INTERNATIONAL STANDARD

ISO 17454

First edition
2006-02-01

Plastics piping systems — Multilayer pipes — Test method for the adhesion of the different layers using a pulling rig

Systèmes de canalisations en plastiques — Tubes multicouches — Méthode d'essai de l'adhérence des différentes couches utilisant un anneau de traction

Reference number
ISO 17454:2006(E)

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
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Published in Switzerland

Foreword

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ISO 17454 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*.

Introduction

In response to the worldwide demand for specifications, requirements and test methods for multilayer pipes, WG 16 of ISO/TC 138/SC 5 was created at a meeting held in Kyoto, Japan, in 1998. The working group then started drafting three test standards (including ISO 17454) for multilayer pipes:

— ISO 17456, *Plastics piping systems — Multilayer pipes — Determination of long-term hydrostatic strength*;

— ISO 17455, *Plastics piping systems — Multilayer pipes — Determination of the oxygen permeability of the barrier pipe.*

Only multilayer pipes are dealt with in this International Standard and for these purposes cross-linked polyethylene (PE-X) as well as adhesives are to be considered as a thermoplastics material.

Plastics piping systems — Multilayer pipes — Test method for the adhesion of the different layers using a pulling rig

1 Scope

This International Standard specifies a method for testing the adhesion between layers of multilayer pipes using a pulling test rig.

The bond between the metal layer and the inside (underlying) layer is measured.

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 5893, *Rubber and plastics test equipment — Tensile, flexural and compression types (constant rate of traverse) — Specification*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
multilayer pipe
pipe comprising layers of different materials

3.2
multilayer M pipe
multilayer pipe comprising layers of polymers and one or more metal layers

NOTE The wall thickness of the pipe consists of at least 60 % polymer layers.

3.3
inner layer
layer in contact with the liquid or gas

3.4
outer layer
layer exposed to the outer environment

3.5
embedded layer
layer between the outer and inner layer

NOTE There can be more than one embedded layer.

3.6
joint line
location of the joint line (welded or adhesion bonded) of the metal layer

4 Symbols

d_i	inside diameter of the test piece (pipe), in millimetres (mm)
d_e	manufacturer's nominal outside diameter, expressed in millimetres (mm)
n	number of measurements
F_p	pulling force of the pulling rig, in newtons
$F_{cal,i}$	calibration force, all forces occurring during the pulling process, other than the adhesion force, in newtons per millimetre
F_{cal}	average calibration force, in newtons per millimetre
$F_{d,i}$	general force, all forces occurring during the pulling process, in newtons per millimetre
F_d	average minimum general force, in newton per millimetre
F_{ad}	adhesion force, in newtons per millimetre
W_p	length of the test piece, in millimetres
l_c	needed (fixed) length ($\pm$ 0,1 mm) for the clamp-grip, in millimetres

5 Principle

A tensile-force is introduced to the metal (embedded) layer of a test piece perpendicular to the axial direction. This pulling force is measured.

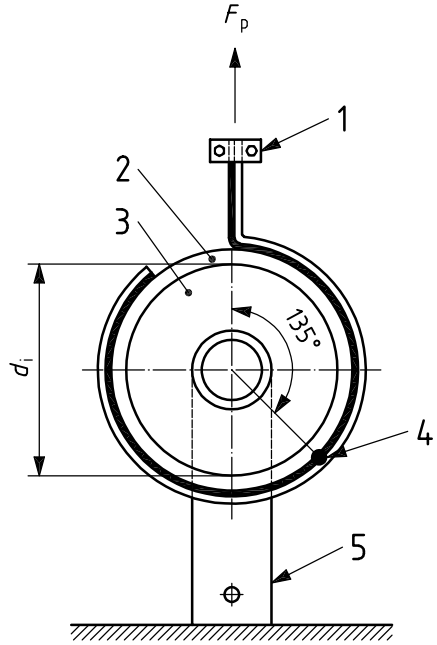
6 Apparatus

6.1 Tensile testing machine, in accordance with ISO 5893.

6.2 Rotating test rig, with

a) for every pipe diameter (d_i), a **support mandrill**, having an outside diameter of 0,95d_i and a length of at least (12 $\pm$ 1) mm, able to rotate without significant resistance, preferably by the inclusion of a roller bearing, and

b) a **pulling rig**, conforming to the principle as represented in Figure 1.



Key

1 clamp
2 inner layer
3 support axle that includes a roller bearing
4 weld line
5 pivoted sample holder

Figure 1 — Pulling rig (Test I shown)

6.3 Device capable of monitoring the force applied to the metal (embedded) layer of a test piece.

6.4 Device capable of measuring either the pulling speed arranged so as to subject the test piece to a constant pulling speed, or the angle of rotation of the support mandrill.

