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DIN 8078:2007-05

Polypropylene (PP) pipes – PP-H, PP-B, PP-R, PP-RCT – General quality requirements and testing

Rohre aus Polypropylen (PP) – PP-H, PP-B, PP-R, PP-RCT – Allgemeine Güteanforderungen, Prüfung

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In case of doubt, the German-language original should be consulted as the authoritative text.

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Foreword

This standard has been prepared by Technical Committee NA 054-05-02 AA *Prüfverfahren für Rohre* of the *Normenausschuss Kunststoffe* (Plastics Standards Committee).

DIN, the German Institute for Standardization, would like to bring attention to the fact that complying with this standard can involve exploitation of Patent EP1448631 in regard to material PP-RCT.

DIN takes no postition on the legitimacy, validity or scope of this patent.

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Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. DIN shall not be held responsible for identifying any or all such patent rights.

Amendments

This standard differs from DIN 8078:1996-04 as follows:

a) Type PP-RCT polypropylene has been included.

b) The material designation has been modified.

c) An equation for the reference curves has been included.

This standard differs from DIN 8078:2007-05 as follows:

a) A reference to patent rights has been added to the Foreword.

b) The description of PP-RCT polypropylene has been modified.

c) A reference to existing European product standards has been added to the Scope.

Previous editions

DIN 8078-2:1980-05
DIN 8078: 1972-02, 1984-04, 1996-04, 2007-05

1 Scope

This standard is applicable to circular-cross-section seamless polypropylene (PP) pipes made from homopolymer polypropylene (PP-H), block copolymer polypropylene (PP-B), random copolymer polypropylene (PP-R) or random copolymer polypropylene with modified crystalline structure and elevated temperature resistance (PP-RCT).

Individual requirements specified in this standard may be omitted or supplemented in technical delivery conditions relating to particular applications.

Attention is brought to the fact that existing European product standards apply for some specific applications, which are to be complied with where necessary. Some of these product standards are listed in the bibliography for the information of users of this standard. Please note that because European Standards are continually being developed, this list is not exhaustive.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

DIN 323-1, *Preferred numbers and series of preferred numbers — Basic values, calculated values, rounded values*

DIN 8077, *Polypropylene (PP) pipes — PP-H, PP-B, PP-R, PP-RCT — Dimensions*

DIN 16887, *Determination of the long-term hydrostatic pressure resistance of thermoplastics pipes*

DIN EN 10204, *Metallic products — Types of inspection documents*

DIN EN ISO 179-1, *Plastics — Determination of Charpy impact properties — Part 1: Non-instrumented impact test*

DIN EN ISO 1167-1, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 1: General method*

DIN EN ISO 1167-2, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 2: Preparation of pipe test pieces*

DIN EN ISO 2505, *Thermoplastics pipes — Longitudinal reversion — Test methods and parameters*

DIN EN ISO 9080, *Plastics piping and ducting systems — Determination of the long-term hydrostatic strength of thermoplastics materials in pipe form by extrapolation*

3 Material

3.1 General

Pipes shall be made from polypropylene (PP) moulding material stabilized with suitable antioxidants.

The choice of stabilizers and other additives shall be left to the manufacturer.

Moulding materials of unknown composition shall not be used (see Appendix A: Explanatory notes).

3.2 Proof of long-term hydrostatic strength

For PP-H, PP-B, PP-R and PP-RCT, it shall be proven that the long-term hydrostatic strength lies on or above the corresponding reference characteristic curves (minimum curves), see Figure 1 to Figure 4. The proof shall be provided by means of a suitable method, for example, according to DIN EN ISO 9080 or DIN 16887 and shall take into account the temperature-time limits.

The reference characteristic curves are based on equation (1).

$$\lg t = A + \frac{B}{T} \times \lg\sigma + \frac{C}{T} + D \times \lg\sigma \qquad (1)$$

where

A, B, C and D are the coefficients according to Table 1;

T is the temperature, in K;

t is the time, in h.

Table 1 — Coefficients for calculating the reference characteristic curves

Material	Part of reference characteristic curve	Coefficients			
		A	B	C	D
PP-H	flat slope	–46,364	–9 601,1	20 381,5	15,24
	steep slope	–18,387	0	8 918,5	–4,1
PP-B	flat slope	–56,086	–10 157,8	23 971,7	13,32
	steep slope	–13,699	0	6 970,3	–3,82
PP-R	flat slope	–55,725	–9 484,1	25 502,2	6,39
	steep slope	–19,98	0	9 507	–4,11
PP-RCT	flat slope	–119,546	–23 738,797	52 176,696	31,279

The coefficients given in Table 1 to describe the reference characteristic curves apply in the temperature range 10 °C to 95 °C for materials PP-H, PP-B and PP-R and in the temperature range 10 °C to 110 °C for material PP-RCT.

