INTERNATIONAL STANDARD

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Polybutene-1 (PB-1) pipes — Effect of time and temperature on the expected strength

Tubes en polybutène-1 (PB-1) — 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 12230 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*.

This second edition cancels and replaces the first edition (ISO 12230:1996), which has been technically revised.

Introduction

The development of new polybutene-1 compounds based on random copolymers called PB-R means there is a need to rename the existing PB-1 homopolymer compounds PB-H. At the same time a new set of reference lines and tabulated expected hoop strength values for various times and temperatures needs to be included.

The main changes since the previous edition of this International Standard are

— new definition of PB-1 compounds PB-H (homopolymer) and PB-R (copolymers),

— new set of reference lines (coefficients and diagram),

— new table containing calculated expected hoop strength values,

— recalculation of hoop strength data of PB-H and specifying values rounded down to one decimal place,

— clearer specification of showing conformance to reference lines, and

— conformance to reference lines can be shown by not failed data points running at sufficiently high hoop stress, too.

Polybutene-1 (PB-1) pipes — Effect of time and temperature on the expected strength

1 Scope

This International Standard specifies minimum values for the expected strength as a function of time and temperature in the form of reference lines and tabulated data, for use in calculations on pipes made of

— polybutene-1 homopolymer (PB-H), and

— polybutene-1 random copolymer (PB-R).

For the sake of simplicity the designation polybutene and the abbreviation PB are used throughout.

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 pieces*

3 Terms and definitions

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

3.1
reference line
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 polybutene (PB) have been agreed upon by a group of experts after considering experimental data, and have been accepted by the relevant technical committees in ISO.

3.2
polybutene-1 homopolymer
PB-H
compound prepared by polymerization of no less than 95 % butene-1 by weight

3.3
polybutene-1 random copolymer
PB-R
compound prepared by polymerization of no less than 85 % butene-1 and no less than 95 % of total olefins by weight

4 Basic equations

4.1 General

The reference lines are based on the four-parameter model and are described by the following equations:

$$\text{First branch: } \lg t = A_1 + (B_1/T)\lg \sigma + C_1/T + D_1 \lg \sigma \quad (1)$$

$$\text{Second branch: } \lg t = A_2 + (B_2/T)\lg \sigma + C_2/T + D_2 \lg \sigma \quad (2)$$

where

t is the time, in hours;

T is the temperature, in kelvins;

σ is the hoop stress, in megapascals.

The lower value obtained from Equation (1) or Equation (2), respectively, represents the expected minimum hoop strength.

4.2 Polybutene homopolymer (PB-H)

The following coefficients are valid for the reference lines of PB-H in the temperature range between 10 °C and 110 °C:

$A_1 = -430{,}866$ $A_2 = -129{,}895$

$B_1 = -125\,010$ $B_2 = -37\,262{,}7$

$C_1 = 173\,892{,}7$ $C_2 = 52\,556{,}48$

$D_1 = 290{,}056\,9$ $D_2 = 88{,}567\,35$

Figure 1 represents the reference lines calculated with the above coefficients in graphical form.

4.3 Polybutene random copolymer (PB-R)

The following coefficients are valid for the reference lines of PB-R in the temperature range between 10 °C and 95 °C:

