INTERNATIONAL STANDARD

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Thermoplastics pipes for the conveyance of fluids — Determination of resistance to rapid crack propagation (RCP) — Full-scale test (FST)

Tubes en matières thermoplastiques pour le transport des fluides — Détermination de la résistance à la propagation rapide de la fissure (RCP) — Essai grandeur nature (FST)

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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.

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 13478 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 13478:1997), which has been technically revised.

Introduction

Test methods that measure the resistance of internally pressurized plastics pipes to rapid fracture propagation (RCP) have been standardized: ISO 13477 [1] and this International Standard. The S4 method specified in ISO 13477 utilizes short lengths of pipe to determine a critical RCP pressure or temperature for the pipe. Longer pipes up to 20 m in length are the basis of this full-scale test (FST) method for measurement of these critical parameters. On the one hand, the S4 method uses internal baffles to prevent rapid decompression of the internal test pressure, thus ensuring that the high-speed crack tip is exposed to the full pipe pressure throughout the test. The FST, on the other hand, has no baffles installed and is more related to field service. The crack tip is subjected to a reducing pressure by decompression effects as the crack propagates. This arrangement reflects the RCP mode of failure of long pipelines and is assumed to be the reference test method. The critical RCP values derived from each test are different but can be correlated experimentally. A mathematical equation for correlation has been developed for polyethylene (PE) pipes (see ISO 13477).

Thermoplastics pipes for the conveyance of fluids — Determination of resistance to rapid crack propagation (RCP) — Full-scale test (FST)

1 Scope

This International Standard specifies a full-scale test (FST) method for determining the arrest or propagation of a crack initiated in a thermoplastics pipe at a specified temperature and internal pressure. The method is also suitable for the determination of defined critical pressure, critical stress and critical temperature parameters.

It is applicable to the assessment of the performance of thermoplastics pipes intended for the supply of gases or liquids. In the latter case, air could also be present in the pipe.

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 3126, *Plastics piping systems — Plastics components — Determination of dimensions*

ISO 11922-1, *Thermoplastics pipes for the conveyance of fluids — Dimensions and tolerances — Part 1: Metric series*

3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO 11922-1 and the following apply.

3.1
critical pressure
p_c
highest crack-arrest pressure below the lowest crack-propagation pressure

3.2
critical hoop stress
σ_c
highest crack-arrest hoop stress below the lowest crack-propagation hoop stress

3.3
critical temperature
T_c
lowest crack-arrest temperature above the highest crack-propagation temperature

3.4
crack arrest
event characterized by the length of the longest crack that is less than or equal to 90 % of the length of the test pipe

3.5
rapid crack propagation
RCP
event characterized by the length of the longest crack that is greater than 90 % of the length of the test pipe

4 Symbols

p test pressure, in bar [1)]

p_c critical pressure, in bar [1)]

σ_c critical hoop stress, in megapascals (MPa)

T_c critical temperature, in degrees Celsius (°C)

d_{em} mean outside diameter of test pipe, in millimetres

D average of the mean outside diameters, d_{em}, of the pipe sections, in millimetres

e_t mean wall thickness of the test pipe along the (main) crack, in millimetres.

5 Principle

A thermoplastics pipe, maintained at a specified temperature and containing a fluid at a specified test pressure, is subjected to an impact designed to initiate a crack. The crack can then arrest within a short distance or continue to propagate at high speed along the pipe.

The test temperature and test pressure are as defined in the referring standard and are related to the intended operating conditions.

The pressurizing fluid is identical to that used in the intended application, or else is a substitute fluid, e.g. air or nitrogen, which gives equivalent results.

The test simulates the performance of a buried pipe in service under conditions which do not retard the rate of decompression of the pressurizing fluid through any fracture.

The pipe is subsequently examined to determine whether arrest or propagation of the crack has occurred.

From a series of such tests at different pressures but at a constant temperature, a critical pressure or critical stress for crack propagation can be determined (see Annex A).

Similarly, by testing at a series of temperatures while maintaining a constant pressure or hoop stress, the critical temperature for RCP can be determined (see Annex B).

1) 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2.

6 Test parameters

It is assumed that the following parameters will be set by the referring product standard:

a) the diameter(s) and series of the pipe(s) to be tested;

b) the pressurizing fluid (7.4), e.g. gas, water, water plus air or nitrogen;

c) the test pressure(s);

d) the test temperature(s).

7 Materials

7.1 Methylated spirits or ethanol, for use as a cooling fluid (see 8.4.3).

7.2 Solid carbon dioxide, for use as a cooling agent (see 8.4.3).

7.3 Washed gravel, with a size range of 20 mm to 40 mm diameter (see Clause 10).

7.4 Pressurizing fluid, which shall be as specified in the referring standard.

NOTE 1 It is satisfactory to use nitrogen or air as the pressurizing fluid instead of natural gas, as the measured pressure for rapid crack propagation (RCP) will be only slightly less than that obtained with natural gas. The decompression speed (velocity of sound) at 0 °C of nitrogen and air is 337 m/s and 334 m/s, respectively, compared with approximately 430 m/s for natural gas.

