INTERNATIONAL STANDARD

ISO 4433-2

First edition
1997-12-15

Thermoplastics pipes — Resistance to liquid chemicals — Classification —

Part 2:
Polyolefin pipes

Tubes en matières thermoplastiques — Résistance aux liquides chimiques — Classification —

Partie 2: Tubes en polyoléfines

Reference number
ISO 4433-2:1997(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 4433-2 was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 3, *Plastics pipes and fittings for industrial applications.*

Together with the other parts (see below), this part of ISO 4433 cancels and replaces ISO 4433:1984, which has been technically revised.

ISO 4433 consists of the following parts, under the general title *Thermoplastics pipes — Resistance to chemical fluids — Classification*:

— *Part 1: Immersion test method*

— *Part 2: Polyolefin pipes*

— *Part 3: Unplasticized poly(vinyl chloride) (PVC-U), high-impact poly(vinyl chloride) (PVC-HI) and chlorinated poly(vinyl chloride) (PVC-C) pipes*

— *Part 4: Poly(vinylidene fluoride) (PVDF) pipes*

Annex A of this part of ISO 4433 is for information only.

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Introduction

This part of ISO 4433 gives a system for preliminary classification of the chemical resistance of polyolefin pipes.

The method is based on the change in mass and changes in tensile properties resulting from immersion of test pieces, taken from the walls of polyolefin pipes, in the liquid to be conveyed, in the absence of pressure.

If the pipes are to be used under stress, for example for conveying liquids under pressure, the method only allows incompatibilities between the liquid and the material to be detected; a "satisfactory" or "limited" result needs to be confirmed by subsequent tests using ISO 8584-1[1] (see annex A).

NOTES

1 If pertinent to the proposed application, consideration should be given to whether particular liquids permeate the pipe wall.

2 The possibility of a build-up of electrostatic charge in pipes during use should also be considered.

Thermoplastics pipes — Resistance to liquid chemicals — Classification —

Part 2:
Polyolefin pipes

1 Scope

The method of classification given in this part of ISO 4433 serves to determine the chemical resistance of polyolefin pipes designed for the conveyance of liquids in the absence of pressure and stress (e.g. due to earth loads or traffic loads, dynamic or internal stresses).

To determine the chemical resistance, the method uses the change in mass and the changes in tensile properties which result from the immersion of test pieces, taken from such pipes, in liquid chemicals. The immersion test is carried out in accordance with ISO 4433-1.

This part of ISO 4433 is also applicable to polyolefin sheets as appropriate.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this part of ISO 4433. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this part of ISO 4433 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 4433-1:1997, *Thermoplastics pipes — Resistance to liquid chemicals — Classification — Part 1: Immersion test method.*

3 Symbols

The following symbols are used to designate the behaviour of pipes in contact with liquid chemicals:

"S": satisfactory resistance

The pipes can be used for applications where there is no pressure or other stress; for applications where there is pressure, the final evaluation needs to be on the basis of a subsequent test under pressure.

"L": limited resistance

The pipes can be used for applications where there is no pressure or other stress, but a certain amount of change in properties due to the chemical can be accepted; for applications where there is pressure, the final evaluation needs to be based on a subsequent test under pressure.

"NS": non-satisfactory resistance

The pipes are severely attacked: they are unsuitable for either pressure or non-pressure applications; there is no purpose in conducting tests under pressure as the results would certainly be unfavourable.

4 Principle

The behaviour of a pipe material under the influence of the liquid to be conveyed is determined by immersion of test pieces, taken from the pipe wall, in the liquid at ambient pressure.

Immersion tests in accordance with ISO 4433-1 give changes in mass and tensile properties in comparison with non-immersed pieces. These changes depend, in general, on the immersion time and the immersion temperature.

This part of ISO 4433 establishes limits for permissible variations in properties at the test temperature in the absence of stress and classifies the measured performance by one of three designations (see clause 3).

5 Determination of chemical resistance

5.1 Change in mass

Determine the change in mass by immersion testing in accordance with ISO 4433-1. Calculate the percentage change in mass of each test piece using the equation

$$\Delta m = \frac{m_2 - m_1}{m_1} \times 100$$

where

m_1 is the initial mass of the test piece before immersion;

m_2 is the mass of the test piece after immersion.

