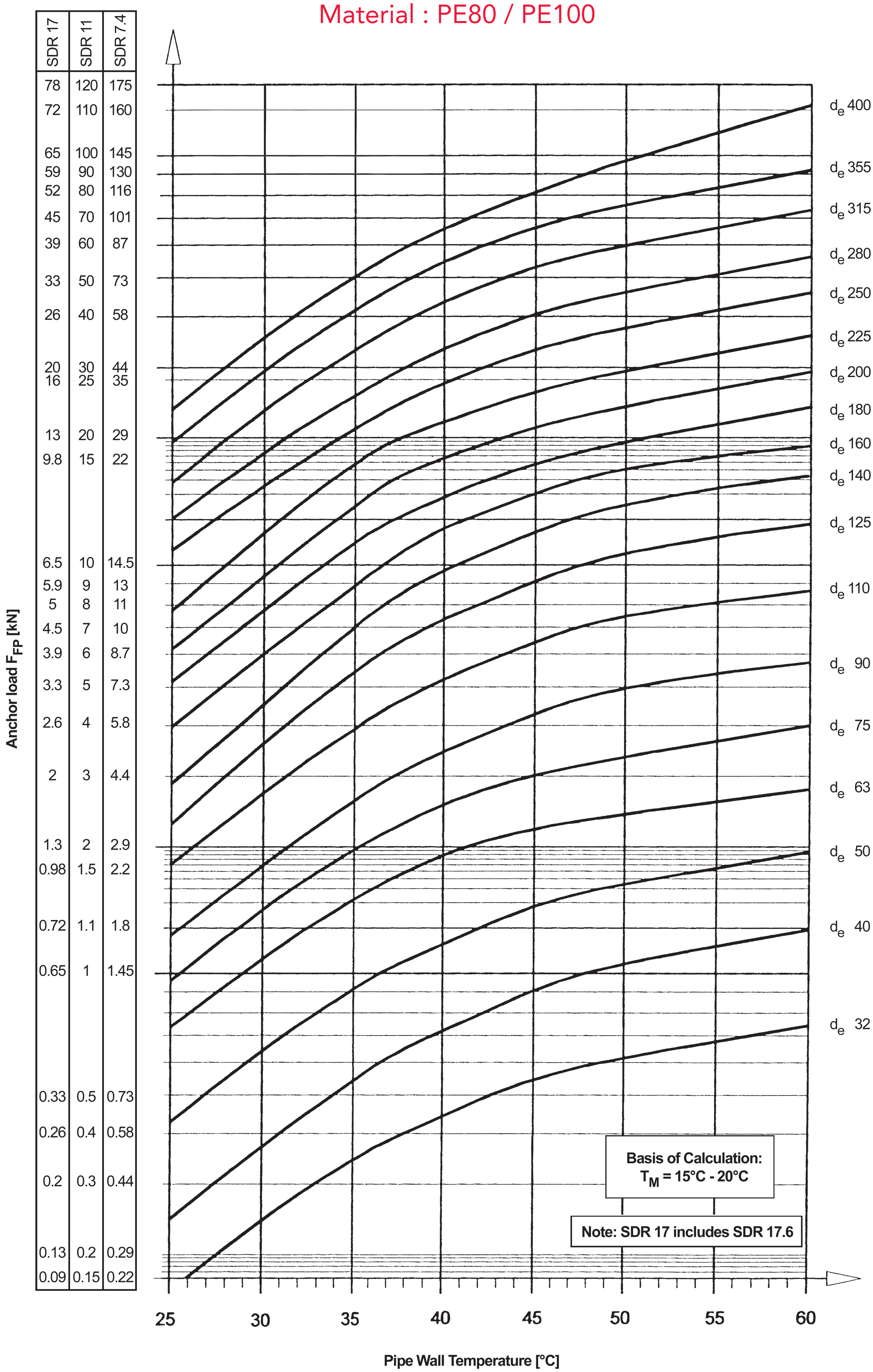
3.2.0 Internal Pressure Creep Curves for PE80 pipes



3.3.0 Internal Pressure Creep Curves for PE100 pipes



3.4.0 Anchor Foreces in Axially Constrained Plastic Pipelines
Material : PE80 / PE100



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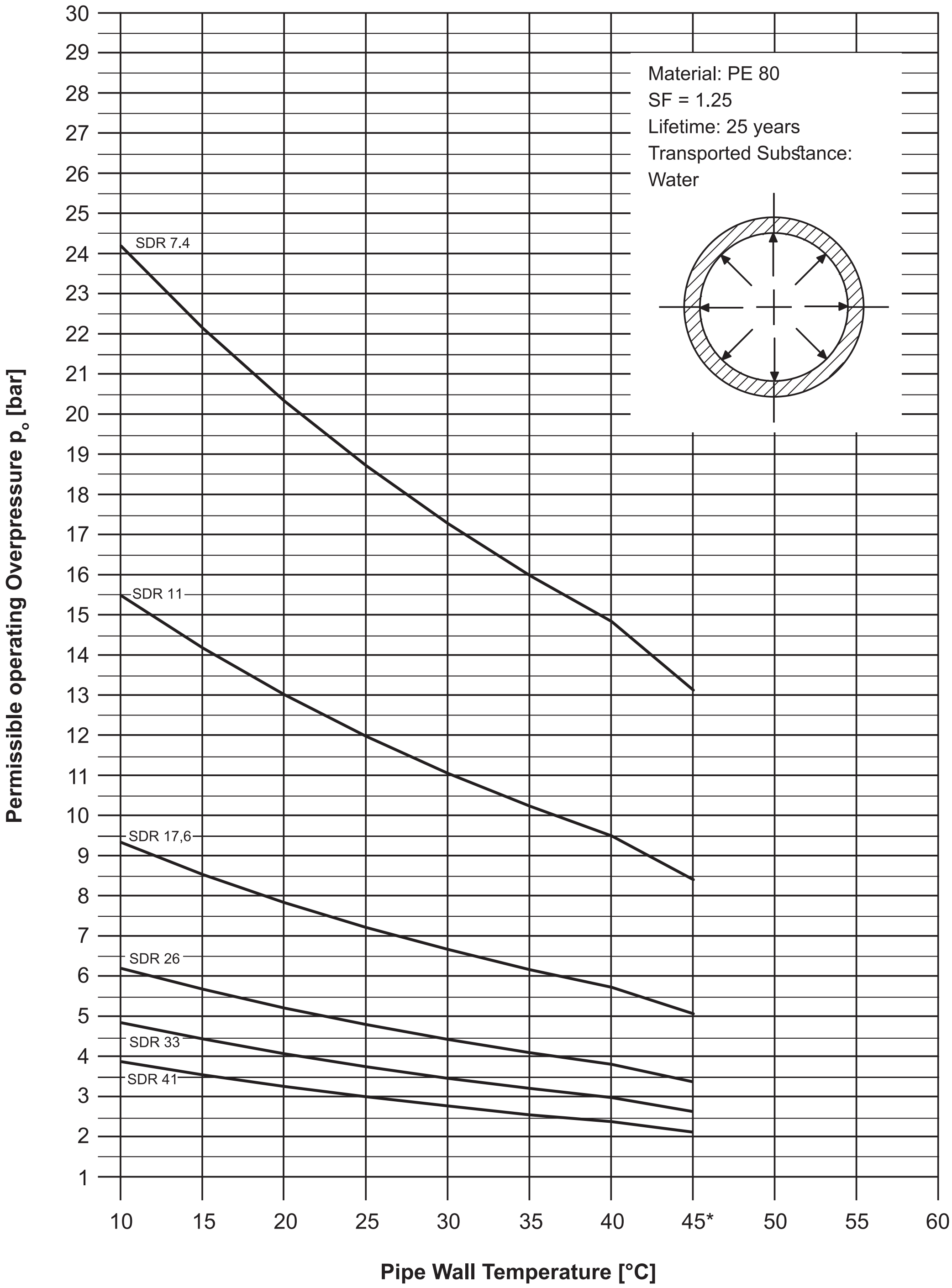
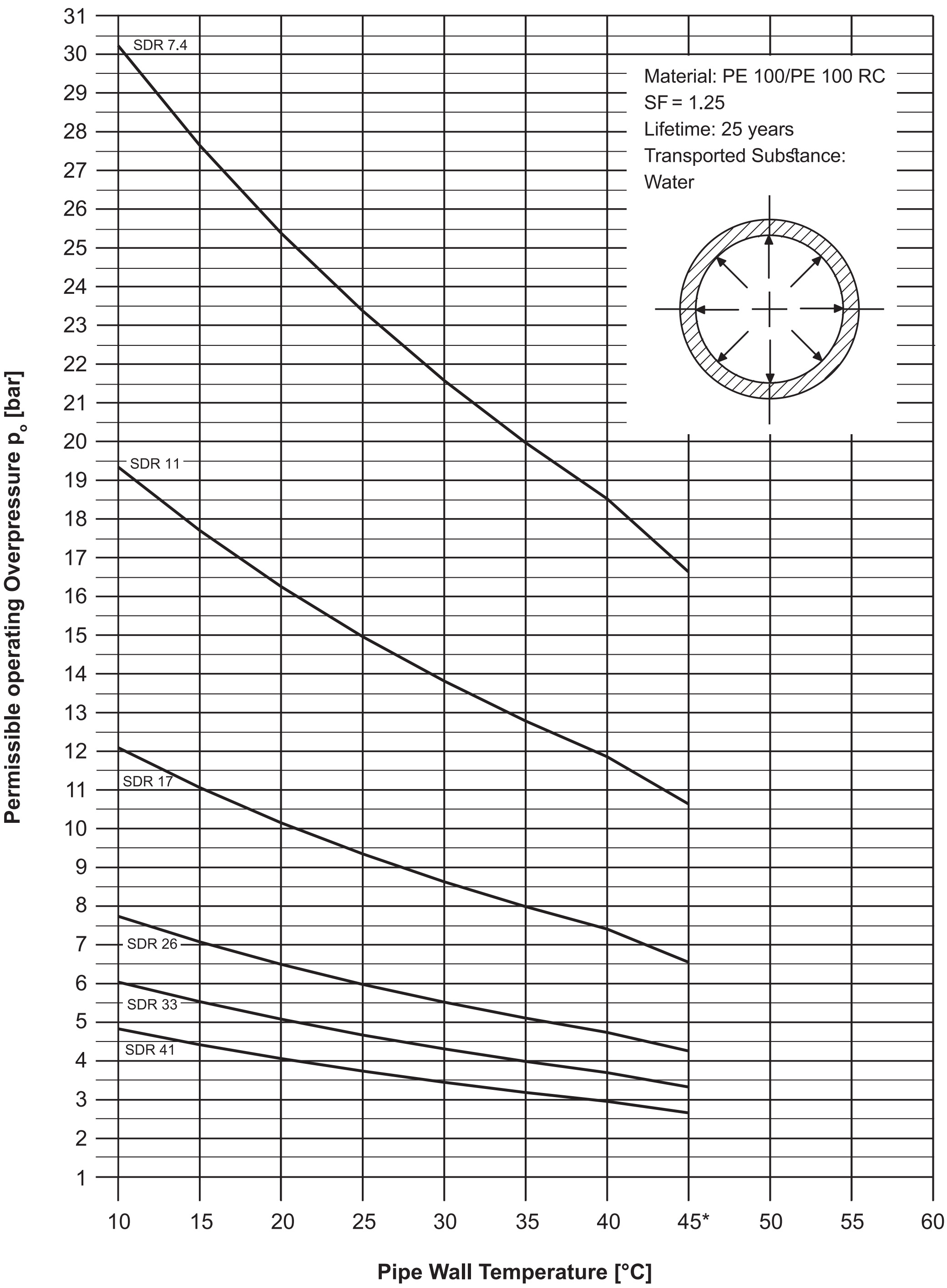
3.5.0 Permissible loads for Plastic pipelines under internal overpressure
Material: PE80
SDR 41 / 33 / 26 / 17.6 / 11 / 7.4
SF = 1.25



Note: Higher temperatures possible for decreased lifetimes (see DIN EN 8074)

* Service life temperature limit at 25 years due to thermal ageing (effects related to thermooxydation)

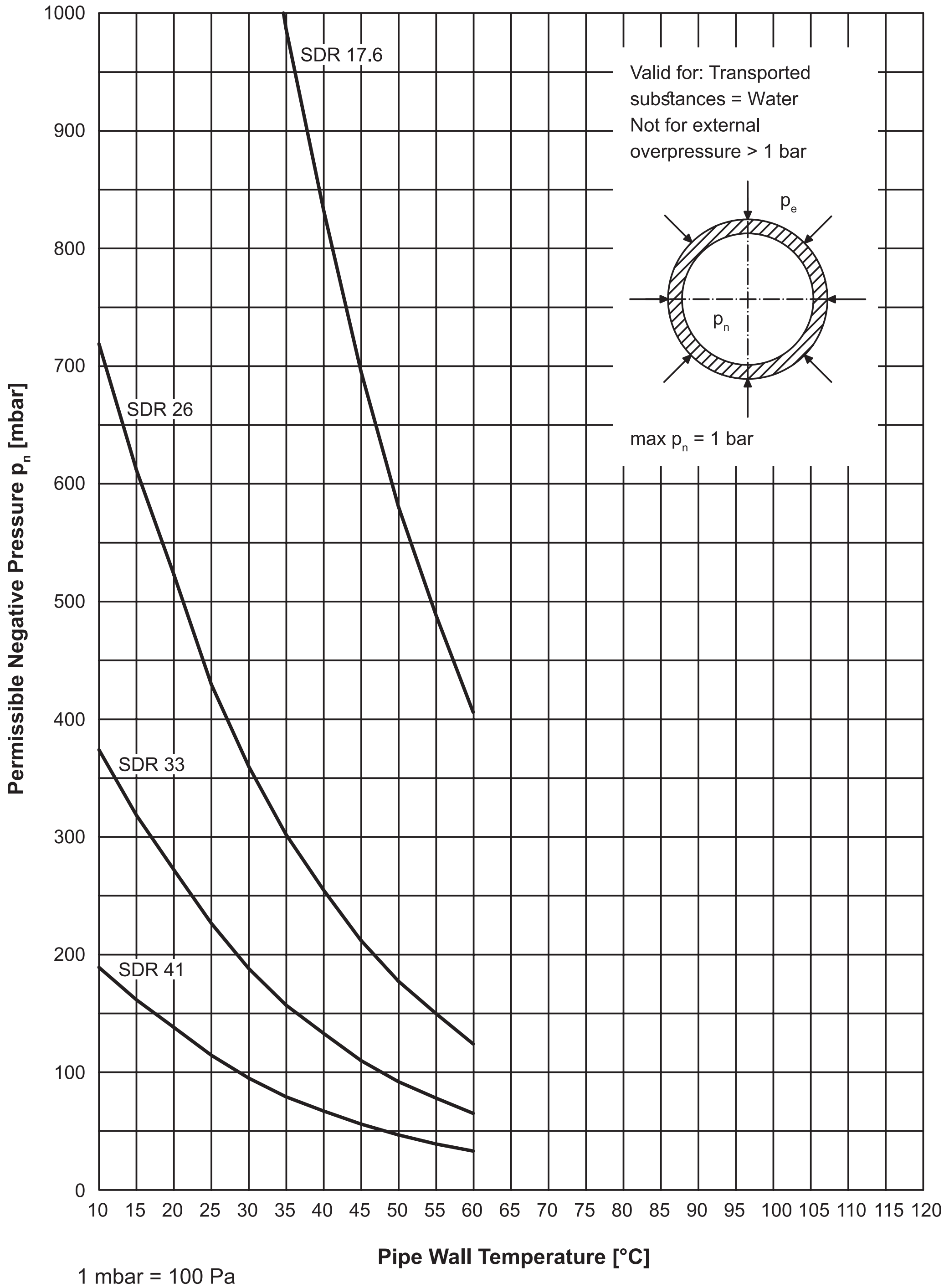
3.6.0 Permissible loads for Plastic pipelines under internal overpressure
Material: PE100 / PE100 RC
SDR 41 / 33 / 26 / 17 / 11 / 7.4
SF = 1.25



Note: Higher temperatures possible for decreased lifetimes (see DIN EN 8074)

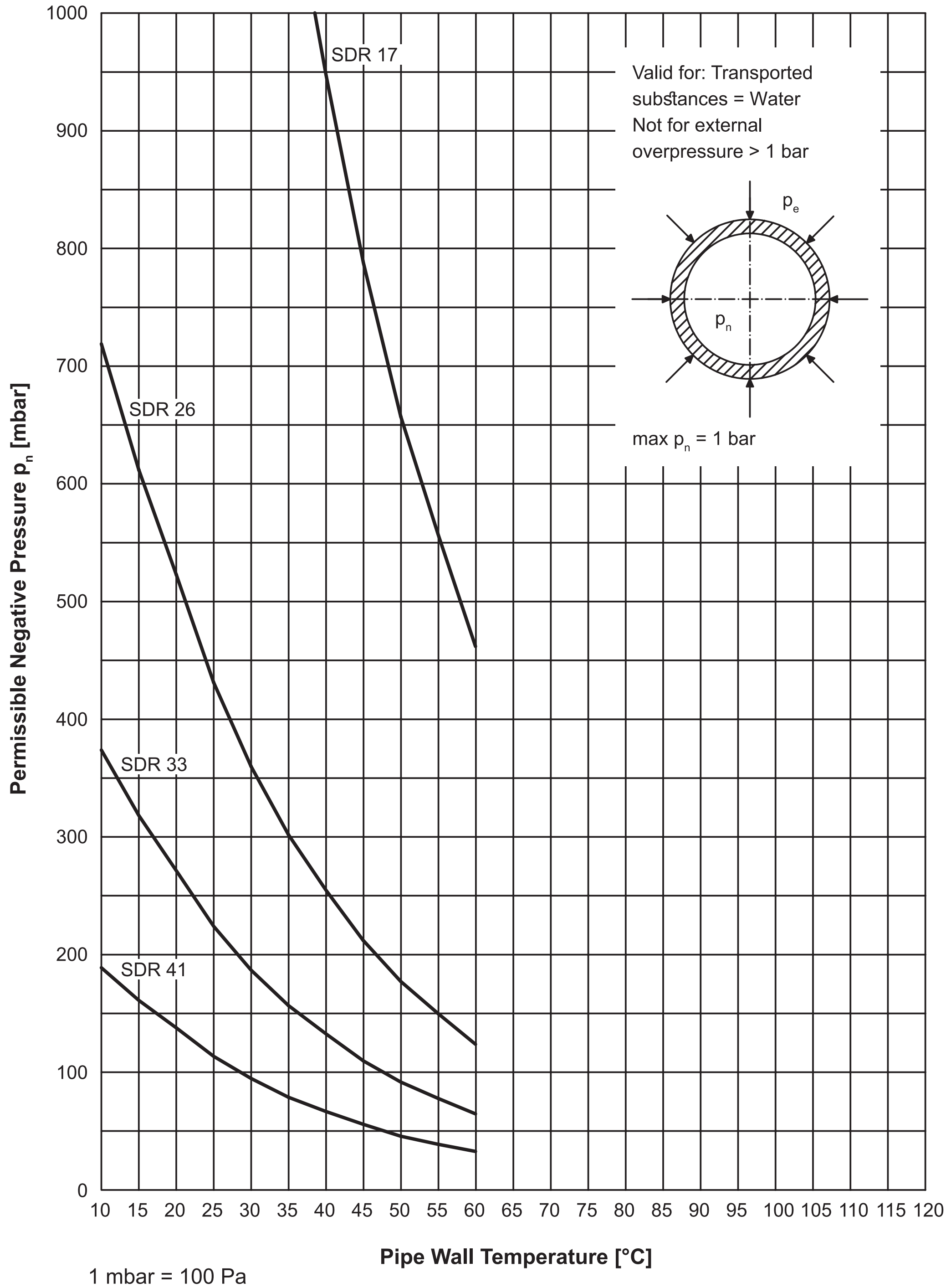
* Service life temperature limit at 25 years due to thermal ageing (effects related to thermooxydation)

3.7.0 load Capacity for Plastic pipelines under negative pressure
Material: PE80
SDR 41 / 33 / 26 / 17.6
SF = 2,0



1 mbar = 100 Pa
p_e = external overpressure
p_n = internal negative pressure

3.8.0 load Capacity for Plastic pipelines under negative pressure
Material: PE100 / PE100 RC
SDR 41 / 33 / 26 / 17
SF = 2,0



1 mbar = 100 Pa
p_e = external overpressure
p_n = internal negative pressure

3

4 Designing of PE pipes

4.1.0 The meaning of the designations PE80 and PE100

The polyethylene material types are classified according to their minimum strength, their minimum resistance to stress, at 20°C over a time period of 50 years.

This strength is classified in MRS: minimum required strength (MPa). MRS represents the long-term circumferential stress in the pipe where the break may occur after 50 years at the earliest.
The designations PE80 and PE100 are based on the long-term strength of the respective materials, known as the minimum required strength (MRS) in accordance with ISO 12162.

The meaning of the designations PE80 and PE100

Material Designation	Minimum Required Strength (MRS) MPa	Hydrostatic Design Stress (HDS) MPa
PE 100	10.0	8.0
PE 80	8.0	6.3

The MRS is determined by performing regression analysis in accordance with ISO 9080 on the test data from the results of long-term pressure testing.

The regression analysis allows for the prediction of the minimum strength for a specific service lifetime. The data is extrapolated to predict the minimum strength at 20°C and at the specified 50 year design lifetime.

Full details of the analysis can be found in ISO 9080 .

The MRS value, multiplied by 10 is the "classification" of the material. As an example, the now generally applied high performance PE pipes, made from materials with an MRS of 10 MPa and are therefore classified as PE 100 pipes.

the allowable tangential wall stress (s) of the material is applied for dimensioning of the piping network. This is calculated from

$$\sigma_s = \frac{MRS}{C}$$

Where:

C is the 'overall service (design) coefficient, or Safety Factor

Coefficient, or Safety Factor

Pipeline Application in 20°C	Design Factor C
Water Supply	1.25
Natural Gas	2
Compressed Air	2
LPG	2.2

4.1.1 The Hydrostatic Design Stress (HDS)

4

The Hydrostatic Design Stress (HDS) is obtained by application of a Design or Safety Factor (C) to the MRS

$$HDS = \frac{MRS}{C}$$

The specific value selected for the Design Factor depends on a number of variables, including the nature of the transmitted fluid, the location of the pipeline, and the risk of third party damage.

4.1.2 Standard dimension ratio (SDR)

$$SDR = \frac{d_n}{e_n}$$

Where:
d_n = nominal outside diameter
e_n = nominal minimum wall thickness

4.2.0 Maximum Operating Pressure for a PE pipe

The relationship between the maximum operating pressure (MOP), the minimum required strength of the PE pipe grade (MRS) and the pipe geometry (SDR standard dimension ratio) is given by the following industrially recognised and applied formula:

$$MOP = \frac{20 \times MRS}{C \times (SDR - 1)}$$

$$MOP = \frac{20 \times \sigma}{(SDR - 1)}$$

4.2.1 Hoop stress in the pipe specimens

Hoop stress in the pipe specimens is calculated using equation (approximation) for the hoop stress, The average value of the stress that is generated in the thermoplastic pipe is calculated using a thinwall pressure vessel equation which takes the stress at the mid-wall of the pipe.

