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Metallic materials — Sheet and strip — Earing test

Matériaux métalliques — Tôles et bandes — Essai de corne

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

This third edition cancels and replaces the second edition (ISO 11531:2015), of which it constitutes a minor revision.

The main changes are as follows:

— Clause 2 "Normative references" and Clause 3 "Terms and definitions" have been added;

— the previous Clause 2 "Symbols and their meanings" has been modified to Clause 4 "Symbols and designations";

— the title of Table 1 has been modified to "Symbols and designations";

— in Figure 2, "5 test piece" has been added;

— Clause 9 has been modified editorially and divided into two subclauses 9.1 and 9.2.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Metallic materials — Sheet and strip — Earing test

1 Scope

This document specifies a method for determining the ear height of metal sheet and strip of nominal thickness from 0,1 mm to 3 mm after deep drawing.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

4 Symbols and designations

The symbols and designations used in the earing test are given in Table 1 and illustrated in Figure 1 and Figure 2.

Table 1 — Symbols and designations

Symbol	Designations	Unit
a	Thickness of test piece	mm
d_1	Diameter of punch	mm
R_1	Corner radius of punch	mm
d_2	Inside diameter of die	mm
R_2	Corner radius of die	mm
d_b	Diameter of circular blank	mm
h_t	Distance between outside bottom of cup and any ear peak	mm
$\overline{h}_t$	Mean value of h_t	mm
$h_{t,max}$	Maximum value of h_t	mm
h_v	Distance between outside bottom of cup and any ear valley	mm
$\overline{h}_v$	Mean value of h_v	mm
$h_{v,min}$	Minimum value of h_v	mm
$\overline{h}_e$	Mean ear height	mm
$h_{e,max}$	Maximum ear height	mm
$N_{ear\ peaks}$	Number of ear peaks	—
$N_{ear\ valleys}$	Number of ear valleys	—
Z	Ear height expressed as a percentage	%
R_a	Surface roughness parameter: arithmetic mean deviation of profile	µm

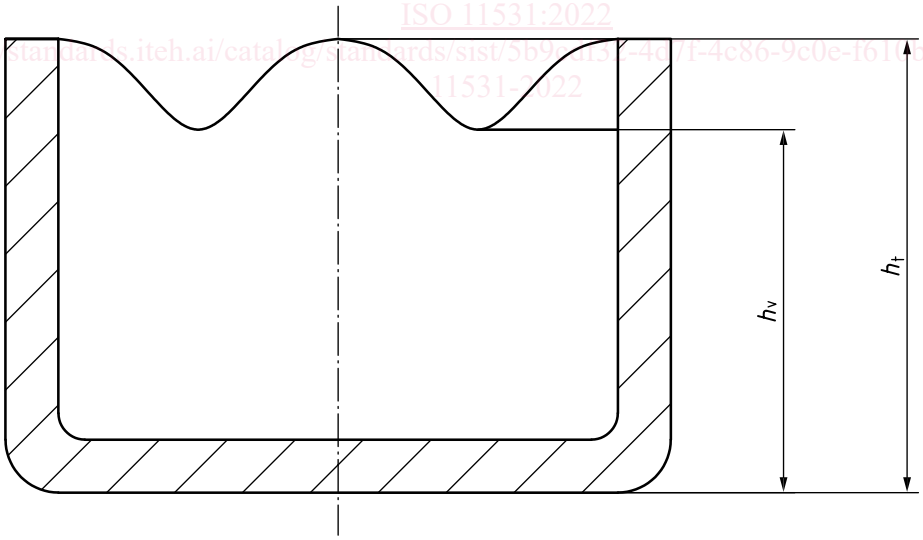
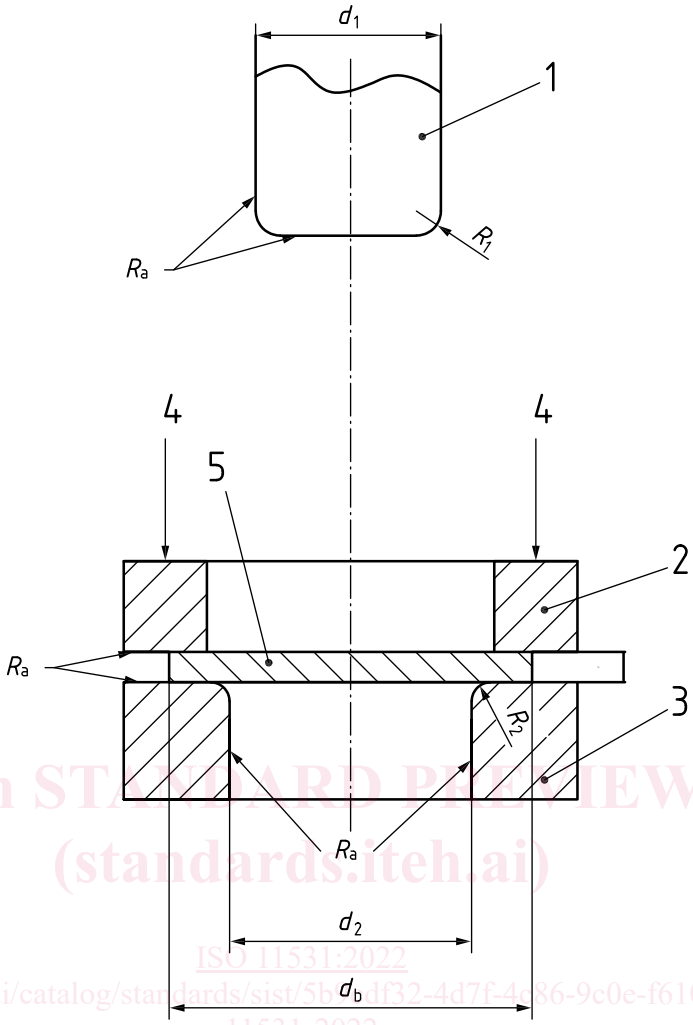