Compare the arithmetic mean $\overline{\Delta m}$ of the percentage change in mass at an immersion time of 112 days with the limits given in table 1. Plot the $\overline{\Delta m}$ values from all the different immersion times on the classification diagram shown in figure 1. Plot $\overline{\Delta m}$ as a function of the square root of the time.

From table 1 and figure 1, determine the classification of the pipe material on the basis of the change in mass.

In particular, in the case of saturation (see ISO 4433-1, annex B, curves No. 4 and No. 7) and if the immersion time is shorter than 112 days, use the diagrams with limit lines given in figures 1 to 6. If saturation or equilibrium is not reached after 112 days, classify the pipe material "NS".

Table 1 — Determination of chemical resistance from the mean percentage change in mass Δm after 112 days' immersion

Pipe material	Limits of the permissible values of $\overline{\Delta m}$ %		
	Satisfactory resistance S	Limited resistance L	Non-satisfactory resistance NS
PE (LD, HD, MD)	$-2 \leqslant \overline{\Delta m} \leqslant 10$	$10 < \overline{\Delta m} \leqslant 15$ $-2 > \overline{\Delta m} \geqslant -5$	$\overline{\Delta m} > 15$ $\overline{\Delta m} < -5$
PP	$-2 \leqslant \overline{\Delta m} \leqslant 10$	$10 < \overline{\Delta m} \leqslant 15$ $-2 > \overline{\Delta m} \geqslant -5$	$\overline{\Delta m} > 15$ $\overline{\Delta m} < -5$
PB	$-2 \leqslant \overline{\Delta m} \leqslant 10$ *)	$10 < \overline{\Delta m} \leqslant 15$ *) $-2 > \overline{\Delta m} \geqslant -5$	$\overline{\Delta m} > 15$ *) $\overline{\Delta m} < -5$
PE-X	$-2 \leqslant \overline{\Delta m} \leqslant 10$	$10 < \overline{\Delta m} \leqslant 15$ $-2 > \overline{\Delta m} \geqslant -5$	$\overline{\Delta m} > 15$ $\overline{\Delta m} < -5$

