TECHNICAL SPECIFICATION

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Metallic materials — Method of hole expanding test

Matériaux métalliques — Méthode d'essai d'expansion de trou

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ISO/TS 16630 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 2, *Ductility testing*.

Introduction

Modern methods of manufacture of automobile components such a wheels, suspension parts and structural components using sheet steel involve, primarily, shearing, bending and stretch drawing operations.

Included with these processes is the bending up (plunging) of flanges (rims) around pierced holes and this may result in rupture of the material.

Various test methods are available to establish the suitability of the sheet metal for the forming processes involved. The hole expansion test is one of the best methods for evaluating the suitability of the sheet steel for forming such “flanges” because it closely resembles the process used under production conditions to form such flanges (plunged rims) starting with punched holes.

Because of the details given in this Technical Specification, the relevance of the test will be immediately apparent. By adhering to the laid-down procedures in the specification, scatter in the test results will be minimized.

Metallic materials — Method of hole expanding test

1 Scope

This Technical Specification describes a method of determining the hole expansion ratio in metallic sheets and strips with a thickness range of 1,2 mm to 6 mm inclusive and a width of at least 90 mm.

NOTE This test is normally applicable to steel sheets and is used to assess the suitability of the product for forming flanges.

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 497, *Guide to the choice of series of preferred numbers and of series containing more rounded values of preferred numbers*

3 Terms and definitions

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

3.1
limiting hole expansion ratio
amount of hole expansion obtained in a circular punched hole of a test piece when a conical expansion tool is forced into the hole until any one crack in the hole edge extends through the test piece thickness

3.2
clearance
⟨between die and punch⟩ gap present when punching a hole in a test piece, expressed as the ratio of the gap to the test piece thickness

4 Symbols and designations

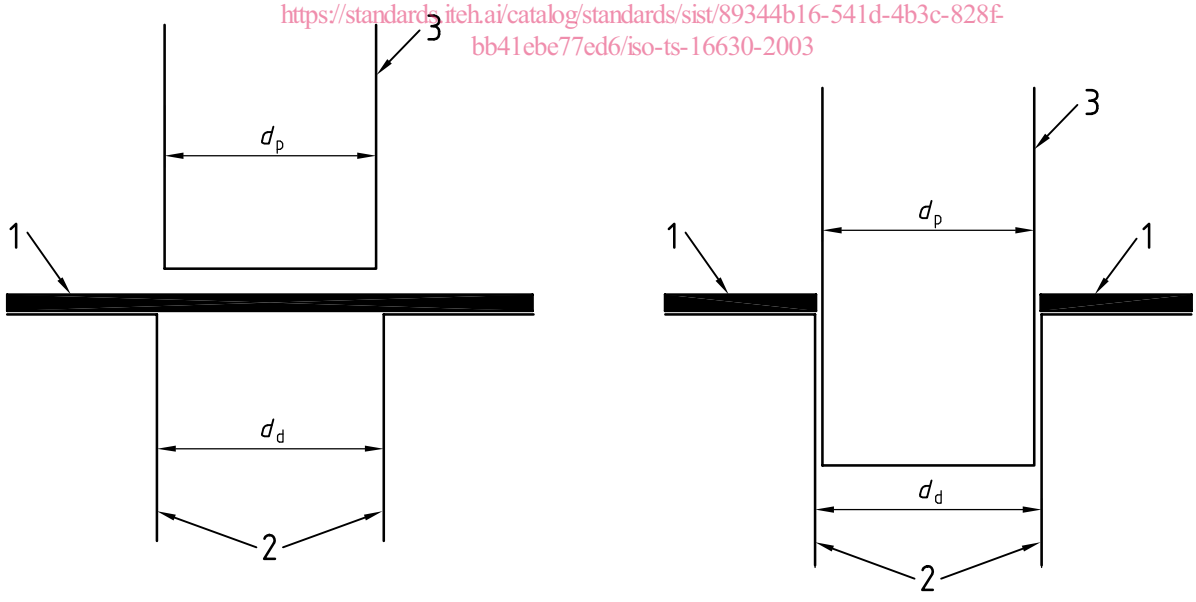
Symbols and corresponding designations are given in Table 1.

