INTERNATIONAL STANDARD

ISO 3928

Third edition
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Sintered metal materials, excluding hardmetals — Fatigue test pieces

Matériaux métalliques frittés, à l'exclusion des métaux-durs — Éprouvettes pour essais de fatigue

Reference number
ISO 3928:2016(E)

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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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 119, *Powder metallurgy*, Subcommittee SC 3, *Sampling and testing for sintered metal materials (excluding hardmetals)*.

This third edition cancels and replaces the second edition (ISO 3928:1999), which has been technically revised.

Sintered metal materials, excluding hardmetals — Fatigue test pieces

1 Scope

This document specifies

— the die cavity dimensions used for making fatigue test pieces by pressing and sintering, together with certain dimensions of the test piece obtained from such a die, and

— the dimensions of the test pieces machined from sintered and powder forged materials.

This document is applicable to all sintered metals and alloys, excluding hardmetals.

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 terminological databases for use in standardization at the following addresses:

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

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

4 Pressed and sintered test pieces for fatigue test by reverse bend and axial testing

4.1 General

The pressed and sintered piece may also be subjected to further treatment, such as sizing, polishing or heat treatment. If such treatments are applied, they shall be stated in the test report. In a metallographically examined cross section of a test piece, in the gauge region, the piece shall show no micro-lamination greater than 0,25 mm in length. The press tool shall be maintained in a good condition to avoid excessive burr. The edges of the sintered parts shall be broken in the gauge area to remove any burr from compaction.

4.2 Test piece specification: unnotched

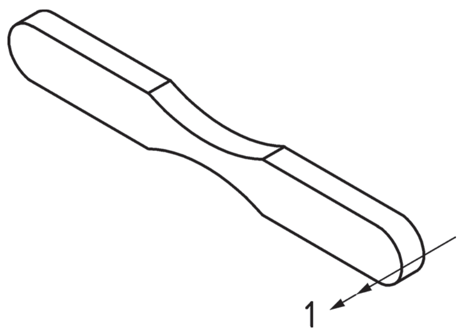
Figure 2 a) shows a drawing of the unnotched test piece. The flatness and parallelism of 0,1 mm are mandatory. The other dimensions are advisory.

4.3 Test piece specification: notched

Figure 3 a) shows a drawing of the notched test piece. The flatness and parallelism of 0,1 mm are mandatory. The other dimensions are advisory. As the 5,5 mm tooling radius of the die is subject to wear, the corresponding radius dimension of the test piece shall be reported.

4.4 Load direction for bending fatigue testing

If nothing else is stated, the specimens shall be oriented such that the torque vector is parallel to the pressing direction during compaction (see Figure 1).



Key

1 M standing orientation

Figure 1 — Fatigue testing

5 Die specifications

5.1 General

The die should preferably be of hardmetal and its surface finish shall be such as to allow compression of test pieces under normal conditions. The die may include a small exit taper to facilitate ejection and avoid cracks or microlaminations in the test pieces. Die cavity may be tapered 0,01 per side to aid ejection. Die bore may be enlarged by 0,5 % for tooling to be used for repressing.

The die should be well supported with shrink rings (of internal diameter 120 mm $^{+0,01}_{\ \ 0}$ mm), so as to minimize lateral expansion during compacting. Such support decreases the possibility of cracking of the specimen at ejection. To reduce the incidence of cracks in the specimen, it is recommended to use top punch hold down during ejection.

5.2 Die specifications for unnotched test pieces

The recommended die cavity is shown in Figure 2 b).

Despite the expression “unnotched”, the test piece shows a stress concentration factor, K_t, as defined in Table 1.

5.3 Die specifications for notched test pieces

The recommended die cavities are shown in Figure 3 b).

The stress concentration factor, K_t, depends upon radius, r, as defined in Table 1.

6 Machined test pieces

Many types of machined test pieces may be used according to the different known procedures of fatigue testing (rotating beam, axial loading, reverse bending, etc.), except that it is not recommended to prepare machined test pieces with square or rectangular cross sections.

An example of the rotating beam piece, is given in Figure 4. For details, see Annex A and References [1], [2], [3] and [4].

Figure 5 shows an example of a test piece for axial loading fatigue testing. For details, see Annex A and References [1], [2], [3] and [4].