*) Proposal

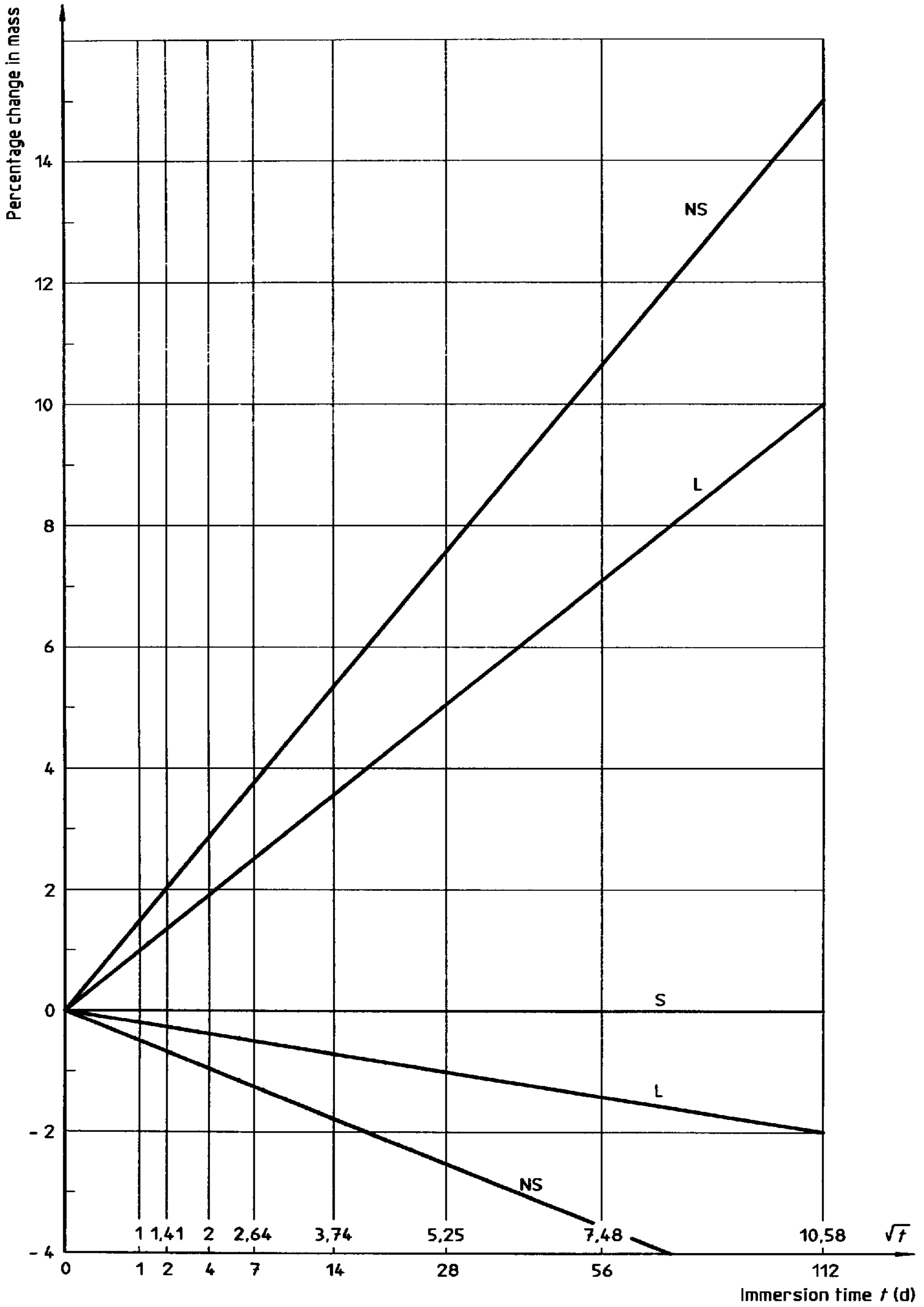

Figure 1 — Classification diagram for polyolefin pipes based on change in mass

5.2 Change in elastic modulus

Determine the change in elastic modulus by immersion testing in accordance with ISO 4433-1. Calculate the elastic modulus of each test piece using the equation given in ISO 4433-1, subclause 9.5. Calculate the mean percentage change Q_E in the elastic modulus using the following equation:

$$Q_E = \frac{\overline{E}_M}{\overline{E}_0} \times 100$$

where

$\overline{E}_0$ is the arithmetic mean of the elastic modulus before immersion;

$\overline{E}_M$ is the arithmetic mean of the elastic modulus after immersion.

Compare the calculated Q_E value at an immersion time of 112 days with the limits given in table 2. Plot the Q_E values from all the different immersion times in the classification diagram shown in figure 2. Plot lg Q_E as a function of the lg of the immersion time.

From table 2 and figure 2, determine the classification of the pipe material on the basis of the change in elastic modulus.

Table 2 — Determination of chemical resistance from the mean percentage change in elastic modulus Q_E after 112 days' immersion

Pipe material	Limits of the permissible values of Q_E %		
	Satisfactory resistance S	Limited resistance L	Non-satisfactory resistance NS
PE (LD, HD, MD)	$Q_E \geqslant 38$	$38 > Q_E \geqslant 31$	$Q_E < 31$
PP	$Q_E \geqslant 38$	$38 > Q_E \geqslant 31$	$Q_E < 31$
PB	$Q_E \geqslant 38$ *)	$38 > Q_E \geqslant 31$ *)	$Q_E < 31$ *)
PE-X	$Q_E \geqslant 38$	$38 > Q_E \geqslant 31$	$Q_E < 31$

