INTERNATIONAL STANDARD

ISO 3213

Second edition
1996-08-01

Polypropylene (PP) pipes — Effect of time and temperature on the expected strength

Tubes en polypropylène (PP) — Influence du temps et de la température sur la résistance espérée

INTERNATIONAL ISO

Reference number
ISO 3213:1996(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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.

International Standard ISO 3213 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 3213:1975), which has been technically revised.

Annex A forms an integral part of this International Standard.

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

Polypropylene (PP) pipes — 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 pipes made of

— polypropylene homopolymer (PP-H);

— polypropylene block copolymer[1] (PP-B);

— polypropylene random copolymer (PP-R).

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 1167:—[2], *Thermoplastics pipes for the conveyance of fluids — Resistance to internal pressure — Test method.*

1) Also called heterophasic copolymer.

2) To be published. (Revision of ISO 1167:1973)

3 Definition

For the purposes of this International Standard, the following definition applies.

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

NOTES

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

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

3 The reference lines for PP-H, PP-B and PP-R have been agreed upon by a group of experts after considering experimental data, and have been accepted by the relevant technical committees in ISO.

4 Basic equations

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

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

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

where

t is the time, in hours;

T is the temperature, in kelvins;

σ is the hoop stress, in megapascals.

for PP-H

$A_1 = -46{,}364$ $A_2 = -18{,}387$

$B_1 = -9\,601{,}1$

$C_1 = 20\,381{,}5$ $C_2 = 8\,918{,}5$

$D_1 = 15{,}24$ $D_2 = -4{,}1$

for PP-B

$A_1 = -56{,}086$ $A_2 = -13{,}699$

$B_1 = -10\,157{,}8$

$C_1 = 23\,971{,}7$ $C_2 = 6\,970{,}3$

$D_1 = 13{,}32$ $D_2 = -3{,}82$

for PP-R

$A_1 = -55{,}725$ $A_2 = -19{,}98$

$B_1 = -9\,484{,}1$

$C_1 = 25\,502{,}2$ $C_2 = 9\,507$

$D_1 = 6{,}39$ $D_2 = -4{,}11$

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 4 The 10 °C line has been added to figures 1, 2 and 3 for information purposes.

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

T °C	K_x
⩽ 100	2,5
⩽ 95	4
⩽ 90	6
⩽ 85	10
⩽ 80	18
⩽ 75	30
⩽ 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

Figures 1, 2 and 3 contain 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 tables 2, 3 and 4 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 tables 2, 3 and 4 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, 3 and 4.

