Thermoplastics pipes
Determination of resistance to internal pressure at constant temperature
English version of DIN EN 921

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ICS 23.040.20

Descriptors: plastics, pipes, thermoplastics, pressure resistance, testing.

Kunststoff-Rohrleitungssysteme; Rohre aus Thermoplasten; Bestimmung des Zeitstand-Innendruckverhaltens bei konstanter Temperatur

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A comma is used as the decimal marker.

National foreword

This standard has been prepared by CEN/TC 155.

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EN 921

November 1994

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English version

Plastics piping systems

Thermoplastics pipes

Determination of resistance to internal pressure at constant temperature

Systèmes de canalisations plastiques; tubes thermoplastiques; détermination de la résistance à la pression interne à température constante

Kunststoff-Rohrleitungssysteme; Rohre aus Thermoplasten; Bestimmung des Zeitstand-Innendruckverhaltens bei konstanter Temperatur

This European Standard was approved by CEN on 1994-11-08.

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Ref. No. EN 921:1994 E

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 155 'Plastics piping systems and ducting systems', the Secretariat of which is held by NNI.

This standard is based on the second edition of International Standard

ISO 1167 Thermoplastics pipes for the transport of fluids; resistance to internal pressure; test method

prepared by the International Organization for Standardization (ISO). The International Standard has been editorially revised so that the wording corresponds to that in other standards on test methods. The technical content has also been modified as follows:

- the variety of end caps described under type a) has been extended and type c) end caps have been omitted;
- the time for pressurization has been changed from 60 s to between 30 s and 1 h to allow for the testing of pipes with larger diameters, for which pressurization within 60 s was not possible;
- the minimum free lengths of test pieces have been extended.

The material-dependent parameters and/or performance requirements have been incorporated into the relevant system standards.

This standard is one of a series of standards on test methods which support system standards for plastics piping systems and ducting systems.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, and conflicting national standards withdrawn, by May 1995 at the latest.

In accordance with the CEN/CENELEC Internal Regulations, the following countries are bound to implement this European Standard:

Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

Introduction

This standard describes a method for determining the resistance of thermoplastics pipes to constant internal pressure at constant temperature.

It is a method which uses the following conditions:

- water as the reference liquid inside the pipes;
- water, air or a specified liquid as the environment outside the pipes.

The method can be used for short or long-term tests, at different temperatures.

Through interaction with the referring standard, it may be used to determine the time-to-failure at a specified pressure or to test for resistance to internal pressure using a specified pressure/temperature/time combination.

The results obtained can differ depending on whether the environment is air, water or another liquid.

For specific tests, particularly where other liquids such as corrosive liquids are used, other test methods may be used.

This method may be used to obtain data to establish stress/time-to-failure graphs at different temperatures. The rules for drawing these graphs are not within the scope of this document. For such purposes attention is drawn to "Plastics piping and ducting systems - Thermoplastics pipes - Determination of long-term hydrostatic strength of thermoplastics pipe materials by extrapolation" (under preparation at the time of publication of this standard).

1 Scope

This standard specifies a method for determining the resistance of thermoplastics pipes to constant internal water pressure at constant temperature.

This standard is applicable to thermoplastics pipes intended for the transport of fluids.

2 Normative references

This standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter.
For dated references, subsequent amendments to, or revisions of, any of these publications apply to this standard only when incorporated in it by amendment or revision.
For undated references the latest edition of the publication referred to applies.

EN 496 *Plastics piping systems - Plastics pipes and fittings - Measurements of dimensions and visual inspection of surfaces.*

3 Principle

After conditioning, test pieces are subjected to a specified constant internal hydrostatic pressure for a specified period of time or until the test piece(s) fail(s).

Throughout the test, the test pieces are kept in an environment at a specified constant temperature: this is water ("water-in-water" test), another liquid ("water-in-liquid" test) or air ("water-in-air" test).

NOTE: It is assumed that the following test parameters are set by the standard making reference to this standard:

a) the type of end cap to be used (see 4.1);

b) the test temperature (see 4.2, clause 8 and 9.1);

c) the orientation of test pieces (e.g. horizontal or vertical) while under pressure (see 4.3 and 9.1);

d) for evaluation purposes, the size and S-series of pipe to be used (see 5.1);

e) the sampling procedure (see 6.1);

f) for pipes of nominal outside diameter, d_n, greater than 315 mm, the free length of the test piece, if other than 1000 mm (see 6.3.1);

g) the number of test pieces (see 6.4);

h) the test pressure, p, or the circumferential (hoop) stress, σ, to be induced by the test pressure (see 7.2.2);

i) the conditioning period (see clause 8);

j) the type of test, i.e. water-in-water/air/liquid (see this clause and 9.1);

k) the duration of the test under pressure and the criteria for a failure (see 9.3);

l) the requirements, or patterns of requirements, if any, which determine the initiation of additional testing.