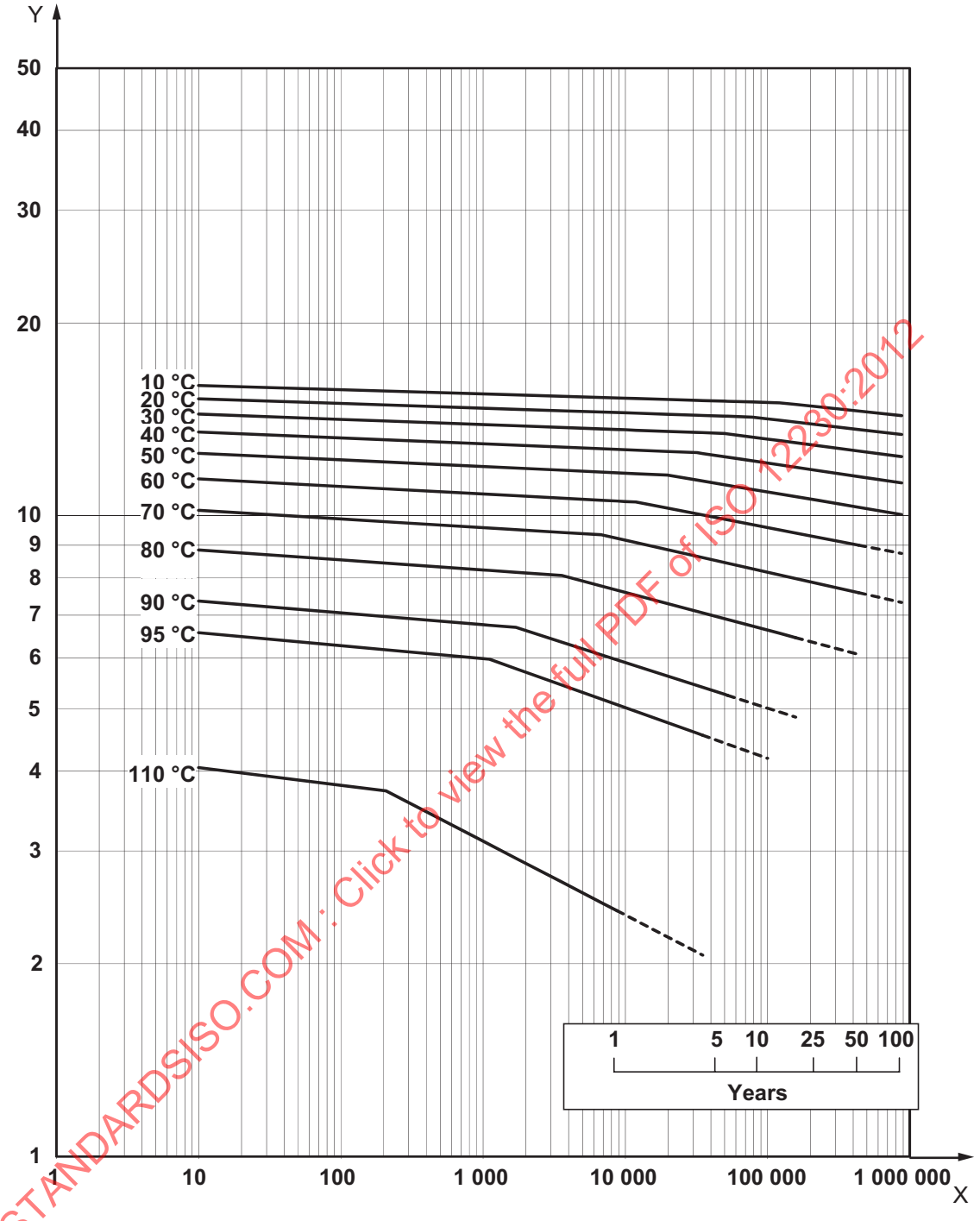
$A_1 = -367{,}801\,9$

$B_1 = -104\,096{,}6$

$C_1 = 145\,940{,}231$

$D_1 = 245{,}538\,6$

The line at 110 °C has been determined separately and is only used for obtaining the extrapolation time limits.

