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Pipes made of raised-temperature-resistance polyethylene (PE-RT) — Effect of time and temperature on the expected strength

Tubes en polyéthylène de meilleure résistance à la température (PE-RT) — Influence du temps et de la température sur la résistance espérée

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 24033 was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 5, *General properties of pipes, fittings and valves of plastic materials and their accessories — Test methods and basic specifications*.

Introduction

An increasing number of types of polyethylene (PE) polymers, made in a variety of processes, is on the market for different applications in plastic piping and ducting systems. Many applications have their own system standard that defines the properties and requirements for the pipes and fittings used.

The types of PE suitable for use in hot and cold water systems are basically different from those for applications at ambient temperatures such as in water supply, sewage and drainage, or gaseous fuels.

Therefore, it makes sense to differentiate those PE having raised temperature resistance by terming them “PE-RT” (for *polyethylene of raised temperature resistance*) [1)].

1) Abbreviated term based on the provisions of, and guidance for preparing new abbreviated terms for basic polymers, mixtures of polymers and related terms given in, ISO 1043-1[1].

Pipes made of raised-temperature-resistance polyethylene (PE-RT) — Effect of time and temperature on the expected strength

1 Scope

This International Standard lays down the minimum values for expected strength as a function of time and temperature in the form of reference lines, for use in calculations on polyethylene of raised temperature resistance (PE-RT) pipes.

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.

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

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 piece*

ISO 1167-3, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 3: Preparation of components*[2)]

ISO 1167-4, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 4: Preparation of assemblies*[2)]

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
reference lines
generic description of the minimum long-term hydrostatic strength to be expected from a particular polymer

NOTE 1 Reference lines are not to be considered as characteristic of a specific grade or of material from a specific supplier.

NOTE 2 The lines are described by a mathematical equation, which permits interpolation and extrapolation in an unambiguous way at various temperatures.

NOTE 3 The reference lines for polyethylene of raised temperature resistance (PE-RT) were agreed upon by a group of experts after considering experimental data, and have been accepted by the relevant technical committees in ISO.

2) To be published. (Revision of ISO 1167:1996)

4 Basic equations

The reference lines for temperatures between 20 °C and 95 °C are described by the following equations:

$$\lg t = A_1 + (B_1/T) \lg \sigma + C_1/T + D_1 \lg \sigma \quad (1)$$

$$\lg t = A_2 + (B_2/T) \lg \sigma + C_2/T + D_2 \lg \sigma \quad (2)$$

where

t is the time, in hours (h);

T is the temperature, in kelvin (K);

σ is the hoop stress, in megapascals (MPa);

A_1 = –190,481; A_2 = –23,7954;

B_1 = –58219,035; B_2 = –1723,318;

C_1 = 78763,07; C_2 = 11150,56;

D_1 = 119,877; D_2 = 0.

The 110 °C values have been determined separately using water inside and air outside the test specimen and have not been derived from these equations.

NOTE ISO 9080[2] quotes formulas in a different sequence, where $C_1 = A$, $C_2 = C$, $C_3 = D$ and $C_4 = B$.

5 Expected strength

5.1 Extrapolation limits

The extrapolation limits (the end points of the reference lines) are based on an experimentally determined life at 110 °C and an Arrhenius equation for the temperature dependence with an activation energy of 110 kJ/mole (≈ 26 kcal/mole). This yields the values given in Table 1 for the extrapolation factor K_x (i.e. the expected lifetime at a given temperature divided by the lifetime at 110 °C):

Table 1 — Extrapolation factors K_x

T °C	K_x
$100 \geqslant T > 95$	2,5
$95 \geqslant T > 90$	4
$90 \geqslant T > 85$	6
$85 \geqslant T > 80$	12
$80 \geqslant T > 75$	18
$75 \geqslant T > 70$	30
$T \leqslant 70$	50

With a life of one year at 110 °C, these values are therefore the number of years the pipes would be expected to last at each of the temperatures given.

For temperatures up to and including 50 °C, an extrapolation factor K_x of 100 is acceptable.

5.2 Graphical representation

Figure 1 contains the reference lines corresponding to the values of the parameters given in Clause 4, to be used for demonstrating conformance to this specification, as described in Annex A.

The broken lines represent the extrapolation of the reference lines, applicable when longer failure times are obtained at 110 °C, extrapolation being permitted up to the limits given by the extrapolation factors in Table 1.