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

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

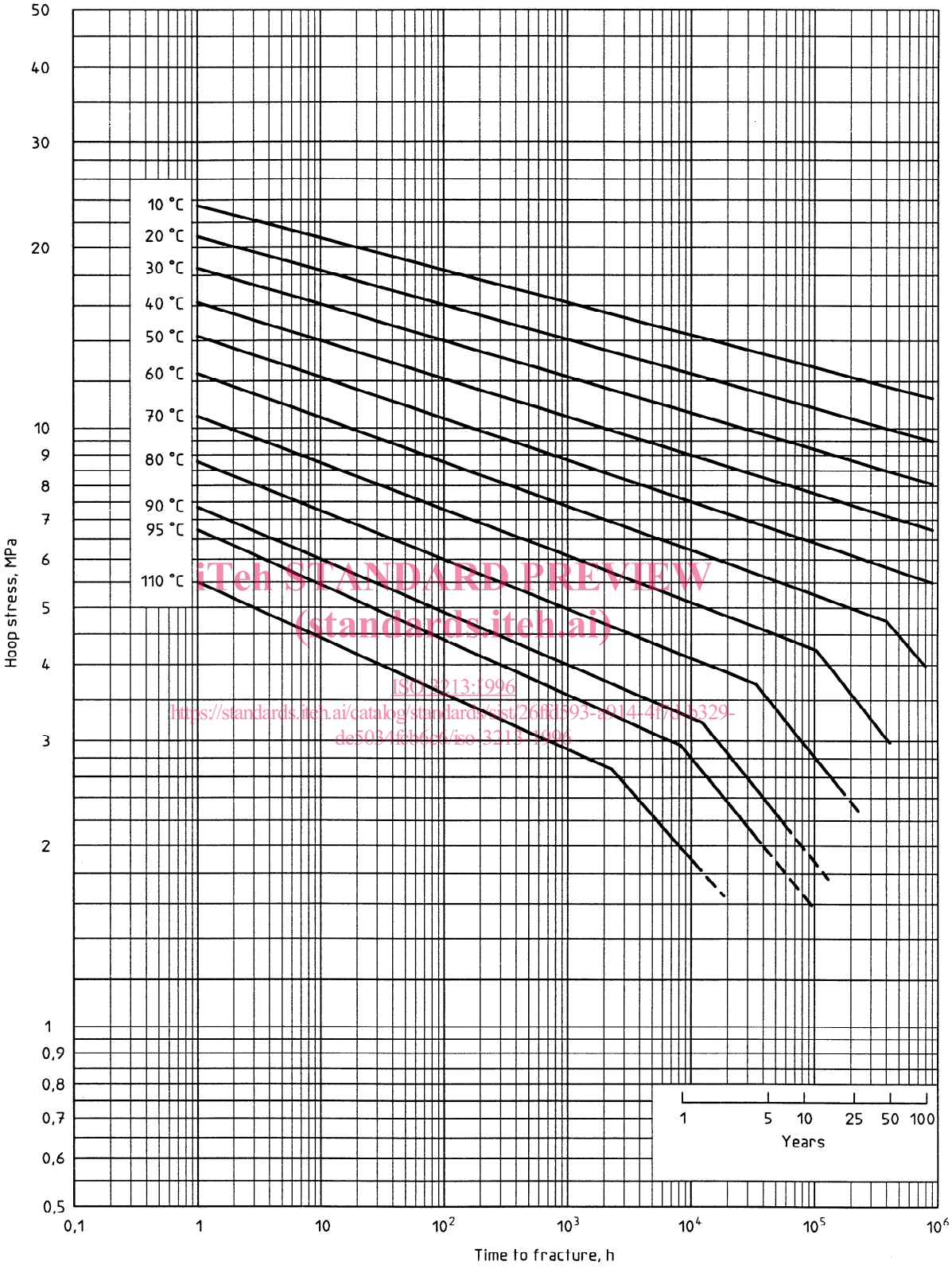

Figure 1 — Expected strength of PP homopolymer pipes

Table 3 — Expected hoop strength values for various values of time and temperature for PP block copolymer

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

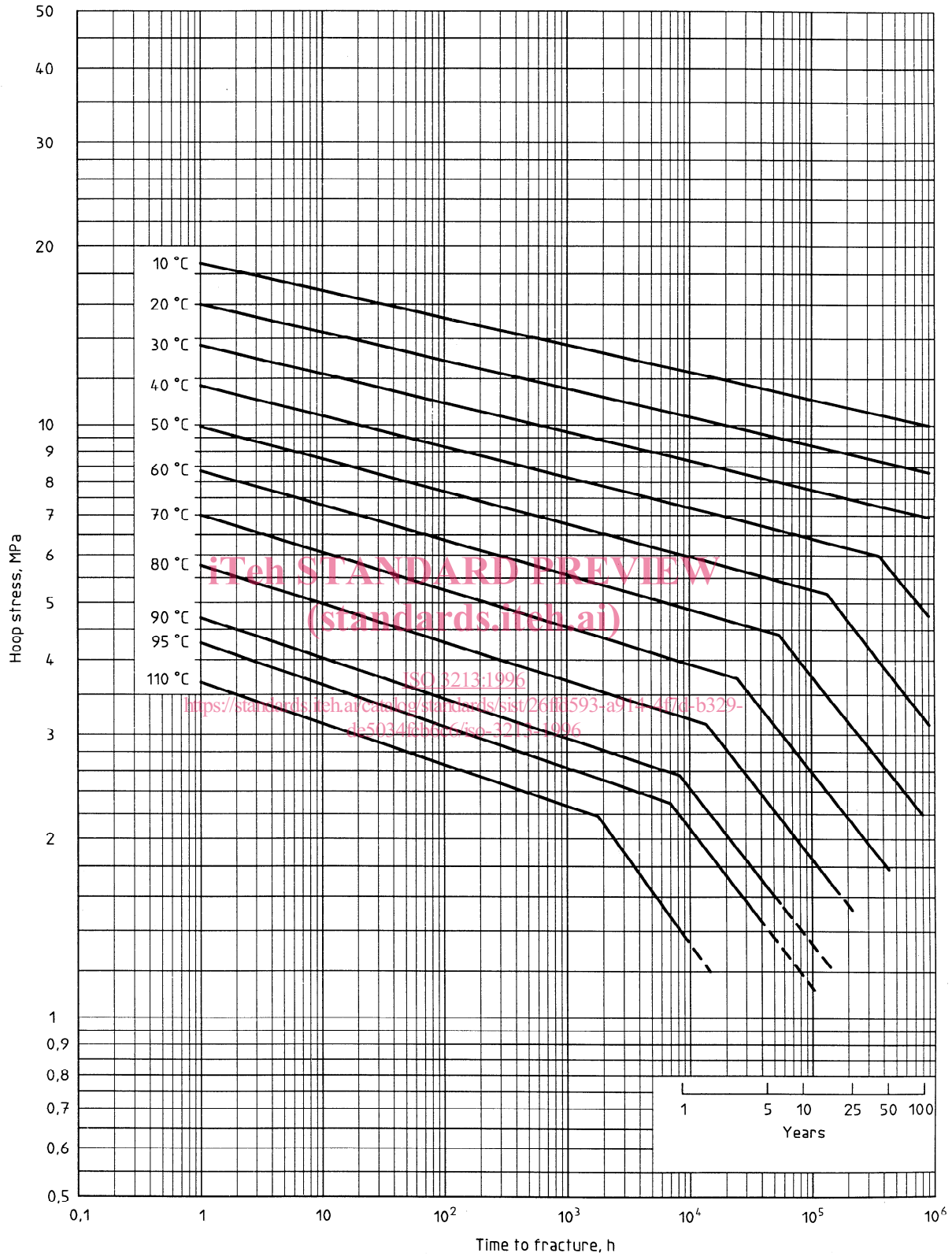

Figure 2 — Expected strength of PP block copolymer pipes