Since most thermoplastics have a relatively low elastic modulus (compared to metals) it is considered that this method is appropriate for even heavy wall pipe

$$S = \frac{P(D - t)}{2t} \qquad (1)$$

or

$$S = \frac{P(DR - 1)}{2} \qquad (2)$$

Where:

S = Hoop stress, Psi (MPa)
P = internal Pressure, psig (MPa)
D = measured average outside diameter, in . (mm), For reinforced thermosetting pipe, outside diameter shall not incude nonereinforced covers,
t = measured minimum wall thickness, in. (mm) for reinforced thermosetting pipe use minimum reinforced wall thickness, and
DR = dimension ratio , DR = D/t.

4.2.2 Design Factor and Hydrostatic Design Stress

Once the HDB has been determined for a thermoplastic compound, it is necessary to then reduce this strength into an allowable working stress (i.e., the stress induced only by the internal pressure) for a longterm design in a way that will assure an indefinite design life with a satisfactory margin of safety, even when stresses other than those induced from internal pressure exist on the piping system (e.g., soil loads, bends, joints, rock impingement, scratches, gouges, etc…).

This maximum allowable stress, or the hydrostatic design stress (HDS), is derived by multiplying the HDB by a strength reduction factor called the design factor (DF), which should not be confused with the traditional safety factor

$$HDS = HDB \times DF$$

Where:
HDS = hydrostatic design stress, psi
HDB = hydrostatic design basis, psi
DF = design factor, a number less than one

Astm Long-Term Hydrostatic Strength and Design of Thermoplastic Piping Compounds

4.2.3 Internal Pressure

To move a material along a pipeline, forces of gravity, or internal pressure, differentials are required. For atmospheric systems (gravity flow), gravitational forces provide the impetus for movement of heavier-than-air mass.

To move the same against gravity (pressure flow) additive internal forces are generated, which must be recognized in the design stage in order to provide desired operational life. In some cases a gravity flow system must be treated comparable to the design consideration of a pressure flow system.

Calculations for determining the internal pressure rating of hdpe pipe are based on the ISO equation, which is

$$P = \frac{2 \cdot HDB}{(DR - 1)} \cdot DF$$

Where:
P = Internal pressure, psi
HDB = Hydrostatic Design Basis, (1600 psi for PE3408
DR = Pipe dimension ratio (D/t)
D = Outside diameter, Inches
t = minimim wall thickness, inches
DF = Design factor (0.5 for water @ 73°F (23°C))

Use of additional factors will provide for a more defined performance characteristic for systems with higher operation temperatures, shorter operational time and system fluid other than water.

These additional factors are defined as the following:

F_1 = factor used where where the operational life is less than 50 years. Refer to Figure A-1.

F_2 = Temperature correction factor for service other than 73oF (23oC). Refer to Figure A-2.

F_3 = Environmental factor utilized to compensate for the effect of substances other than water. Refer to
Table 11.

With the implementation of additional factors, the ISO equation2 now becomes:

$$P = \frac{2 \bullet HDB}{(DR - 1)} \bullet DF \bullet F_1 \bullet F_2 \bullet F_3$$

Where

P = Internal pressure, psi
HDB = Hydrostatic Design Basis, (1600 psi for PE3408)
DR = Pipe dimension ratio (D/t)
D = Outside diameter, inches
t = Minimum wall thickness, inches
DF = Design factor (0.5 for water @ 73oF (23oC))
F1 = Operational life factor (Figure A-1)
F2 = Temperature correction factor (Figure A-2)
F3 = Environmental service factor (Table 11)

It should be noted the maximum recommended service temperatures, under continuous pressure service, for polyethylene pipe is 150°F (66°C). However, for a non-pressure application, temperatures as high as 180°F (82°C) can be considered. In such cases, consult your polyethylene pipe supplier for additional design assistance

NOTE:

Compressed air service (greater than atmospheric pressure) can significantly shorten service life at temperatures above 73°F (37°C). Abrah Dashte Markazi does not recommend its' product for compressed air service for a service life greater than 5 years at 100°F.

Further, Abrah Dashte Markazi recommends all polyethylene piping in use for air service be buried.

Refer to Recommendation "B", published by PPI, for further information regarding the use of polyethylene piping for compressed air service

4.2.4 Critical Buckling : Internal negative pressure or external overpressure

For pipelines under negative (low) internal pressure, respectively external overpressure, the pipe wall tends toward elastic buckling. If loads are large enough, plastic deformation may occur.

The basic standards and guidelines for pipes contain no data on permissible negative pressure loads.

In the design of a polyethylene piping system, external fluid pressure and/or internal vacuum may be treated comparably:

$$P_{Crit} = \frac{2E}{1 - \nu^2} \bullet \frac{t^3}{D^3} \bullet 10$$

Where:

Pcrit = critical buckling pressure [bar]
D = outer pipe diameter [mm]
t = Pipe Wall thickness [mm]
E = short-time elastic modulus at max Top [N/mm2]
v = cross contraction (Poisson) ratio = 0.38 [–]
10 = conversion factor from [N/mm2] to [bar]

or

$$P_{Crit} = \left(\frac{2E}{1-\nu^2}\right)\cdot\left(\frac{t}{(D-t)}\right)^3 \cdot SF$$

where:

P = Critical buckling pressure, psi
E = Modulus of elasticity, psi
D = Outside diameter, inches
t = Wall thickness, inches
v = Poisson's ratio, dimensionless
SF = Safety Factor

4.2.5 The allowable buckling pressure

The summation of external loads should be equal to or less than the allowable buckling pressure. The allowable buckling pressure qa may be determined by the following:

$$q_a = \frac{1}{FS}\left(32\, R_\omega B' E' \frac{EI}{D^3}\right)^{\frac{1}{2}}$$

where
qa = allowable buckling pressure, lb/in2

FS = design factor

$$= \begin{cases} 2.5 & for\ \frac{h}{D} \geq 2 \\ 3.0 & for\ \frac{h}{D} \prec 2 \end{cases}$$

h= height of ground surface above top of pipe, in
D= diameter of pipe, in
Rw = water bouyancy factor

$$= 1 - 0.33\frac{h_\omega}{h} \qquad 0 \leq h_\omega \leq h$$

hw = height of water surface above top of pipe, in
B' = empirical coefficient of elastic support (dimensionless)
E' = soil modulus

4

And for

4.2.6 Buckling safty factor :

$$S.f_{buck} = \frac{P_{critical}}{P_{rate}} \geq 2 \quad ①$$

Where:

P critical = external pressure – internal pressure difference for which buckling begins (critical buckling pressure) [mbar, bar]
P rate = internal negative pressure or external overpressure that pipeline could be subjected to [mbar, bar]

① **If the verification calculation does not take the pipe's deviation from perfect roundness explicitly into account, S.f buck should be set ≥ 2.5.**

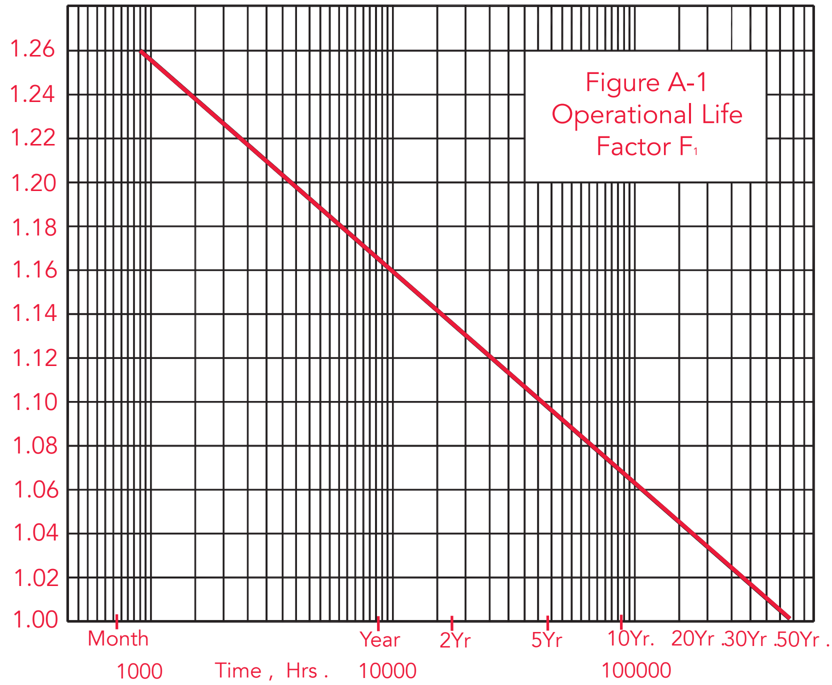
4.2.7 The buckling tension

The buckling tension can be calculated directly:

$$\sigma_k = P_{crit}\,\frac{r_m}{S}$$

Where:
Pcrit = Critical buckling pressure [bar]
rm = Medium pipe radius [mm]
S = Wall thickness [mm]

Figure A-1
Operational Life Factor
To use Figure A-1 for determining operational life multiplier (F_1). Select expected operating life of less than 50 years on horizontal time line, move upwards to intersect diagonalt turn line, then left to take reading at vertical axis.
Example: for a 5 years operational life F_1 = 1.09.



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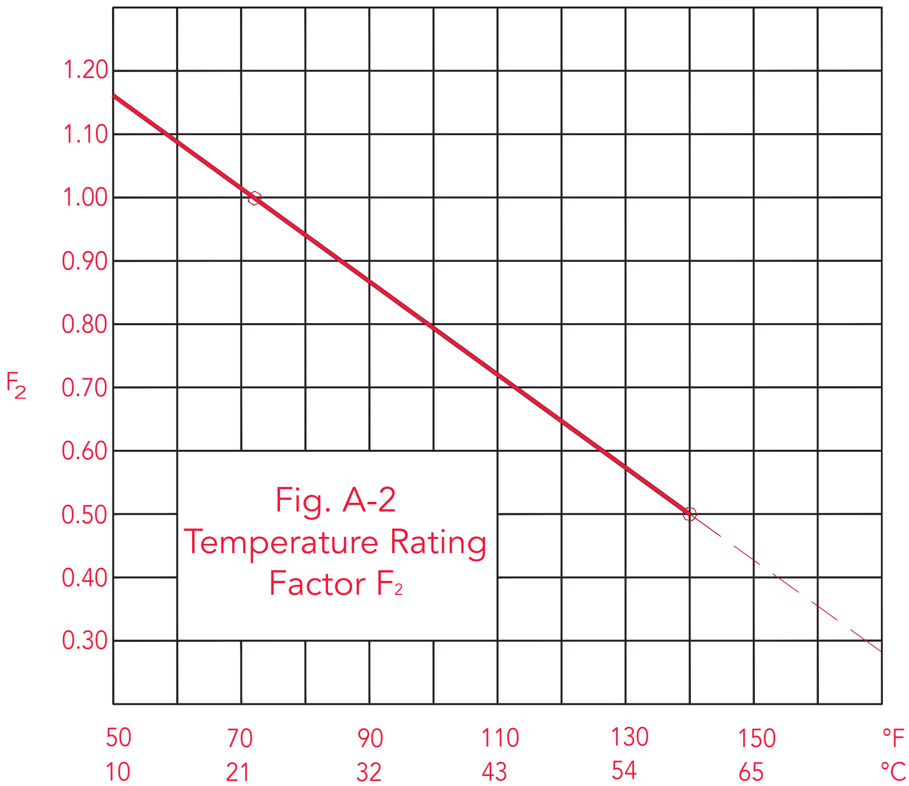


Figure A-2
Temperature Correction
Similarly, the temperature rating factor, F_2 , may be read from figure A - 2

Example: A polyethylene line operating at 125°F would given an F_2 = 0.62.

Table 11
Environmental service factor, F_3

Substance	*Service factor, F_3*
Crude oil	*0.50*
Wet natural Gas	*0.50*
Regulated dry Natural Gas	*0.64*

4.3.0 What factors can influence the design or service lifetime?

The service lifetime is influenced by five factors:

- The pipe operating conditions (temperature and pressure)
- The pipe material used
- External pipe loading (traffic loading, high water table, etc.)
- The surrounding environment, including the chemical loading from, for example, contaminated soil.
- Installation conditions and methods

4.3.1 Standard Equation for Determining the Major Stress Induced in a Pressurized Pipe

There are two major stresses which are induced in the wall of a closed cylindrical vessel, such as a pipe, when it is subjected to internal fluid pressure.

One runs along the axis of the vessel, often called the axial (longitudinal) stress, and the other, which is often called the hoop stress, runs along its circumference.

Since the magnitude of the hoop stress is about twice that of the axial stress the hoop stress is considered as the significant stress for purposes of pressure pipe design.

The hoop stress is not constant across a pipe's wall thickness. It tends to be larger on the inside than on the outside of a pipe. And, this tendency is heightened in the case of materials having high stiffness and in thicker walled pipes.

However, in the case of pipes made from thermoplastics – materials which are characterized by significantly lower stiffness than metals – it has long been accepted that the hoop stress is constant through the pipe's wall thickness.

For such case the so called thin-walled hoop stress equation is accepted as satisfactory and it has been adopted by standards which cover thermoplastics pipe.

4.3.2 Hoop stress

This equation, which more commonly is identified as the ISO (International Organization for Standardization) equation because it has been also adopted for thermoplastic pipes by that organization, is as follows:

(1)

4

$$S = \frac{P}{2}\frac{D_m}{t}$$

Where:
S = Hoop stress (psi or, MPa)
P = Internal pressure (psi or, MPa)
Dm = Mean diameter (in or, mm)
t = minimum wall thickness, (in or, mm)

Because PE pipe is made either to controlled outside diameters or in some cases, to controlled inside diameters the above equation appears in PE pipe standards in one of the following forms:

4.3.3 Hoop stress When the pipe is made to a controlled outside & inside diameter:

When the pipe is made to a controlled outside diameter:

(2)

$$S = \frac{P}{2}\left[\frac{D_o}{t} - 1\right]$$

Where Do is the average outside diameter

When the pipe is made to a controlled inside diameter:
(3)

$$S=\frac{P}{2}\left[\frac{D_i}{t}+1\right]$$

Where Di is the average inside diameter

4.3.4 pressure pipe design

For purposes of pressure pipe design, the pipe's pressure rating (PR) is determined the hydrostatic design stress (HDS) that is assigned to the material from which the pipe is made.

Therefore, Equation (2) can be re-arranged and written in terms of HDS and as follows:
(4)

$$PR=\frac{2(HDS)}{\left[\frac{D_o}{t}-1\right]}$$

Where PR is the pressure rating (psi or, MPa) and HDS is the hydrostatic design stress (psi or, MPa

And, Equation (3) becomes:
(5)

$$PR=\frac{2(HDS)}{\left[\frac{D_t}{t}+1\right]}$$

The term Do/t is referred to as the outside diameter dimension ratio and the term Di/t as the inside diameter dimension ratio. However, the convention in PE pipe standards is to limit these ratios to a standard few. The ASTM terms and abbreviations for these preferences are:

- Standard Dimension Ratio (SDR), for a standard Do/t dimension ratio
- Standard Inside Diameter Ratio (SIDR), for a standard Di/t dimension ratio

4.4.0 Hydraulic calculation

4.4.1 Volumetric flow rate

for calculating Volumetric flow for fluids with constant volume flow :

$$\dot{V} = 0.0036 \bullet A \bullet v$$

Where:

V = volume flow (m^3/h)
A= Free pipe cross section (mm^2)
v= Flow velocity (m/s)

4.4.2 flow velocity

the volumetric flow rate can be converted to flow velocity by using this eqyation:

$$V = \frac{0.40085 \bullet Q}{d^2}$$

where:

V = Flow velocity in feet per second
Q= Volumetric flow rate in gallons per minute
d= pipe inside diameter in inches

or

$$d = \sqrt{\frac{Q}{2.448 \bullet V}}$$

or

$$ID = 18.8 \bullet \sqrt{\frac{Q}{v}}$$

Where:
ID = inside diameter of pipe (mm)
Q = conveyed quantity (m^3/h)
v = flow celocity (m/s)

the material flow remains constant for gases and vapours. the following eqation results for

4.4.3 mass flow rate:

$$\dot{m} = 0.0036 \bullet A \bullet v \bullet \rho$$

where:
m = material flow (kg/h)
p = density of the medium depending on pressure and tempereture (kg/m^3)

4

4.4.4 Hydraulic pressure losses

Factors that affect Head Loss:

- **Laminar or turblent type of the flow rate**
- **lengh of the piping system**
- **Inside diameter of the pipe**
- **Viscosity of the flowing medium**
- **Straightness of the pipe**
- **Fittings**
- **Roughness of the pipe inside surface**
- **density of flowing medium**

The Hazen-Williams formula can be used to calculate any one of the following variables:

- **frictional pressure loss**
- **volumetric flow rate (Q)**
- **velocity (V)**
- **inside pipe diameter (d)**

4.5.0 Hazen-Williams Formula

One of the most commonly accepted formulas for head loss approximation and the basis for the pressurized flow is the Hazen-Williams Equation.

This relationship, expressed as a function of pressure loss in feet per 100 feet of pipe, is presented below.

$$HL = 0.2083 \bullet \frac{100^{1.852}}{C^{1.852}} \bullet \frac{Q^{1.852}}{d^{4.8655}}$$

Where:

HL = Head Loss in feet per 100 feet of pipe
C = Hazen-Williams Flow Factor (150 for thermoplastic pipe)
Q = Volumetric Flow Rate in gallons per minute
d = Pipe inside diameter in inches

the head loss of straight pipe line can be calculated from :

$$HL = \lambda \bullet \frac{L}{ID} \bullet \frac{\rho}{2 \bullet 10^2} \bullet v^2$$

where:

HL = head loss of straight pipe sections (bar)

λ = Pipe frictional index =0.02 according to dvs 2210-1:1997

L = length of piping system (meter)

ID = inside diameter of pipe (mm)
p = medium density (kg/m³)
v = flow velocity (m/s)

4.5.1 for pressure drop in fittings :

$$HL_{fittings} = K \bullet \frac{\rho \bullet v^2}{2}$$

where:
$HL_{fittings}$ = head loss across fitting (Pa)
p = medium density, (kg/m³)
v = flow volecity in the pipe (m/s)
K = resistance coeffcient (Dimensionless)

Type	*resistance conflicent (K)*
45° Elbows	*0.3*
90° Elbows (Standard Radius)	*0.6 - 0.8*
30° Mitre Bends	*0.2*
45° Mitre Bends	*0.375*
60° Mitre Bends	*0.625*
90° Square Elbows	*1.2*
180° Return Bend (Close Pattern)	*1.25*
T-Piece (Side Connection)	*1.2 - 1.8*
T-Piece (Flow through)	*0.5*
Globe Valves (Fully Open)	*1.2 - 6.0*
Gate Valves (Fully Open)	*0.15*
Gate Valves (3/4 Open)	*1*
Gate Valves (1/2 Open)	*4*
Gate Valves (1/4 Open)	*16*
Plug Valves (Fully Open)	*0.45*
3-Way Valve (Straight Thru')	*0.75*
3-Way Valve (Side Connection)	*2.25*
Ball Valves	*0.075*
Butterfly Valves (less than 10" 250mm NB)	*1.125*
Butterfly Valves (10" 250mm NB – 14" 350mm NB)	*0.875*
Butterfly Valves (Greater than 14" 350mm NB)	*0.625*
Check Valves (Swing Type)	*2.5*
Check Valves (Lift Type)	*15*
Pipe Exits	*1*
Pipe Entrances	*0.78*

4.5.2 head loss of finished joints or couplings:

$$HL_{joints} = K \bullet \frac{\rho \bullet v^2}{2}$$

resistance coefficient K = 0.1 for each joints in a thermoplastic piping system, such as butt and socket welding as well as flanges.

4.5.3 For total head loss drop :

$$HL_{total} = HL_{straight\ pipe\ section} + HL_{valves} + HL_{Fittings} + HL_{joints}$$

4

4.6.0 Gravity flow

The Hazen-Williams Formula may be used for the approximation of gravity flow as well as pressurized flow , A more commonly accepted approximation for gravity flow is the Manning Equation. This relatively straightforward equation is:

4.6.1 Average flow velocity in imperial and metric

$$V = \frac{1.486 \bullet R^{0.667} \bullet S^{0.5}}{n}$$

Where:
V = Average flow velocity in feet per second
R = Hydraulic radius in feet
= ID/4 for full flow
= Cross sectional area of flow / wetted perimeter
S = Slope in feet per foot
n = Manning flow coefficient

in metric Units:

$$V = \frac{1}{n} \bullet R^{\frac{2}{3}} \bullet S^{\frac{1}{2}}$$

Where:

$$R = \left(\frac{Vn}{S^{\frac{1}{2}}} \right)^{\frac{3}{2}}$$

$$S = \left(\frac{Vn}{R^{\frac{2}{3}}} \right)^{2}$$

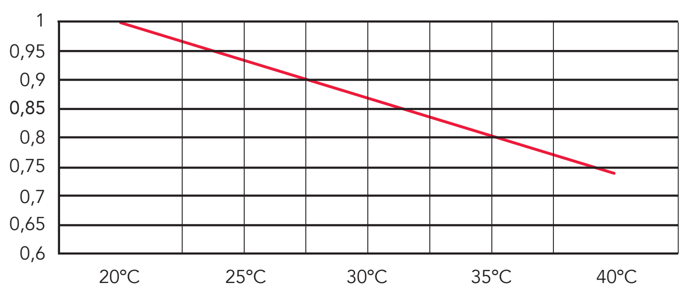
V = mean velocity in meters per second
n = manning coefficient of roughness
R = hydraulic radius in meters (the cross-sectional area of flow divided by the wetter perimeter)
S = hydraulic slope in meters per meter

4.6.2 Thermal loading

For operation of systems at temperatures between 20°C and 40°C, the nominal pressure is reduced by applying the pressure reduction factor derived from the graph in the nominal pressure for 20°C operation.

Multiply this nominal pressure by this pressure reduction factor in order to obtain the nominal operating pressure at the required operating temperature.

When temperatures are lower than 20°C, up-rating of the allowable pressures would be applicable, but this is usually not done, implying that then an even higher factor of safety on the allowable pressure is present.