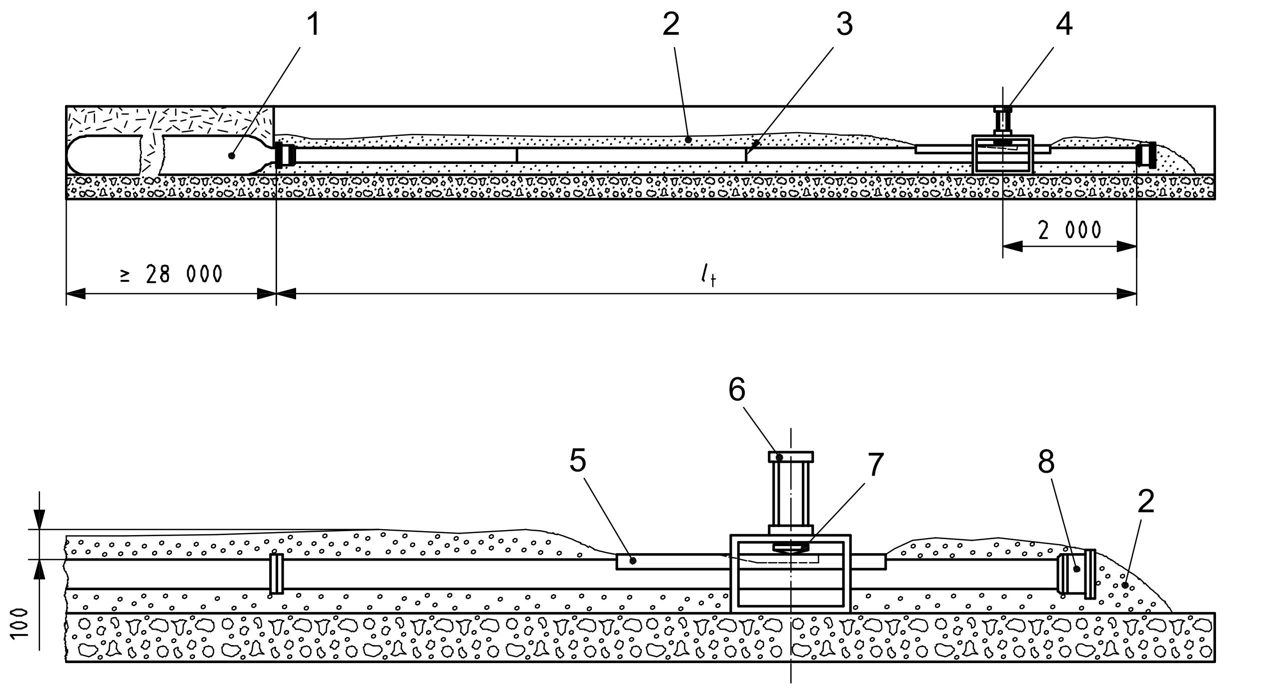
NOTE 2 In water-pipeline systems, which contain water only, the phenomenon of crack propagation is unlikely to occur. However, when entrained air bubbles or air pockets are present, it is possible. It is usual to test with between 5 % and 10 % by volume of air in the water to determine the resistance to crack propagation. A test on water pipe using 100 % gas, air or nitrogen is more likely to result in RCP and therefore will be expected to give a pessimistic result (also see Reference [2] for RCP testing of pipes filled or partially filled with water).

8 Apparatus

8.1 Temperature-controlled trough, capable of accommodating the overall pipe length normally of 14 m to 20 m (also see Clause 9). The trough shall have means for maintaining the temperature specified by the referring standard to within ± 1,5 °C along the whole test pipe length. The temperature may be controlled by recirculation of water or air around the test pipe (see Figure 1). The temperature shall be monitored at intervals along the test length. If necessary, the water shall contain antifreeze to avoid ice build-up around the test pipe.

NOTE Temperature monitoring along the test length at intervals not exceeding 3 m and around the pipe at the 3 o'clock and 9 o'clock positions has been found to be satisfactory.

Dimensions in millimetres



Key

l_t test length (overall pipe length, l, 14 m to 20 m)

1 steel pipe reservoir

2 gravel

3 required butt-fusion joints

4 initiation ring

5 cooling trough

6 pneumatic piston

7 blade

8 end cap

Figure 1 — Example of test facility for full-scale rapid crack propagation

8.2 Steel-pipe reservoir, connected to the test pipe at one end of the trough. The steel pipe shall have a bore diameter greater than or equal to the test-pipe bore diameter. The pipe reservoir shall have a minimum length of twice that of the test pipe and a minimum volume of three times that of the test pipe.

Axial alignment of the reservoir with the test pipe is preferred.

8.3 Pressurization equipment, for pressurizing the test pipe and steel reservoir (8.2) with the test fluid (7.4) to within ± 2 % of the test pressure specified by the referring standard.