7 Calibration

7.1 Principle

Before starting the test, all forces F_{cal} (e.g. the bending force) other than the adhesive force shall be determined by following the procedure given in 7.4. The force remaining after reduction of the test results using F_{cal} is the adhesive force.

7.2 Test piece sampling procedure

Samples for the pipe diameter to be tested shall contain no adhesive between the metal layer and the inner layer. In total, five samples shall be used for the calibration procedure.

7.3 Preparation of test pieces

The test pieces shall be rings cut from the pipe.

Each test piece shall have a minimum length W_p of 10 mm and shall have no loose layers.

The metal layer shall be cut in the axial direction and pulled loose over fixed length l_c to enable the clamp to be attached for pulling and where

$l_c \leqslant 12$ mm

The outer layer has no significant contribution to the bending force and the test can therefore be carried out without the outer layer.

7.4 Procedure

7.4.1 Unless otherwise specified in the referring system standard or product standard, conduct the test at a temperature of (23 ± 2) °C.

7.4.2 Insert the support-axle into the test piece and ensure free rotation of the (pipe) test piece.

7.4.3 Install the clamp on the loosened part and check that the joint will be measured during the test.

7.4.4 Apply a crosshead spread speed of (50 ± 5) mm/min.

7.4.5 For the calculation of the results, use only the range of the angle of rotation from 30° to 255°.

7.4.6 For all five test pieces, record the applied forces $F_{p,max}$ and $F_{p,min}$.The average between the minimum and the maximum measured force shall be used to calculate F_{cal}.

7.5 Processing the results

Calculate the average force, $F_{cal,i}$, using Equation (1):

$$F_{cal,i} = \frac{F_{p,max} - F_{p,min}}{2W_p} \quad \text{[N/mm]} \tag{1}$$

Calculate the force F_{cal} using Equation (2):

$$F_{cal} = \frac{\sum_{i=1}^{n} F_{cal,i}}{n} \quad \text{[N/mm]} \tag{2}$$

where $n = 5$ (for five samples).

Reduce the test results from Clause 8 using F_{cal} to obtain the remaining force corresponding to the adhesive force.

8 Test method

8.1 Sampling

In total, 10 samples shall be cut from the pipe to be tested, equally divided over 1 m of the pipe.

8.2 Preparation of test piece

The test pieces shall be rings cut from the pipe.

Each test piece shall have a minimum length W_p of 10 mm and shall have no loose layers.

The metal layer shall be cut in the axial direction and pulled loose over fixed length l_c to enable the clamp to be attached for pulling, where

$l_c \leqslant 12$ mm

For the location of the joint line, the test procedure shall be followed according to 8.3.

8.3 Location of joint line

To neutralize the negative influence of the cutting, two series of tests shall be performed at different angles α:

For **Test I**, the angle α shall be 135° ± 5°, see Figure 1.

For **Test II**, the angle α shall be 315° ± 5°.

The joint shall be measured in both tests.

8.4 Procedure

8.4.1 Unless otherwise specified in the referring system standard or product standard that refer to this International Standard, conduct the test at a temperature (23 ± 2) °C.

8.4.2 Insert the support-axle into the test piece and ensure free rotation of the test (pipe) piece.

8.4.3 Install the clamp on the loosened part and check that the angle α is still as specified in 8.3.

8.4.4 Apply a crosshead spread speed of (50 ± 5) mm/min.

8.4.5 Record the applied force F_p over the angle of rotation from 30° to 255° during the test.

8.5 Processing of results

For all 10 samples, the minimum value for F_p is recorded.

Calculate the force $F_{d,i}$ using Equation (3):

$$F_{d,i} = \frac{F_p}{W_p} \text{ [N/mm]} \tag{3}$$

Calculate the minimum force F_d using Equation (4):

$$F_d = \frac{\sum_{i=1}^{n} F_{d,i}}{n} \text{ [N/mm]} \tag{4}$$

where $n = 10$ (for 10 samples).

Calculate the adhesive force F_{ad} using Equation (5):

$$F_{ad} = F_d - F_{cal} \text{ [N/mm]} \tag{5}$$

9 Test report

The test report shall include the following information:

a) reference to this International Standard, as well as to the referring standard and the manufacturer's information;

b) complete identification of the multilayer pipe component from which the test piece was taken, including manufacturer, material type, code number, size, source and significant history, if any;

c) dimensions of the pipes tested;

d) test conditions;

e) number of test pieces;

f) calculated values;

g) any observations of damage;

h) location of failures relative to the joint line;

i) details of any factors which could have affected the results, such as incidents or any operational details not mentioned in this International Standard;

j) date of the test.

ICS 23.040.20

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