

4 Standards

4.1 General

Harmonisation of European standards for plastic piping systems is an ongoing process. Plastic pressure pipe systems are subject to:

prEN 15014 Pressure Drainage & Sewerage

This harmonised European standard contains only the performance characteristics needed to meet the essential requirements of EU Directive(s). It does not cover all the characteristics of the products. These are specified in the product standards listed in table 4.1 "European product standards for PE pipe systems" and other appropriate product specifications. This listing represents the situation at the time this document was published and may be changed if new standards are developed.

The harmonised European standard belongs to a family or cluster of standards aimed at plastic pipe systems. The relationship is shown in figure 4.1.

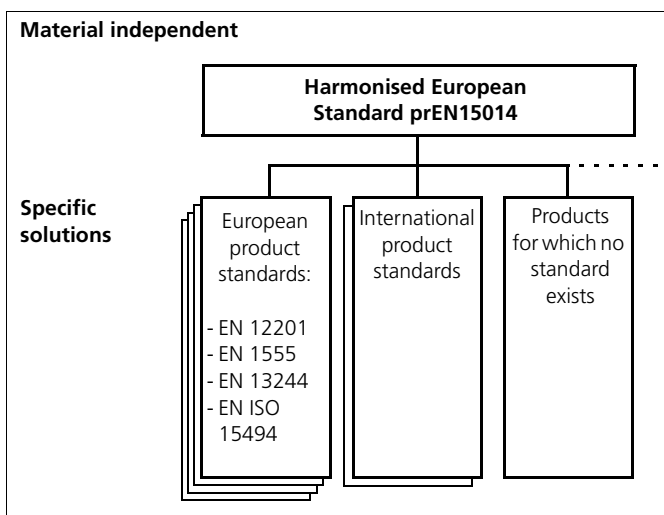


Figure 4.1

For the harmonisation of pressure plastic pipe systems figure 4.2 applies:

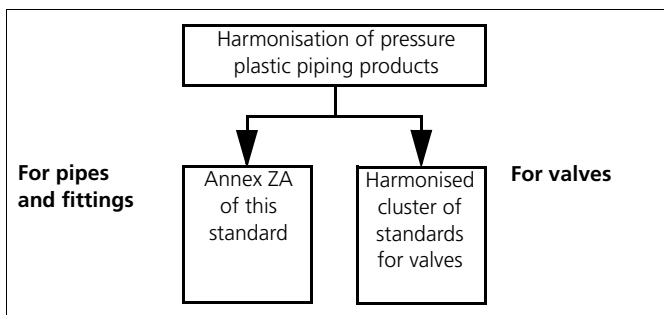


Figure 4.2

The harmonised European standard prEN 15014 specifies performance requirements for plastic pipes, fittings and their joints for buried or above ground pressure applications involving general purpose water, drainage, sewerage and irrigation, as well as for any other pressure application with other fluids covered by the Construction Products Directive, with the exception of drinking water for human consumption. It gives associated test methods for verification and evaluation of compliance with this standard.

European product standards for PE pipe systems

EN 12201	Plastic pipe systems for water supply - Polyethylene (PE)
EN 1555	Plastic pipe systems for the supply of gaseous fuels - Polyethylene (PE)
EN 13244	Plastic pipe systems for buried and aboveground pressure systems for general purpose water, drainage and sewerage - Polyethylene (PE) - Part 1: General
EN ISO 15494	Plastic pipe systems for industrial applications - Polybutene (PB), Polyethylene (PE), Polypropylene (PP) - Specifications for components and the system - Metric series

Table 4.1

4.2 Minimum required strength (MRS)

As mentioned in section 1.6.1, the internal pressure creep test is one of the most important indicators of a thermoplastic pipe's capacity. The ISO DIS 12162 classification system was created to classify pipe material in a meaningful manner. The basis for this classification is formed by the measurement and analysis of creep rupture curves according to the standard extrapolation method specified in ISO/TR 9080. For the circumferential stress (measured at a temperature of 20°C, a life-span of 50 years and using water as test medium), this enables us to determine:

- the expectation value for long terms hydrostatic strength (LTHS)
- the 97.5% lower confidence level (LCL)

The LCL value is categorised according to the Renard 10 number series (R10). This standard number series (DIN 323, ISO 30) involves the subdivision of a decade into 10 equal parts, plotted on a logarithmic scale. This produces the following series $(\sqrt[10]{10})^n$ with $n = 1, 2, 3, \dots, n$. Rounding these values produces the following number series: 1 - 1.25 - 1.6 - 2 - 3.2 - 4 - 5 - 6.3 - 8 - 10. The smooth values result from the fact that these results are rounded down to the next lowest R10 number. The outcome is viewed as the minimum required strength (MRS). The significance of the MRS values will be illustrated using an example involving PE:

MRS 6.3 = $\sigma_{ref} = 6.3$ MPa (Mega Pascal) and corresponds to PE63.
MRS 8 = $\sigma_{ref} = 8$ MPa and corresponds to PE80.
MRS 10 = $\sigma_{ref} = 10$ MPa and corresponds to PE100.

