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Crosslinked polyethylene (PE-X) pipes — Effect of time and temperature on the expected strength

*Tubes en polyéthylène réticulé (PE-X) — Influence du temps et de la
température sur la résistance espérée*

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Reference number
ISO 10146:1997(E)

ISO 10146:1997(E)**Foreword**

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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 10146 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*.

Annex A forms an integral part of this International Standard.

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Crosslinked polyethylene (PE-X) 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 crosslinked polyethylene (PE-X) pipes.

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 1167:1996, *Thermoplastics pipes for the conveyance of fluids — Resistance to internal pressure — Test method*.

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 crosslinked polyethylene (PE-X) 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 equation

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

$$\lg t = A + (B/T) \lg \sigma + C/T + D \lg \sigma$$

where

- t is the time, in hours;
- T is the temperature, in kelvins;
- σ is the hoop stress, in megapascals;
- $A = -105,861\ 8$
- $B = -18\ 506,15$
- $C = 57\ 895,49$
- $D = -24,799\ 7$

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

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 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

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.

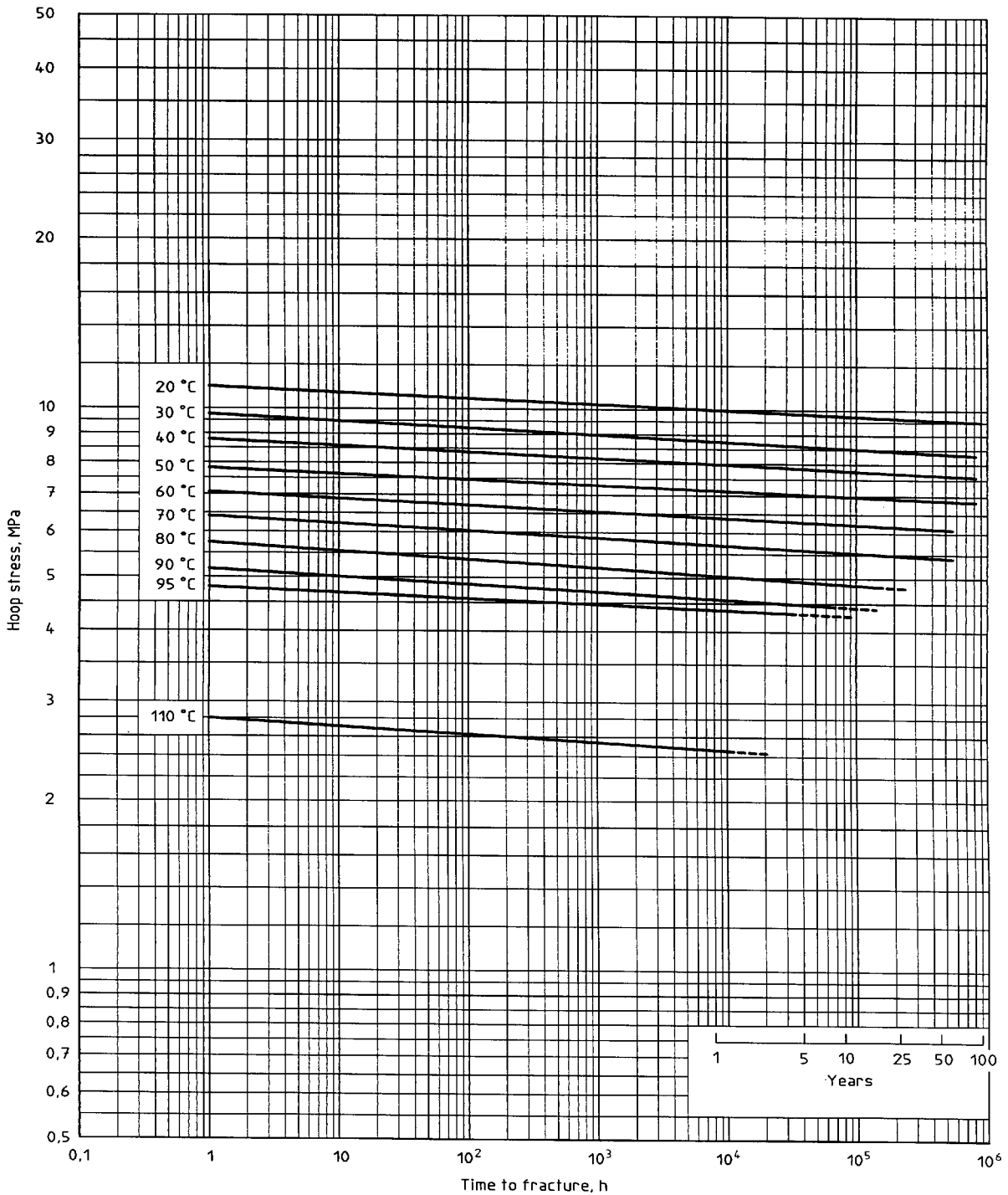


Figure 1 — Expected strength of crosslinked polyethylene (PE-X) pipes

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

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

Annex A

(normative)

Demonstrating conformance of pipes to the reference lines

At each of the following temperatures, specimens shall be tested at various hoop stresses such that, at each of the temperatures given, 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 1 000 h
1 000 h to 8 760 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.

ICS 23.040.20

Descriptors: plastics products, pipes (tubes), thermoplastic resins, cross-linked materials, polyethylene, plastic tubes, determination, mechanical strength, rules of calculation, reference data.

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