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4.7.0 Frictional Pressure Loss in Low Pressure Polyethylene Gas Pipelines

For Natural Gas assuming:

General Flow Equation Constant (C) = 7.57 x 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)

4.7.1 Low pressure FLow equation

$$(P1-P2)=\frac{Q^2 \bullet 1.841 \bullet 10^6 \bullet f_{SpL} \bullet L}{d^5}$$

where:

P1 = Upstream pressure bar (absolute)
p2 = Downstream pressure bar (absolute)
d = internal pipe diameter (mm)
L = pipe length
Q = Gas flow at base conditions m^3/hr
F spl = Friction factor (spl = smooth pipe law) assuming Pipe Absolute roughness (k) for new pipework = 0.003 (mm)
Efficiency factor (e) = 0.97
Friction factor (f) = fspl/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) = $25053 \bullet \frac{Q}{D}$

The above is considered valid for pressyre up to 75mbar

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)

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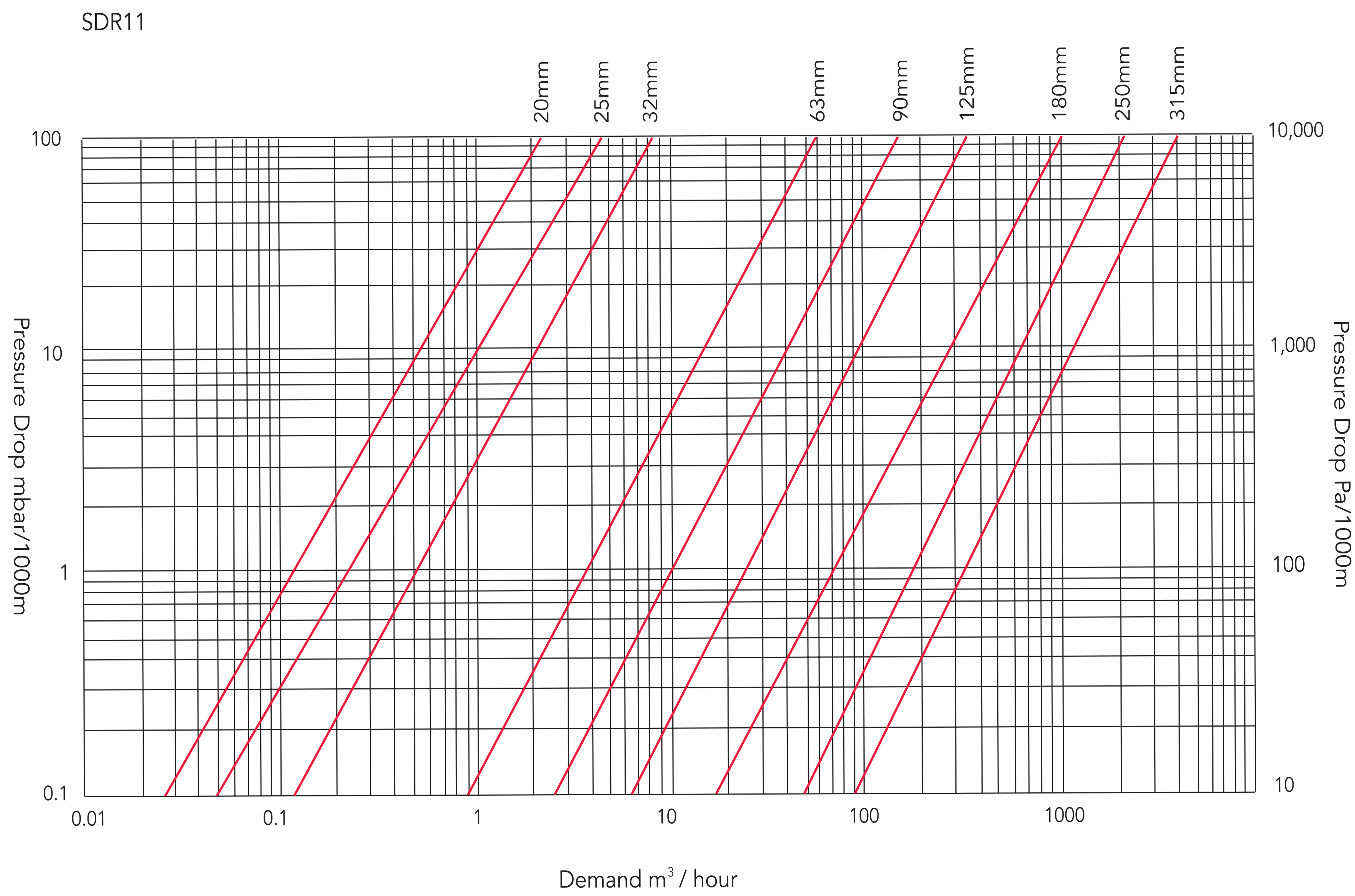
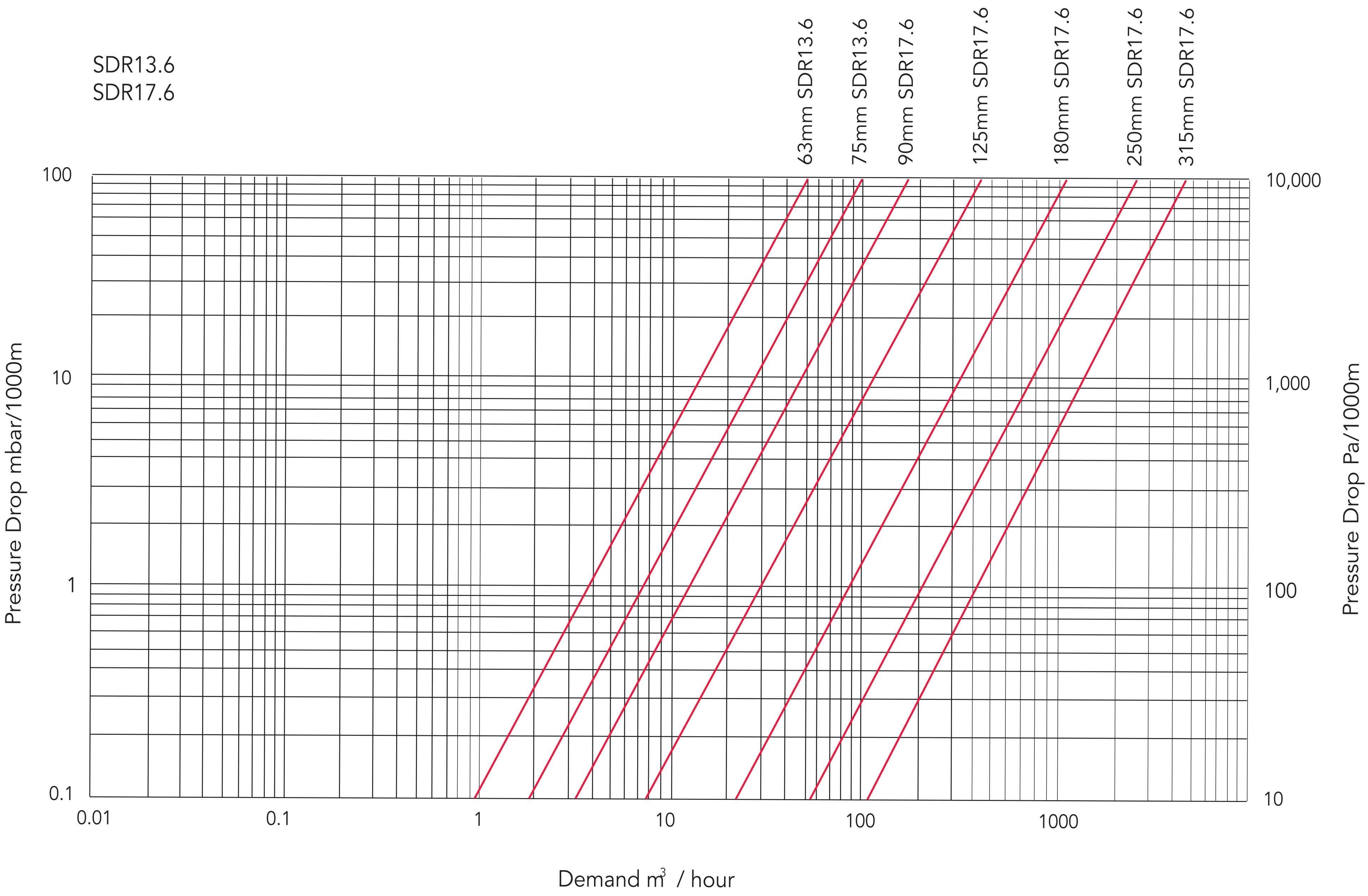
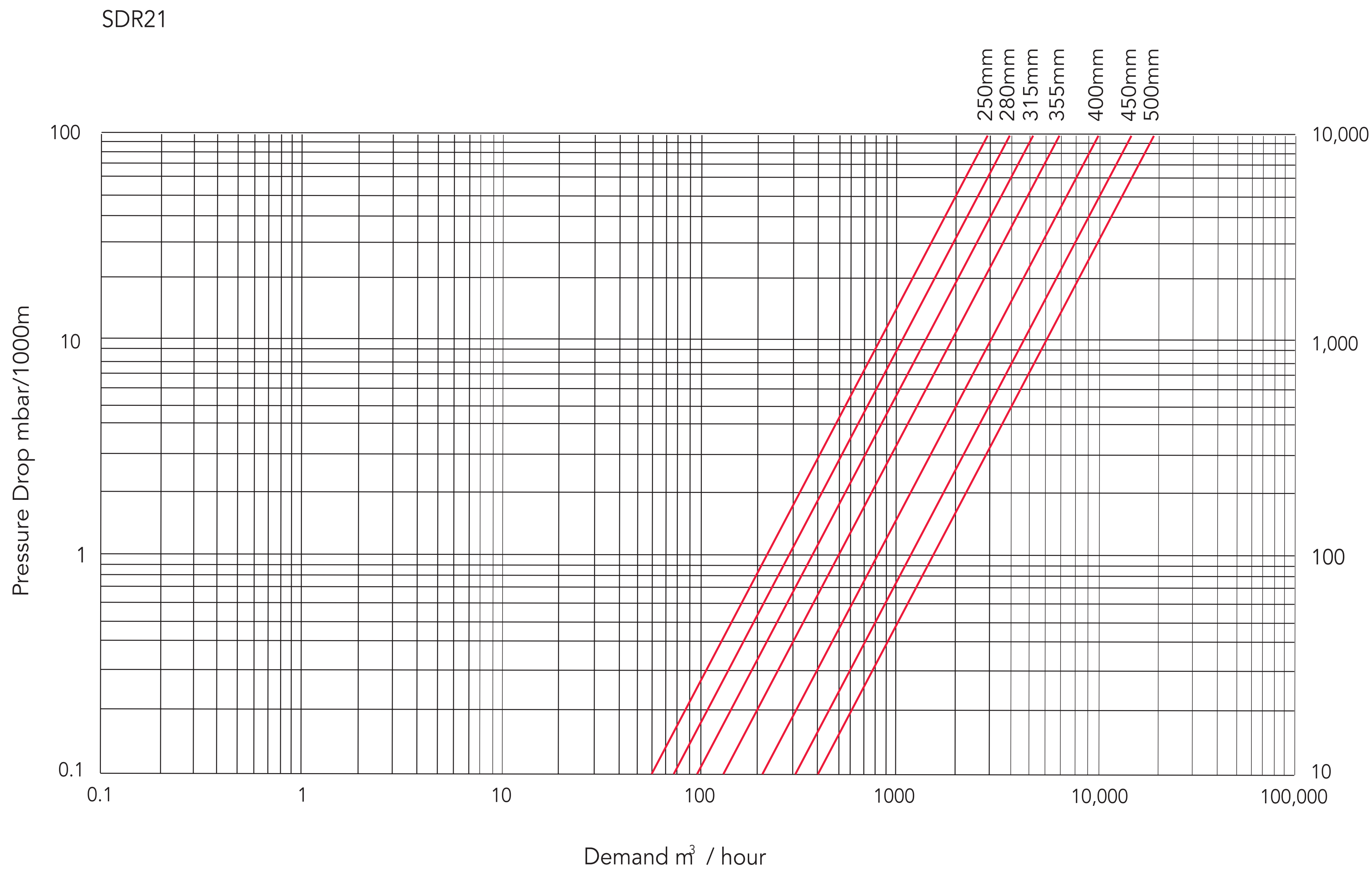


SDR11
20mm
25mm
32mm
63mm
90mm
125mm
180mm
250mm
315mm
100
10
1
0.1
Pressure Drop mbar/1000m
10,000
1,000
100
10
Pressure Drop Pa/1000m
0.01
0.1
1
10
100
1000
Demand m3 / hour


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

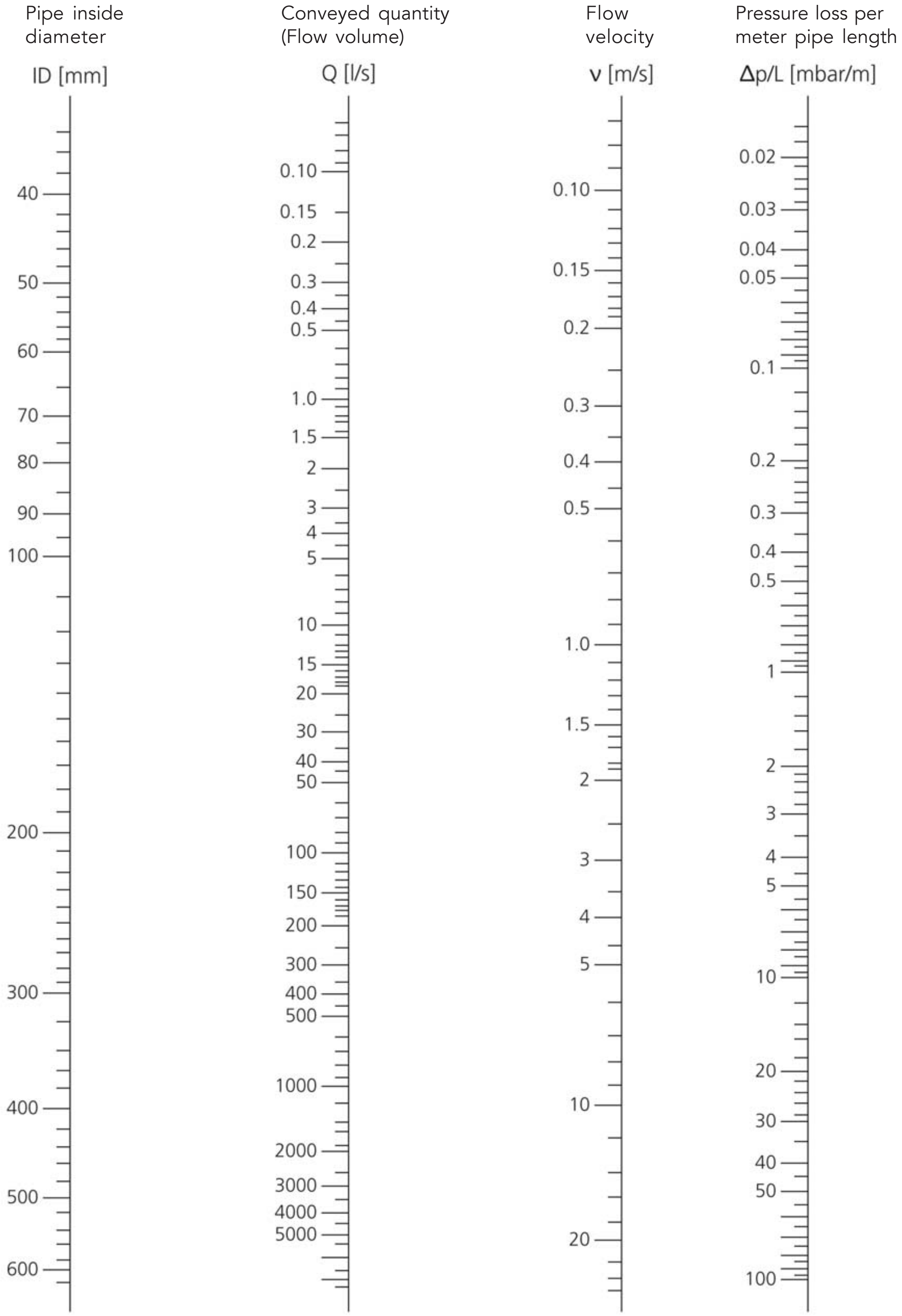

SDR21
250mm
280mm
315mm
355mm
400mm
450mm
500mm
Pressure Drop mbar/1000m
100
10
1
0.1
Pressure Drop Pa/1000m
10,000
1,000
100
10
0.1
1
10
100
1000
10,000
100,000
Demand m3 / hour

5 Flow Nomogramm

5.1.0 Flow Nomogramm

5.1.0 Flow Nomogramm

For rough determination of flow velocity, pressure loss and conveying quantity serves the following flow nomogram. At an average flow velocity up to 20m of pipe length are added for each tee, reducer and 90° elbow, about 10m of pipe for each bend r = d and about 5m of pipe length for each bend r = 1,5 x d.



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6 Change in length

6.0.0 Change in length

When a pipe is anchored at one end but can otherwise freely move in the axial direction, an increase in temperature causes the pipe to increase in overall length.A decrease in temperature would cause an opposite change. The following expression predicts the net expansion/contraction in the length of a fully unrestrained pipe that occurs in consequence of a given change in temperature
changes in operrating and test process can cause to change in lengh of plastic piping systems, there is 3 elements than can influence on changes in length :

- change in length by temperature or Unrestrained Thermal Effects is the most important one to be considered in a piping system design
- change in length by internal pressure
- change in length by chemical effects

6.1.1 Unrestrained Thermal Effects

The theoretical change in length for an unrestrained pipe placed on a frictionless surface can be determined from this Equation:

$$\Delta L = \Delta T \bullet \alpha \bullet L$$

where:

Delta L = longitudinal expansion/contraction (m)
Delta T = difference in temperature (°C) (e.g. between pipe temp.during installation and regular soil temp.)
L = length of section (m)
Alpha = coefficient of linear thermal expansion (PE = 0.15 - 0.20)

6.1.2 change in length by internal pressure

the length expansion caused by the internal pressure can be calculate by :

$$\Delta L_p = \frac{0.1 \bullet p \bullet (1-2\bullet\mu)}{E_c \bullet \left(\frac{OD^2}{ID^2} - 1\right)} \bullet L$$

Where:

6

ΔL_p = change in length by internal pressure load (mm)

p = Operating pressure (bar)

m = Transversal contraction coefficicient

E_c = creep modulus (n/mm²) for t = 100 min

OD = pipe outside diameter (mm)

ID = pipe inside diameter (mm)

6.1.3 change in length by chemical effects

solvents for example, at the same time , it come to reduction of machanical strengh properties it may also come to change in length of pe pipe or we can call it (swelling).

it is recommended to take a swelling factor for material like solvents (e. g.)

f_{ch} = 0,025 ÷ 0,040 (mm/mm)

$$\Delta L_{ch} = f_{ch} \bullet L$$

Δ L = Change in length by swelling (mm)
f_{ch} = Swelling factor
L = Length of piping system (mm)

6.1.4 Change in length and flexible sections

Thermoplastics are subject to greater thermal expansion and contraction than metals.
On installation of piping systems above ground against walls or in ducts, especially those exposed to temperature variations, require changes in length to be taken up in order to prevent extra strain on the pipes. Length changes can be taken up by:

Flexible sections
compensators

The most common solution, and most economical and the simplest are the flexible sections

The low modulus of elasticity of thermoplastics allows changes in length to be taken up by special pipe sections, where pipe supports are positioned so that they can take advantage of the natural flexibility of the material.

The length of such sections is determined by the diameter of the pipeline and the extent of the thermal expansion to be compensated.

Flexible sections arise naturally at any branching or change in direction of the pipeline. The movement L_B of the flexible section as a result of a change ΔL in the length must not be restrained by fixed pipe brackets, protrusions wall, girders or the like.

The minimum straight length is expressed by:
or min LB:

$$L_B = K \cdot \sqrt{\Delta L \cdot de}$$

Where:
L_B = Minimum strught length (mm)
ΔL = change in length (mm)
de = pipe outside diameter (mm)
K = material specific proportionality factor

(PE 26)

or

The required length of the flexible section can be calculated using the following formula:

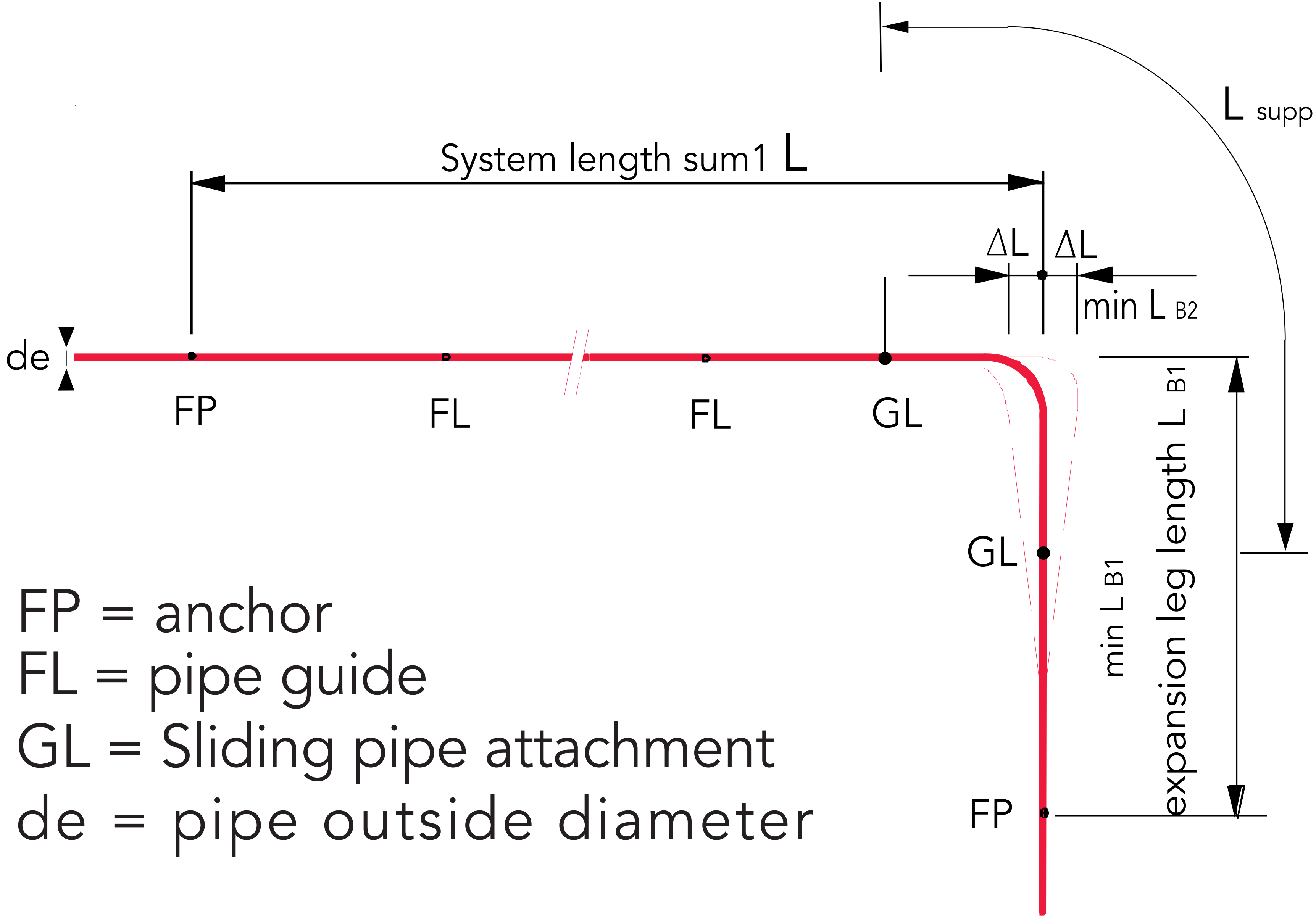
$$L_B = \sqrt{\frac{3 \cdot d_e \cdot \Delta L \cdot E_{cm}}{\sigma_b}}$$

where:
de = pipe outside diameter (mm)
ΔL = change in length (mm)
Ecm = average bending creep modulus for t= 25 a (N/mm^2)
σ_b = permitted bending stress for t = 25 a (N/mm^2)