Table 1 — Symbols and designations

Symbol	Designation	Unit
c	Clearance	%
d_d	Inside diameter of the die used for punching a hole in the test piece	mm
d_p	Diameter of the punch used for punching a hole in the test piece	mm
D_d	Inside diameter of the die of expansion tool	mm
D_h	Hole diameter after rupture	mm
D_o	Original hole diameter	mm
D_p	Diameter of the punch of expansion tool	mm
F	Clamping force	N
R	Corner radius of the die of expansion tool	mm
t	Thickness of the test piece	mm
λ	Limiting hole expansion ratio	%
$\bar{\lambda}$	Average limiting hole expansion ratio	%

5 Principle

The hole expansion test consists of forcing a conical expansion tool into a pre-punched hole (see Figure 1) until any one crack extends through the test piece thickness of the metallic sheet.



Key

1 test piece
2 punching die
3 punching punch

Figure 1 — Illustration of punching

6 Apparatus

6.1 Testing machine

The testing machine shall have the capability of holding a test piece in place during the test and being able to stop the expansion tool as soon as a crack occurs in the hole edge.

The testing machine shall also be capable of controlling the rate of displacement of the expansion tool.

NOTE A testing machine for the exclusive use of a hole expanding test, or a deep drawing test machine, or any other press testing machine may be used.

6.2 Testing tools

6.2.1 Dimensions and shape of the die and the punch used in the hole expanding test are given in 6.2.2 to 6.2.5 (see Figure 1).

6.2.2 The punch shall be a conical expansion tool with a top angle of 60° ± 1°. The diameter, D_p, of the cylindrical portion of the tool shall be sufficiently large so that it can expand the hole to such an extent that cracks are generated in the hole edge of the test piece.

6.2.3 The test tool clamping die inside diameter, D_d, shall be selected on the basis of the expected limiting hole expansion ratio.

The inside diameter, D_d, should not be smaller than 40 mm.

6.2.4 The corner radius, R, of the test tool clamping die shall be between 2 mm and 20 mm. The recommended radius is 5 mm.

6.2.5 The conical expansion tool shall have a minimum hardness of 55 HRC.

7 Test piece

7.1 Three test pieces shall be taken from the same sample.

7.2 The test piece shall be flat and of such dimensions that the centre of any hole is not less than 45 mm from any edge of the test piece and not less than 90 mm from the centre of the adjacent hole. For narrow test pieces the centres of the holes shall be in the centre of the test piece width and at least one test strip width from the centre of an adjacent hole.

7.3 In the central part of the test piece a hole is punched using a 10 mm diameter punch (see Figure 1).

7.4 In punching a hole, select a die that satisfies the clearance given in Table 2. The selection of the die's inside diameter shall be in increments of 0,1 mm.

Table 2 — Tolerance on clearance between die and punch

Thickness t mm	Clearance c %
$t < 2$	12 ± 2
$t \geqslant 2$	12 ± 1

NOTE Table 3 gives an example of a set of diameters for punching dies which comply with both of the above mentioned requirements

Table 3 — Examples of inside diameter of punching die

Dimensions in millimetres

Thickness t	Inside diameter of the die d_d
$1,2 \leqslant t < 1,5$	10,3
$1,5 \leqslant t < 1,9$	10,4
$1,9 \leqslant t < 2,3$	10,5
$2,3 \leqslant t < 2,7$	10,6
$2,7 \leqslant t < 3,1$	10,7
$3,1 \leqslant t < 3,6$	10,8
$3,6 \leqslant t < 4$	10,9
$4 \leqslant t < 4,4$	11
$4,4 \leqslant t < 4,8$	11,1
$4,8 \leqslant t < 5,2$	11,2
$5,2 \leqslant t < 5,7$	11,3
$5,7 \leqslant t \leqslant 6$	11,4

7.5 Tolerances of specified dimensions of the punching tools used for the preparation of test pieces shall correspond to the values given in Table 4.

Table 4 — Tolerances of specified dimensions of the punching tools

Dimension	Tolerance (mm)
Punching punch diameter d_p (10 mm)	$^{+0,02}_{-0,03}$
Inside diameter of the punching die d_d — Table 3	$^{+0,03}_{-0,02}$

Clearance is defined by the following equation:

$$c = \frac{d_d - d_p}{2t} \times 100$$

where

c is the clearance as a percentage;

d_d is the inside diameter of the die used for punching a hole in the test piece, in millimetres;

d_p is the diameter of the punch used for punching a hole in the test piece (d_p = 10 mm);

t is the thickness of test piece, in millimetres.