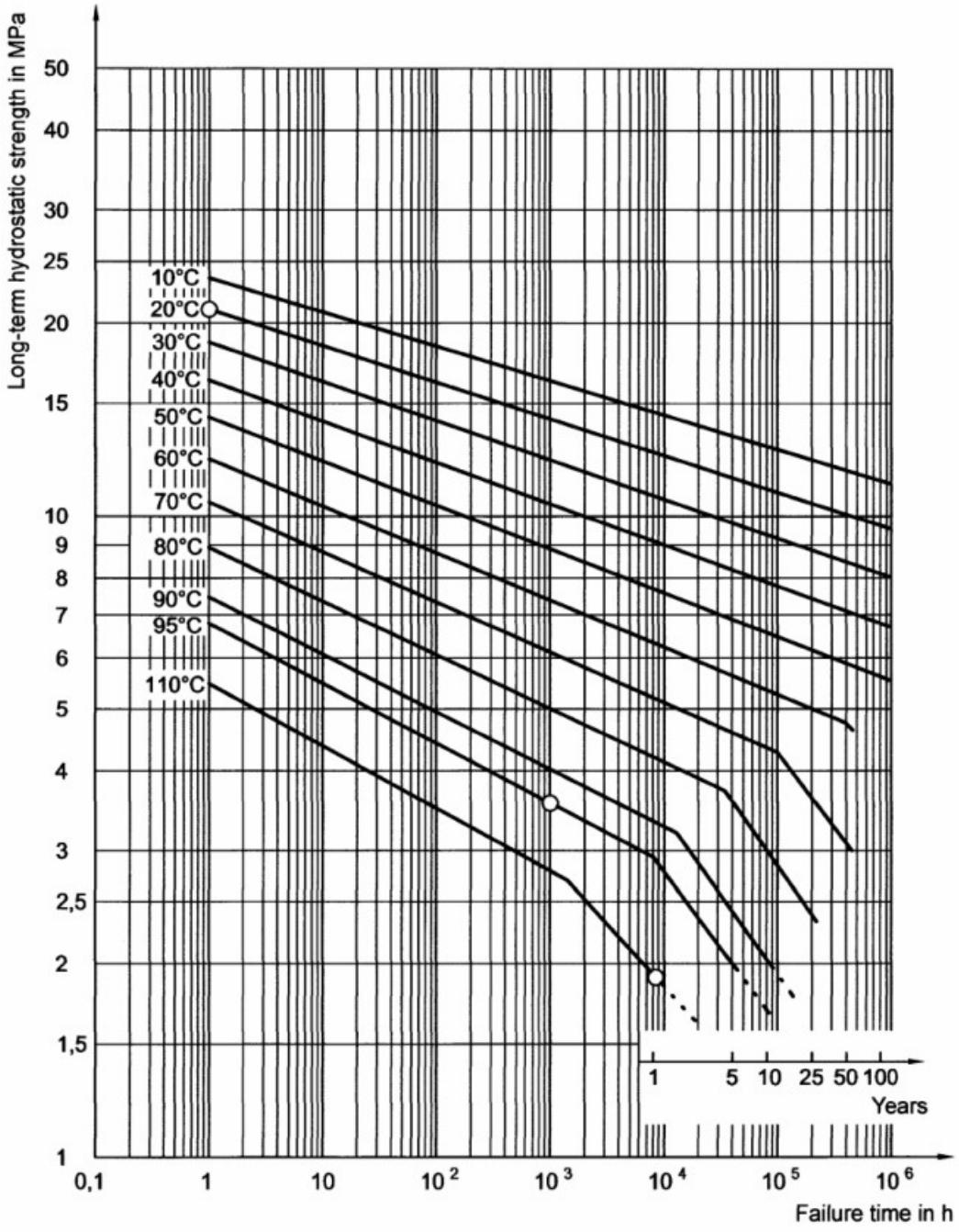

Figure 1 — Reference characteristic curves of the long-term hydrostatic strength (minimum curves) for PP-H pipes