*) Proposal

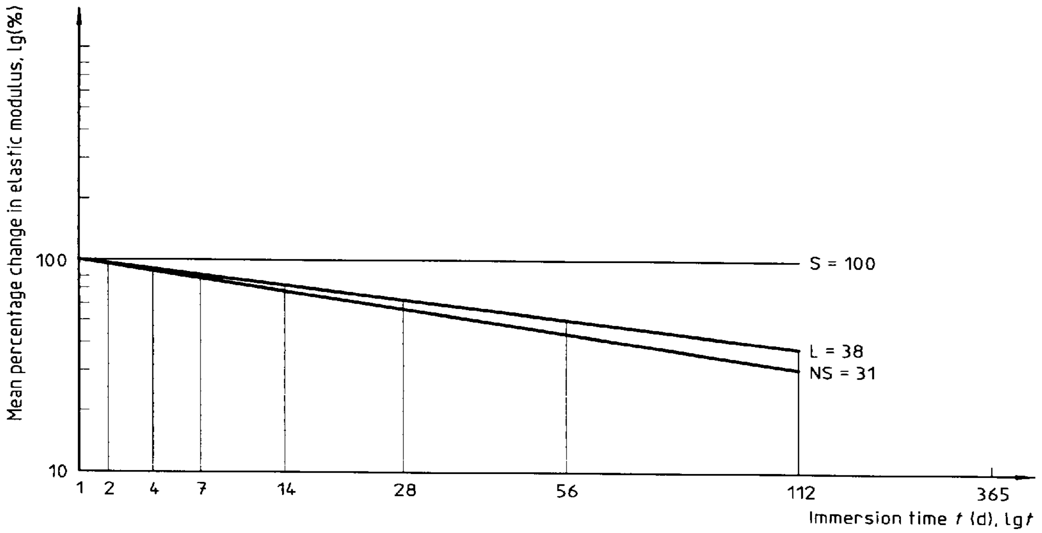

Figure 2 — Classification diagram for polyolefin pipes based on percentage change in elastic modulus

5.3 Change in tensile strength at yield

Determine the change in tensile strength at yield by immersion testing in accordance with ISO 4433-1. Calculate the tensile strength at yield of each test piece using the equation given in ISO 4433-1, subclause 9.6. Calculate the mean percentage change Q_{ty} in the tensile strength at yield using the following equation:

$$Q_{ty} = \frac{\overline{\sigma}_{tyM}}{\overline{\sigma}_{ty0}} \times 100$$

where

$\overline{\sigma}_{ty0}$ is the arithmetic mean of the tensile strength at yield before immersion;

$\overline{\sigma}_{tyM}$ is the arithmetic mean of the tensile strength at yield after immersion.

Compare the calculated Q_{ty} value at an immersion time of 112 days with the limits given in table 3. Plot the Q_{ty} values from all the different immersion times on the classification diagram shown in figure 3. Plot lg Q_{ty} as a function of the lg of the immersion time.

From table 3 and figure 3, determine the classification of the pipe material on the basis of the change in tensile strength at yield.

Table 3 — Determination of chemical resistance from the mean percentage change in tensile strength at yield Q_{ty} after 112 days' immersion

Pipe material	Limits of the permissible values of Q_{ty} %		
	Satisfactory resistance S	Limited resistance L	Non-satisfactory resistance NS
PE (LD, HD, MD)	$Q_{ty} \geqslant 80$	$80 > Q_{ty} \geqslant 46$	$Q_{ty} < 46$
PP	$Q_{ty} \geqslant 80$	$80 > Q_{ty} \geqslant 46$	$Q_{ty} < 46$
PB	$Q_{ty} \geqslant 80$ *)	$80 > Q_{ty} \geqslant 46$ *)	$Q_{ty} < 46$ *)
PE-X	$Q_{ty} \geqslant 80$	$80 > Q_{ty} \geqslant 46$	$Q_{ty} < 46$