6

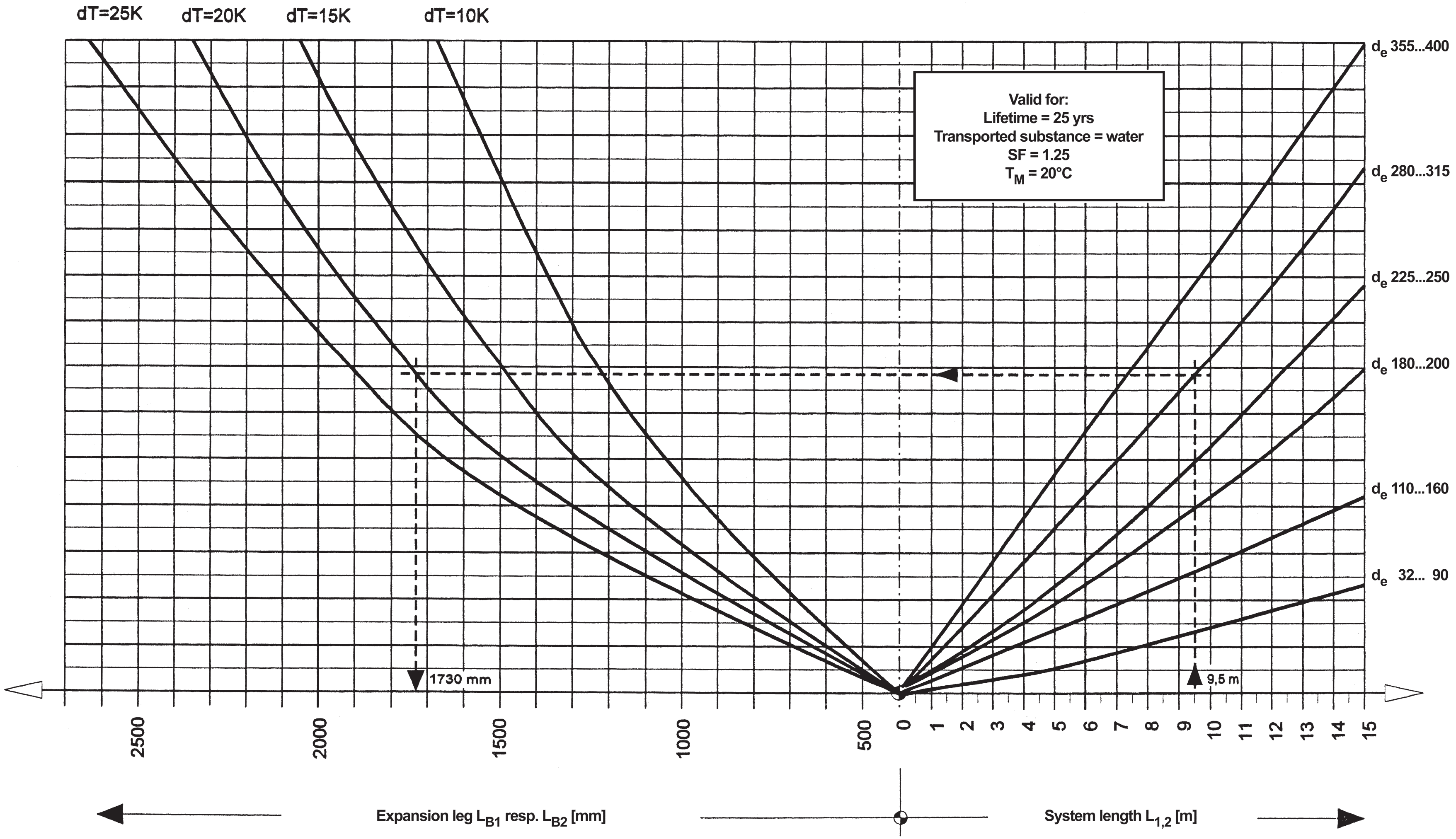
7 (L - U - Z) Expansions Design

Principle drawing L-compensation elbow

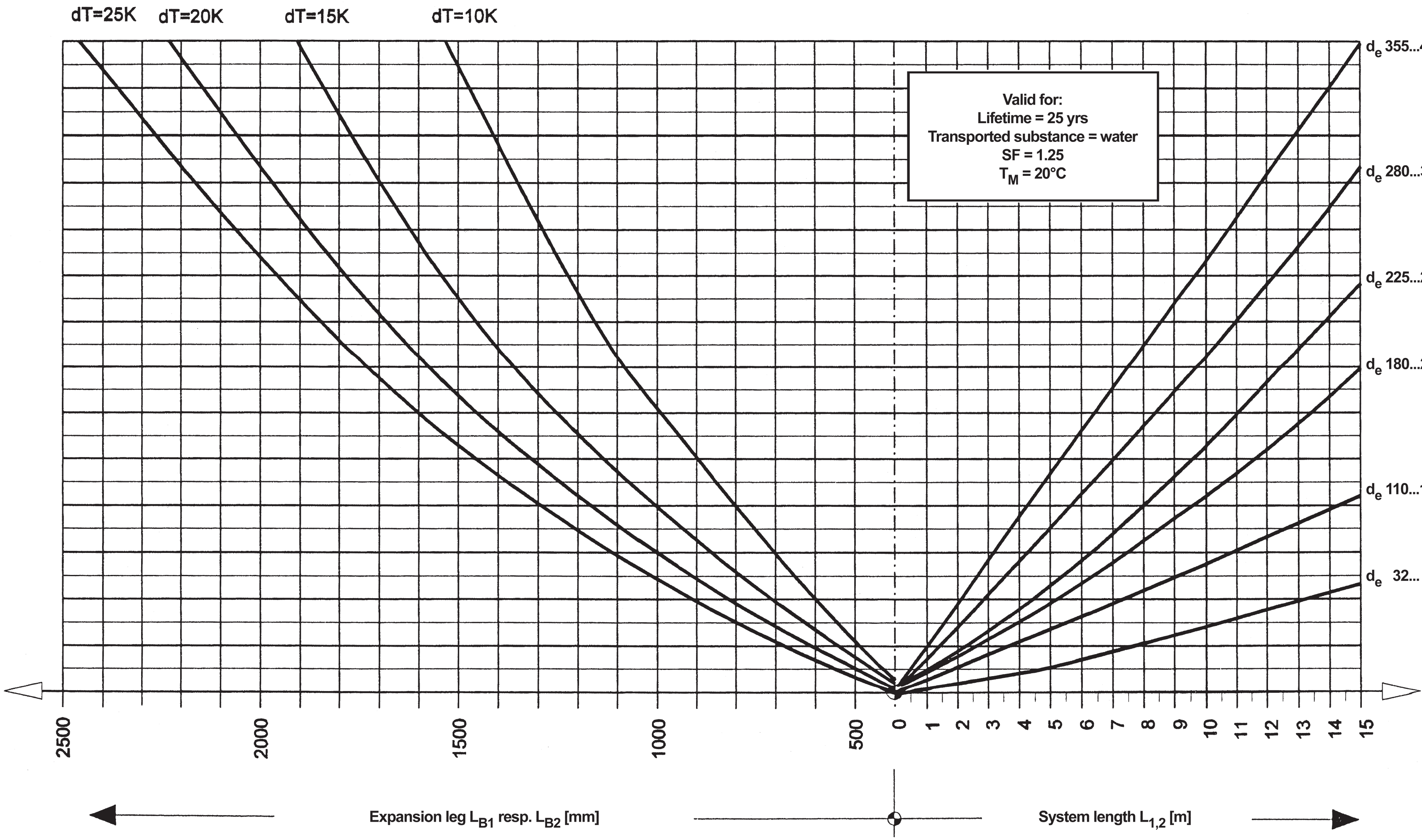


FP = anchor
FL = pipe guide
GL = Sliding pipe attachment
de = pipe outside diameter

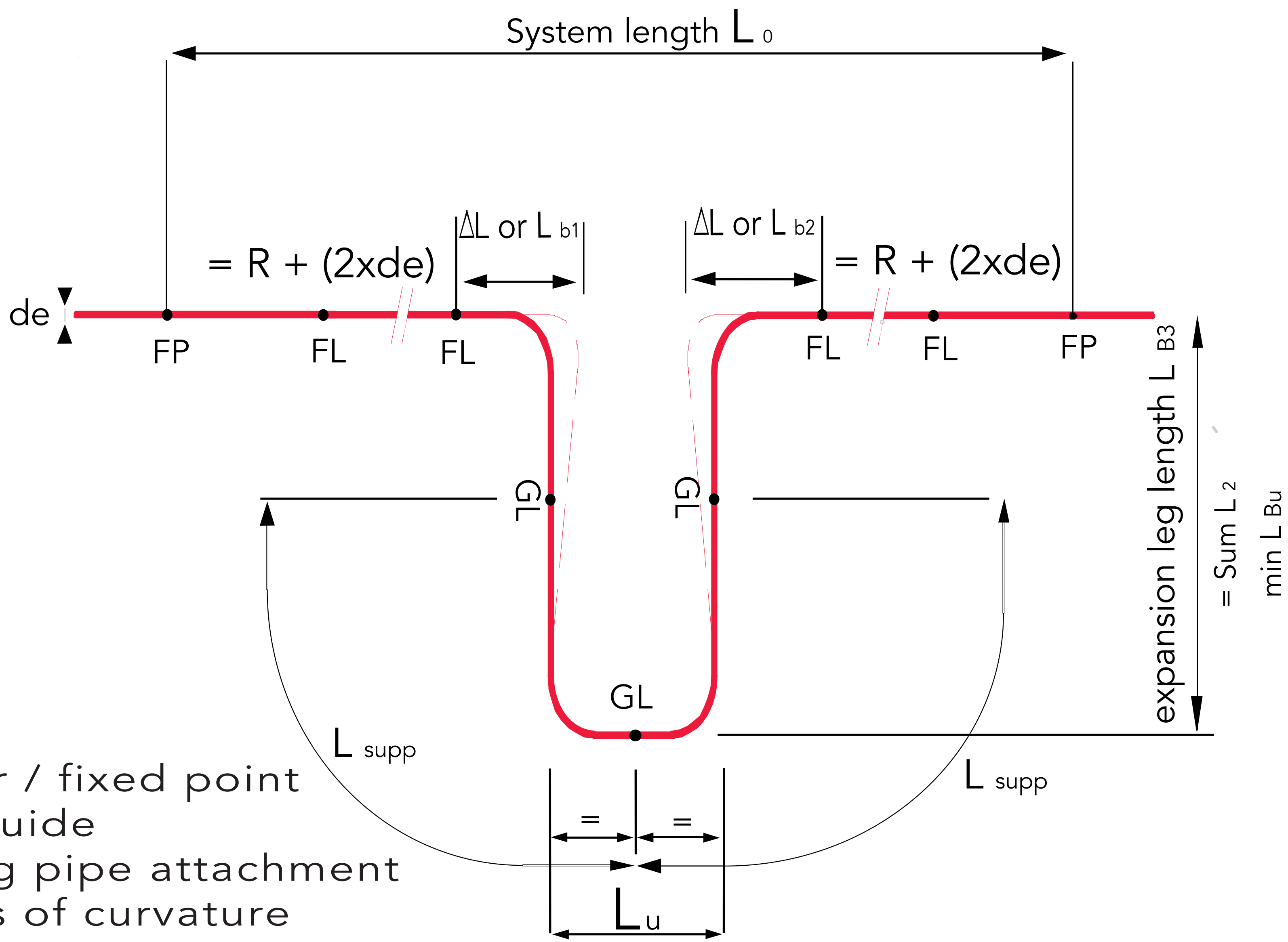
System Measurements: L Expansion Bend
Material: PE 80



System Measurements: L Expansion Bend
Material: PE 100

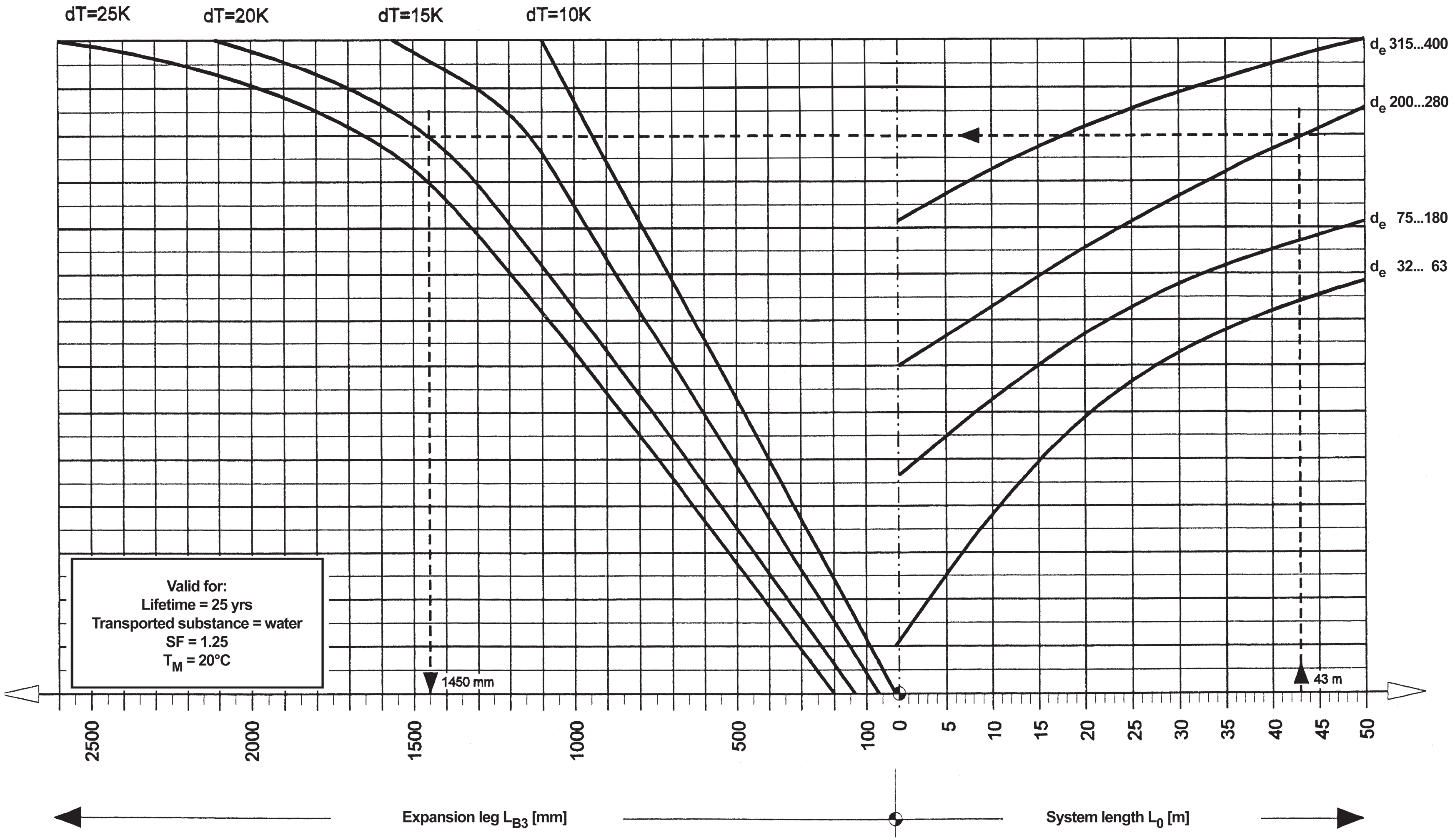


Principle drawing U-compensation elbow

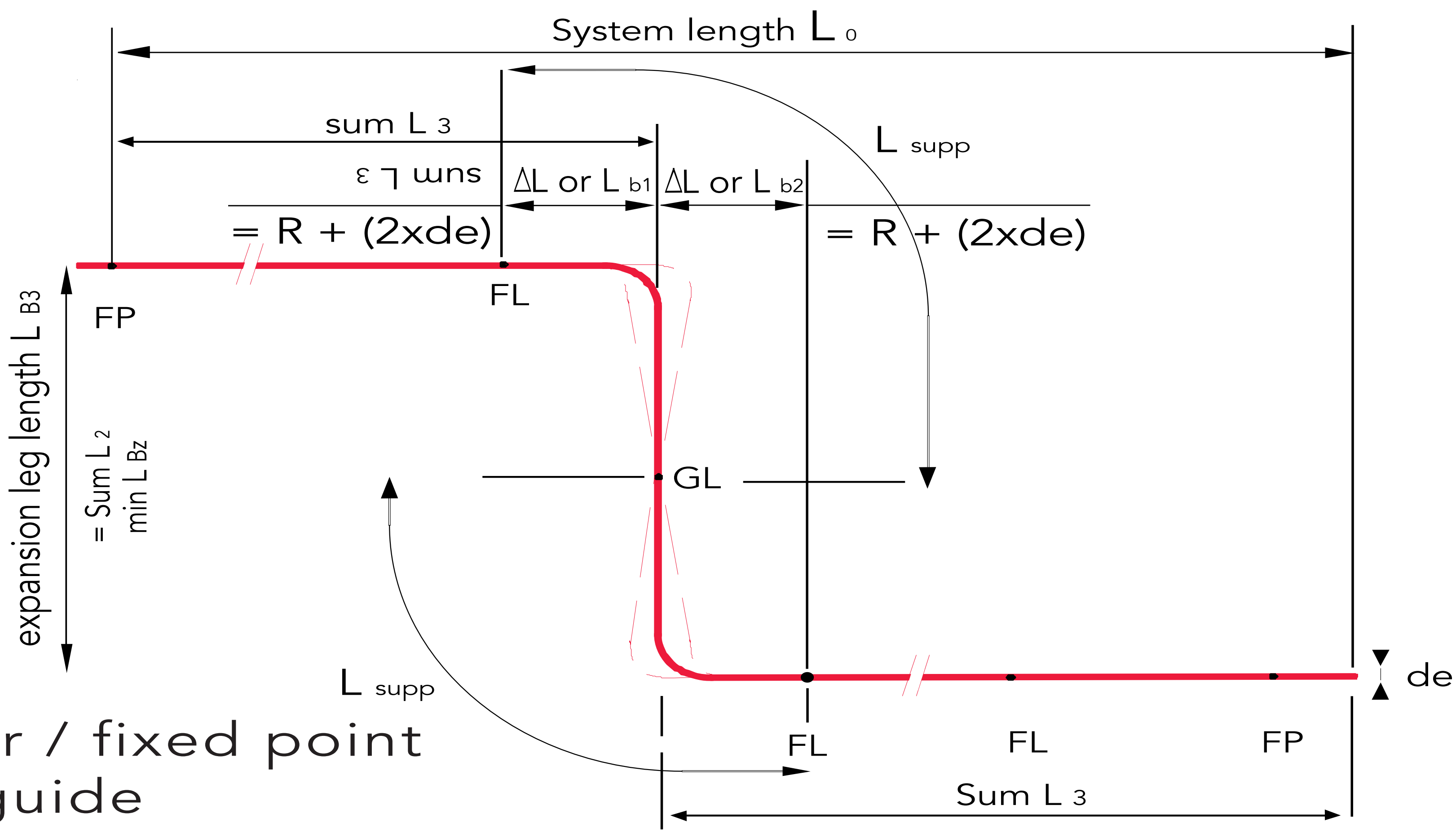


FP = anchor / fixed point
FL = pipe guide
GL = Sliding pipe attachment
R = Radius of curvature
$L_u \geqslant 2 \times (R + de) + \text{sum } \Delta L$
de = pipe outside diameter