Figure 1 — Schematic section of cup



Key

1 punch
2 blankholder
3 die
4 direction of blankholder force
5 test piece

Figure 2 — Schematic diagram of test equipment

5 Principle

Cylindrical cups are drawn from circular blanks taken from metal sheets or strips, and the height of any earing produced by this process is measured.

6 Test equipment

6.1 The general arrangement of the test equipment is given in Figure 2. The punch shall be capable of moving along the central axis of the die and blankholder and the blank. The equipment shall be such that ironing of ears due to the blankholder force and/or due to insufficient clearance between the punch and die is avoided and such that the cup can be removed without damaging the ears.

6.2 The machine shall be capable of controlling the speed of drawing and the blankholder force.

6.3 The machine shall be equipped with a device for positioning the blank concentrically with the central axis of the machine. The blank-positioning device is not required if the blank is produced as part of the cup-forming process.

6.4 The dimensions of the punch and die shall be chosen as a function of the sheet thickness in accordance with Table 2, unless otherwise specified in the product standard or by agreement. The punch and die dimension combinations given in Table 2 are general and may not be ideal for all materials due to the influence of the clearance between the punch and die. It is recommended that the product standard specify the combinations required for each product.

6.5 The die, the blankholder and the punch shall be sufficiently rigid so as not to deform appreciably during the test. The Vickers hardness of the working surfaces of the die, the blankholder and the punch shall be at least 750 HV 30. The surfaces (of the die, the blankholder and the punch) which contact the test piece shall be polished. The roughness value R_a, of the surfaces shall be in accordance with Table 2.