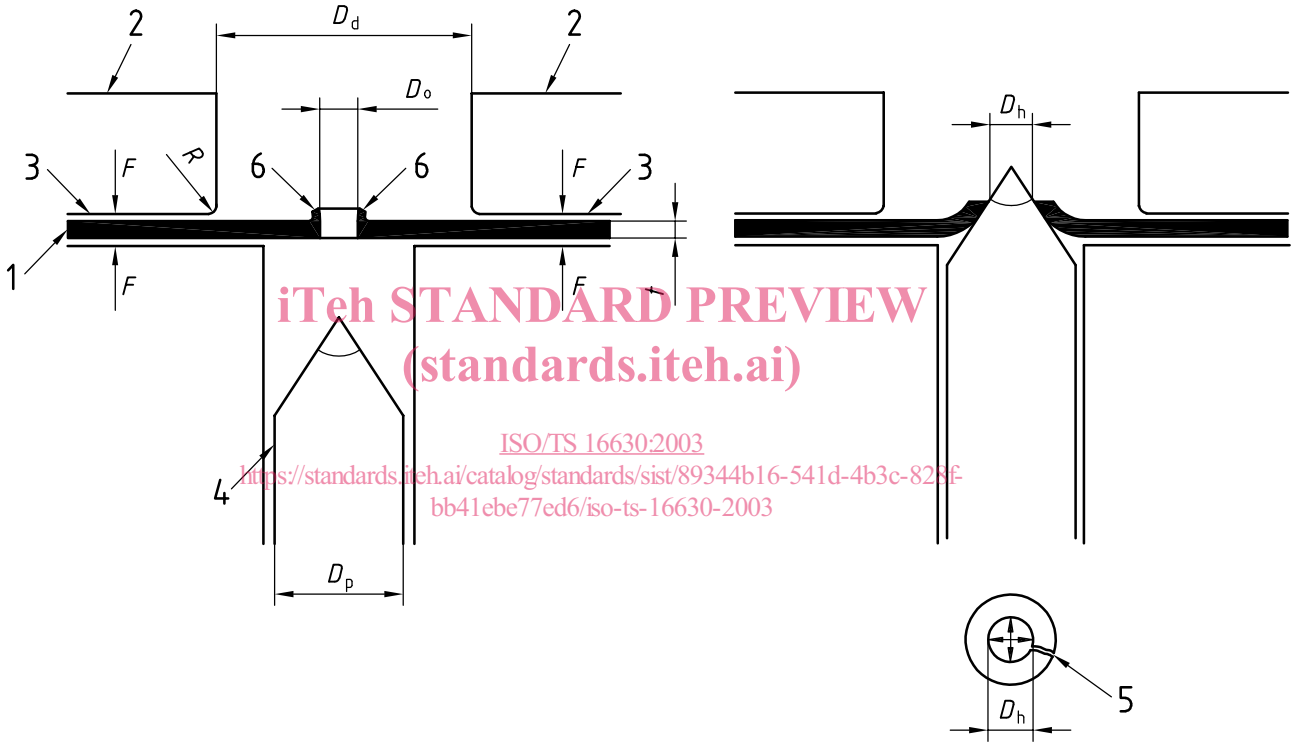
8 Test conditions

In general, tests are carried out at a temperature between 10 °C and 35 °C. Tests carried out under controlled conditions, where required, shall be made at temperature of (23 ± 5) °C.

9 Procedure

9.1 A minimum of three tests shall be carried out.

9.2 Place the test piece on the die so that the centre of the punched hole in the test piece coincides with the axis of the conical expansion tool and that the plane of the test piece is perpendicular to the drive direction of the conical punch (see Figure 2). Place the test piece so that the exit surface of the punched hole faces the die.



a) Before the test **b) After the test**

Key

1	test piece	4	punch
2	die	5	crack
3	die shoulder	6	burr

Figure 2 — Illustration of hole expanding test

9.3 Apply a clamping force to the test piece to prevent any material draw-in from the clamping area during the test.

NOTE As an example, a clamping force of 50 kN or greater should be applied for a 150 mm × 150 mm test piece.

If drawing-in occurs, the test results shall be rejected and another test shall be made.