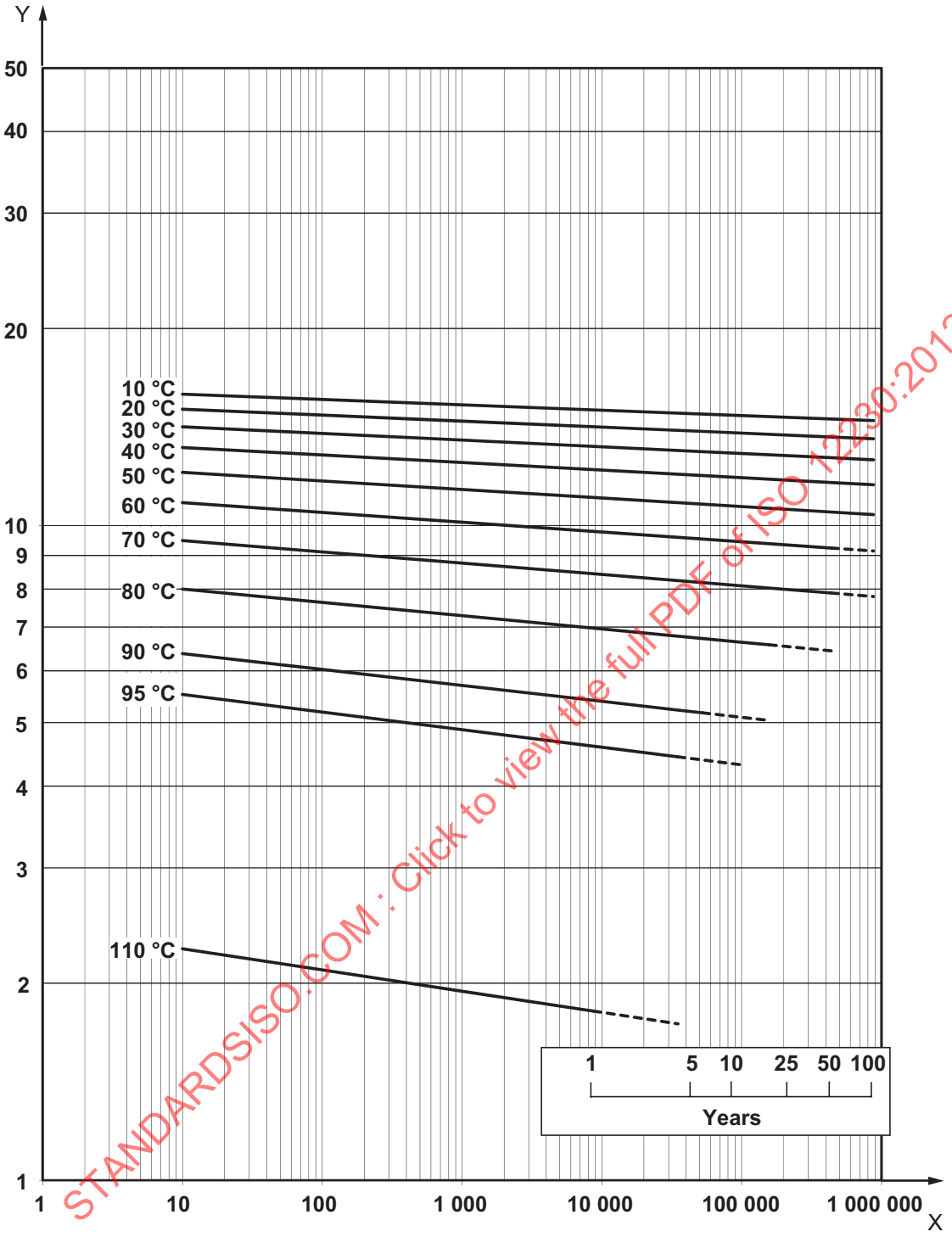


Key

Y hoop stress (MPa)

X time (h)

Figure 1 — Expected strength of polybutene homopolymer (PB-H) pipes



Key

Y hoop stress (MPa)

X time (h)

Figure 2 — Expected strength of polybutene random copolymer (PB-R) pipes

5 Expected strength

5.1 General

Prior to testing, pipes prepared from PB-H and PB-R compounds shall be conditioned in accordance with recommendations obtained from the manufacturer.

Pipes prepared from PB-R compounds shall be annealed for 96 h at 95 °C prior to thermal stability testing at 110 °C.

5.2 Extrapolation limits

The extrapolation limits (the end points of the reference lines) are based on an experimentally determined life at 110 °C for PB-H and for PB-R, respectively, 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 for PB-H and for PB-R).

Table 1 — Extrapolation time factors for PB-H and PB-R

k_x	T [°C]
2,5	$100 \geq T > 95$
4	$95 \geq T > 90$
6	$90 \geq T > 85$
10	$85 \geq T > 80$
18	$80 \geq T > 75$
30	$75 \geq T > 70$
50	$T \leq 70$

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.

5.3 Graphical representation

Figures 1 and 2 contain the reference lines for PB-H and PB-R, respectively, corresponding to the values of the parameters given in this clause, which shall be used for demonstrating conformance to this specification in accordance with 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.

5.4 Tabulated values

The calculated hoop strength values to be used for various temperatures and times are given in Table 2 for PB-H and Table 3 for PB-R and do not include design factors.

The times at 80 °C, 90 °C and 95 °C not in brackets in the “time” column in Table 2 for PB-H and Table 3 for PB-R 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 Tables 2 and 3.

Table 2 — Expected hoop strength values of PB-H pipes for various values of time and temperature

Temperature °C	Time years	Expected strength MPa	Temperature °C	Time years	Expected strength MPa
20	1 5 10 25 50 100	14,5 14,3 14,2 13,9 13,6 13,4	70	1 5 10 25 50	9,2 8,5 8,2 7,8 7,6
30	1 5 10 25 50 100	13,6 13,4 13,2 12,9 12,6 12,3	80	1 5 10 18 (25)	7,6 6,9 6,7 6,4 (6,3)
40	1 5 10 25 50 100	12,7 12,4 12,1 11,8 11,5 11,2	90	1 4 6 (10) (15)	5,9 5,4 5,2 (5,0) (4,9)
50	1 5 10 25 50 100	11,6 11,2 10,9 10,6 10,3 10,0	95	1 4 (6) (10)	5,1 4,5 (4,4) (4,2)
60	1 5 10 25 50	10,5 9,9 9,6 9,2 9,0			