4 Apparatus

4.1 End caps, fixed to the ends of the pipe.

By means of an appropriate system, they shall allow sealing, venting of air and connection to the pressurizing equipment.

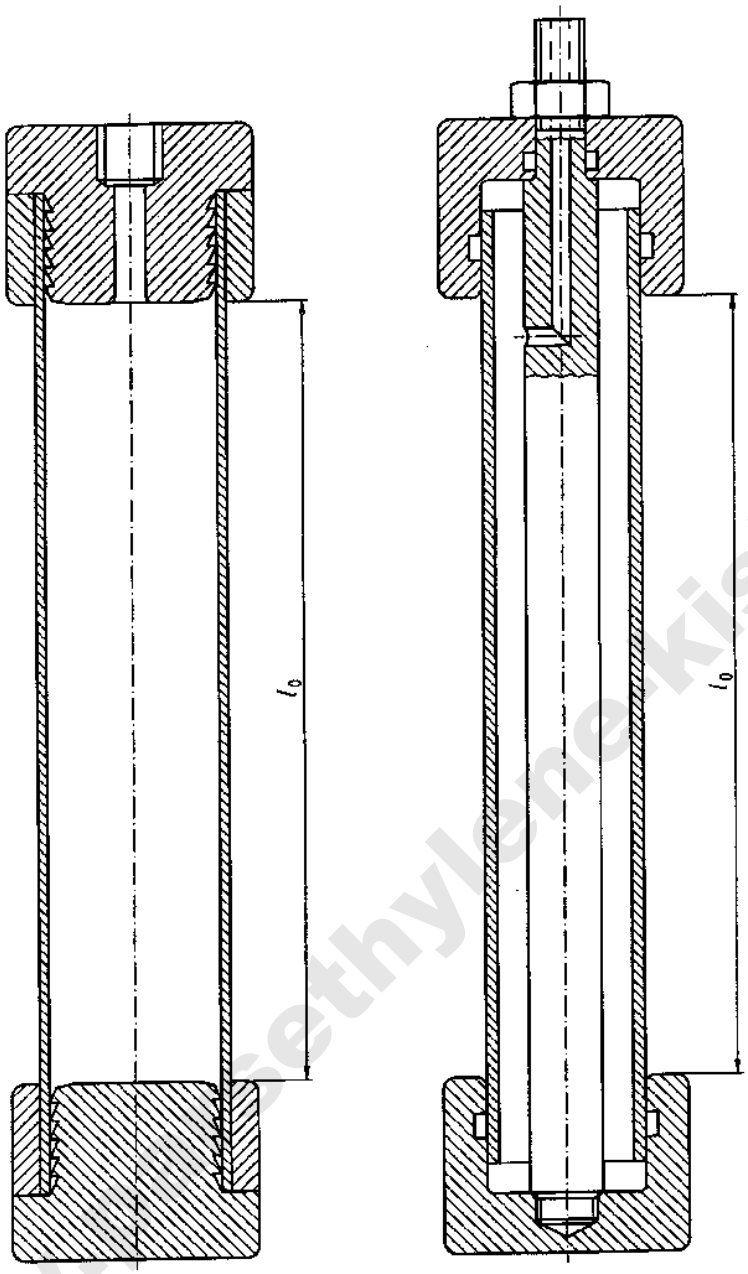
The constituent material of the end cap shall not have any adverse effect on the pipe under test; e.g. end caps of copper-based alloys shall not be used for testing polypropylene (PP) pipes at temperatures above 100 °C.

The end cap shall be one of the following types:

type a). Fittings rigidly connected to the test piece but not to each other, and hence transmitting the hydrostatic end thrust to the test piece e.g. as shown in figure 1 or equivalent. They may comprise flanged plates on the ends of a large diameter pipe, optionally fused when flanges, caps, plugs or plates are of the same material as the test pieces;

type b). Female parts, made of metal, fitted with joints ensuring sealing onto the external surface of the test piece and connected to one another and hence not transmitting the hydrostatic end thrust to the test piece. They may comprise one or more metal rods, see figure 1, allowing sufficient longitudinal movement at the ends of the test piece, to avoid buckling due to thermal expansion when the caps are mounted at a lower temperature than the test temperature.

Other than toothed grips, any sharp edges which would come into contact with the outside surface of the pipe shall be rounded off.