*) Proposal

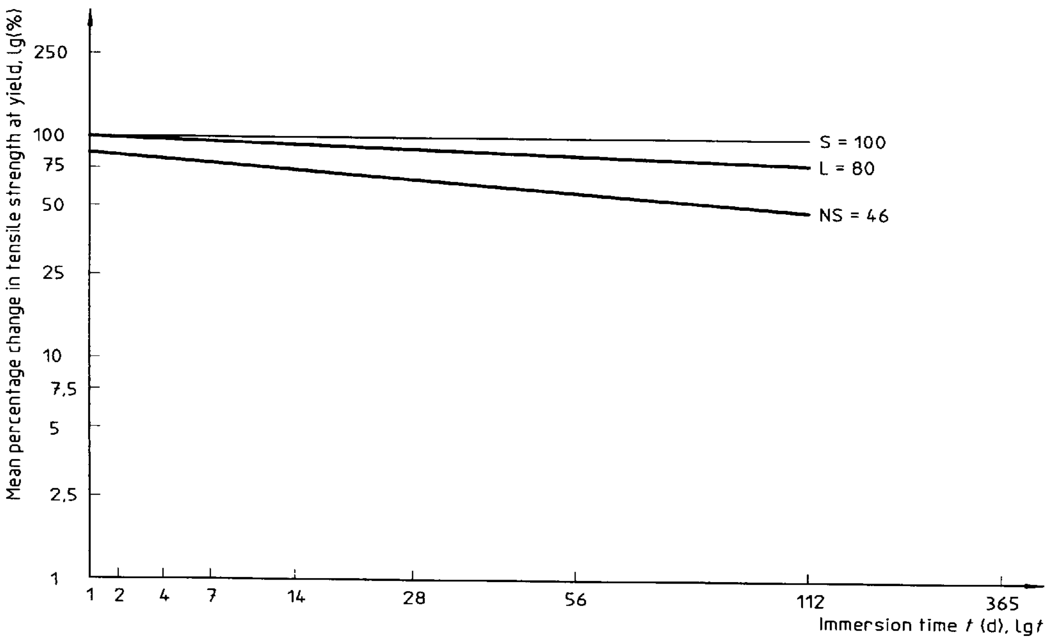

Figure 3 — Classification diagram for polyolefin pipes based on the percentage change in tensile strength at yield

5.4 Change in tensile strength at break

Determine the change in tensile strength at break by immersion testing in accordance with ISO 4433-1. Calculate the tensile strength at break of each test piece using the equation given in ISO 4433-1, subclause 9.6. Calculate the mean percentage change Q_{tb} in the tensile strength at break using the following equation:

$$Q_{tb} = \frac{\overline{\sigma}_{tbM}}{\overline{\sigma}_{tb0}} \times 100$$

where

$\overline{\sigma}_{tb0}$ is the arithmetic mean of the tensile strength at break before immersion;

$\overline{\sigma}_{tbM}$ is the arithmetic mean of the tensile strength at break after immersion.

Compare the calculated Q_{tb} value at an immersion time of 112 days with the limits given in table 4. Plot the Q_{tb} values from all the different immersion times on the classification diagram shown in figure 4. Plot lg Q_{tb} as a function of the lg of the immersion time.

From table 4 and figure 4, determine the classification of the pipe material on the basis of the change in tensile strength at break.

Table 4 — Determination of chemical resistance from the mean percentage change in tensile strength at break Q_{tb} after 112 days' immersion

Pipe material	Limits of the permissible values of Q_{tb} %		
	Satisfactory resistance S	Limited resistance L	Non-satisfactory resistance NS
PE (LD, HD, MD)	$Q_{tb} \geqslant 80$	$80 > Q_{tb} \geqslant 46$	$Q_{tb} < 46$
PP	$Q_{tb} \geqslant 80$	$80 > Q_{tb} \geqslant 46$	$Q_{tb} < 46$
PB	$Q_{tb} \geqslant 80$ *)	$80 > Q_{tb} \geqslant 46$ *)	$Q_{tb} < 46$ *)
PE-X	$Q_{tb} \geqslant 80$	$80 > Q_{tb} \geqslant 46$	$Q_{tb} < 46$