The machined test pieces shall be ground over their active length, using a diamond wheel, and lapped longitudinally in order to remove all traces of circumferential scratches. Final polishing should be in the longitudinal direction (no circumferential scratch lines should be visible); try to achieve a smooth blend with no undercut.

Cold work and stresses from machining significantly increase the yield strength of austenitic stainless steel. Annealing or stress relieving may be required to duplicate the as-sintered structure. Any such heat treatment shall be reported.

Practical experience with fatigue testing of carefully machined test pieces of circular cross section has shown that their endurance limits may be 20 % to 30 % higher than those obtained on unmachined, as-compacted test pieces with square or rectangular cross sections.

Use progressively lighter machining passes to minimize residual stresses. Diameter in gauge length should be uniform within ±0,025 mm.

7 Identification of test pieces

For the identification of test pieces, the following shall be stated:

a) a reference to this document, i.e. ISO 3928;

b) the type of material;

c) the density of test piece;

d) the dimensions of test piece (thickness);

e) when pressed and sintered test pieces are made according to Clause 4, the nature of any finishing treatment shall be stated and also, preferably, the material and surface finish of the compacting tool;

f) the form of test piece, i.e. figure number;

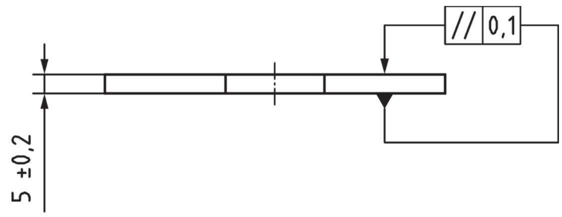
g) the die material, i.e. tool steel or hardmetal/carbide;

h) whether as-sintered or heat treated;

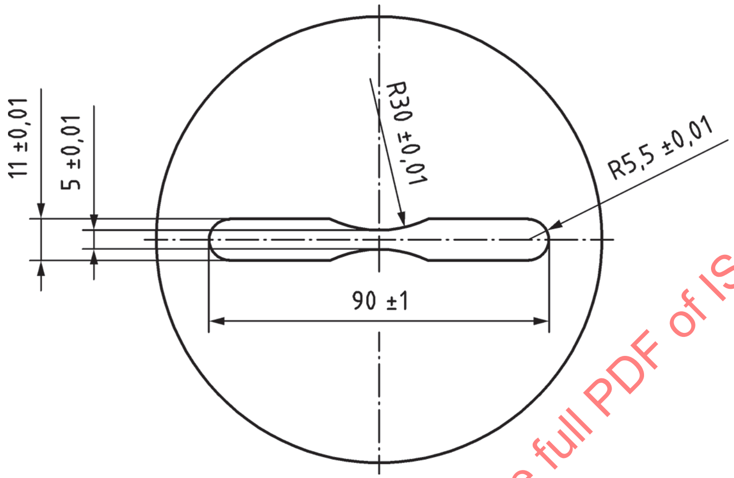
i) the hardness of test piece according to heat treatment;

j) the bottom of notch radius used on notched test piece, Figure 2.

Dimensions in millimetres



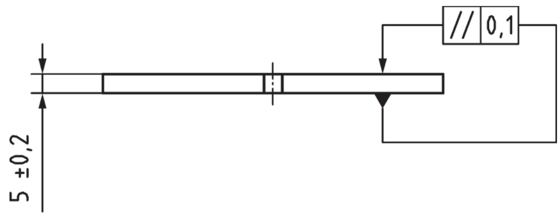
a) Test piece



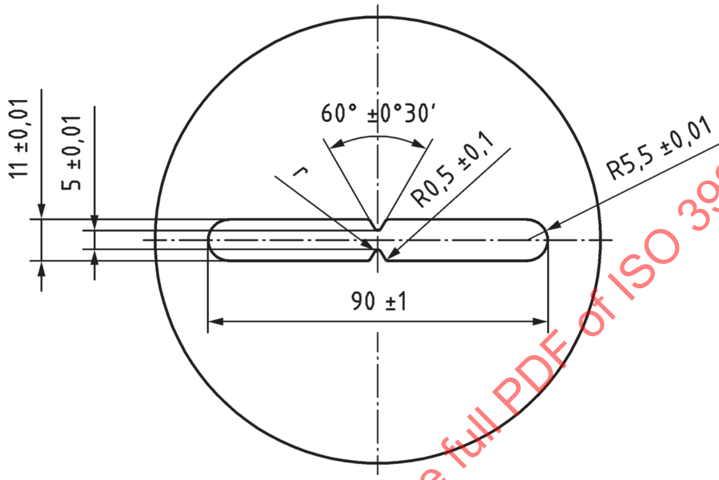
b) Die

Figure 2 — Unnotched test piece and compacting die for use with unnotched fatigue test pieces