System Measurements: U Expansion Bend
Material: PE 80 / PE 100

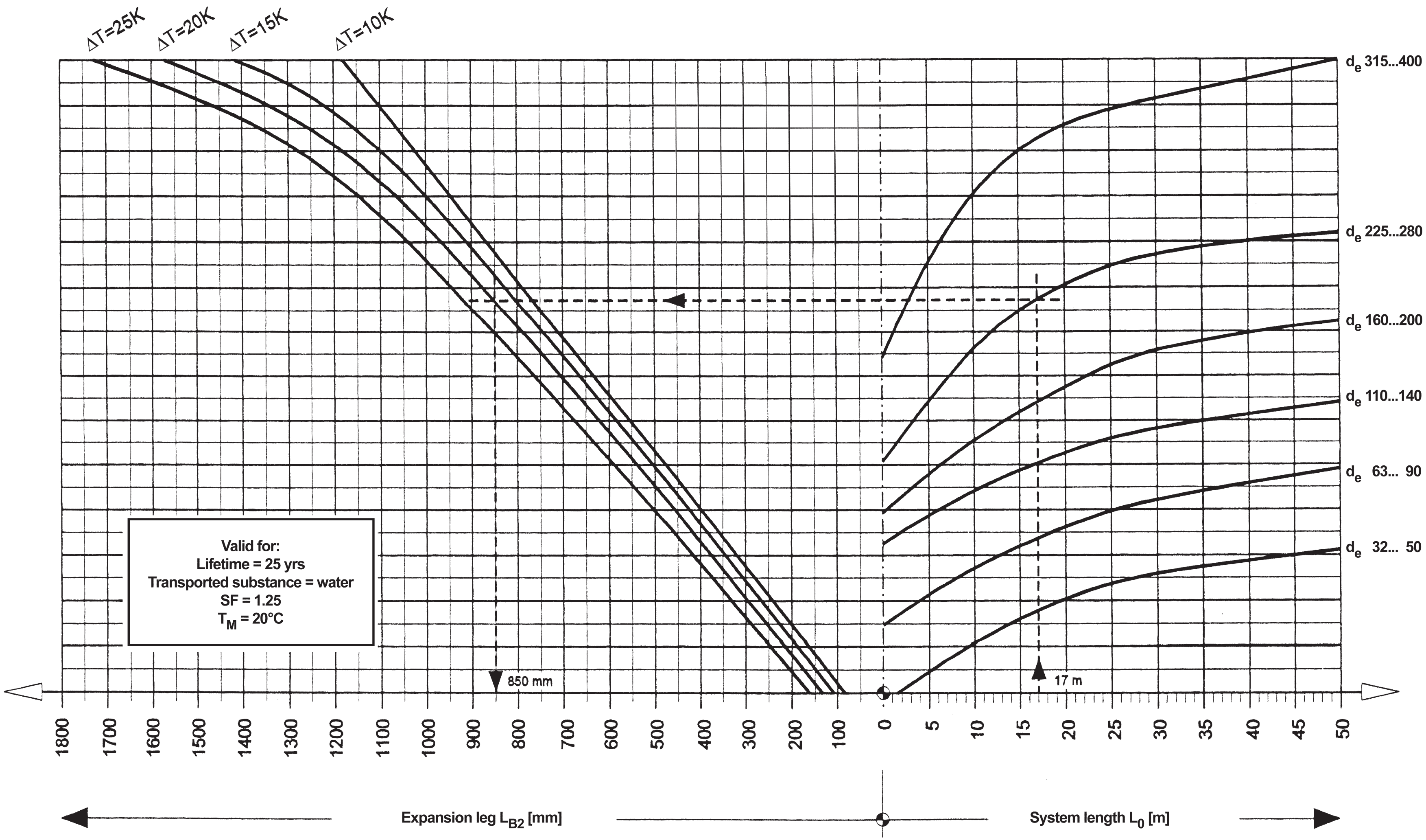


Principle drawing Z-compensation elbow



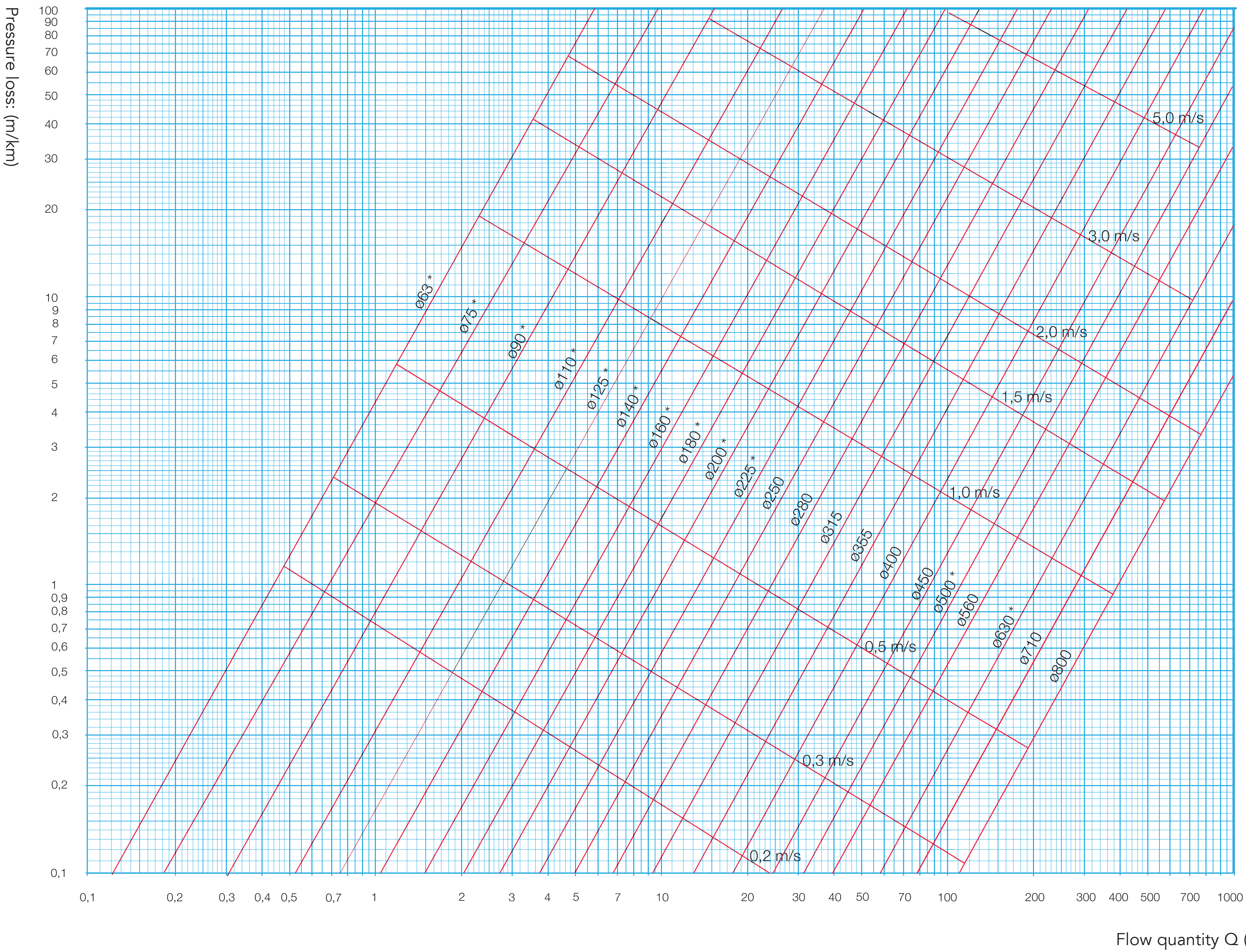
FP = anchor / fixed point
FL = pipe guide
GL = Sliding pipe attachment
R = Radius of curvature
$L_u \geqslant 2 \times (R + de) + \text{sum } \Delta L$
de = pipe outside diameter

System Measurements: Z Expansion Bend
Material: PE 80 / PE 100

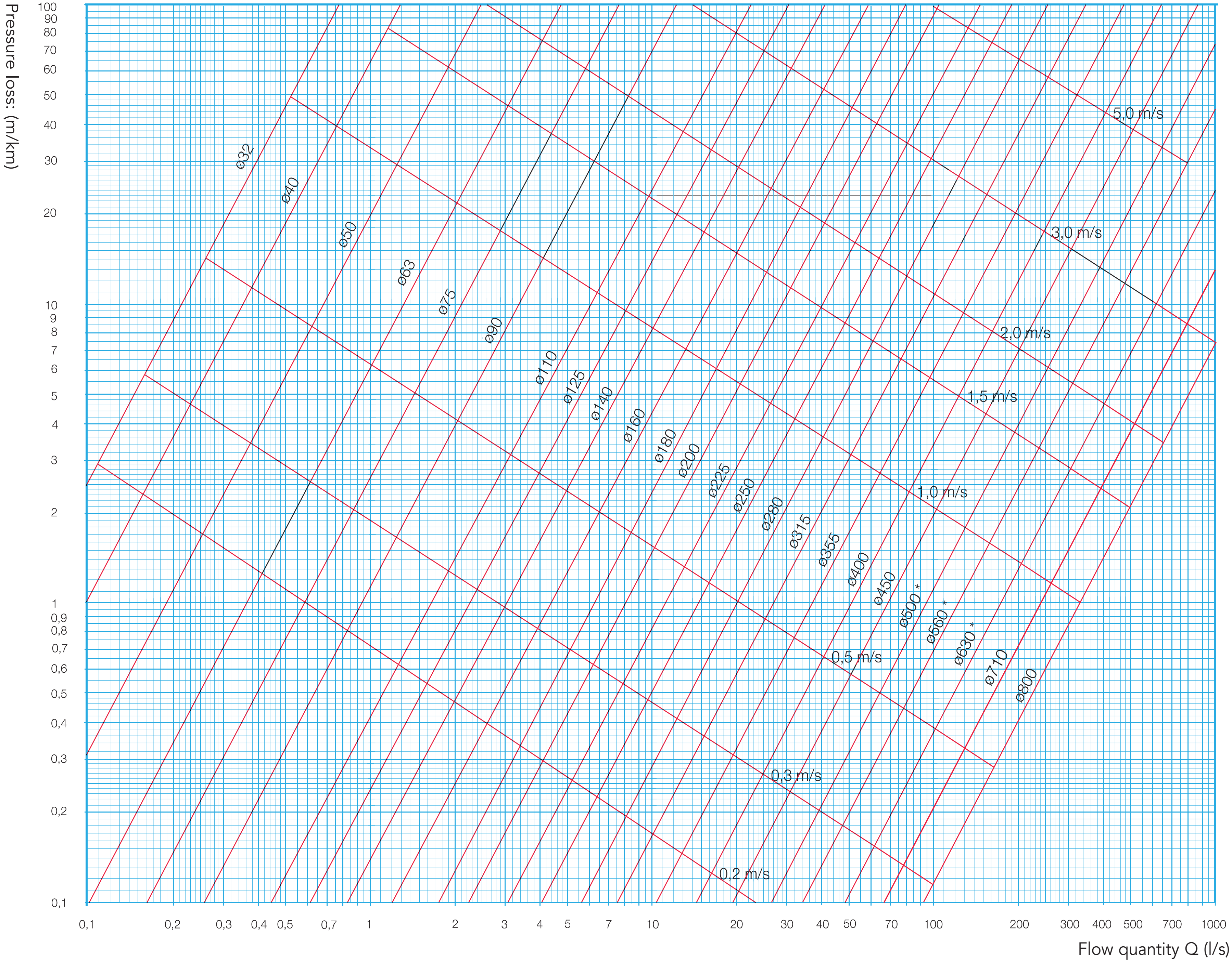


8 Flow Graph of PE 100 pipes

8.1.0 Flow graph for PE100 pipes PN10 (SDR 17)



8.2.0 Flow graph for PE100 pipes PN16 (SDR 11)



9 Laying, mounting of PE pipes

9.0.0 Above ground installation

Abrah Dashte Markazi's pe pipes can be installed above ground for pressure and non pressure applications

PE pipes made with carbon black or other uv stablizer in accurdance to Din 8074-8075 requirements may be used in direct sunlight exposure conditions without any additional protection.

9.1.1 Installation Characteristics

There are two basic types of above-ground installations.

- stringing-out the pipe over the naturally-occurring grade or terrain.
- suspending the pipe from various support structures available along the pipeline right-of-way.

Each type of installation involves different design methodologies, so the installation types are discussed separately.

9.1.2 On-Grade Installations

As indicated previously, pipe subjected to temperature variation will expand and contract in response to temperature variations. The designer has two options available to counteract this phenomenon. Basically the pipe may be installed in an unrestrained manner, thus allowing the pipe to move freely in response to temperature change. Or the pipe may be anchored by some means that will control any change of physical dimensions; anchoring can take advantage of PE's unique stress relaxation properties to control movement and deflection mechanically

9.1.3 Free Movement

An unrestrained pipe installation requires that the pipe be placed on a bed or right of way that is free of material that may abrade or otherwise damage the exterior pipe surface. The object is to let the pipe "wander" freely without restriction or potential for point damage. This installation method usually entails "snaking" the PE pipe along the right-of-way. The excess pipe then allows some slack that will be taken up when the temperature drops and the pipe contracts

In all likelihood, a free-moving PE pipe must eventually terminate at or connect to a rigid structure of some sort. It is highly recommended that transitions from freemoving PE pipe to a rigid pipe appurtenance be fully stabilized so as to prevent stress concentration within the transition connection.
Figure 1-3 illustrates some common methods used to restrain the pipe at a distance of one to three pipe diameters away from the rigid termination. This circumvents the stress-concentrating effect of lateral pipe movement at termination points by relieving the stresses associated with thermal expansion or contraction within the pipe wall itself

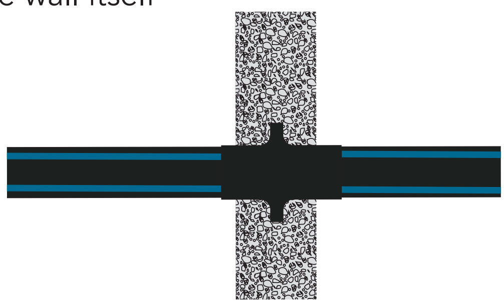


Figure 1.

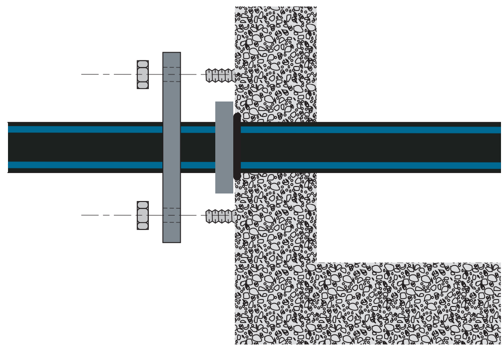


Figure 2.

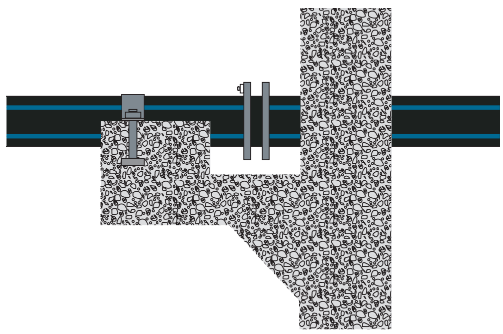


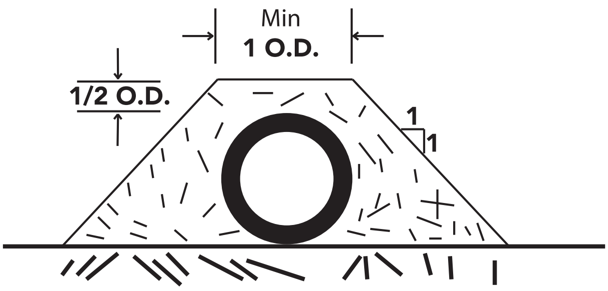
Figure 3.

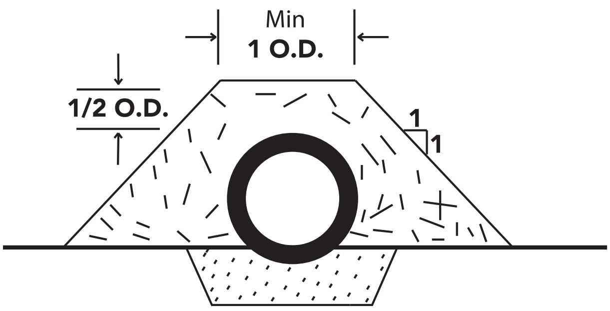
9

9.2.0 Restrained Pipelines

The design for an above-ground installation that includes restraint must consider the means by which the movement will be controlled and the anchoring or restraining force needed to compensate for, or control, the anticipated expansion and contraction stresses. Common restraint methods include earthen berms, pylons, augeredanchors, and concrete cradles or thrust blocks.

The earthen berm technique may be either continuous or intermittent. The pipeline may be completely covered with a shallow layer of native earth over its entire length, or it may be stabilized at specific intervals with the earthen berms between the anchor locations. Typical earthen berm configurations are presented in Figure.





9.2.1 Supports

Pipe hangers, or supports, should be located evenly along the length of the PE pipeline, and additionally at localised points with heavy items such as valves, and fittings.

The supports should provide a bearing surface of 120° under the base of the pipes. The PE pipes may need to be protected from damage at the supports. This protection may be provided by a membrane of PE, PVC or rubber.

Location and type of support must take into account provision for thermal movement, if required. If the supports are to resist thermal movement, an assessment of the stress induced in pipes, fittings and supports may need to be made.

9.2.2 Support Spans

Support spans depend on the pipe material and dimensions, nature of flow medium, operating temperature, and arrangement of the pipes.

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 20°C.

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 For other service temperatures, the spans should be reduced accordingly.

For pipes where the material temperature is likely to reach 60°C the pipe should be continuously supported. For vertical pipes, the support span can be doubled.

For fluids with density between 1000 kg/m^3 and 1250 kg/m^3, decrease spans by 4%.

For PE pipes used in air systems, the spans may be increased by up to 30%.

* Extracted from chapter 8 handbook of pe pipe , PPI

Recommendations for maximum support spacing are given in the table below.

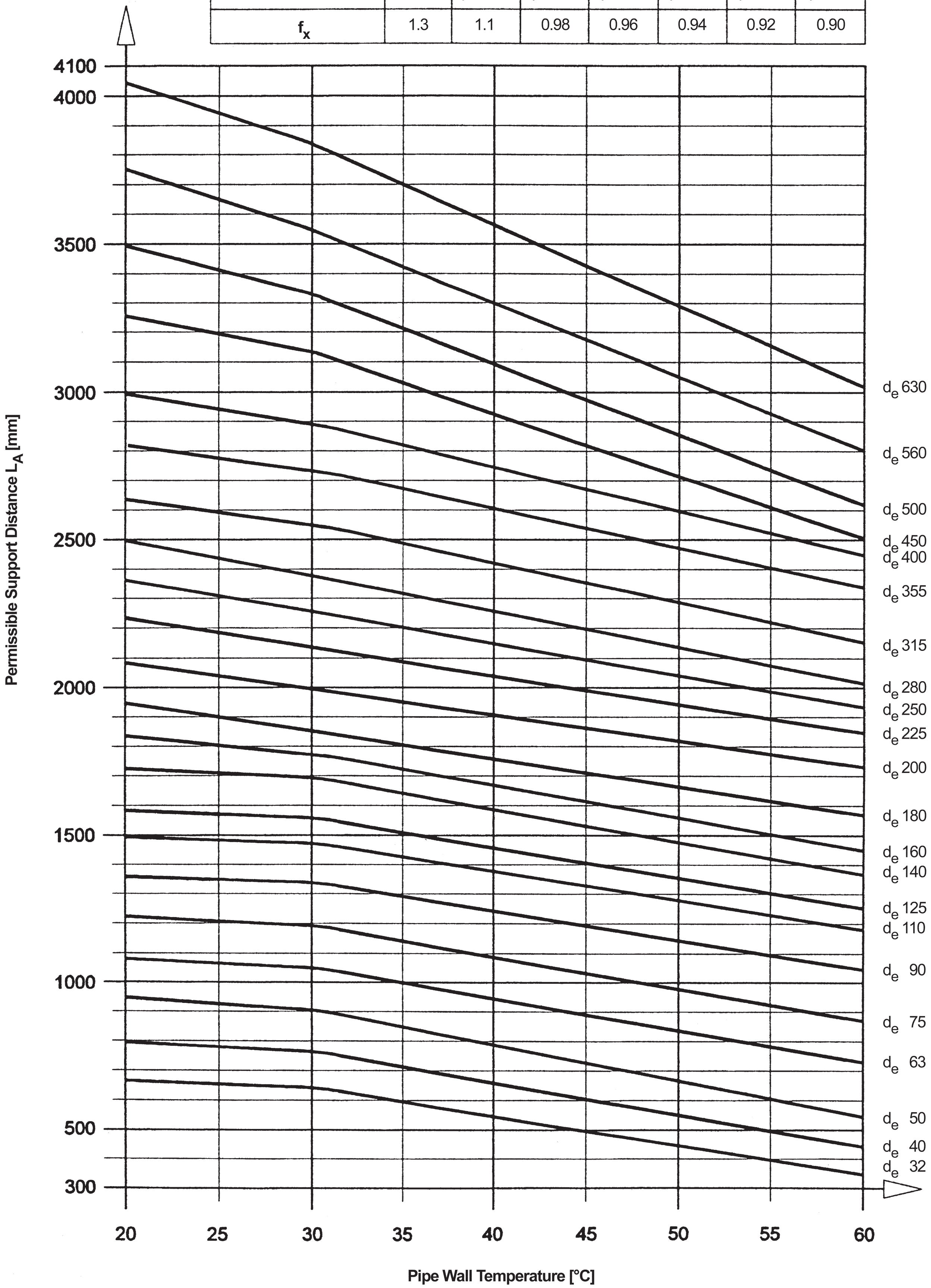
Above ground pipe work Maximum Support Spacing (Meters)

PIPE	SDR 11	SDR 17	SDR 21	SDR 26
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

- For pipes where the material temperature is likely to reach 60°C the pipe should be continuously supported. For vertical pipes, the support span can be doubled.
- For fluids with density between 1000 kg/m^3 and 1250 kg/m^3, decrease spans by 4%.
- For PE pipes used in air systems, the spans may be increased by up to 30%.

Supported Distances for PE 80/PE 100 Plastic Pipelines

	Transported substance density [g/cm³]						
Conversion factor	Gas	ρ = 1.0	ρ = 1.1	ρ = 1.2	ρ = 1.3	ρ = 1.4	ρ = 1.5
f_x	1.3	1.1	0.98	0.96	0.94	0.92	0.90



9

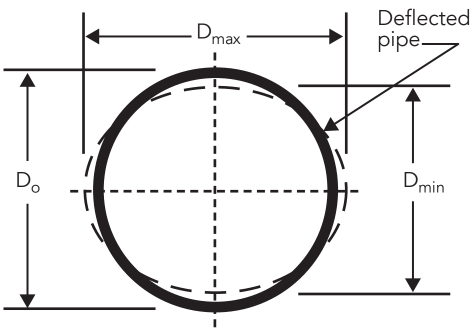
9.3.0 Buried pipeline design

PE pipes can deflect up to their allowable deflection limit without damage. Most PE pipes can withstand large amounts of deflection without damage but for practical purposes PE pipes are limited to 7.5% deflection or less depending on the DR and application the degree of deflection will depend on several factor

- Trench width
- Soil conditions
- depth of burial
- burial conditions

The load carrying capability of a PE pipe, particularly a pipe with a high DR, can be greatly increased by the soil in which it is embedded. When the pipe is loaded, load is transferred from the pipe to the soil by a horizontal outward movement of the pipe wall This enhances contact between pipe and soil and mobilizes the passive resistance of the soil This resistance aids in preventing further pipe deformation and contributes to the support for the vertical loads. The amount of resistance found in the embedment soil is a direct consequence of the installation procedure. The stiffer the embedment materials are, the less deflection occurs. Because of this, the combination of embedment and pipe is often referred to as a pipe-soil system.

Deflected pipe



Soil arching reduces the external load on a flexible pipe to less than the stress caused by the burden of soil directly above the pipe ("ge static" stress). This reduction results in flexible pipes having lower bending and compressive stresses than rigid pipes. And because PE is a viscoelastic material, the ring bending stress decreases over time.When plastic is essentially under constant strain, the load required to maintain the constant deformation gradually decreases, and after a sufficient length of time, it can be as low as a fourth of the initial value.

When a buried flexible pipe is pressurized internally, the compressive and bending stresses caused by external loads are reduced as the pipe rerounds so combined internal and external loading analysis is not necessary for PE pipe

The accepted convention is to design PE pipe as if internal and external loads act independently. Most often, pressure design is the controlling factor. Generally, the design procedure is to select a pipe that satisfies the internal working pressure, maximum anticipated surge, and flow capacity requirements and then to analyze the subsurface installation to ensure that the pipe, as installed, will withstand the external loads.

External load capacity is normally checked by the following steps:

1. Determine the external loads applied to pipe.

2. Verify that the deflection caused by external loads does not exceed the allowable value.

3. Verify that the combined pressure caused by external loads and internal vacuum is less than the allowable buckling pressure of the pipe.

4. Verify that the compressive stress in the pipe wall caused by external loads does not exceed the allowable value.

NOTE: This chapter is limited to loading on pipes buried in trenches. The load and pipe reaction calculations may not apply to pipes installed by trenchless technologies, such as pipe bursting and directional drilling. Directional drilled pipe typically does not have side support as provided by the embedment for pipe installed in trenches. See ASTM F1962.

9.3.1 Deflection Limit

[1)]Field inspection of the installation procedure is generally adequate for controlling deflection of most PE fusion joined pipes. Very large diameter pipes (man entry) and gasketed jointed PE pipes are sometimes inspected for vertical deflection.

Typically deflection measurements are made only after the backfill has been placed on the pipe for at least 30 days. The engineer will specify an acceptance deflection. Commonly a limit of 5 percent is used. This provides an additional safety factor as most gravity flow PE pipe can withstand higher deflection without damage.

9.4.1 General Buried Design

The quality of the embedment material and its compaction, combined with the type and density of the native soil are all relevant to the ultimate performance of pipes once installed The overall trench construction and pipe placement procedures should be consistent with the recommended pipe design and trench design and construction guidelines

9.5.1 Pipe Embedment Materials

The embedment is the material immediately surrounding the pipe. The embedment material should provide adequate strength, stiffness, uniformity of contact (i.e., completely envelop the pipe) and stability to minimize deformation of the pipe due to earth pressures.

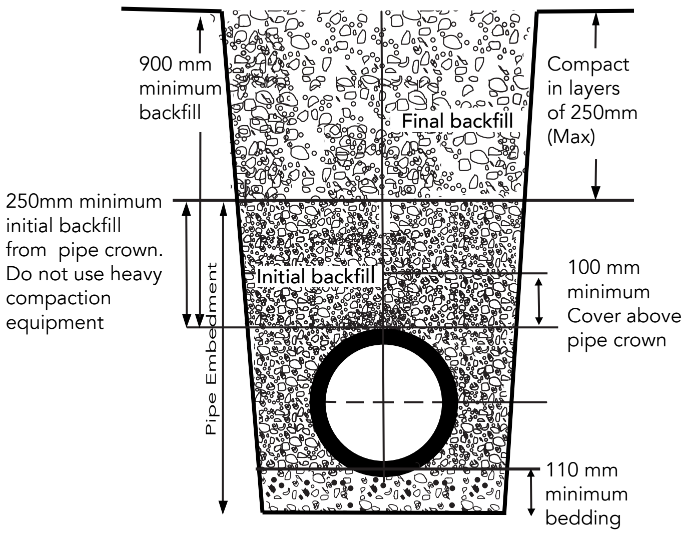
In general, soils with large grains such as gravel have the highest stiffness and thus provide the most supporting strength. Aside from the grain characteristics, the density has the greatest effect on the embedment's stiffness. Loose soil will permit more deflection of pipe for a given load than dense soil.