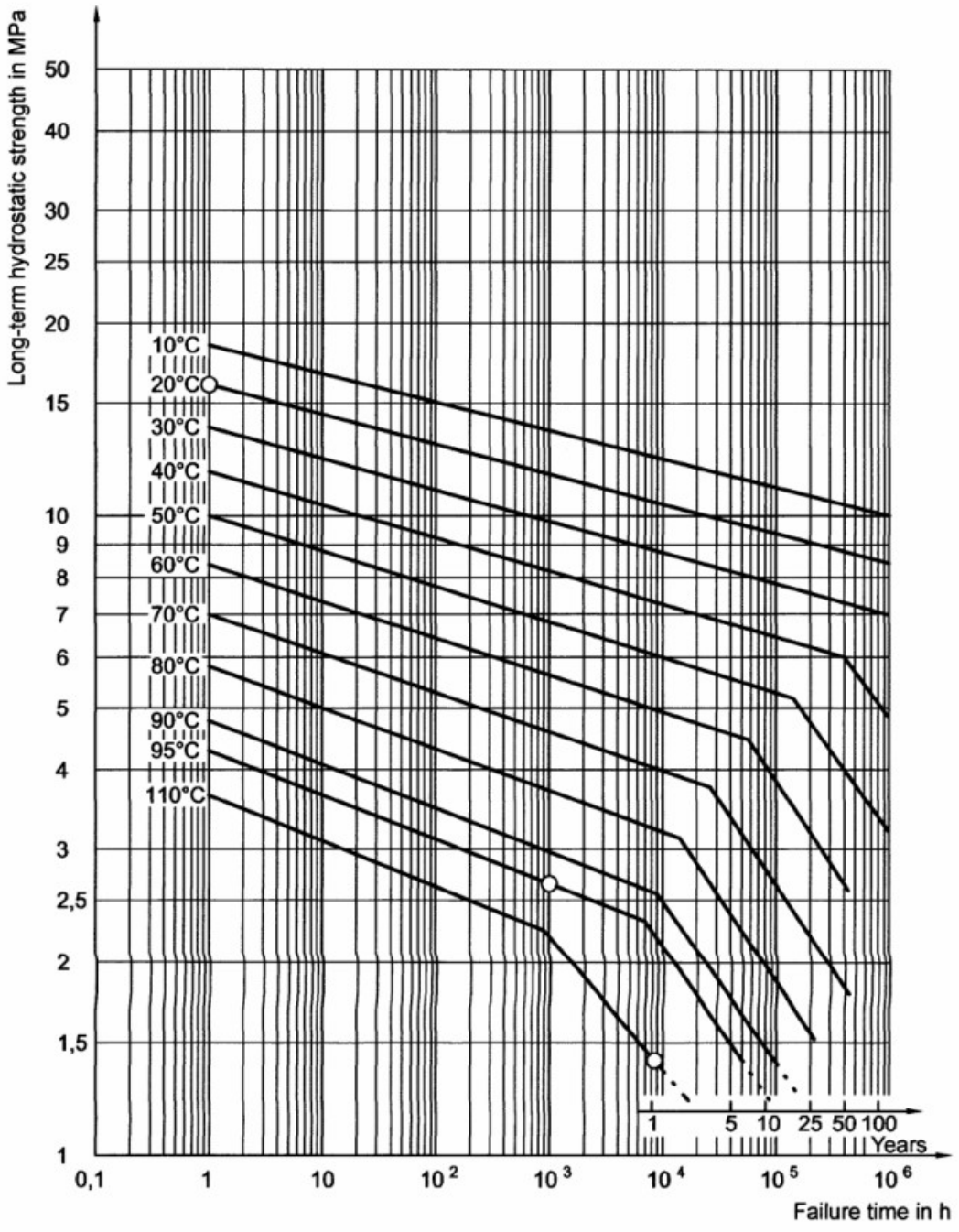

Figure 2 — Reference characteristic curves of the long-term hydrostatic strength (minimum curves) for PP-B pipes