4.3 Pipe series number (ISO-S)

To calculate wall thickness, material-specific variables are reinforced by a safety factor in order to guarantee the permissible internal pressure load for the pipe.

For the transport of water through a pipe system, calculations are performed using an aggregate pipe coefficient (C) = safety factor (SF) ≥ 1.25 . For the transport of gas in pipe systems an aggregate pipe coefficient (c) = Safety Factor (SF) > 2.0 is used. The aggregate pipe coefficient is comparable to the safety factor (SF) in its size and significance, as it comprises the safety reserves required under certain circumstances when additional loads affect the pipe. For instance, pressure surges, heat stresses during temperature changes, agitations and ground subsidences can reduce internal pressure load capacity. In contrast to the calculation of minimum values when sizing pipes, which are determined simply by running tests, the calculation of pipe safety factors must resort to empirical values. Dividing the MRS value by the aggregate pipe coefficient (C) yields the reference stress (σ_{ref}), and the acceptable stress (σ_{acc}) is produced by dividing the reference stress (σ_{ref}) by the aggregate pipe coefficient (C) (equation 4.1).

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$$\sigma_{ref} = \frac{MRS}{C} \quad \text{c.q.} \quad \sigma_{acc} = \frac{\sigma_v}{C}$$

Equation 4.1

MRS = Minimum required stress (-)
 σ_{ref} = Reference stress (N/mm²)
 σ_{acc} = Acceptable stress (N/mm²)
 C = SF = Aggregate pipe coefficient (safety factor) (-)

The safety factor underlying calculations for an entire pipe system has to be established in the context of individual applications (consideration is first given to the weakest pipe elements, such as branches, tees, etc.). The values of the safety coefficient for an entire pipe system are normally always larger than the values indicated in the DIN, which only apply to a straight pipe.

4.4 Maximum operating pressure (MOP)

Before introduction of the European standard the internal pressure load capacity of PE pressure pipes and fittings was indicated by the nominal pressure stages of a pipe in terms of a PN rating. For instance, pipes rated PN 6 meant that the permissible internal pressure load capacity of the pipe was 6 bar for water at a temperature of 20°C over a lifespan of 50 years.

According to the present European standard, the designation (PN) is replaced by the designations (SDR) or (ISO-S), whereby:

$$(ISO - S = \frac{SDR - 1}{2})$$

Equation 4.2

The permissible internal pressure load capacity or maximum operating pressure of PE pipes (PE80, PE100) are based on variable safety factors SF = 1.25 (for water supply pipes) and SF = 2.0 (for gas pipes). The significance of these specifications will be investigated further in the rest of this chapter.

4.5 Standard dimension ratio (SDR)

In European standards the notion of nominal pressure "PN" is being largely abandoned. Instead, the previously used pipe series number "ISO-S" and the standard dimension ratio "SDR" are being emphasised. The relationship between ISO-S and SDR is shown in equation 4.3.

This ratio is indicated in the form of an SDR mark (standard dimension ratio). Within a pipe series, this SDR number is constant and corresponds to the value of the rounded outside diameter of the pipe divided by the wall thickness of the pipe.

$$SDR = \frac{d_e}{e}$$

Equation 4.3

SDR = standard dimension ratio (-)
 d_e = rounded outside diameter of the pipe (mm)
 e = pipe wall thickness (mm)

Application	Drinking water	Gas
Material	PE100	PE100
Standards	E DIN 8074	E DIN 8074
σ_{ref} (Water 20°C, 50 years)	10	10
Aggregate pipe coefficient C	1.25	2.0
σ_{acc} (Water 20°C, 50 years)	8	5
SDR	ISO-S	
41	20	4
33	16	5
26	12.5	6.3
17.6	8.3	9.6
17	8	10
11	5	16
9	4	20
7.4	3.2	25
		5
		10
		-
		-

Table 4.2 Internal pressure load capacity for PE100 drinking water and gas pipes

Table 4.2 shows the maximum permissible operating pressure (according to DVGW VP for drinking water and G 472 for gas), the current pipe series as specified in DIN 8074, and their standard dimension ratios (SDR) for the PE100 material classes.

Note on table 4.2

If PE pipes and fittings are used to supply drinking water (e.g. table water, mineral water), an additional test must be conducted regarding any adverse effect on taste. In transporting chemical flow materials (not including gas or tap water), special consideration must be given to the appropriateness of PE with regard to the indicated media. The choice of the appropriate pipe series is fundamentally linked to a consideration of stress reduction factors. Black coloured PE pipes are storable in central European climate zones for 25 years.