Table 2 — Punch and die dimensions

Thickness of test piece a	Inside diameter of die d_2		Inside radius of die R_2		Surface roughness (maximum)
	for d_1 = 33	for d_1 = 50	for d_1 = 33	for d_1 = 50	R_a
mm	mm	mm	mm	mm	µm
0,1 ≤ a ≤ 0,2	33,44	50,44	$2{,}0^{0}_{-0{,}2}$	$2{,}5^{0}_{-0{,}2}$	0,1
0,2 < a ≤ 0,4	33,88	50,88	$2{,}5^{+0{,}2}_{0}$	$3{,}0^{+0{,}2}_{0}$	0,1
0,4 < a ≤ 0,8	34,76	51,76	$3{,}5^{+0{,}2}_{0}$	4,5 ± 0,1	0,8
0,8 < a ≤ 1,6	36,52	53,52	$5{,}0^{+0{,}2}_{0}$	6,5 ± 0,1	0,8
1,6 < a ≤ 3,0	39,60	56,60	$7{,}0^{+0{,}2}_{0}$	$9{,}0^{0}_{-0{,}2}$	1,6
R_1 will be 3,3 mm ± 0,05 mm for d_1 of 33 mm, and 5,0 mm ± 0,05 mm for d_1 of 50 mm.					

7 Test piece

7.1 Circular blanks are used as test pieces. The drawing ratio, i.e. the ratio of blank diameter to punch diameter, shall be as large as possible without any risk of tearing at the bottom of the cup. For a test series or comparative tests, the drawing ratio shall be the same in all cases. A drawing ratio of 1,8 has been found satisfactory.

7.2 The test piece shall be free of burrs on the edges which would interfere with the test.

7.3 Before testing, the test piece shall not be subjected to any hammering or hot or cold working.

8 Procedure

8.1 In general, the test shall be carried out at ambient temperature within the limits of 10 °C and 35 °C. Tests performed under controlled conditions shall be carried out at a temperature of 23 °C ± 5 °C.

8.2 Determine the thickness of the test piece to the nearest 0,01 mm and select the appropriate punch and die in accordance with 6.4.

8.3 Before testing, coat the two faces of the test piece lightly and uniformly with lubricant as specified in the relevant standard or by agreement. The lubricant will depend on the nature of the material.

8.4 Position the blank concentrically between the blankholder and the die. Apply the blankholder force that is just sufficient to prevent wrinkling of the flange.

NOTE If it is not known what blankholder force is required to achieve this, it will have to be found by trial and error. The following values are provided for guidance for the first attempt:

Diameter of punch	Aluminium	Steel
33 mm	1 000 N	2 000 N
50 mm	2 000 N	4 000 N

(See also 6.1.)

8.5 Bring the punch into contact with the test piece and form the cup without a flange.

8.6 All non-concentric cups and those having irregular deformations or other faults shall be rejected.

8.7 Measure the height of each ear peak h_t and each ear valley h_v on the cup with an accuracy of ±0,05 mm.

8.8 Record the orientation of the ears with respect to the direction of rolling of the sheet.

9 Interpretation of results

9.1 From the measurements made, the following parameters can be determined by Formulae (1) to (4).

a) Mean value of the ear peak h_t and the ear valley h_v:

$$\bar{h}_t = \frac{h_{t1} + h_{t2} + h_{t3} + \ldots}{N_{\text{ear peaks}}} \quad (1)$$

$$\bar{h}_v = \frac{h_{v1} + h_{v2} + h_{v3} + \ldots}{N_{\text{ear valleys}}} \quad (2)$$

b) Mean ear height:

$$\bar{h}_e = \bar{h}_t - \bar{h}_v \quad (3)$$

c) Maximum ear height:

$$h_{e,max} = h_{t,max} - h_{v,min} \quad (4)$$

9.2 Ear height expressed as a percentage, Z, shall be calculated according to Formula (5). Z should be rounded to nearest 0,1 %, if not otherwise specified in product standards.

$$Z = \frac{\bar{h}_e}{\bar{h}_v} \times 100 \quad (5)$$

10 Test report

10.1 The test report shall include the following information:

a) a reference to this document, i.e. ISO 11531:2022;

b) all details necessary for identification of the test piece;

c) the thickness and diameter of the blank;

d) the diameter of the punch and that of the die;

e) the punch speed;

f) the number of ears and their orientation;

g) the results from Clause 9 as required by the relevant standard or by agreement.

10.2 The test report may also include the following information:

a) the blankholder force;

b) the type of lubricant used;

c) the non-mandatory results from Clause 9.