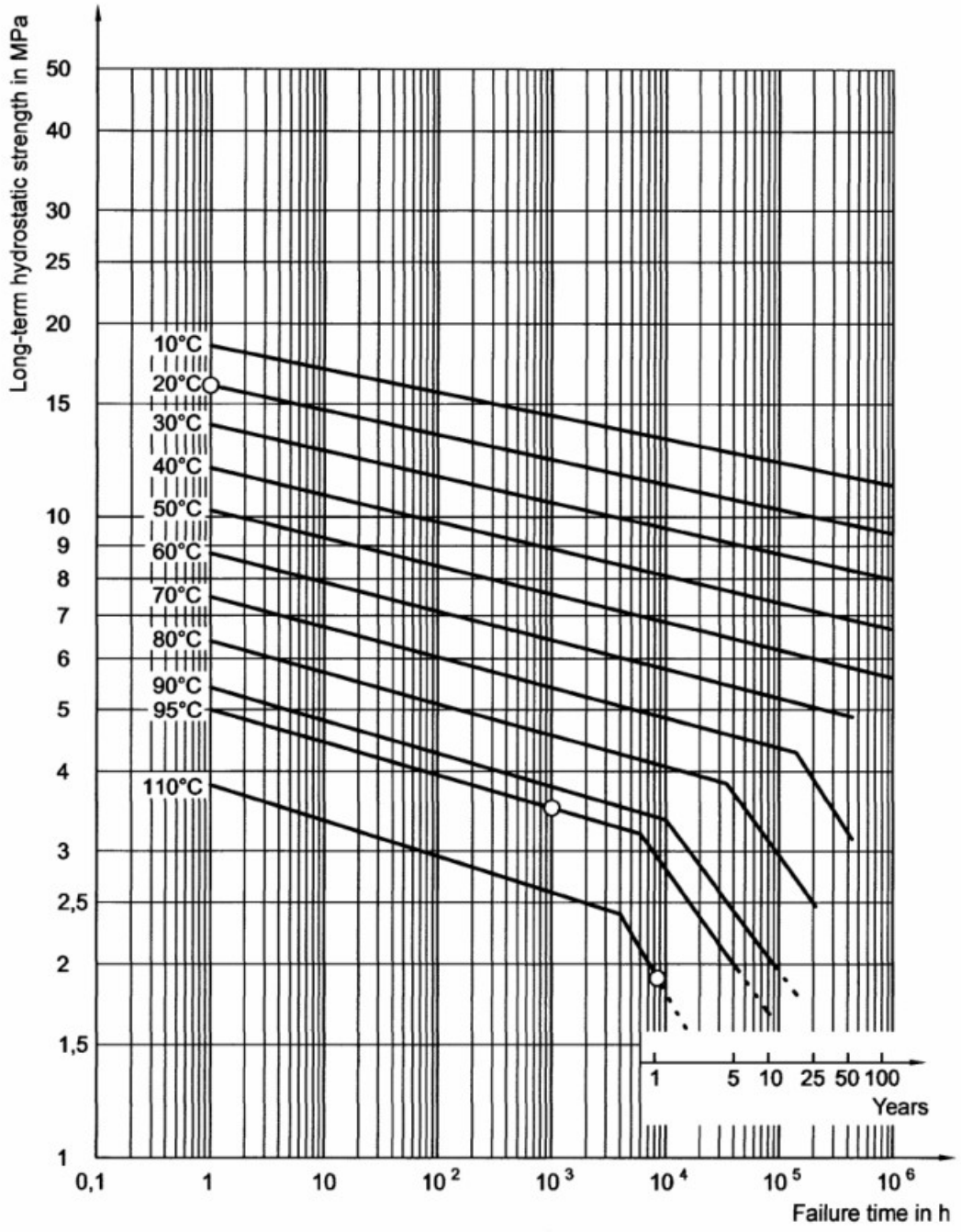

Figure 3 — Reference characteristic curves of the long-term hydrostatic strength (minimum curves) for PP-R pipes