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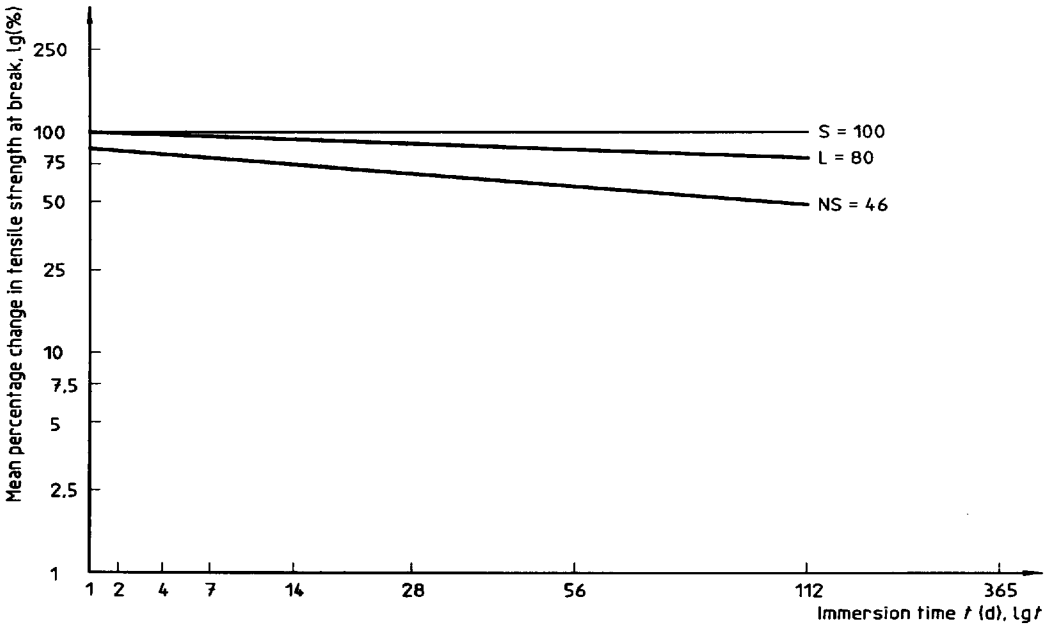

Figure 4 — Classification diagram for polyolefin pipes based on the percentage change in tensile strength at break

5.5 Change in elongation at yield

Determine the change in elongation at yield by immersion testing in accordance with ISO 4433-1. Calculate the elongation at yield of each test piece using the equation given in ISO 4433-1, subclause 9.7. Calculate the mean percentage change $Q_{\varepsilon y}$ in the elongation at yield using the following equation:

$$Q_{\varepsilon y} = \frac{\bar{\varepsilon}_{yM}}{\bar{\varepsilon}_{y0}} \times 100$$

where

$\bar{\varepsilon}_{y0}$ is the arithmetic mean of the elongation at yield before immersion;

$\bar{\varepsilon}_{yM}$ is the arithmetic mean of the elongation at yield after immersion.

Compare the calculated $Q_{\varepsilon y}$ value at an immersion time of 112 days with the limits given in table 5. Plot the $Q_{\varepsilon y}$ values from all the different immersion times on the classification diagram shown in figure 5. Plot lg $Q_{\varepsilon y}$ as a function of the lg of the immersion time.

From table 5 and figure 5, determine the classification of the pipe material on the basis of the change in elongation at yield.

Table 5 — Determination of chemical resistance from the mean percentage change in elongation at yield $Q_{\varepsilon y}$ after 112 days' immersion

Pipe material	Limits of the permissible values of $Q_{\varepsilon y}$ %		
	Satisfactory resistance S	**Limited resistance** L	**Non-satisfactory resistance** NS
PE (LD, HD, MD)	$200 \geqslant Q_{\varepsilon y} \geqslant 80$	$80 > Q_{\varepsilon y} \geqslant 46$ $200 < Q_{\varepsilon y} \leqslant 300$	$Q_{\varepsilon y} < 46$ $Q_{\varepsilon y} > 300$
PP	$200 \geqslant Q_{\varepsilon y} \geqslant 80$	$80 > Q_{\varepsilon y} \geqslant 46$ $200 < Q_{\varepsilon y} \leqslant 300$	$Q_{\varepsilon y} < 46$ $Q_{\varepsilon y} > 300$
PB	$200 \geqslant Q_{\varepsilon y} \geqslant 80$ *)	$80 > Q_{\varepsilon y} \geqslant 46$ *) $200 < Q_{\varepsilon y} \leqslant 300$	$Q_{\varepsilon y} < 46$ *) $Q_{\varepsilon y} > 300$
PE-X	$200 \geqslant Q_{\varepsilon y} \geqslant 80$	$80 > Q_{\varepsilon y} \geqslant 46$ $200 < Q_{\varepsilon y} \leqslant 300$	$Q_{\varepsilon y} < 46$ $Q_{\varepsilon y} > 300$