ASTM International D 2321 describes five related embedment classes. Class I and II soils are granular and tend to provide the maximum embedment support as illustrated by the potentially high E' (modulus of soil reaction) values. Class I material is generally manufactured aggregate, such as crushed stone, while Class II materials consist of clean sands and gravels and are more likely to be naturally occurring soils such as river deposits. The favorable characteristics of these type soils, or in combination, lead many designers to select these materials when they are readily and economically available. Maximum aggregate size of Class I and Class II materials when used next to the pipe (i.e., bedding, haunches and initial backfill) should be compatible with the pipe size. The smaller the rock size, the easier it is to place in the haunches. *

* 1) From Plastics Pipe Institute

http://plasticpipe.org/municipal_pipe/advisory/opencut/trench-embedment.html

note : below bedding section foundation must be considered if required in trench plan



One The best granular material available and the most modern quarries that has been approved by WRc is designated 803X.

803x 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 placing the pipe into position, the trench can be backfilled and the layers easily consolidated.

9.6.0 Normal sidefill & backfill requirements

material can be returned to the trench and compacted in layer thicknesses For minor roads, excavated specified by the Utility Company

The space between the pipe and trench wall must be enough for the compaction equipment used in the pipe zone.Minimum width shall be not less than the greater of either the pipe outside diameter plus 16 in. (400 mm) or the pipe outside diameter times 1.25, plus 12 in. (300 mm).

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.

9.6.1 Migration

When the pipe is located beneath the ground water level, consideration must be given to the possibility of loss of side support through soil migration (the conveying by ground water of finer particle soils into void spaces of coarser soils). Generally, migration can occur where the void spaces in the embedment material are sufficiently large to allow the intrusion of eroded fines from the trench side walls.

As with any pipe, groundwater or seasonal high water tables may impede installation. De-watering is necessary for a safe, and effective installation

9.6.2 Strength of Embedment Soil

in selecting embedment material, consideration should be given to how the grain size, shape, and distribution will affect its supporting strength.

In general, soils with large grains such as gravel have the highest stiffness and thus provide the most supporting strengths. Rounded grains tend to roll easier than angular, or sharp grains, which tend to interlock, and resist shear better. Well graded mixtures of soils (GW, SW), which contain a good representation of grains from a wide range of sizes, tend to offer more resistance than uniform graded soils (GP, SP).

Aside from the grain characteristics, the density has the greatest effect on the embedment's stiffness. For instance, in a dense soil there is considerable interlocking of grains and a high degree of grain-to-grain contact. Movement within the soil mass is restricted as the volume of the soil along the surface of sliding must expand for the grains to displace. This requires a high degree of energy. In a loose soil, movement causes the grains to roll or to slide, which requires far less energy. Thus, loose soil has a lower resistance to movement. Loose soil will permit more deflection of pipe for a given load than a dense soil.

9.6.3 Class I and Class II

Class I and II soils are granular and tend to provide the maximum embedment support as illustrated by the high E' values that can be achieved with them.

Class I material is generally manufactured aggregate, such as crushed stone.

Class II materials consist of clean sands and gravels and are more likely to be naturally occurring soils such as river deposits.

Class I and Class II materials can be blended together to obtain materials that resist migration of finer soils into the embedment zone (as will be explained below.)

In addition, Class I and II materials can be placed and compacted over a wide range of moisture content more easily than can other materials. This tends to minimize pipe deflection during installation. The high permeability of open-graded Class I and II materials aids in de-watering trenches, making these materials desirable in situations such as rock cuts where water problems may be encountered. This favorable combination of characteristics leads many designers to select these materials over others when they are readily and economically available

9.6.4 Class III and Class IVA

Class III and Class IVA materials provide less supporting stiffness than Class I or II materials for a given density or compaction level, in part because of the increased clay content. In addition, they require greater compactive effort to attain specified densities and their moisture content must be closely controlled within the optimum limit. Placement and compaction of Class IVA materials are especially sensitive to moisture content. If the Class IVA material is too wet, compaction equipment may sink into the material; if the soil is too dry, compaction may appear normal, but subsequent saturation with ground water may cause a collapse of the structure and lead to a loss of support. Typically, Class IVA material is limited to applications with pressure pipe at shallow cover.

9.6.5 Class IVB and Class V

Class IVB and Class V materials offer hardly any support for a buried pipe and are often difficult to properly place and compact. These materials are normally not recommended for use as pipe embedment unless the pipe has a low SDR (or high ring stiffness), there are no traffic loads, and the depth of cover is only a few feet. In many cases the pipe will float in this type of soil if the material becomes saturated.

9.6.6 Cold (Field) Bending

Coiled lengths and long strings of PE fused pipe may be cold bent in the field. The allowable bend ratio is determined by the pipe diameter and the dimension ratio.

Because fittings and flange connections are rigid compared to the pipe, the minimum bend radius is 100 times the pipe's outside diameter (OD), when a fitting or flange connection is present in the bend. The bend radius should be limited to 100 x OD for a distance of about 5 times the pipe diameter on either side of the fitting location.

Minimum Bend Radius for PE Pipe Installed in Open Cut Trench

Dimension Ration, DR	Minimum Cold Bend Radius
7, 7.3, 9	20 x Pipe OD
11, 13.5	25 x Pipe OD
17, 21	27 x Pipe OD
26	34 x Pipe OD
32.5	42 x Pipe OD
41	52 x Pipe OD
Fitting or flange present in bend	100 x Pipe OD

9.6.7 Installation of Pipe in Curves

Field bending involves excavating the trench to the desired bend radius, then sweeping or pulling the pipe string into the required bend and placing it in the trench. Temporary restraints may be required to bend the pipe, and to maintain the bend while placing the pipe in the trench and placing initial backfill. Temporary blocks or restraints must be removed before installing final backfill, and any voids must be filled with compacted initial backfill material. Considerable force may be required to field bend the pipe, and the pipe may spring back forcibly if the restraints slip or are inadvertently released while bending. Observe appropriate safety precautions during field bending.

*From Plastics Pipe Institute hand book of pe pipe chapter 7

Class of Embedment and backfill Materials

Class	Type	Soil Group Symbol D 2487	Description	Percentage Passing Sieve Sizes		
				1 1/2 in. (40 mm)	No. 4 (4.75 mm)	No. 200 (0.075 mm)
IA	Manufactured Aggregates: open-graded, clean.	None	Angular, crushed stone or rock, crushed gravel, broken coral, crushed slag, cinders or shells; large void content, contain little or no fines.	100 %	⩽10 %	<5 %
IB	Manufactured, Processed Aggregates; dense-graded, clean.	None	Angular, crushed stone (or other Class 1A materials) and stone/sand mixtures with gradations selected to minimize migration of adjacent soils; contain little or no fines	100 %	⩽50 %	<5 %
II	Coarse-Grained Soils, clean	GW	Well-graded gravels and gravel-sand mixtures; little or no fines.	100 %	<50 % of "Coarse Fraction	<5 %
		GP	Poorly-graded gravels and gravel-sand mixtures; little or no fines.			
		SW	Well-graded sands and gravelly sands; little or no fines.		>50 % of "Coarse Fraction"	
		SP	Poorly-graded sands and gravelly sands; little or no fines.			
	Coarse-Grained Soils, borderline clean to w/fines	e.g. GW-GC, SP-SM.	Sands and gravels which are borderline between clean and with fines.	100 %	Varies	5 % to 12 %
III	Coarse-Grained Soils With Fines	GM	Silty gravels, gravel-sand-silt mixtures.	100 %	<50 % of "Coarse Fraction	12 % to 50 %
		GC	Clayey gravels, gravel-sandclay mixtures.			
		SM	Silty sands, sand-silt mixtures.		>50 % of "Coarse Fraction"	
		SC	Clayey sands, sand-clay mixtures.			
IVA	Fine-Grained Soils (inorganic)	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, silts with slight plasticity.	100 %	100 %	>50 %
		CL	Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clays, lean clays.			
IVB	Fine-Grained Soils (inorganic)	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	100 %	100 %	>50 %
		CH	Inorganic clays of high plasticity, fat clays.			
V	Organic Soils	OL	Organic silts and organic silty clays of low plasticity.	100 %	100 %	>50 %
		OH	Organic clays of medium to high plasticity, organic silts.			
		PT	Peat and other high organic soils.			

Extracted from ASTM D2321

9

10 Welding of Pe pipes

10.0.0 Welding of Pe pipes

10.1.0 Definition of Installation

for proper installation of pe pipe a Preparation is require such as:

- Inspection Pipe Delivery
- Pipe Storage
- Pipe Handling
- Pipe LayingWelding
- Pipe Alignment
- Preparation for Welding
- LayingWelding Process
- Documentation
- Pressure Test

10.1.1 Inspection Pipe Deliver

an important initial step is a receiving inspection of incoming products , Before piping system installation begins Construction costs can be minimized, and schedules maintained by checking incoming goods to be sure the parts received are the parts that were ordered, and that they arrived in good condition and ready for installation

When a shipment is received, it should be checked to see that the correct products and quantities have been delivered in a condition that is suitable for installation.

There is no substitute for visually inspecting an incoming shipment to verify that the paperwork accurately describes the load. Products are usually identified by markings on each individual product. These markings should be checked against the Order Acknowledgment and the Packing List. The number of packages and their descriptions should be checked against the Bill of Lading.

Before and during unloading, the load should be inspected for damage that may occur anytime products are handled. Obvious damage such as cuts, abrasions, scrapes, gouges, tears, and punctures should be carefully inspected. Manufacturers should be consulted for damage assessment guidelines. Product with damage that could compromise product performance should be segregated and a resolution discussed with the manufacturer.

PE pipe is tough, lightweight, and flexible. Installation does not usually require high capacity lifting equipment. Pipe up to about 8" (219 mm) diameter and weighing roughly 6 lbs per foot (9 kg per m) or less can frequently be handled manually. Heavier, larger diameter pipe will require appropriate handling equipment to lift, move and lower the pipe. Pipe must not be dumped, dropped, pushed, or rolled into a trench.

10.1.2 Pipe Storage

The size and complexity of the project and the components, will determine preinstallation storage requirements. For some projects, se veral storage or staging sites along the right-of-way may be appropriate, while a single storage location may be suitable for another job.
The site and its layout should provide protection against physical damage to components. General requirements are for the area to be of sufficient size to accommodate piping components, to allow room for handling equipment to get around them and to have a relatively smooth, level surface free of stones, debris, or other material that could damage pipe or components, or interfere with handling. Pipe may be placed on 4-inch wide wooden dunnage, evenly spaced at intervals of 4 feet or less.

10.2.0 Welding of Pe pipe

A pipeline is as good as its weakest point the methodology used to join the pipes most be effective and strong as the material of pe pipeline

HDPE piping systems can be joined with heat fusion welds Heat fusion involves the heating of two HDPE surfaces then bringing them together to form a permanent, monolithic, leak-free system

HDPE pipe can be heat fused together in several methods (butt welding or butt fusion , socket fusion , Sidewall fusion , Electrofusion) to form a joint that is as strong or stronger than the pipe itself and is leak free.

Butt fusion and electrofusion are the most common and reliable welding techniques used to weld HDPE and offer significant installation advantages compared to traditional pipe materials.

the fusion process for HDPE is proven and has been used by the natural gas industry for over 40 years. Approximately 95% of all gas distribution piping in the United States is polyethylene pipe joined by heat fusion (butt welding)

10.2.1 Butt welding

Butt welding is the most simple method of jointing pe pipes together and providing the many advantageous benefits of preformation

HDPE pipe fused joints are self restraining and costly thrust restraints or thrust blocks are not required

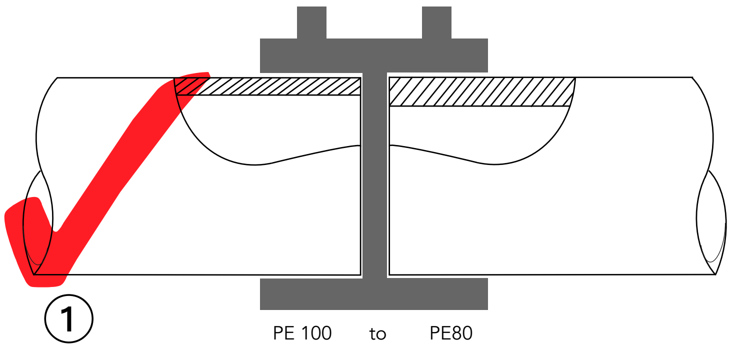
Butt welding Connection properties :

- A simple reliable connection
- Tension-resistant
- Permanent leak free jointing
- Rigid, non-removable

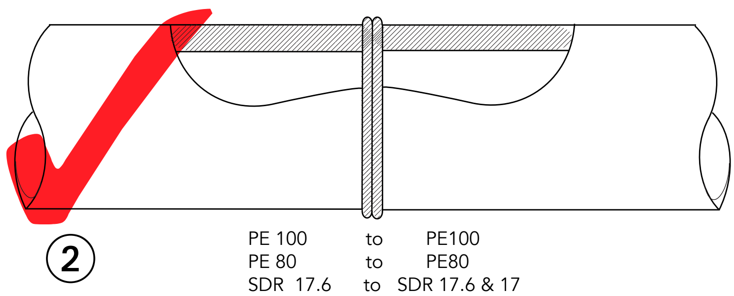
Different materials and different wall thicknesses can be jointed by electrofusion. the maximum working pressure should not exceed the lower of the twom pipes (Figure 1)

Butt-fusion should only be used for jointing pipes of the same outside diameter and SDR value (Figure 2)

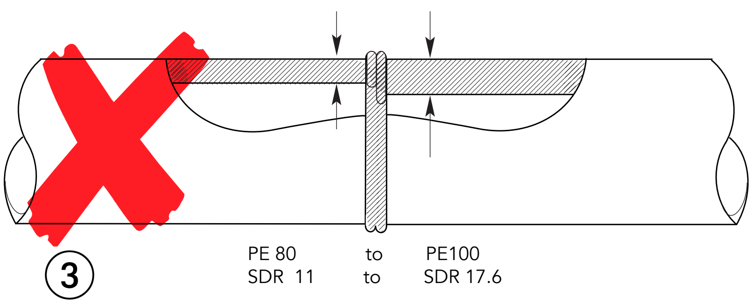
Different wall thicknesses must not be jointed by butt fusion. (PE80 can be butt fused to PE100 under closely controlled factory conditions.) (Figure 3)



PE 100 to PE80
SDR 17.6 to SDR 11
Same pressure class
only with Electrofusion



PE 100 to PE100
PE 80 to PE80
SDR 17.6 to SDR 17.6 & 17

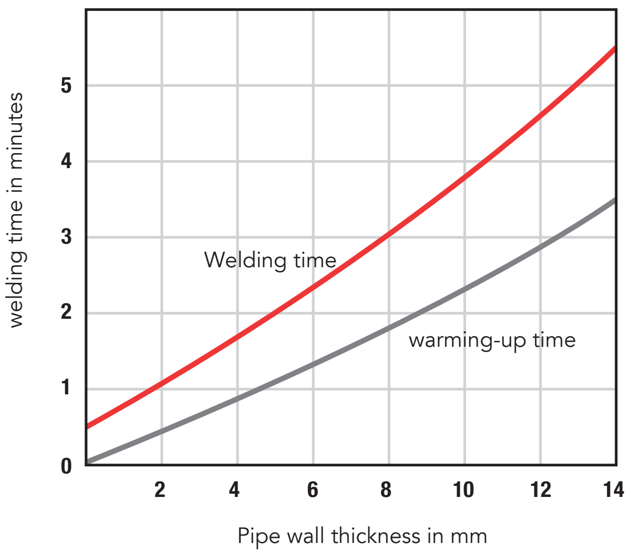


PE 80 to PE100
SDR 11 to SDR 17.6

10.2.2 The required conditions for welding

- the welding plate and parts most be clean
- A curret welding plate tempreture and right warm up time for welding proccess most be considerd
- enough prressure for jointing the parts most be considerd
- The parts to be welded must be cut square 90°
- pipes most be round and ends match
- Do not accelerate the cooling down by contact with cold objects or water.

Indicative values for welding and warming up times.



Indicative values for welding pressure

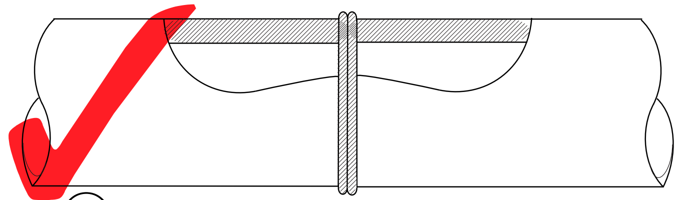
OD	Pressure kg	OD	pressure kg
40	6	110	22
50	7	125	28
56	8	160	45
63	9	200	57
75	10	250	90
90	15	315	140

Allowance for butt welds

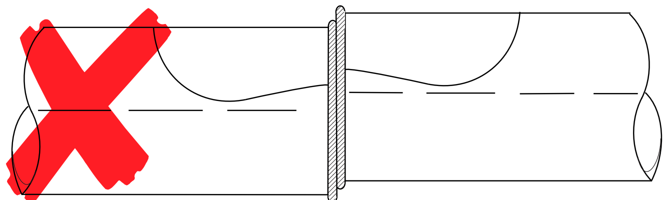
The allowance for butt welds is approximately as big as the wall thickness of the pipe.

Allowance for butt welds

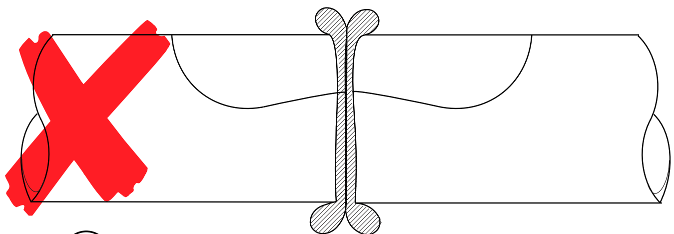
Pipe Diameter (mm)	Butt welds (mm)
40 - 75	3
90	4
110	5
125	5
160	7
200	7
250	8
315	10



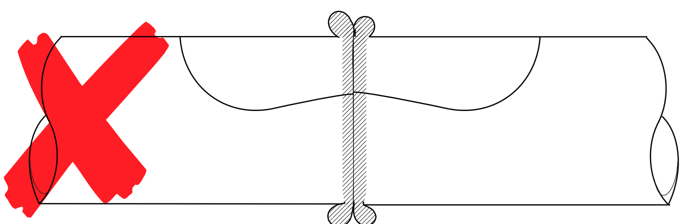
1 Correct



2 Out of axial alignment



3 Too much pressure at the start of the welding



4 Uneven welding heat

Buttweld Time and Pressure Tables

outside diameter	SDR	Wall Thick-ness (min)	Bead up inter-face stress	Initial bead size (approx)	Soak time	Min soak inter-face stress	Max plate removal time	Fusion and cooling inter-face stress	Cooling time in clamps	Cooling time out of clamps	Cooling time for coiled pipe in clamps	Typical final overall baed width	
mm		mm	Mpa	MM	sec	Mpa	sec	Mpa	min	min	min	min mm	max 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	0,15	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	16
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		5			

Single pressure Butt-fusion jointing conditions for PE63, PE80 and PE100 Heater Plate Surface Temperature: 195˚C to200˚C

10.3.1 Electrofusion coupling

Connection properties :

- Simple, reliable joint.
- Rigid, non-removable.
- Tension-resistant

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.

1) Electrofusion fittings must be installed at least three pipe diameters or 12", whichever is greater, from a squeeze-off point

Inspect PE plastic pipe, tubing, and fittings prior to installation to verify:

No cuts, gouges, deep scratches, or other defects.

PE plastic material is high density polyethylene (HDPE), PE3408/4710, and manufactured per ASTM D2513.

PE plastic material is NOT older than 2 years old.

Before beginning the process to install an electrofusion fitting, ensure the pipe is clean and dry. Clean the pipe outside diameter (OD), inside diameter (ID), and ends with a clean, dry, lint-free non-synthetic (e.g. cotton) cloth or paper towel

When making the final tie-in to existing PE plastic pipe in an excavation, electrofusion coupling(s) should be used to make the final tie-in, rather than trying to butt fuse or use mechanical fittings in the excavation. Use of two (2) electrofusion couplings with a short length of plastic pipe will facilitate pipe lineup. If electrofusion fittings cannot be used due to a hazardous environment, mechanical fittings are permitted

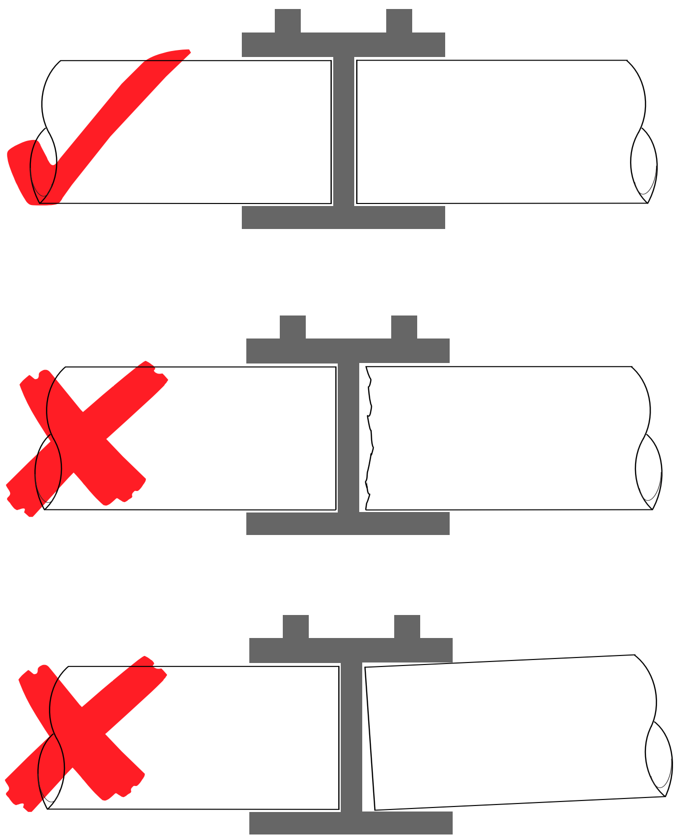
Misaligned PE plastic pipe shall not be joined using electrofusion couplings, butt fusion, or mechanical fittings in order to prevent mechanical stress on the pipe and joint during and after the joining process. PE plastic pipe alignment in the field can be corrected prior to joining to other PE plastic, steel, or cast iron pipe

Heat fusion of PE plastic pipe, tubing, and fittings of different SDR shall only be performed between one change in SDR.

SDR is found on the print line of the PE plastic pipe and tubing, or on the fitting label Joining of PE plastic pipe/fitting with SDR wall thickness greater than one change in SDR shall only be done using electrofusion.