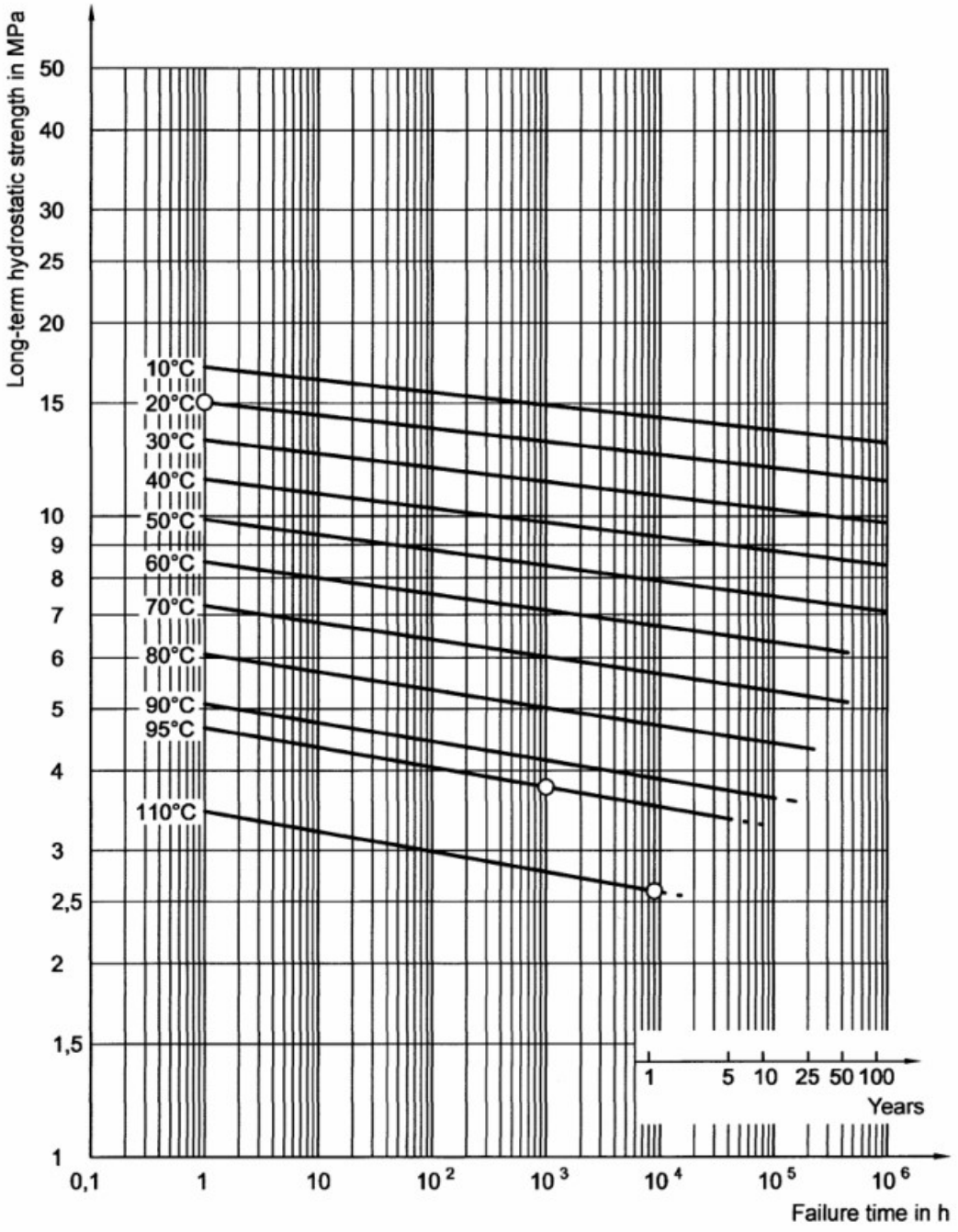

Figure 4 — Reference characteristic curves of the long-term hydrostatic strength (minimum curves) for PP-RCT pipes

4 Requirements

4.1 Delivery condition

The pipe ends should be as perpendicular as possible to the pipe axis. The pipes shall be free of blisters, shrink holes and inhomogeneities that would impair their performance in service. They shall be of uniform colour throughout.

4.2 Surface condition

The internal and external pipe surfaces shall be smooth. Slight corrugations and the resultant irregularities in the wall thickness are permitted provided the wall thickness does not go below the nominal values specified in DIN 8077. No sharp-edged grooves or sink marks are permitted.

Testing shall be as specified in 5.1.

4.3 Dimensions and tolerances

The dimensions and tolerances specified in DIN 8077 apply for the outside diameters, wall thickness and out-of-roundness.

Testing shall be as specified in 5.2 and 5.3.

For pipes with special dimensions not covered in DIN standards as a result of deviations from preferred numbers (see DIN 323-1) and international specifications, the calculation principles of DIN 8077 apply.

4.4 Long-term hydrostatic strength

The long-term resistance to internal pressure shall be determined in a long-term hydrostatic strength test (5.4).

The long-term hydrostatic strength test conditions are specified in Table 2.

The pipes shall not leak or otherwise fail during the specified stressing period (failure time).

4.5 Impact strength test behaviour (inspection by attributes)

When tested according to 5.5, the failure rate of the test pieces shall not exceed 10 %.

4.6 Changes after heat treatment

When tested according to 5.6, the mean relative change in length of the pipe shall not exceed 2 %.

Table 2 — Test conditions for the long-term hydrostatic test

Pipe material	Environment (test medium)	Test temperature °C	Hoop stress σ_0 MPa	Stressing period (failure time) t h
PP-H	Air or water	20	21	1
	Air or water	95	4,2	165
	Air or water	95	3,5	1 000
	Air	110	1,9	8 760[a]
PP-B	Air or water	20	16	1
	Air or water	95	3,0	165
	Air or water	95	2,6	1 000
	Air	110	1,4	8 760[a]
PP-R	Air or water	20	16	1
	Air or water	95	3,8	165
	Air or water	95	3,5	1 000
	Air	110	1,9	8 760[a]
PP-RCT	Air or water	20	15	1
	Air or water	95	4,0	165
	Air or water	95	3,8	1 000
	Air	110	2,6	8 760[a]

[a] Quality control for initial production, or change of material or manufacture.