*) Proposal

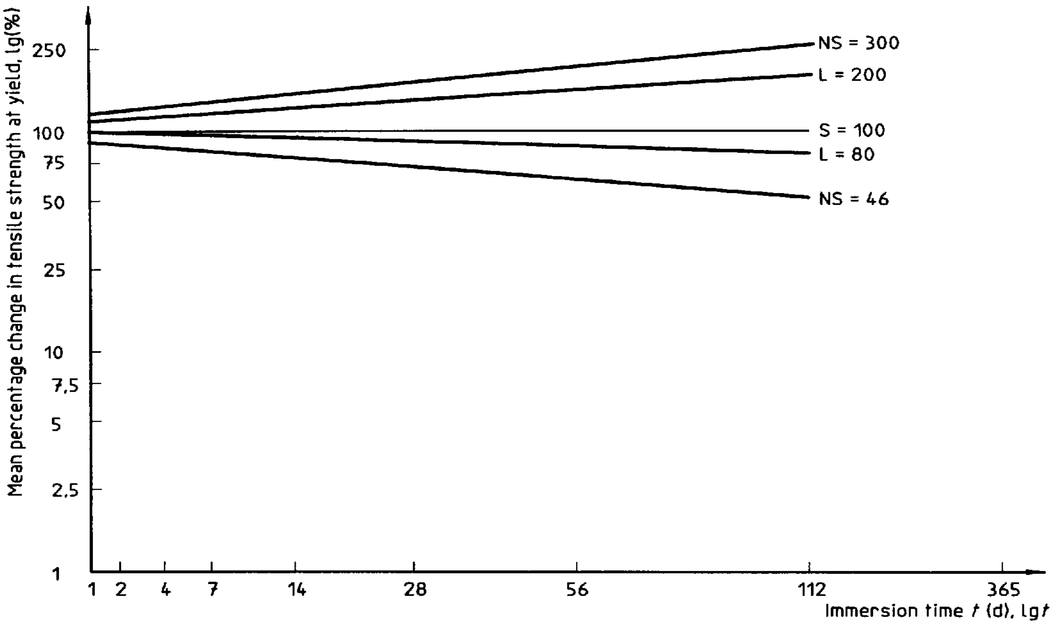

Figure 5 — Classification diagram for polyolefin pipes based on the percentage change in elongation at yield point

5.6 Change in elongation at break

Determine the elongation at break by immersion testing in accordance with ISO 4433-1. Calculate the elongation at break of each test piece using the equation given in ISO 4433-1, subclause 9.7. Calculate the mean percentage change $Q_{\varepsilon b}$ in the elongation at break using the following equation:

$$Q_{\varepsilon b} = \frac{\bar{\varepsilon}_{bM}}{\bar{\varepsilon}_{b0}} \times 100$$

where

$\bar{\varepsilon}_{b0}$ is the arithmetic mean of the elongation at break before immersion;

$\bar{\varepsilon}_{bM}$ is the arithmetic mean of the elongation at break after immersion.

Compare the calculated $Q_{\varepsilon b}$ value at an immersion time of 112 days with the limits given in table 6. Plot the $Q_{\varepsilon b}$ values from all the different immersion times on the classification diagram shown in figure 6. Plot lg $Q_{\varepsilon b}$ as a function of the lg of the immersion time.

From table 6 and figure 6, determine the classification of the pipe material on the basis of the change in elongation at break.

Table 6 — Determination of chemical resistance from the mean percentage change in elongation at break $Q_{\varepsilon b}$ after 112 days' immersion

Pipe material	Limits of the permissible values of $Q_{\varepsilon b}$ %		
	Satisfactory resistance S	Limited resistance L	Non-satisfactory resistance NS
PE (LD, HD, MD)	$50 \leqslant Q_{\varepsilon b} \leqslant 200$	$50 > Q_{\varepsilon b} \geqslant 30$ $200 < Q_{\varepsilon b} \leqslant 300$	$Q_{\varepsilon b} < 30$ $Q_{\varepsilon b} > 300$
PP	$50 \leqslant Q_{\varepsilon b} \leqslant 200$	$50 > Q_{\varepsilon b} \geqslant 30$ $200 < Q_{\varepsilon b} \leqslant 300$	$Q_{\varepsilon b} < 30$ $Q_{\varepsilon b} > 300$
PB	$50 \leqslant Q_{\varepsilon b} \leqslant 200$ *)	$50 > Q_{\varepsilon b} \geqslant 30$ *) $200 < Q_{\varepsilon b} \leqslant 300$	$Q_{\varepsilon b} < 30$ *) $Q_{\varepsilon b} > 300$
PE-X	$50 \leqslant Q_{\varepsilon b} \leqslant 200$	$50 > Q_{\varepsilon b} \geqslant 30$ $200 < Q_{\varepsilon b} \leqslant 300$	$Q_{\varepsilon b} < 30$ $Q_{\varepsilon b} > 300$
*) Proposal			