Approved restraining-type mechanical couplings may only be used for joining PE plastic pipe when an electrofusion coupling is unavailable.

1)
IPN-27-5 INSTALLATION OF ELECTROFUSION FITTINGS ON PE PLASTIC PIPE/TUBING AND MOLDED FITTINGS USING A UNIVERSAL ELECTROFUSION PROCESSOR



10

11 Procedures & Techniques for PE Pipeline Installations

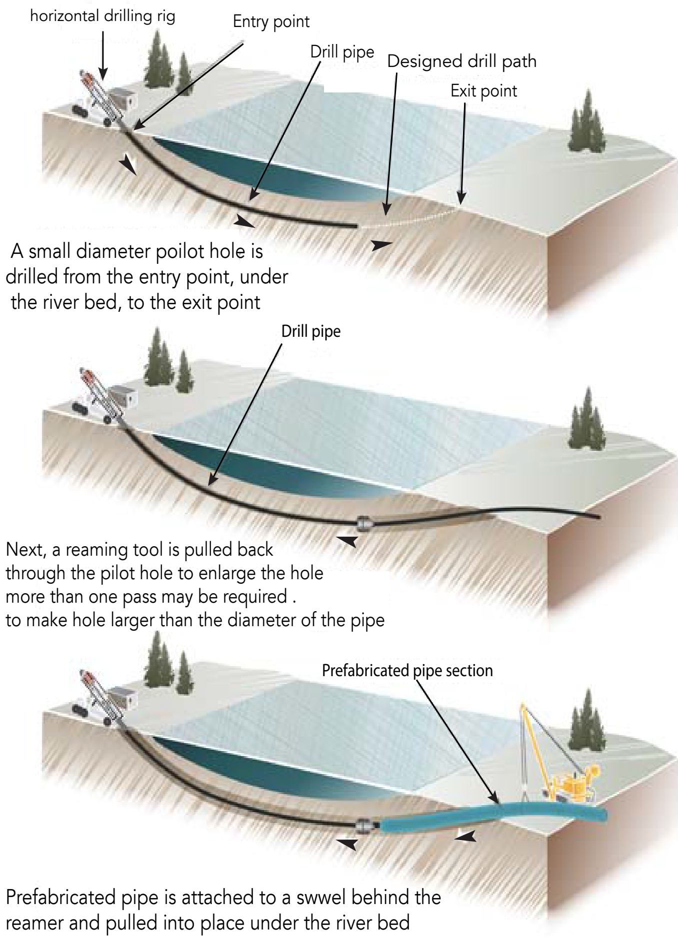
11.1.0 Horizontal Directional Drilling (HDD)

This is a pipe installation technique that require minimal exacavation work , it was originaly developed for oil and gas wells. it is most commenly use for Pe pipes installation becouse of easiy and clean accessablity it gives to have installation under roads and rivers etc.

the Directional boring is used for installing infrastructure such as telecommunications and power cable conduits, water lines, sewer lines, gas lines, oil lines, product pipelines, and environmental remediation casings.

It is used for crossing waterways, roadways, shore approaches, congested areas, environmentally sensitive areas, and areas where other methods are costlier or not possible.

It is used instead of other techniques to provide less traffic disruption, lower cost, deeper and/or longer installation, no access pit, shorter completion times, directional capabilities, and environmental safety



Urban Underground Solutions Inc

- A small diameter poilot hole is drilled from the entry point, under the river bed, or a road etc to the exit point
- Next, a reaming tool is pulled back through the pilot hole to enlarge the hole. more than one pass may be required to make hole larger than the diameter of the pipe
- Prefabricated pipe is attached to a swwel behind the reamer and pulled into place under the river bed

11.2.0 Pipe bursting

a trenchless process that breaks apart the old pipe and replaces it with a seamless high-density polyethylene (HDPE) pipe

Pipe bursting is a well-established trenchless method that is widely used for the replacement of deteriorated pipes with a new pipe of the same or larger diameter

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 Pipe bursting is an economic pipe replacement alternative that reduces social disturbance to business and residents when it is compared to the open cut technique or pipeline rehabilitation techniques

bursting is especially effective if the existing pipe has inadequate capacity and has substantial structural defects preventing other trenchless methods from being utilized. This method can be used advantageously to reduce damage to pavements and disruptions to traffic, hence reducing the social costs associated with pipeline replacement, as well as providing a significantly smaller environmental footprint.

The pipe bursting method results in an existing pipe being replaced with a new factory manufactured pipe in the same location that will have the same or larger inner diameter.

A hydraulic power pack provides the power to burst the pipes and create an underground tunnel trenchlessly.

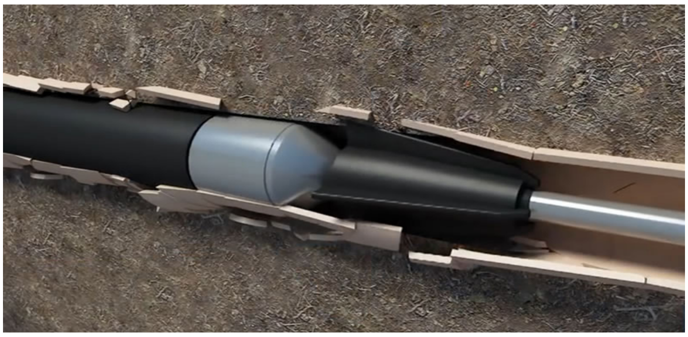
Typical pipe bursting involves inserting a coni cally shaped tool (the bursting head) into the old pipe.

The head fractures the old pipe and forces the old pipes fragments into the surrounding soil. The trenchless contractor then pulls or pushes a pipe in behind the bursting head , The base of bursting head is larger than the inside diameter of the old pipe to cause fracturing and slightly larger than the outside diameter of the new pipe, to reduce friction on the new pipe and to provide space for maneuvering the pipe.

The front end is connected to a cable or pulling rod and the rear of the bursting head is connected to the new pipe.

The bursting head and the new pipe are launched from the insertion pit, and the cable or pulling rod is pulled from the reception pit. The cable/rod pull together with the shape of the bursting head keeps the head following the existing pipe, and specially designed heads can help to reduce the effects of existing sags or misalignment on the new pipeline

The end result is a high-quality pipe replacement without the expense or disruption of excavation.



trenchless solutions co

11.3.0 Ploughing

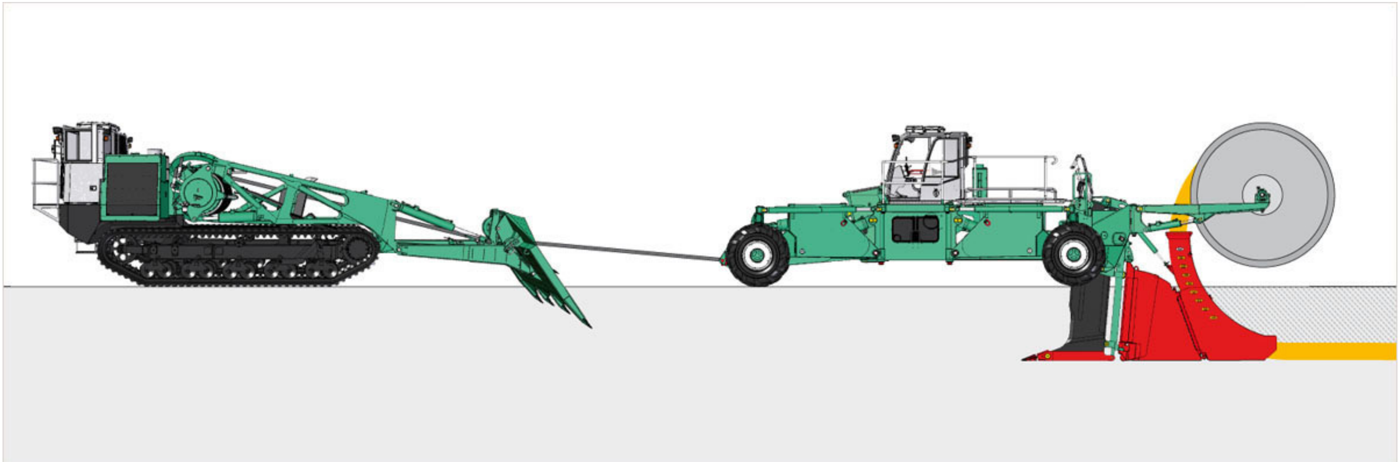
Ploughing is one of the most cost-effective method of laying PE pipe when the time and speed is the essnece of the project. and it is environmentally friendly with minimum impact on subsoil

A winch is used to pull a plough blade and pipe-laying unit through the ground. Once the pipe has been installed, the furrow (trench) is automatically closed as the plough blade advances. This method is also suitable for the parallel installation of several pipelines.

As the soil initially displaced by the plough is re-used without any further processing, the pipes deployed have to be highly resistant to point, i.e. concentrated, loads.

Pipes are jointed above ground into runs depending upon the size pipe to be laid and taking into account site and ground conditions. The blade is correctly positioned in a pre-excavated starting pit and the pipe attachec to the rear of the expander by a gripper serving also to blank off the open end of the pipe to prevent the ingress of soi I into the line.

The blade is then pulled through the ground, the expander fitted to its base forrrs the tunnel and the pipe is drawn into the tunnel directly behind the expander.



Foeck gmbh

12 Wall thickness and Mass table and allowable working pressure for PE pipes

Wall thickness and mass table of PE pipe base on Din 8074 with SF 1.25

Outside diameter d (mm)	Nominal bore DN (inch)	Pipe Series (S) 25		20		16		12.5		10.5		10		8.3		8		6.3		5		4		3.2		2.5		2	
		Standard Dimension Ratio (SDR) 51		41		33		26		22		21		17.6		17		13.6		11		9		7.4		6		5	
		PE80 Material		PN 3.2		PN 4		PN 5				PN 6				PN 8		PN 10		PN 12.5		PN 16		PN 20		PN 25			
		PE100 Material		PN 4		PN 5		PN 6				PN 8				PN 10		PN 12.5		PN 16		PN 20		PN 25					
		e_{min} mm	mass in kg/m	e_{min} mm	mass in kg/m	e_{min} mm	mass in kg/m	e_{min} mm	mass in kg/m	e_{min} mm	mass in kg/m	e_{min} mm	mass in kg/m	e_{min} mm	mass in kg/m	e_{min} mm	mass in kg/m	e_{min} mm	mass in kg/m	e_{min} mm	mass in kg/m	e_{min} mm	mass in kg/m	e_{min} mm	mass in kg/m	e_{min} mm	mass in kg/m	e_{min} mm	mass in kg/m
10	1/8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,8	0,048	2,0	0,052
12	¼	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,8	0,060	2,0	0,065	2,4	0,075
16	3/8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,0	0,092	2,3	0,103	3,0	0,125	3,3	0,135
20	½	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,0	0,118	2,3	0,134	3,0	0,164	3,4	0,182	4,1	0,209
25	¾	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,0	0,151	2,3	0,173	3,0	0,202	3,5	0,243	4,2	0,281	5,1	0,323
32	1	-	-	-	-	-	-	-	-	-	-	-	-	2,0	0,198	2,0	0,198	2,4	0,235	3,0	0,282	3,6	0,331	4,4	0,390	5,4	0,458	6,5	0,525
40	1¼	-	-	-	-	-	-	1,8	0,229	1,9	0,240	2,0	0,251	2,3	0,288	2,4	0,299	3,0	0,360	3,7	0,434	4,5	0,514	5,5	0,607	6,7	0,708	8,1	0818
50	1½	-	-	-	-	1,8	0,290	2,0	0,317	2,3	0,365	2,4	0,378	2,9	0,445	3,0	0,458	3,7	0,555	4,6	0,673	5,6	0,796	6,9	0,945	8,3	1,10	10,1	1,27
63	2	-	-	1,8	0,368	2,0	0,403	2,5	0,500	2,9	0,569	3,0	0,586	3,6	0,695	3,8	0,728	4,7	0,883	5,8	1,06	7,1	1,27	8,6	1,49	10,5	1,74	12,8	2,02
75	2½	1,8	0,440	1,9	0,462	2,3	0,557	2,9	0,683	3,5	0,816	3,6	0,836	4,3	0,987	4,5	1,03	5,6	1,25	6,8	1,48	8,4	1,78	10,3	2,12	12,5	2,47	15,1	2,85
90	3	1,8	0,531	2,2	0,647	2,8	0,800	3,5	0,988	4,1	1,15	4,3	1,20	5,1	1,40	5,4	1,47	6,7	1,79	8,2	2,14	10,1	2,57	12,3	3,03	15,0	3,54	18,1	4,09
110	4	2,2	0,795	2,7	0,952	3,4	1,19	4,2	1,45	5,0	1,69	5,3	1,79	6,3	2,10	6,6	2,19	8,1	2,64	10,0	3,18	12,3	3,82	15,1	4,54	18,3	5,29	22,1	6,10
125	4½	2,5	1,01	3,1	1,25	3,9	1,53	4,8	1,86	5,7	2,19	6,0	2,29	7,1	2,69	7,4	2,79	9,2	3,40	11,4	4,12	14,0	4,92	17,1	5,84	20,8	6,82	25,1	7,87
140	5	2,8	1,26	3,5	1,56	4,3	1,90	5,4	2,35	6,4	2,75	6,7	2,86	8,0	3,37	8,3	3,50	10,3	4,26	12,7	5,13	15,7	6,18	19,2	7,33	23,3	8,56	28,1	9,87
160	6	3,2	1,65	4,0	2,02	4,9	2,45	6.2	3,08	7,3	3,58	7,7	3,75	9,1	4,40	9,5	4,57	11,8	5,56	14,6	6,74	17,9	8,04	21,9	9,54	26,6	11,2	32,1	12,9
180	7	3,6	2,07	4,4	2,51	5,5	3,10	6,9	3,83	8,2	4,52	8,6	4,71	10,2	5,54	10,7	5,77	13,3	7,05	16,4	8,51	20,1	10,2	24,6	12,1	29,9	14,1	36,1	16,3
200	8	3,9	2,48	4,9	3,08	6,2	3,88	7,7	4,74	9,1	5,57	9,6	5,84	11,4	6,86	11,9	7,12	14,7	8,65	18,2	10,5	22,4	12,6	27,4	14,9	33,2	17,4	40,1	20,1
225	9	4,4	3,16	5,5	3,90	6,9	4,82	8,6	5,96	10,3	7,07	10,8	7.37	12,8	8,64	13,4	9,03	16,6	11,0	20,5	13,3	25,2	15,9	30,8	18,8	37,4	22,1	45,1	25,4
250	10	4,9	3,88	6,2	4,88	7,7	5,98	9,6	7,38	11,4	6,68	11,9	9,02	14,2	10,7	14,8	11,1	18,4	13,5	22,7	16,3	27,9	19,6	34,2	23,3	41,5	27,2	50,1	31.4
280	11	5,5	4,88	6,9	6,04	8,6	7,47	10,7	9,20	12,8	10,9	13,4	11,4	15,9	13,3	16,6	13,9	20,6	16,9	25,4	20,5	31,3	24,6	38,3	29,2	46,5	34,1	56,2	39,4
315	12	6,2	6,18	7,7	7,59	9,7	9,47	12,1	11,7	14,4	13,8	15,0	14,3	17,9	16,9	18,7	17,6	23,2	21,5	28,6	25,9	35,2	31,1	43,1	36,9	52,3	43,2	63,2	49,8
355	14	7,0	7,81	8,7	9,65	10,9	12,0	13,6	14,8	16,2	17,5	16,9	18,2	20,1	21,4	21,1	22,4	26,1	27,2	32,2	32,9	39,7	39,5	48,5	46,8	59,0	54,8	-	-
400	16	7,9	9,92	9,8	12,2	12,3	15,2	15,3	18,8	18,2	22,1	19,1	23,1	22,7	27,2	23,7	28,3	29,4	34,5	36,3	41,7	44,7	50,1	54,7	59,4	66,5	69,6	-	-
450	18	8,8	12,4	11,0	15,4	13,8	19,2	17,2	23,7	20,5	28,0	21,5	29,3	25,5	34,3	26,7	35,8	33,1	43,7	40,9	52,8	50,3	63,4	61,5	75,2	-	-	-	-
500	20	9,8	15,4	12,3	19,2	15,3	23,6	19,1	29,2	22,8	34,5	23,9	36,1	28,3	42,3	29,7	44,2	36,8	53,9	45,4	65,2	55,8	78,1	68,3	92,8	-	-	-	-

Allowable working pressure for pipes made from PE 80, conveying water,with a safty factor of 1.25

tempe-reture-,in C°	Years of service	Pipe series													
		25	20	16	12.5	10.5	10	8.3	8	6.3	5	4	3.2	2.5	2
		Standard dimension ratio (SDR)													
		51	41	33	26	22	21	17.6	17	13.6	11	9	7.4	6	5
		Allowable working pressure													
10	5	3,1	4,0	5,0	6,3	7,5	7,9	9,4	10,1	12,6	15,8	20,2	25,3	31,6	40,5
	10	3,1	3,9	4,9	6,2	7,4	7,8	9,3	9,9	12,4	15,5	19,8	24,8	31,0	39,7
	25	3,0	3,8	4,8	6,0	7,2	7,6	9,0	9,7	12,1	15,1	19,4	24,2	30,3	38,8
	50	2,9	3,8	4,7	5,9	7,1	7,5	8,9	9,5	11,9	14,8	19,0	23,8	29,7	38,0
	100	2,9	3,7	4,6	5,8	7,0	7,3	8,7	9,3	11,6	14,6	18,7	23,3	29,2	37,4
20	5	2,6	3,4	4,2	5,3	6,3	6,6	7,9	8,5	10,6	13,2	17,0	21,2	26,5	34,0
	10	2,6	3,3	4,1	5,2	6,2	6,5	7,8	8,3	10,4	13,0	16,7	20,8	26,0	33,4
	25	2,5	3,2	4,0	5,0	6,1	6,4	7,6	8,1	10,1	12,7	16,2	20,3	25,4	32,5
	50	2,5	3,2	4,0	5,0	6,0	6,3	7,5	8,0	10,0	12,5	16,0	20,0	25,0	32,0
	100	2,4	3,1	3,9	4,9	5,8	6,1	7,3	7,8	9,8	12,2	15,7	19,6	24,5	31,4
30	5	2,2	2,8	3,6	4,5	5,4	5,6	6,7	7,2	9,0	11,2	14,4	18,0	22,5	28,9
	10	2,2	2,8	3,5	4,4	5,3	5,5	6,6	7,0	8,8	11,0	14,1	17,7	22,1	28,3
	25	2,1	2,7	3,4	4,3	5,1	5,4	6,4	6,9	8,6	10,8	13,8	17,3	21,6	27,6
	50	2,1	2,7	3,3	4,2	5,0	5,3	6,3	6,7	8,4	10,6	13,5	16,9	21,2	27,1
40	5	1,9	2,4	3,1	3,8	4,6	4,8	5,8	6,2	7,7	9,6	12,4	15,5	19,3	24,8
	10	1,9	2,4	3,0	3,8	4,5	4,7	5,7	6,0	7,6	9,5	12,1	15,2	19,0	24,3
	25	1,8	2,3	2,9	3,7	4,4	4,6	5,5	5,9	7,4	9,2	11,8	14,8	18,5	23,7
	50	1,8	2,3	2,9	3,6	4,3	4,5	5,4	5,8	7,2	9,1	11,6	14,5	18,2	23,3
50	5	1,6	2,1	2,6	3,3	4,0	4,2	5,0	5,3	6,7	8,4	10,7	13,4	16,8	21,5
	10	1,6	2,0	2,5	3,2	3,8	4,0	4,8	5,1	6,4	8,1	10,3	12,9	16,2	20,7
	15	1,4	1,8	2,2	2,8	3,4	3,6	4,3	4,5	5,7	7,1	9,1	11,4	14,3	18,3
60	5	1,1	1,4	1,8	2,2	2,7	2,8	3,3	3,6	4,5	5,6	7,2	9,0	11,3	14,4
70	2	0,8	1,1	1,3	1,7	2,0	2,2	2,6	2,7	3,4	4,3	5,5	6,9	8,7	11,1

Allowable working pressure for pipes made from PE 80, conveying water,with a safty factor of 1.6

tempe-reture-,in C°	Years of service	Pipe series													
		25	20	16	12.5	10.5	10	8.3	8	6.3	5	4	3.2	2.5	2
		Standard dimension ratio (SDR)													
		51	41	33	26	22	21	17.6	17	13.6	11	9	7.4	6	5
		Allowable working pressure													
10	5	2,5	3,1	3,9	5,0	6,0	6,3	7,6	7,9	10,0	12,6	15,8	19,4	25,3	31,6
	10	2,4	3,1	3,8	4,9	5,9	6,2	7,4	7,7	9,8	12,4	15,5	19,1	24,8	31,0
	25	2,4	3,0	3,7	4,8	5,7	6,0	7,3	7,5	9,6	12,1	15,1	18,6	24,2	30,3
	50	2,3	2,9	3,7	4,7	5,6	5,9	7,1	7,4	9,4	11,9	14,8	18,3	23,8	29,7
	100	2,3	2,9	3,6	4,6	5,5	5,8	7,0	7,3	9,2	11,6	14,6	17,9	23,3	29,2
20	5	2,1	2,6	3,3	4,2	5,0	5,3	6,4	6,6	8,4	10,6	13,2	16,3	21,2	26,5
	10	2,0	2,6	3,2	4,1	4,9	5,2	6,2	6,5	8,2	10,4	13,0	16,0	20,8	26,0
	25	2,0	2,5	3,1	4,0	4,8	5,0	6,1	6,3	8,0	10,1	12,7	15,6	20,3	25,4
	50	2,0	2,5	3,1	4,0	4,7	5.0	6,0	6,2	7,9	10,0	12,5	15,3	20,0	25,0
	100	1,9	2,4	3,0	3,9	4,6	4,9	5,9	6,1	7,7	9,8	12,2	15,1	19,6	24,5
30	5	1,8	2,2	2,8	3,6	4,3	4,5	5,4	5,6	7,1	9,0	11,2	14,4	18,0	22,5
	10	1,7	2,2	2,7	3,5	4,2	4,4	5,3	5,5	7,0	8,8	11,0	14,1	17,7	22,1
	25	1,7	2,1	2,7	3,4	4,1	4,3	5,1	5,4	6,9	8,6	10,8	13,8	17,3	21,6
	50	1,6	2,1	2,7	3,3	4,0	4,2	5,0	5,3	6,7	8,4	10,6	13,5	16,9	21,2
40	5	1,5	1,9	2,4	3,1	3,6	3,8	4,6	4,8	6,1	7,7	9,6	11,9	15,5	19,3
	10	1,5	1,9	2,3	3,0	3,6	3,8	4,5	4,7	6,0	7,6	9,5	11,7	15,2	19,0
	25	1,4	1,8	2,3	2,9	3,5	3,7	4,4	4,6	5,8	7,4	9,2	11,4	14,8	18,5
	50	1,4	1,8	2,2	2,9	3,4	3,6	4,3	4,5	5,7	7,2	9,1	11,2	14,5	18,2
50	5	1,3	1,6	2,1	2,6	3,2	3,3	4,0	4,2	5,3	6,7	8,4	10,3	13,4	16,8
	10	1.2	1,6	2,0	2,5	3,0	3,2	3,9	4,0	5,1	6,4	8,1	9,9	12,9	16,2
	15	1,1	1,4	1,7	2,2	2,7	2,8	3,4	3,5	4,5	5,7	7,1	8,8	11,4	14.3
60	5	0,9	1,1	1,4	1,8	2,1	2,2	2,7	2,8	3,5	4,5	5,6	6,9	9,0	11,3
70	2	0,6	0,8	1,0	1,3	1,6	1,7	2,1	2,1	2,7	3,4	4,3	5,3	6,9	8,7