5 Testing

5.1 Surface condition

The internal and external surfaces of the pipe shall be examined against the light without optical aids.

5.2 Dimensions

The mean outside diameter of the pipe shall be determined to the nearest 0,1 mm at both ends of the pipe by measuring the circumference. The wall thicknesses of the pipe shall be determined to the nearest 0,1 mm at 4 points at each pipe end with the measurement points being distributed as uniformly as possible around the circumference of the pipe. The measurements shall be carried out at (23 ± 2) °C.

5.3 Out-of-roundness (ovality)

Out-of-roundness (the difference between the measured maximum outside diameter and the measured minimum outside diameter in the same cross-section of the pipe) shall be measured to the nearest 0,1 mm immediately after production.

5.4 Long-term hydrostatic strength test

For general information on the test see DIN EN ISO 1167-1 and DIN EN ISO 1167-2. For each hoop stress as in Table 2, take three pipe sections (called "pipes" for short in the following) of the following lengths l_1 (see Figure 5):

for $d \leq$ 250 mm: $l_1 \approx 3\,d + 2\,l_5 + 250$ mm

for $d >$ 250 mm: $l_1 \approx 1\,000$ mm $+ 2\,l_5$

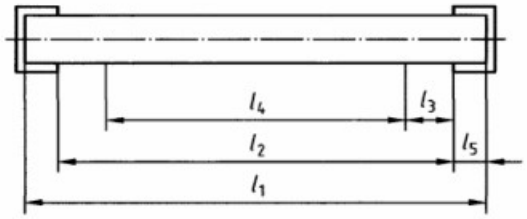

Figure 5 — Test pieces for long-term hydrostatic test

where

d is the outside diameter of the pipe, in mm

l_1 is the length of the test piece, in mm;

l_2 is the test length, in mm;

l_3 is the length of the zone affected by the end sealing devices, in mm;

for $d \leq$ 250 mm: $l_3 = d$

for $d >$ 250 mm: $l_3 = 250$ mm

l_4 is the assessment length, in mm; $l_4 = l_2 - 2\,l_3$;

l_5 is the length required for attaching the end cap, in mm.

Measure the wall thickness e to the nearest 0,1 mm at eight points distributed along l_4, and the outside diameter d to the nearest 0,1 mm by measuring the pipe circumference at three points, and then determine the minimum wall thickness e_{min} and mean outside diameter d_m.

Fit the pipe with caps at both ends. It shall remain free to move in the axial direction during the test. Fill the pipe with water at the test temperature specified in Table 2 (tolerance: ± 5 K) through an aperture in one of the caps and place it in a bath heated to the test temperature (tolerance: ± 1 K) for at least 1 h until the temperature is constant. If the pipe is filled with water at a lower temperature, leave it in the bath for 12 h to ensure thermal equilibrium.

Then, steadily increase the pressure in the pipe in the bath so that the specified test pressure is reached within 1 minute. Maintain the test pressure to within ± 2,5 % for the stressing period specified in Table 2.

Calculate the test pressure $p_{e,p}$ using equation (2):

$$p_{e,p} = \frac{2 \times e_{min} \times \sigma_0}{\overline{d} - e_{min}} \quad (2)$$

where

$\overline{d}$ is the mean outside diameter over l_4, in mm,

e_{min} is the minimum wall thickness over l_4, in mm,

σ_0 is the hoop stress specified in Table 1, in MPa.

Determine whether the pipe has leaked or otherwise failed during the specified stressing period.

Tests in which the pipe has failed within l_3 during the stressing period are not to be evaluated and shall be repeated.

5.5 Impact strength test (inspection by attributes)

Pipe sections or bar-shaped test pieces in the longitudinal direction (see Figure 6) shall be taken from the pipes according to the data in Table 3. The bar-shaped test pieces shall be taken from pipe sections (50 ± 1) mm or (120 ± 2) mm long from points spaced as uniformly as possible around the circumference. The test piece width given in Table 2 corresponds to chord length b of the circular cut-out both of the external and internal pipe wall (see Figure 6).