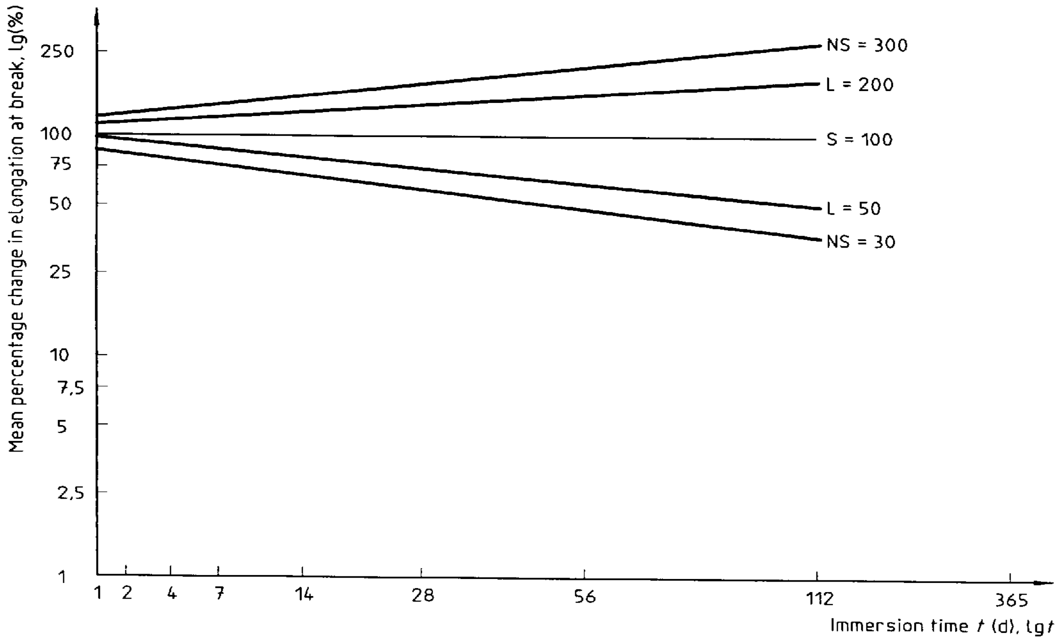

Figure 6 — Classification diagram for polyolefin pipes based on the percentage change in elongation at break

6 Classification of the chemical resistance

List the individual determinations of $\overline{\Delta m}$, Q_E, Q_{ty}, Q_{tb}, $Q_{\varepsilon y}$ and $Q_{\varepsilon b}$. Take as the final classification the lower of $\overline{\Delta m}$ and $Q_{\varepsilon b}$.

NOTE — The strength at break is not of major interest to the design of pipes, which are used at stresses much lower than the yield point.

7 Test report

The test report shall include the following information:

a) a reference to this part of ISO 4433;

b) all details necessary for complete identification of the pipe tested, including material, trade name, dimensions;

c) all details necessary for identification of the immersion liquid used, including type, concentration, composition;

d) the immersion temperature, in degrees Celsius;

e) the immersion period, in days;

f) the mean percentage change in mass;

g) the mean percentage change in elastic modulus;

h) the mean percentage change in tensile strength at yield;

i) the mean percentage change in tensile strength at break;

j) the mean percentage change in elongation at yield;

k) the mean percentage change in elongation at break;

l) the classification of the pipe tested based on each of the parameters measured, and the final classification (see clause 6);

m) the dates of the tests.

Annex A
(informative)

Bibliography

[1] ISO 8584-1:1990, *Thermoplastics pipes for industrial applications under pressure — Determination of the chemical resistance factor and of the basic stress — Part 1: Polyolefin pipes.*

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