Type a)
(without metal rod)
(hydrostatic end thrust transmitted to the test piece)

Type b)
(with metal rod)
(hydrostatic end thrust not transmitted to the test piece)

Figure 1: Illustrated principles for the two types of end devices for the internal pressure testing of pipes

NOTE: In general, times to failure with end caps type b) are shorter than those obtained with end caps of type a).

4.2 **Tank**, filled with water or other liquid, kept at a temperature as specified in the referring standard to within ± 1 °C or $^{+3}_{-1}$ °C, as applicable, (see 9.1), or **oven**, the temperature of which shall be kept at the specified value to within $^{+3}_{-1}$ °C.

NOTE: As the results are strongly influenced by temperature, the tolerance on temperature should be kept as small as possible within the specified limits, e.g. by using forced circulation of the fluid.

The water shall not contain impurities which could affect the results.

When an environment other than water is used, necessary precautions shall be taken, in particular those concerning safety and any interaction between liquids and the material(s) of the test piece.

For obtaining comparable results, tests shall be carried out in the same environment.

4.3 **Supports or hangers**, enabling test pieces to be placed in the tank or oven (see 4.2) in such a way that there is no contact between them or with the sidewalls of the tank or oven.

4.4 **Pressurizing equipment**, capable of applying the required pressure gradually and evenly in accordance with 9.1 and then of keeping it constant to within $^{+2}_{-1}$ % for the duration of the test.

NOTE 1: As the results are strongly influenced by pressure, the deviation of pressure should be kept as small as possible within the specified limits.

NOTE 2: The pressure should, preferably, be applied individually to each test piece. However, the use of equipment enabling the pressure to be applied simultaneously to several test pieces is also permitted if there is no danger of interference when failure occurs (e.g. by the use of an isolation valve or a test based on the first failure in a batch). If the tests are carried out at a specified stress, the dimensions of the test pieces should be comparable.

NOTE 3: To maintain the pressure within the specified tolerance, it is recommended that a system be introduced which automatically resets the pressure, when it drops slightly (e.g. because of swelling of the test piece), to the specified value.

4.5 **Pressure measurement devices**, capable of checking the conformity to the specified test pressure [see 7.2.2. and item h) in the note to clause 3]. In the case of gauges or similar calibrated pressure measurement devices, the range of the gauge shall be such that the required pressure setting shall lie within the calibrated range of the device used (see 7.1).

The pressure measurement devices shall not contaminate the test fluid.

NOTE: The use of master gauges for calibration of the apparatus is recommended.

4.6 **Thermometer or equivalent**, capable of checking conformity to the specified test temperature [see 4.2 and item c) of the note to clause 3].

4.7 **Timer**, capable of recording the duration of the pressure application up to the moment of failure of, or the first decrease in pressure in, the test piece.

NOTE: It is recommended that equipment be used which is sensitive to pressure variations due to leaks or a failure and which is capable of stopping the timer and, if necessary, closing the pressure circuit for the test piece concerned.

4.8 **Means of measuring the wall thickness**, conforming to EN 496 and of such a design that measurements along the whole length of the pipe can be made.

NOTE: Use of a calibrated ultrasonic measuring device is recommended if applicable.

4.9 **Means of measuring the mean outside diameter of the pipe**, conforming to EN 496, e.g. a metal tape.

5 Test objective and choice of end caps

NOTE: Stress in and deformation of the test piece are different when using end caps type a) or type b).
When no precautions are taken, end caps type b) can cause buckling of the test piece when the test piece is assembled with the end caps at a lower temperature than the test temperature.

5.1 Evaluation of pipe and/or fitting materials

The following shall apply for the evaluation of pipe and/or fitting materials, unless otherwise specified in the referring standard:

a) end caps type a) shall be used;

b) the test pieces shall be of S series 6.3 or smaller, or have an SDR of 13.6 or smaller, as applicable.

5.2 Other test objectives

For other test objectives, it is permitted to use end caps type a) and/or end caps type b) as specified in the referring standard.

6 Test pieces

6.1 Sampling

The sampling requirements shall be those specified in the referring standard.

6.2 Cutting

Test pieces shall be cut so that their ends are perpendicular to the axis of the pipe.

6.3 Dimensions

6.3.1 Free length

The free length, l_0, of each test piece between the end caps shall be at least three times the outside diameter for pipes with a nominal outside diameter smaller than or equal to 315 mm, with a minimum of 250 mm. For pipes with a nominal outside diameter greater than 315 mm, a minimum free length of larger than or equal to 1000 mm shall be used.

For testing fitting material in the form of injection-moulded pipe, the free length, l_0, excluding the integral closed end, if any, shall be not less than 140 mm.

6.3.2 Total length

For type b) end caps the total length of the test piece shall be such that the test piece shall not make contact with the end surface of the end caps during the test.