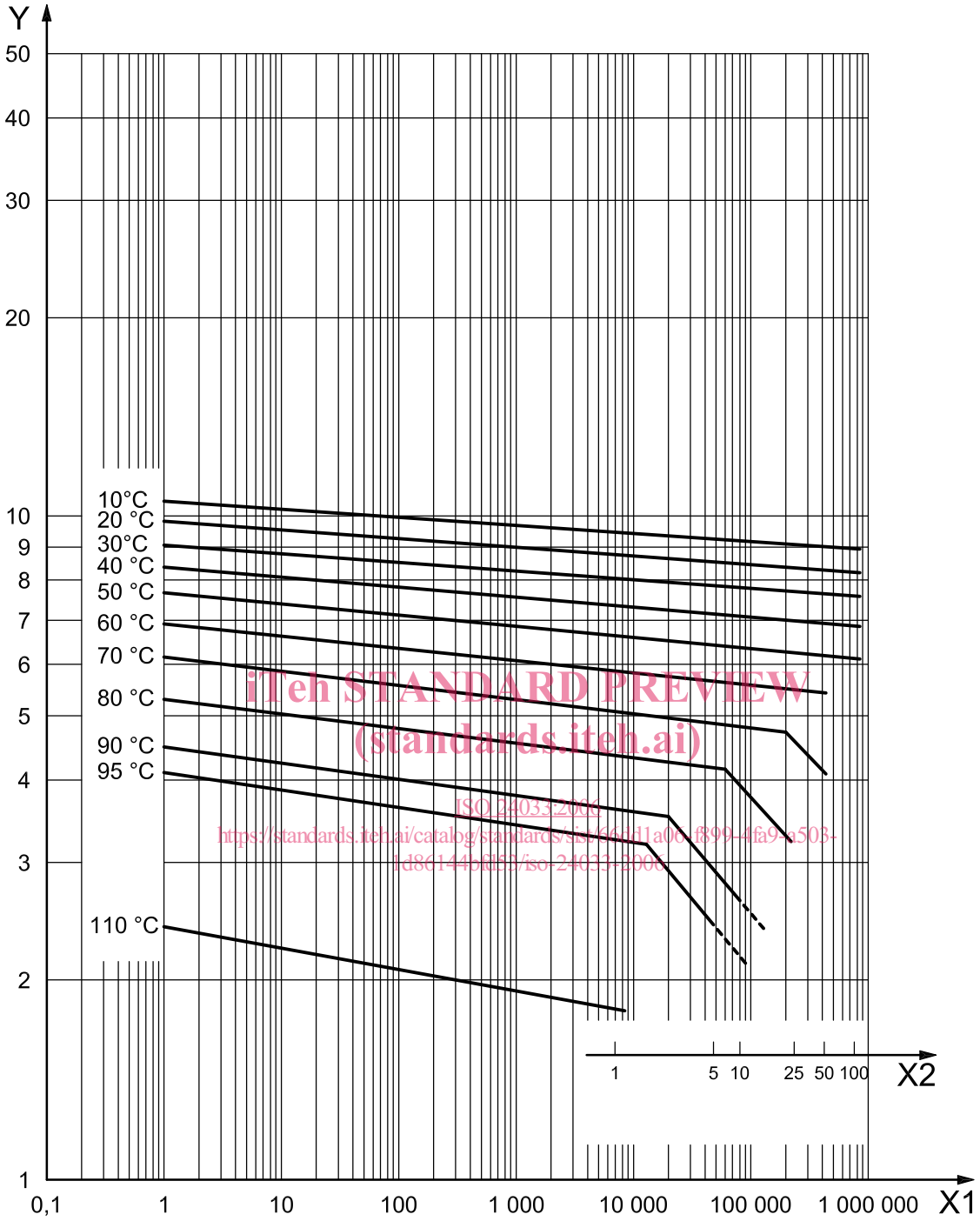
5.3 Tabulated values

The calculated hoop strength values to be used for various temperatures and times are given in Table 2 and include no safety factors or design factors.

The times at 80 °C, 90 °C and 95 °C not in brackets in the “Time” column in Table 2 are based on a lifetime of one year at 110 °C. Proof of a longer lifetime at 110 °C allows a corresponding extension of the times at lower temperatures. Such values are given in brackets in Table 2.

Table 2 — Expected hoop strength values for various values of time and temperature

Temperature °C	Time Years	Expected strength MPa
20	1 5 10 25 50 100	8,8 8,6 8,5 8,4 8,3 8,3
30	1 5 10 25 50 100	8,1 7,9 7,8 7,7 7,6 7,6
40	1 5 10 25 50 100	7,3 7,2 7,1 7,0 6,9 6,8
50	1 5 10 25 50 100	6,6 6,4 6,3 6,2 6,2 6,1
60	1 5 10 25 50	5,8 5,7 5,6 5,5 5,4
70	1 5 10 25 50	5,1 4,9 4,9 4,7 4,1
80	1 5 10 18 (25)	4,3 4,2 3,9 3,4 (3,2)
90	1 4 6 (10) (15)	3,6 3,2 2,9 (2,6) (2,4)
95	1 4 (6) (10)	3,2 2,6 (2,4) (2,2)



Key

X1 time, t, to fracture, h

X2 years

Y hoop stress, σ, MPa

Figure 1 — Expected strength of PE-RT pipes

Annex A
(normative)

Demonstrating conformance of pipes to reference lines

At each of the following temperatures, specimens shall be tested at each of the temperatures given, such that at least three failure times fall in each of the following time intervals:

Temperatures: 20 °C, 60 °C to 82 °C, 95 °C.

Time intervals: 10 h to 100 h;

100 h to 1000 h;

1000 h to 8760 h;

> 8 760 h.

In the case of tests lasting longer than 8 760 h, any time after the reference value may be considered as the failure time.

Testing shall be carried out in accordance with ISO 1167.

Conformance to the reference lines shall be demonstrated by plotting the individual experimental results on the graph. At least 97,5 % of them shall lie on or above the reference lines.