The pipe surfaces of the test pieces shall not be machined if the wall thickness $e \leq 10{,}5$ mm. For test pieces from pipes with wall thicknesses greater than 10,5 mm, the external pipe surface shall be machined down to a thickness of (10 ± 0,5) mm. The machined surface shall be smoothed with emery paper (grain size No. 220 or finer) in the longitudinal direction.

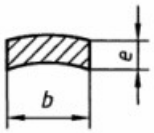

Figure 6 — Bar-shaped test piece for impact strength test

The impact strength test shall be carried out according to DIN EN ISO 179-1 on 10 test pieces using a 15 J pendulum impact testing machine with the blow being applied to the external pipe surface or the machined side.

The test shall be carried out at (23 ± 2) °C for pipes made from PP-H and at (0 ± 2) °C for pipes made from PP-B, PP-R and PP-RCT.

It shall be established whether the test pieces fail. If more than one test piece fails, the impact strength test shall be repeated on 20 further test pieces taken from the same pipe. In this case, the failure rate of the first and second test shall be evaluated together.

Table 3 — Impact strength test pieces

Type of test piece	Pipe		Test piece			Distance between supports
	outside diameter d mm	wall thickness e mm	length mm	width mm	height mm	$^{+0,5}_{0}$ mm
1	< 25	e	Pipe section (100 ± 2) mm long			70
2	≥ 25	≤ 4,2	50 ± 1	6 ± 0,2	e	40
3	> 25	> 4,2	120 ± 2	15 ± 0,5	max. 10,5	70

5.6 Heat reversion

The longitudinal reversion shall be determined according to DIN EN ISO 2505.

Table 4 — Test conditions for heat treatment

Pipe material	Test temperature °C	Stressing period t min
PP-H	150 ± 2	120 ± 2
PP-B	150 ± 2	120 ± 2
PP-R	135 ± 2	120 ± 2
PP-RCT	135 ± 2	120 ± 2

5.7 Inspection documents

If so agreed, the pipe manufacturer shall issue an inspection document in accordance with DIN EN 10204.

Annex A
(informative)

Explanatory notes

This standard has been prepared by NA 054-05-02 AA *Prüfverfahren für Rohre*.

This standard is a basic standard covering the general quality requirements and tests for pipes made from PP-H, PP-B, PP-R and PP-RCT. Requirements relating to scope of testing, inspection and special applications are left to the relevant bodies.

The main feature of these general quality requirements and tests is the long-term hydrostatic strength test. The technical committee was convinced that the test had to be carried out on the pipe itself – and not on a test piece taken from the pipe. Tests have been carried out over several years at different test temperatures, amongst other things to establish to what extent the long-term hydrostatic strength test can be carried out to reduce the test duration at elevated temperatures. The specifications regarding long-term hydrostatic strength given here were based on the results of these tests, and the probable service lives and various safety factors were also given due consideration.

Extrapolation of the long-term strength and extrapolation time limit requirements follow the principles set down in DIN EN ISO 9080 or DIN 16887.

Long-term tests and experience show that the extended service life for PP pipes specified in the April 1996 edition of this standard as being at least 100 years at operating temperatures of up to 50 °C can still be maintained.

In the material designation, the classification number based on the MRS value as in DIN EN ISO 12162 has been omitted as this classification does not conform to the long-term hydrostatic strength requirements. In addition, the MRS classification describes the behaviour only for a specific interval of 50 years at 20 °C and does not cover behaviour at elevated temperatures. However, PP pipes are frequently used at elevated temperatures. The long-term hydrostatic strength specified in DIN 8078 is the defining characteristic for the suitability and dimensioning of PP pipes.

The material designations PP-H, PP-B, PP-R and PP-RCT are in accordance with DIN EN ISO 1043-1. The symbols used for PP-RCT indicate the fact that these are random copolymers (R = random), with modified crystalline structure (C = crystalline). In addition, the PP-RCT is characterized by improved long-term hydrostatic strength, particularly at elevated temperatures (T = temperature (resistance)).

The dimensions specified in DIN 8077 apply for PP-H, PP-B, PP-R and PP-RCT pipes, although the operating pressures vary.

In the long-term hydrostatic strength test, the strength requirement for the quality assurance of the pipes has been fixed in such a way that the pipes have to withstand a specific hoop stress (σ_0 value) at an elevated temperature for a specified time without failing. In addition, a long-term hydrostatic strength test has been specified at 20 °C over a period of only one hour.

As the behaviour in the impact strength test is an important criterion for the quality of the PP pipes, the impact strength test has been specified as a further quality characteristic. Initially, use has been made of the well-known impact strength test on test pieces machined from pipes in the longitudinal direction.