6.4 Number

The number of test pieces to be prepared shall be as specified in the referring standard.

NOTE: The number of test pieces depends on the purpose of the test (e.g. performance test, internal and/or external quality control test, initial type testing, audit testing, batch release tests or confirmation tests).

7 Calibration of the apparatus and calculation of the test pressure

7.1 Calibration of the apparatus

The temperature and pressure control systems, and the equipment for measuring temperature, pressure and time shall be regularly calibrated, to an accuracy compatible with the scales used and at a frequency commensurate with the conditions of use.

7.2 Calculation of the test pressure

7.2.1 Determine, in accordance with EN 496, the minimum wall thickness and the mean outside diameter of the free length of each test piece, using apparatus conforming to 4.7 and 4.8 respectively.

7.2.2 If necessary [see item h) of the note to clause 3], calculate the test pressure, p, in bars [1], to three significant figures, using the following equation:

$$p = 10\sigma \times \frac{2e}{d_e - e}$$

where:

σ is the circumferential (hoop) stress to be induced by the applied pressure, in megapascals;

d_e is the measured mean outside diameter of the test piece, in millimetres;

e is the measured minimum wall thickness of the free length of the test piece, in millimetres.

8 Conditioning

Clean and dry the test pieces (see clause 6) to remove any traces of dirt, oil, wax or other contamination, and fit them with the end caps (see 4.1) chosen for the test. Fill the test pieces with water, which may be preheated to a temperature not more than 5 °C above the test temperature.

After bringing the test piece to the specified temperature, condition them for the period specified in the referring standard [see items i) of the note to clause 3].

NOTE 1: When the referring standard does not cover conditioning, the conditioning periods given in table 1 are recommended.

Table 1

$e_{min.}$ mm	Conditioning periods
$e < 3$	1 h ± 5 min
$3 \leq e < 8$	3 h ± 15 min
$8 \leq e < 16$	6 h ± 30 min
$16 \leq e$	16 h ± 1 h

NOTE 2: The test pieces should not be tested within a period of 15 h after production of the pipes, except for manufacturing checks, unless there are specifications in the referring standard to the contrary for the given materials.

9 Procedure

9.1 Connect the conditioned test pieces (see clause 8) to the pressurizing equipment (see 4.4) and bleed off the air. Progressively and smoothly apply the test pressure (calculated in accordance with 7.2) to $^{+2}_{-1}$ %, in the shortest time practicable between 30 s and 1 h depending upon the material, the size of the pipe and the capabilities of the pressurizing equipment. Record the time taken to achieve the test pressure.

Throughout the following procedure, ensure that while the test pieces are under pressure they are suspended in the thermally controlled environment.
For evaluation tests maintain the test temperature (see the referring standard) constant to ± 1 °C when a liquid environment is used and to $^{+3}_{-1}$ °C in the case of an air-oven (see 4.2).
For other tests maintain the temperature within $^{+3}_{-1}$ °C of the test temperature.

The type of test, i.e. "water-in-water", "water-in-air" or "water-in-liquid", shall be as specified by the referring standard.

Record the orientation of the suspended test piece, e.g. horizontal or vertical, and the type of test.

9.2 Start the timer when the test pressure is achieved.(See 7.2.2).

9.3 Stop the test either when the specified duration is reached [see item k) of the note to clause 3], or when a failure or leak occurs in the test piece, in which case record the time to failure unless the procedure given in 9.4 is applicable.

If a failure occurs, record the type, i.e. brittle or ductile.

NOTE: Failure is "brittle" if no plastic deformation has occurred in the failure zone. If the failure is accompanied by plastic deformation in the failure zone, visible without magnification, it is of the "ductile" type.

9.4 If a break occurs in a test piece at a distance of less than 0,1 l_0 from an end cap, disregard the result and repeat the test on another test piece.

10 Test report

The test report shall include the following information:

a) a reference to this standard and to the referring standard;

b) the complete identification of the sample;

c) the type of the material;

d) the nominal dimensions of the pipe;

e) the measured dimensions of the test pieces;

f) the test temperature and accuracy of its measurement;

g) the stress applied;

h) the calculated test pressure and accuracy of its measurement;

i) the nature of the environment, i.e. air, water or liquid (and nature of the liquid, if used);

j) the type of end cap;

k) the total and free lengths of the test pieces;

l) the number of test pieces tested;

m) the orientation of the test pieces in the tank or oven;

n) the time to achieve the test pressure (see 9.1);

o) the duration of the test;

p) the type(s) of failure, if any;

q) observations made during and after the test;

r) any factors which may have affected the results, such as any incidents or any operating details not specified in this standard;

s) the date of test or dates between which the test was conducted.