8.4 Crack-initiation equipment, for driving a metal blade (8.4.2) through the test pipe at high speed.

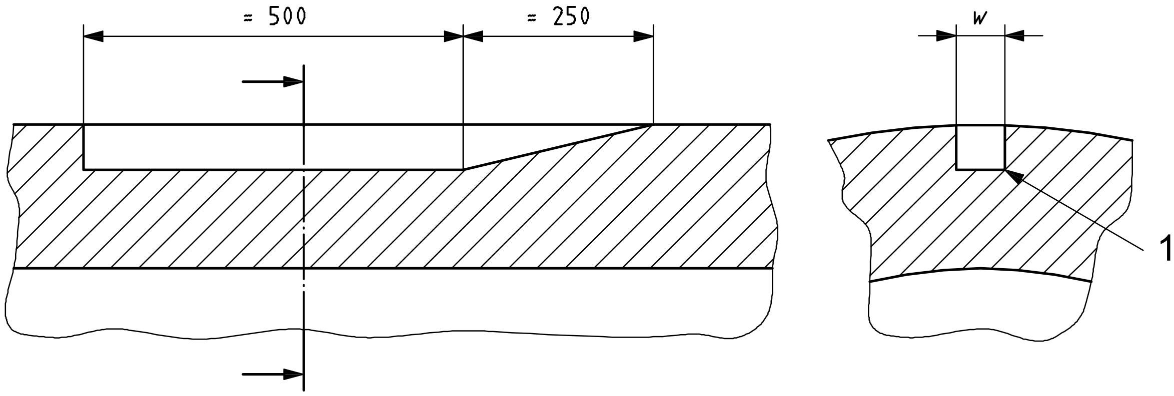
8.4.1 Router, capable of machining a longitudinal slot to an appropriate depth in the test-pipe wall for approximately 500 mm and then gradually decreasing the groove depth to zero over approximately 250 mm (see Figure 2).

NOTE Normally, the slot is machined whilst the test pipe is in the trench.

8.4.2 Metal blade, which can be aligned with the external slot in the test pipe and be driven through the residual pipe-wall thickness.

NOTE A 400 mm long steel blade driven by a fast-acting pneumatic impact piston has been found to be suitable for polyethylene pipe (see Figure 3).

Dimensions in millimetres



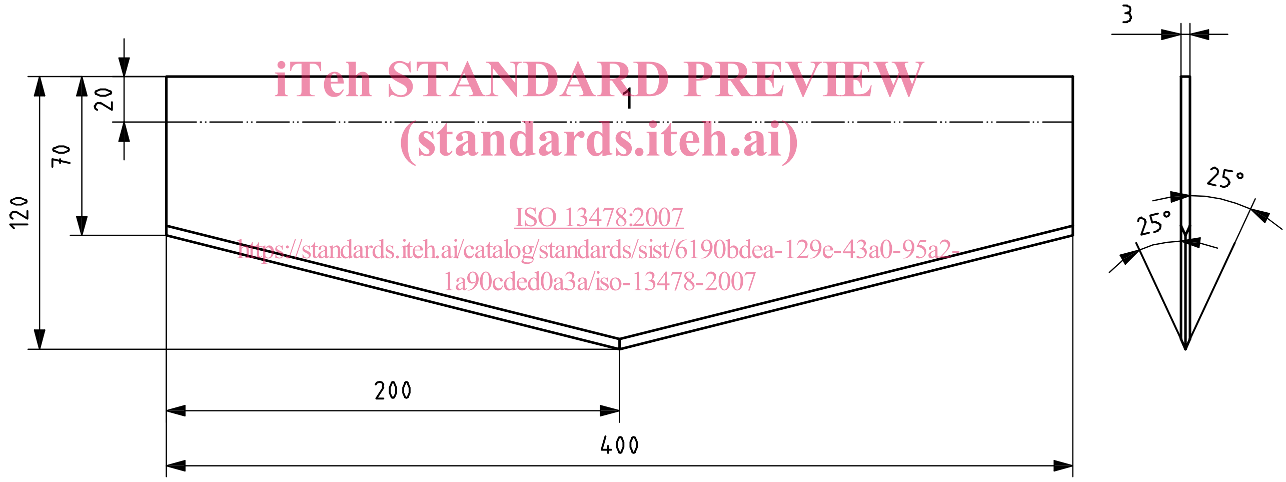
Key

w slot width (8 mm to 25 mm, depending on the wall thickness)

1 rounded corners at bottom of slot

Figure 2 — Slot machined in external surface of pipe wall

Dimensions in millimetres



Key

1 part of blade gripped in blade holder

NOTE Blade sharpened by light grinding.

Figure 3 — Steel blade found to be suitable for initiating crack in polyethylene pipe

8.4.3 Crack initiation cooling system, used to apply methylated spirits or ethanol, cooled by solid carbon dioxide, to the top of the pipe in order to cool the slot and a strip of pipe on either side and approximately 1 m in the direction of the steel-pipe reservoir.

It is recommended that a wooden frame be used, resting on the top of the pipe and lined with a thin polyethylene sheet, to contain the cooling fluid (see Figure 4). The slot, under the polyethylene (PE) sheet, is filled with methylated spirits or ethanol to avoid ice formation.

8.4.4 Close-fitting wooden plug, approximately 0,5 m long, used to support the test pipe internally beneath the slot sufficiently to prevent severe pipe distortion during crack initiation (see Figure 4).