Allowable working pressure for pipes made from PE 80, conveying water,with a safty factor of 2.0

tempe-reture-,in C°	Years of service	*Pipe series*													
		25	20	16	12.5	10.5	10	8.3	8	6.3	5	4	3.2	2.5	2
		Standard dimension ratio (SDR)													
		51	41	33	26	22	21	17.6	17	13.6	11	9	7.4	6	5
		Allowable working pressure													
10	5	2,0	2,5	3,1	4,0	4,8	5,0	6,0	6,3	7,7	10,1	12,6	15,5	20,2	25,3
	10	1,9	2,4	3,1	3,9	4,7	4,9	5,9	6,2	7,6	9,9	12,4	15,2	19,8	24,8
	25	1,9	2,4	3,0	3,8	4,6	4,8	5,8	6,0	7,4	9,7	12,1	14,9	19,4	24,2
	50	1,9	2,3	2,9	3,8	4,5	4,7	5,7	5,9	7,3	9,5	11,9	14,6	19,0	23,8
	100	1,8	2,3	2,9	3,7	4,4	4,6	5,6	5,8	7,1	9,3	11,6	14,3	18,7	23,3
20	5	1,7	2,1	2,6	3,4	4,0	4,2	5,1	5,3	6,5	8,5	10,6	13,0	17,0	21,2
	10	1,6	2,0	2,6	3,3	3,9	4,1	5,0	5,2	6,4	8,3	10,4	12,8	16,7	20,8
	25	1,6	2,0	2,5	3,2	3,8	4,0	4,9	5,0	6,4	8,1	10,1	12,5	16,2	20,3
	50	1,6	2,0	2,5	3,2	3,8	4,0	4,8	5,0	6,3	8,0	10,0	12,3	16,0	20,0
	100	1,5	1,9	2,4	3,1	3,7	3,9	4,7	4,9	6,0	7,8	9,8	12,0	15,7	19,6
30	5	1,4	1,8	2,2	2,8	3,4	3,6	4,3	4,5	5,5	7,2	9,0	11,1	14,4	18,0
	10	1,4	1,7	2,2	2,8	3,3	3,5	4,2	4,4	5,4	7,0	8,8	10,9	14,1	17,7
	25	1,3	1,7	2,1	2,7	3,2	3,4	4,1	4,3	5,4	6,9	8,6	10,6	13,8	17,3
	50	1,3	1,6	2,1	2,7	3,2	3,3	4,0	4,2	5,3	6,7	8,4	10,4	13,5	16,9
40	5	1,2	1,5	1,9	2,4	2,9	3,1	3,7	3,8	4,7	6,2	7,7	9,5	12,4	15,5
	10	1,2	1,5	1,9	2,4	2,9	3,0	3,6	3,8	4,6	6,0	7,6	9,3	12,1	15,2
	25	1,1	1,4	1,8	2,3	2,8	2,9	3,5	3,7	4,5	5,9	7,4	9,1	11,8	14,8
	50	1,1	1,4	1,8	2,3	2,7	2,9	3,5	3,6	4,4	5,8	7,2	8,9	11,6	14,5
50	5	1,0	1,3	1,6	2,1	2,5	2,6	3,2	3,3	4,1	5,3	6,7	8,2	10,7	13,4
	10	1,0	1,2	1,6	2,0	2,4	2,5	3,1	3,2	3,9	5,1	6,4	7,9	10,3	12,9
	15	0,9	1,1	1,4	1,8	2,1	2,2	2,7	2,8	3,5	4,5	5,7	7,0	9,1	11,4
60	5	0,7	0,9	1,1	1,4	1,7	1,8	2,1	2,2	2,7	3,1	3,9	4,9	6,3	7,9
70	2	0,5	0,6	0,8	1,1	1,3	1,3	1,6	1,7	2,1	2,7	3,4	4,3	5,5	6,9

Allowable working pressure for pipes made from PE 100, conveying water,with a safty factor of 1.25

tempe-reture-,in C°	Years of service	Pipe series													
		25	20	16	12.5	10.5	10	8.3	8	6.3	5	4	3.2	2.5	2
		Standard dimension ratio (SDR)													
		51	41	33	26	22	21	17.6	17	13.6	11	9	7.4	6	5
		Allowable working pressure													
10	5	4,0	5,0	6,3	7,9	9,4	10,1	12,1	12,6	15,7	20,2	25,2	31,5	40,4	50,5
	10	3,9	4,9	6,2	7,8	9,3	9,9	11,9	12,4	15,5	19,8	24,8	31,0	39,7	49,6
	25	3,8	4,8	6,0	7,6	9,0	9,6	11,6	12,1	15,1	19,3	24,2	30,2	38,7	48,4
	50	3,8	4,7	5,9	7,5	8,9	9,5	11,4	11,9	14,8	19,0	23,8	29,7	38,0	47,6
	100	3,7	4,6	5,8	7,3	8,7	9,3	11,2	11.6	14,6	18,7	23,3	29,2	37,4	46,7
20	5	3,3	4,2	5,3	6,6	7,9	8,4	10,2	10.6	13,2	16,9	21,2	26,5	33,9	42,4
	10	3,3	4,1	5,2	6,5	7,8	8,3	10.0	10.4	13,0	16,6	20,8	26,0	33,3	41,6
	25	3,2	4,0	5,0	6,4	7,6	8,1	9,8	10.1	12,7	16,2	20,3	25,4	32,5	40,7
	50	3,2	4,0	5,0	6,3	7,5	8,0	9,6	10.0	12,5	16,0	20,0	25,0	32,0	40,0
	100	3,1	3,9	4,9	6,1	7,3	7,8	9,4	9.8	12,2	15,7	19,6	24,5	31,4	39,2
30	5	2,8	3,6	4,5	5,6	6,7	7,2	8,6	9.0	11,2	14,4	18,0	22,5	28,8	36,0
	10	2,8	3,5	4,4	5,5	6,6	7,0	8,5	8.8	11,0	14,1	17,7	22,1	28,3	35,4
	25	2,7	3,4	4,3	5,4	6,4	6,9	8,3	8.6	10,8	13,8	17,2	21,6	27,6	34,5
	50	2,7	3,3	4,2	5,3	6,3	6,7	8,1	8.4	10,6	13,5	16,9	21,2	27,1	33,9
40	5	2,4	3,0	3,8	4,8	5,8	6,1	7,4	7.7	9,6	12,3	15,4	19,3	24,7	30,9
	10	2,4	3,0	3,8	4,7	5,7	6,0	7,3	7.6	9,5	12,1	15,2	19,0	24,3	30,4
	25	2,3	2,9	3,7	4,6	5,5	5,9	7,1	7.4	9,2	11,8	14,8	18,5	23,7	29,7
	50	2,3	2,9	3,6	4,5	5,4	5,8	7,0	7.2	9,1	11,6	14,5	18,2	23,3	29,1
50	5	2,1	2,6	3,3	4,2	5,0	5,3	6,4	6.7	8,3	10,7	13,4	16,7	21,4	26,8
	10	2,0	2,6	3,2	4,0	4,8	5,2	6,2	6.5	8,1	10,4	13,0	16,2	20,3	26,0
	15	1,9	2,3	2,9	3,7	4,4	4,7	5,7	5,9	7,4	9,5	11,8	14,8	19,0	23,7
60	5	1,5	1,9	2,4	3,0	3,6	3,8	4.6	4,8	6,0	7,7	9,7	12,1	15,5	19,4
70	2	1,2	1,5	1,9	2,4	2,9	3,1	3.7	3,9	4,9	6,2	7,8	9,8	12,5	15,7

Allowable working pressure for pipes made from PE 100, conveying water,with a safty factor of 1.6

tempe-reture-,in C°	Years of service	Pipe series													
		25	20	16	12.5	10.5	10	8.3	8	6.3	5	4	3.2	2.5	2
		Standard dimension ratio (SDR)													
		51	41	33	26	22	21	17.6	17	13.6	11	9	7.4	6	5
		Allowable working pressure													
10	5	3,1	3,9	4,9	6,3	7,5	7,8	9,5	9,8	12,5	15,7	19,7	24,2	31,5	39,4
	10	3,1	3,8	4,8	6,2	7,3	7,7	9,3	9,6	12,3	15,5	19,3	23,8	31,0	38,7
	25	3,0	3,7	4,7	6,0	7,2	7,5	9,1	9,4	12,0	15,1	18,9	23,3	30,2	37,8
	50	2,9	3,7	4,6	5,9	7,0	7,4	8,9	9,3	11,8	14,8	18,6	22,8	29,7	37,2
	100	2,9	3,6	4,5	5,8	6,9	7,3	8,8	9,1	11,6	14,6	18,2	22,4	29,2	36,5
20	5	2,6	3,3	4,1	5,3	6,3	6,6	7.9	8.2	10.5	13,2	16,5	20,4	26,5	33,1
	10	2,6	3,2	4,0	5,2	6,2	6,5	7,8	8,1	10,3	13,0	16,2	20,0	26,0	32,5
	25	2,5	3,1	3,9	5,0	6,0	6,3	7,6	7,9	10,0	12,7	15,9	19,5	25,4	31,8
	50	2,5	3,1	3,9	5,0	5,9	6,2	7,5	7,8	9,9	12,5	15,6	19,2	25,0	31,2
	100	2,4	3,0	3,8	4,9	5,8	6,1	7,3	7,6	9,7	12,2	15,3	18,8	24,5	30,6
30	5	2,2	2,8	3,5	4,5	5,3	5,6	6,7	7,0	8,9	11,2	14,0	17,3	22,5	28,1
	10	2,2	2,7	3,4	4,4	5,2	5,5	6,6	6,9	8,7	11,0	13,8	17,0	22,1	27,6
	25	2,1	2,7	3,3	4,3	5,1	5,4	6,5	6,7	8,5	10,8	13,5	16,6	21,6	27,0
	50	2,1	2,6	3,3	4,2	5,0	5,3	6,3	6,6	8,4	10,6	13,2	16,3	21,2	26,5
40	5	1,9	2,4	3,0	3,8	4,6	4,8	5,8	6,0	7,6	9,6	12,0	14,8	19,3	24,1
	10	1,9	2,3	2,9	3,8	4,5	4,7	5,7	5,9	7,5	9,5	11,8	14,6	19,0	23,7
	25	1,8	2,3	2,9	3,7	4,4	4,6	5,5	5,8	7,3	9,2	11,6	14,2	18,5	23,2
	50	1,8	2,2	2,8	3,6	4,3	4,5	5,4	5,6	7,2	9,1	11,3	14,0	18,2	22,7
50	5	1,6	2,0	2,6	3,3	3,9	4,1	5,0	5,2	6,6	8,3	10,4	12,8	16,7	20,9
	10	1,6	2,0	2,5	3,2	3,8	4,0	4,8	5,0	6,4	8,1	10,1	12,5	16,2	20,3
	15	1,4	1,8	2,3	2,9	3,5	3,7	4,4	4,6	5,8	7,4	9,2	11,4	14,8	18,5
60	5	1,2	1,5	1,9	2,4	2,8	3,0	3,6	3,8	4,8	6,0	7,6	9,3	12,1	15,2
70	2	0,9	1,2	1,5	1,9	2,3	2,4	2,9	3,0	3,8	4,9	6,1	7,5	9,8	12,2

Allowable working pressure for pipes made from PE 100, conveying water,with a safty factor of 2,0

tempe-reture- ,in C°	Years of service	*Pipe series*													
		25	20	16	12.5	10.5	10	8.3	8	6.3	5	4	3.2	2.5	2
		Standard dimension ratio (SDR)													
		51	41	33	26	22	21	17.6	17	13.6	11	9	7.4	6	5
		Allowable working pressure													
10	5	2,5	3,1	3,9	5,0	6,0	6,3	7,6	7,8	10,0	12,6	15,7	19,4	25,2	31,5
	10	2,4	3,1	3,8	4,9	5,9	6,2	7,4	7,7	9,8	12,4	15,5	19,0	24,8	31,0
	25	2,4	3,0	3,7	4,8	5,7	6,0	7,3	7,5	9,6	12,1	15,1	18,6	24,2	30,2
	50	2,3	2,9	3,7	4,7	5,6	5,9	7,1	7,4	9,4	11,9	14,8	18,3	23,8	29,7
	100	2,3	2,9	3,6	4,6	5,5	5,8	7,0	7,3	9,2	11,6	14,6	17,9	23,3	29,2
20	5	2,1	2,6	3,3	4,2	5,0	5,3	6,3	6,6	8,4	10,6	13,2	16,3	21,2	26,5
	10	2,0	2,6	3,2	4,1	4,9	5,2	6,2	6,5	8,2	10,4	13,0	16,0	20,8	26,0
	25	2,0	2,5	3,1	4,0	4,8	5,0	6,1	6,3	8,0	10,1	12,7	15,6	20,3	25,4
	50	2,0	2,5	3,1	4,0	4,7	5,0	6,0	6,2	7,9	10,0	12,5	15,3	20,0	25,0
	100	1,9	2,4	3,0	3,9	4,6	4,9	5,9	6,1	7,7	9,8	12,2	15,1	19,6	24,5
30	5	1,8	2,2	2,8	3,6	4,2	4,5	5,4	5,6	7,1	9,0	11,2	13,8	18,0	22,5
	10	1,7	2,2	2,7	3,5	4,2	4,4	5,3	5,5	7,0	8,8	11,0	13,6	17,7	22,1
	25	1,7	2,1	2,7	3,4	4,1	4,3	5,2	5,4	6,8	8,6	10,8	13,3	17,2	21,6
	50	1,6	2,1	2,6	3,3	4,0	4,2	5,1	5,3	6,7	8,4	10,6	13,0	16,9	21,2
40	5	1,5	1,9	2,4	3,0	3,6	3,8	4,6	4,8	6,1	7,7	9,6	11,9	15,4	19,3
	10	1,5	1,9	2,3	3,0	3,6	3,8	4,5	4,7	6,0	7,6	9,5	11,6	15,2	19,0
	25	1,4	1,8	2,3	2,9	3,5	3,7	4,4	4,6	5,8	7,4	9,2	11,4	14,8	18,5
	50	1,4	1,8	2,2	2,9	3,4	3,6	4,3	4,5	5,7	7,2	9,1	11,2	14,5	18,2
50	5	1,3	1,6	2,0	2,6	3,1	3,3	4,0	4,1	5,3	6,7	8,3	10,3	13,4	16,7
	10	1,3	1,6	2,0	2,6	3,0	3,2	3,9	4,0	5,1	6,5	8,1	10,0	13,0	16,2
	15	1,1	1,4	1,8	2,3	2,8	2,9	3,5	3,7	4,7	5,9	7,4	9,1	11,8	14,8
60	5	0,9	1,2	1,5	1,9	2,3	2,4	2,9	3,0	3,8	4,8	6,0	7,4	9,7	12,1
70	2	0,7	0,9	1,2	1,5	1,8	1,9	2,3	2,4	3,1	3,9	4,9	6,0	7,9	9,8

13 Tolerances of PE pipes

Wall thickness deviation limits

Tolerances on mean outside diameter and circularity (ovality)

Wall thickness deviation limits

Wall thickness	limit deviations
e mm	+..... 0
≤ 2	+0,3
> 2 ≤ 3	+0,4
> 3 ≤ 4	+0,5
> 4 ≤ 5	+0,6
> 5 ≤ 6	+0,7
> 6 ≤ 7	+0,8
> 7 ≤ 8	+0,9
> 8 ≤ 9	+1,0
> 9 ≤ 10	+1,1
> 10 ≤ 11	+1,2
> 11 ≤ 12	+1,3
> 12 ≤ 13	+1,4
> 13 ≤ 14	+1,5
> 14 ≤ 15	+1,6
> 15 ≤ 16	+1,7
> 16 ≤ 17	+1,8
> 17 ≤ 18	+1,9
> 18 ≤ 19	+2,0
> 19 ≤ 20	+2,1
> 20 ≤ 21	+2,2
> 21 ≤ 22	+2,3
> 22 ≤ 23	+2,4
> 23 ≤ 24	+2,5
> 24 ≤ 25	+2,6
> 25 ≤ 26	+2,7
> 26 ≤ 27	+2,8
> 27 ≤ 28	+2,9
> 28 ≤ 29	+3,0
> 29 ≤ 30	+3,1
> 30 ≤ 31	+3,2
> 31 ≤ 32	+3,3
> 32 ≤ 33	+3,4
> 33 ≤ 34	+3,5
> 34 ≤ 35	+3,6
> 35 ≤ 36	+3,7
> 36 ≤ 37	+3,8
> 37 ≤ 38	+3,9
> 38 ≤ 39	+4,0
> 39 ≤ 40	+4,1

Wall thickness deviation limits

Wall thickness	limit deviations
e mm	+..... 0
> 40 ≤ 41	+4,2
> 41 ≤ 42	+ 4,3
> 42 ≤ 43	+ 4,4
> 43 ≤ 44	+4,5
> 44 ≤ 45	+4,6
> 45 ≤ 46	+4,7
> 46 ≤ 47	+4,8
> 47 ≤ 48	+ 4,9
> 48 ≤ 49	+ 5,0
> 49 ≤ 50	+ 5,1
> 50 ≤ 51	+5,2
> 51 ≤ 52	+ 5,3
> 52 ≤ 53	+ 5,4
> 53 ≤ 54	+ 5,5
> 54 ≤ 55	+ 5,6
> 55 ≤ 56	+ 5,7
> 56 ≤ 57	+ 5,8
> 57 ≤ 58	+ 5,9
> 58 ≤ 59	+ 6,0
> 59 ≤ 60	+ 6,1
> 60 ≤ 61	+ 6,2
> 61 ≤ 62	+ 6,3
> 62 ≤ 63	+ 6,4
> 63 ≤ 64	+ 6,5
> 64 ≤ 65	+6,6
> 65 ≤ 66	+ 6,7
> 66 ≤ 67	+ 6,8
> 67 ≤ 68	+ 6,9
> 68 ≤ 69	+ 7,0
> 69 ≤ 70	+ 7,1

The given values have been calculated on the following basis : limt deviations of the wall-thickness = 0,1 e_n + 0,1 mm, rounded up to nearest 0,1 mm.

A local increase in wall thickness of up to +0,2 e_n is premissiblle for $e_n \leq$ 10mm, +0,15 e_n for $e_n >$ 10mm the mean of the measurments shall, however, still lie within the given limit deviations

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Tolerances on mean outside diameter and circularity (ovality)

dn mm	Limit deviations for mean outside diameter	Limit deviations for circularity (ovality)
		Straight pipes
10	+0,3	1,2
12	+0,3	1,2
16	+0,3	1,2
20	+0,3	1,2
25	+0,3	1,2
32	+0,3	1,3
40	+0,3	1,4
50	+0,3	1,4
63	+0,4	1,5
75	+0,5	1,6
90	+0,6	1,8
110	+0,7	2,2
125	+0,8	2,5
140	+0,9	2,8
160	+1,0	3,2
180	+1,1	3,6
200	+1,2	4,0
225	+1,4	4,5
250	+1,5	5,0
280	+1,7	9,8
315	+1,9	11,1
355	+2,2	12,5
400	+2,4	14,0
450	+2,7	15,8
500	+3,0	17,5
560	+3,4	19,6
630	+3,8	22,1
710	+6,4	24,9
800	+7,2	28,0
1000	+9,0	35,0
1200	+10,8	42,0
1400	+12,6	49,0
1600	+14,4	56,0

Limit deviations for mean outside diameter for dn ≤ 630mm : limit deviations according to iso 11922-1:1997, grade B, dn ≥ 710 mm according to iso 11922-1:1997 Grade A.

Limit deviations for circularity (ovality) according to iso 11922-1:1997 Grade N.

the limit Deviations does not correspomd with iso 11922-1:1997, grade A, but they are calculated as follow: 0,009 dn

14 SI and Imperial conversion table

Length units

	mm	m	km	in	ft	yd
1mm	1	0,001	10^{-6}	0,03937	$3,281 \bullet 10^{-6}$	$1,094 \bullet 10^{-6}$
1 m	1,000	1	0,001	39,37	3,281	1,094
1 km	10^{6}	1,000	1	39,370	3,281	1,094
1 in	25,4	0,0254	-	1	0,08333	0,02778
1 ft	304,8	0,0254	-	12	1	0,3333
1 yd	914,4	0,9144	-	36	3	1

Area units

	cm^2	dm^2	m^2	sq in	sq ft	sq yd
1 cm^2	1	0.01	0.0001	0,155	$1,076 \bullet 10^{-3}$	$1,197 \bullet 10^{-4}$
1 dm^2	100	1	0,01	15,5	0,1076	0,01196
1 m^2	10,000	100	1	1,550	10,76	1,196
1 sq in	6,452	0,06452	$64,5 \bullet 10^{-5}$	1	$6,944 \bullet 10^{-3}$	$0,772 \bullet 10^{-3}$
1 sq ft	929	0,29	0,0929	144	1	0,1111
1 sq yd	8,361	8361	0,8361	1,296	9	1

volume units

	cm^3	dm^3	m^3	cu in	cu ft	cu yd
1 cm^3	1	0,001	10^{-6}	0,06102	$3,532 \bullet 10^{-8}$	$1.31 \bullet 10^{-6}$
1 dm^3	1,000	1	0,001	61,02	0,03532	0,00131
1 m^3	10^{6}	1,000	1	61,023	35,32	1,307
1 cu in	16,39	0,01639	$1,64 \bullet 10^{-5}$	1	$5,786 \bullet 10^{-4}$	$2,144 \bullet 10^{-5}$
1 cu ft	28,316	28,32	0,0283	1,728	1	0,037
1 cu yd	764,555	764,55	0,7646	46,656	27	1

Mass units

	g	kg	mg	dram	oz	ib
1 g	1	0,001	10^{-6}	0,5643	0,03527	0,002205
1 kg	1,000	1	0,001	564,3	35,27	2.205
1 mg	10^{6}	1,000	1	564.4 • 10^{3}	35,270	2,205
1 dram	1,772	0,00177	1,77 • 10^{-6}	1	0,0625	0,003906
1 oz	28,35	0,02832	28,3 • 10^{-6}	16	1	0,0625
1 lb	453,6	0,4531	4,53 • 10^{-4}	256	16	1

Pressure units

	bar	pa	N/mm^2	Kp/cm^2	tor	at
1 bar	1	10^{5}	0,1	1,02	750	1.0197
1 pa	10^{-5}	1	10^{-6}	1,02 • 10	0,0075	1,0197 • 10^{-5}
1 N/mm^2	10	10^{6}	1	10,2	7,5 • 10^{3}	10.1972
1 Kp/cm^2	0,981	98,100	9,81 • 10^{-2}	1	736	1
torr	1,133 • 10^{-3}	133	0,133 • 10^{-3}	1,36 • 10	1	1,3595 • 10^{-3}
at	0,9806	9,806 • 10^{4}	0,0980	1	735,5592	1

1 Pa = 1 N/m^2
at = technical atmosphere

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