Dimensions in millimetres



a) Test piece



b) Die

Figure 3 — Notched test piece and compacting die for use with notched fatigue test pieces

Table 1 — Stress concentration factor, K_t

Dimensions in millimetres

r[a]	K_t axial loading	K_t bending loading
0,25 ± 0,02	4,41	3,11
0,45 ± 0,02	3,46	2,43
0,9 ± 0,02	2,52	1,89
30[b]	1,06	1,04

a Radius of the tool and its allowance.

b Unnotched test piece.

Dimensions in millimetres

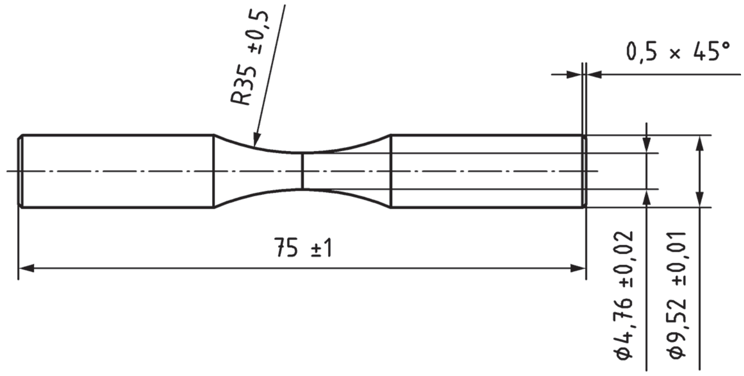


Figure 4 — Machined rotating beam fatigue test piece

Dimensions in millimetres

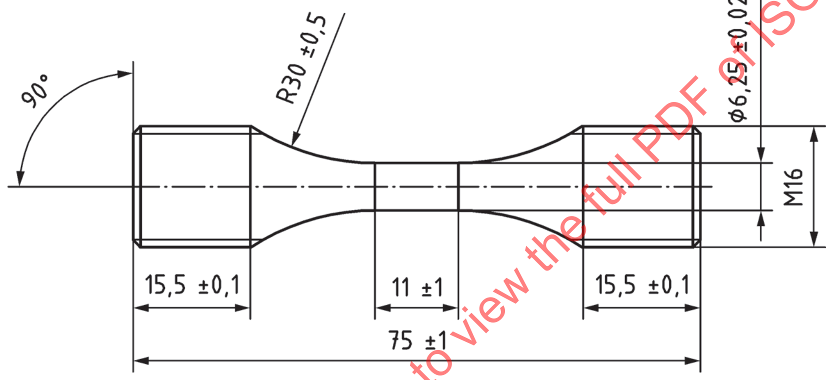


Figure 5 — Machined axial loading test piece

Annex A
(informative)

Remarks

ISO 1099, ISO 1352 and ISO 1143 define the general principles of fatigue testing of metals. These principles are applicable to sintered metals with the following remarks.

a) Sintered metals are characterized by the presence of pores, which are unavoidable stress raisers.

b) Porosity reduces the actual cross section of the specimen to be tested; this means that the nominal stress values, as calculated from the usual formulae, are smaller than the true stresses.

c) In most cases, the presence of interconnected pores opening to the surface makes sintered pieces much more sensitive to environmental conditions than pore-free materials are; porous products can be affected by internal corrosion processes not only during fatigue testing, but also before the test, therefore such test pieces must be stored more carefully than pore-free test pieces.

d) The surface state of a test specimen or PM part significantly influences its fatigue behaviour; therefore, in order to obtain a proper transmission of fatigue data obtained with specimens used to assess the fatigue behaviour of PM component, the surface states of specimens and components must be comparable.

e) Machining by milling or turning densifies the surface and introduces compressive residual stresses. This leads to a much higher fatigue strength compared to the non-machined state. (A grinding operation is much softer.) Therefore, surface machining of test specimens should be carried out only in cases where the critical area of a PM part is also machined. However, as most PM parts have non-machined surfaces, evaluation of the fatigue behaviour should preferably be performed by transmission of fatigue data obtained with non-machined surfaces.