4.6 The polyethylene (PE) mark

The continuous development and improvement of plastic also influences its mechanical properties and variables. These are continuously improved due to years of practical experience, as well as efforts in the research departments of pipe manufacturers in improving the capacity of plastic. Improvements in the mechanical properties of the polyolefin used in plastic pipe construction primarily involve PE compounds.

Associated with changes in material characteristics are corresponding changes in material designations. In plastic pipe construction, reference is no longer made to PE-HD but to the PE types PE63, PE80 and PE100.

It must, however, be noted that only PE100 is, in fact, used in this field. The digits indicate the long-term stability of the material, a conventional practice in labelling metal materials. The long-term stability for PE100 is calculated as follows: $\sigma_{ref} = 100/10 = 10 \text{ MPa} = 10 \text{ N/mm}^2$ and applies to situations where the flow medium is water at 20°C and the load period 50 years. Both German and European standards incorporate the new PE types by adopting the following classification:

- PE63 -> MRS 6,3
- PE80 -> MRS 8,0
- PE100 -> MRS 10,0

Since PE63 has smaller creep strength than PE80 and PE100, it has only limited applications in pressure pipe systems. In terms of strength values, PE80 largely corresponds to PE-HD with partial improvements of material properties.

Due to its greater strength, the use of PE100 is increasingly more common in pipe construction, especially in areas involving high pressure. Initial suspicions with regard to welding have been dispelled, so that manufacturers and contractors can widely benefit from the advantages of PE100.

Standards and application guidelines have been updated so that any impediments in them no longer exist. The new bimodular types of PE80 and PE100 demonstrate, in addition to improvements in strength properties, greater resilience than PE-HD, a quality improvement that yields the following benefits:

- greater creep strength at higher temperatures
- greater resistance to rapid crack growth
- reduced susceptibility to notching

In terms of the service life of the bimodular types, evidence to support assuming it to be 100 years is provided by the standard extrapolation method specified in ISO/TR 9080. Based on years of positive experience, the minimum safety factor (SF) has been established on 1.25 (gas pipe SF = 2.0). The creep rupture curve for calculating strength values can be derived from appendix A1. The important properties and variables of PE are discussed in chapter 2.

4.7 Load capacity of welded PE100 pipe and fittings

PE100 can be welded without restriction. Welding of PE100 onto PE80 components can also be performed unrestricted.

The butt-weld process according to NEN 7200 is specified in chapter 9. The electrofusion process according to NIL weld practice recommendation VM 102 is also specified in chapter 9. In case of application of welded fittings, a reduced pressure load made from pipe has to be taken in account. Please consult Akatherm BV about the internal pressure load capacity.