Pipes made from PP-B, PP-R and PP-RCT have a higher impact strength in cold environments than those made from PP-H.

Pipe manufacturing methods are not specified here so that technical developments are not hindered. This standard specifies that moulding materials of unknown composition are not to be used so that the use of unsuitable material is prevented without excluding the use of reclaimed materials, which can be advantageous for technical and economic reasons.

Table A.1 — Guideline values for some properties of PP materials

Property	PP-H	PP-B	PP-R	PP-RCT
Density (tested according to DIN EN ISO 1183 series)	$\approx 0{,}91\ g/cm^3$	$\approx 0{,}91\ g/cm^3$	$\approx 0{,}91\ g/cm^3$	$\approx 0{,}91\ g/cm^3$
Mean coefficient of linear thermal expansion in the temperature range 0 °C to 110 °C (tested according to DIN 53752)	$\approx 1{,}5 \times 10^{-4}\ K^{-1}$	$\approx 1{,}5 \times 10^{-4}\ K^{-1}$	$\approx 1{,}5 \times 10^{-4}\ K^{-1}$	$\approx 1{,}5 \times 10^{-4}\ K^{-1}$
Thermal conductivity (tested according to DIN 52612-1)	$\approx 0{,}23\ W\ K^{-1}\ m^{-1}$	$\approx 0{,}23\ W\ K^{-1}\ m^{-1}$	$\approx 0{,}23\ W\ K^{-1}\ m^{-1}$	$\approx 0{,}23\ W\ K^{-1}\ m^{-1}$
Surface resistivity (tested according to DIN IEC 60093)	$> 10^{12}\ \Omega$	$> 10^{12}\ \Omega$	$> 10^{12}\ \Omega$	$> 10^{12}\ \Omega$
NOTE As long as no flame retardants are used, pipes as specified in this standard meet the requirements for building material class B 2 as in DIN 4102-4.				

Bibliography

DIN 4102-4, *Fire behaviour of building materials and building components — Synopsis and application of classified building materials, components and special components*

DIN 52612-1, *Testing of thermal insulating materials — Determination of thermal conductivity by the guarded hot plate apparatus — Test procedure and evaluation*

DIN 53752, *Testing of plastics — Determination of the coefficient of linear thermal expansion*

DIN EN 1451-1, *Plastics piping systems for soil and waste discharge (low and high temperature) within the building structure — Polypropylene (PP) — Part 1: Specifications for pipes, fittings and the system*

DIN EN 1852-1, *Plastics piping systems for non-pressure underground drainage and sewerage — Polypropylene (PP) — Part 1: Specifications for pipes, fittings and the system*

DIN EN ISO 1043-1, *Plastics — Symbols and abbreviated terms — Part 1: Basic polymers and their special characteristics*

DIN EN ISO 1183-1, *Plastics — Methods for determining the density of non-cellular plastics — Part 1: Immersion method, liquid pyknometer method and titration method*

DIN EN ISO 1183-2, *Plastics — Methods for determining the density of non-cellular plastics — Part 2: Density gradient column method*

DIN EN ISO 1183-3, *Plastics — Methods for determining the density of non-cellular plastics — Part 3: Gas pyknometer method*

DIN EN ISO 1873-2, *Plastics — Polypropylene (PP) moulding and extrusion materials — Part 2: Preparation of test specimens and determination of properties*

DIN EN ISO 12162, *Classification of thermoplastic materials in pipe form based on the resistance against internal hydrostatic pressure — Material designation and calculations*

DIN EN ISO 15494, *Plastics piping systems for industrial applications — Polybutylene (PB), polyethylene (PE) and polypropylene (PP) — Specifications for components and the system*

DIN EN ISO 15874-1, *Plastics piping systems for hot and cold water installations — Polypropylene (PP) — Part 1: General*

DIN EN ISO 15874-2, *Plastics piping systems for hot and cold water installations — Polypropylene (PP) — Part 2: Pipes*

DIN EN ISO 15874-3, *Plastics piping systems for hot and cold water installations — Polypropylene (PP) — Part 3: Fittings*

DIN EN ISO 15874-5, *Plastics piping systems for hot and cold water installations — Polypropylene (PP) — Part 5: Fitness for purpose of the system*

DIN ISO/TS 15874-7, *Plastics piping systems for hot and cold water installations — Polypropylene (PP) — Part 7: Recommendations for conformity assessment*

DIN IEC 60093, *Methods of test for insulating materials for electrical purposes — Volume resistivity and surface resistivity of solid electrical insulating materials*