4.8 Wall thicknesses and acceptable internal pressure load capacity for PE100 pipes

PE100 (SF = 1.25)	MOP ISO-S SDR	Wall thicknesses of PE100 pipes and fittings of the corresponding SDR series													
		40	(31.9)	25	20	16	12.5	10	(9.7)	8	(7.5)	6.3	5	4	3.2
		2 5	2.5 6	3.2 7.4	4 9	5 11	6.3 13.6	8 17	8.3 17.6	10 21	10.5 22	12.5 26	16 33	20 41	25 51
d_e	Wall thickness (e) (mm)														
10		2.0	1.8												
12		2.4	2.0	1.8											
16		3.3	2.7	2.2	1.8										
20		4.1	3.4	2.8	2.3	1.9	1.8								
25		5.1	4.2	3.5	2.8	2.3	1.9	1.8							
32		6.5	5.4	4.4	3.6	2.9	2.4	1.9	1.8						
40		8.1	6.7	5.5	4.5	3.7	3.0	2.4	2.3	1.9	1.9	1.8			
50		10.1	8.3	6.9	5.6	4.6	3.7	3.0	2.9	2.4	2.3	2.0	1.8		
63		12.7	10.5	8.6	7.1	5.8	4.7	3.8	3.6	3.0	2.9	2.5	2.0	1.8	
75		15.1	12.5	10.3	8.4	6.8	5.6	4.5	4.3	3.6	3.5	2.9	2.3	1.9	1.8
90		18.1	15.0	12.3	10.1	8.2	6.7	5.4	5.1	4.3	4.1	3.5	2.8	2.2	1.8
110		22.1	18.3	15.1	12.3	10.0	8.1	6.6	6.3	5.3	5.0	4.2	3.4	2.7	2.2
125		25.1	20.8	17.1	14.0	11.4	9.2	7.4	7.1	6.0	5.7	4.8	3.9	3.1	2.5
140		28.1	23.3	19.2	15.7	12.7	10.3	8.3	8.0	6.7	6.4	5.4	4.3	3.5	2.8
160		32.1	26.6	21.9	17.9	14.6	11.8	9.5	9.1	7.7	7.3	6.2	4.9	4.0	3.2
180		36.1	29.9	24.6	20.1	16.4	13.3	10.7	10.2	8.6	8.2	6.9	5.5	4.4	3.6
200		40.1	33.2	27.4	22.4	18.2	14.7	11.9	11.4	9.6	9.1	7.7	6.2	4.9	3.9
225		45.1	37.4	30.8	25.2	20.5	16.6	13.4	12.8	10.8	10.3	8.6	6.9	5.5	4.4
250		50.1	41.6	34.2	27.9	22.7	18.4	14.8	14.2	11.9	11.4	9.6	7.7	6.2	4.9
280		56.2	46.5	38.3	31.3	25.4	20.6	16.6	15.9	13.4	12.8	10.7	8.6	6.9	5.5
315		63.2	52.3	43.1	35.2	28.6	23.2	18.7	17.9	15.0	14.4	12.1	9.7	7.7	6.2
355			59.0	48.5	39.7	32.2	26.1	21.1	20.1	16.9	16.2	13.6	10.9	8.7	7.0
400			66.5	54.7	44.7	36.3	29.4	23.7	22.7	19.1	18.2	15.3	12.3	9.8	7.9
450				61.5	50.3	40.9	33.1	26.7	25.5	21.5	20.5	17.2	13.8	11.0	8.8
500				68.3	55.8	45.4	36.8	29.7	28.4	23.9	22.8	19.1	15.3	12.3	9.8
560					62.5	50.8	41.2	33.2	31.7	26.7	25.5	21.4	17.2	13.7	11.0
630						57.2	46.3	37.4	35.7	30.0	28.7	24.1	19.3	15.4	12.3
710						64.5	52.2	42.1	40.2	33.9	32.3	27.2	21.8	17.4	13.9
800							58.8	47.4	45.3	38.1	36.4	30.6	24.5	19.6	15.7
900							66.1	53.3	51.0	42.9	41.0	34.4	27.6	22.0	17.6
1000								59.3	56.7	47.7	45.5	38.2	30.6	24.5	19.6
1200									68.0	57.2	54.6	45.9	36.7	29.4	23.5
1400										66.7	63.7	53.5	42.9	34.4	27.4
1600												61.2	49.0	39.2	31.3

SF = Safety factor (valid for water at 20°C)

Table 4.3 Classification criteria for pressure pipes: PE100 / DIN 8074: 1999-08

Standards

Temperature (°C)	Years of service	SDR	51	41	33	26	22	21	17.6	17	13.6	11	9	7.4	6	5
		ISO-S	25	20	16	12.5	10.5	10	8.3	8	6.3	5	4	3.2	2.5	2
Maximum operating pressure (bar)																
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	
	100	2.6	3.2	4.1	5.1	6.1	6.5	7.9	8.2	10.4	13.3	16.7	21.1	27.0	33.8	
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	
	100	2.2	2.8	3.5	4.4	5.3	5.7	6.9	7.1	8.9	11.4	14.3	18.0	23.0	28.8	
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	

Table 4.4 Acceptable operating overpressures for pressure pipes: PE100 with SF = 1.25 (flow medium: water) / DIN 8074: 1999-08

Note to tables 4.3 and 4.4:

The stated values do not apply to pipes exposed to the effects of UV and pressureless drainage and sewerage pipes with maximum operating pressures <1 bar and are not included in the tables.

4.9 Chapter summary

European standards	prEN 15014 Pressure Drainage & Sewerage is the harmonised European standard for buried or aboveground pressure facilities for general purpose water, drainage, sewerage and irrigation, as well as for any other pressure applications involving other fluids. National standards have been revised in order to comply with European standards.
Minimum required strength (MRS)	The minimum required strength corresponds to the reference stress (σ_{ref}) of water at 20°C and a service life of 50 years.
Maximum operating pressure (MOP)	The internal pressure load capacity was formerly used to designate the nominal pressure "PN" of pipes and fittings. In the European standards, the designation has been abandoned and replaced by (SDR) or (ISO-S).
Standard dimension ratio (SDR)	The standard dimension ratio indicates the relationship of the pipe outside diameter to wall thickness.
Pipe series number (ISO-S)	The pipe series number (ISO-S) indicates the internal pressure load capacity of a pipe, while taking a safety factor into account.
Aggregate pipe coefficient (C)	The aggregate pipe coefficient (C) is a safety buffer (safety reserve) to allow for the additional loads that occur in pipe systems. It corresponds to the safety factor (SF). 1.25 for water and 2.0 for gas.
Safety factor (SF)	The safety factor (SF) corresponds to the aggregate pipe coefficient (C).
Welding property of PE100	Demonstrated by extensive research: no problems have been shown to arise in welding PE80 to PE100 pipe elements of identical SDR values. Welding can therefore be done without restriction.