
**Sintered metal materials, excluding
hardmetals — Fatigue test pieces**

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

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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 3.

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.

International Standard ISO 3928 was prepared by Technical Committee ISO/TC 119, *Powder metallurgy*, Subcommittee SC 3, *Sampling and testing methods for sintered metal materials (excluding hardmetals)*.

This second edition cancels and replaces the first edition (ISO 3928:1977) which has been technically revised.

Annex A of this International Standard is for information only.

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Sintered metal materials, excluding hardmetals — Fatigue test pieces

1 Scope

This International Standard 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;
- the dimensions of the test pieces machined from sintered and powder forged materials.

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

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

2.1 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. Corners shall be broken in the gauge area.

2.2 Test piece specification: unnotched

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

2.3 Test piece specification: notched

Figure 2 a) shows a drawing of the notched test piece. The flatness and parallelism of 0,1 mm are mandatory. The other dimensions are advisory. Burrs shall be avoided. The tooling radius 5,5 mm of the die is subject to wear, then the corresponding radius dimension of the test piece shall be reported.

3 Die specifications

3.1 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 $120 \text{ mm}^{+0,01}_0 \text{ mm}$), 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.

3.2 Die specifications for unnotched test pieces

The recommended die cavity is shown in Figure 1 b).

3.3 Die specifications for notched test pieces

The recommended die cavities are shown in Figure 2 b).

4 Machined test pieces

Many types of machined test piece 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 machine test pieces with square or rectangular cross sections.

An example of the rotating beam piece, is given in Figure 3.

Figure 4 shows an example of a test piece for axial loading fatigue testing.

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-moulded test pieces with square or rectangular cross sections.

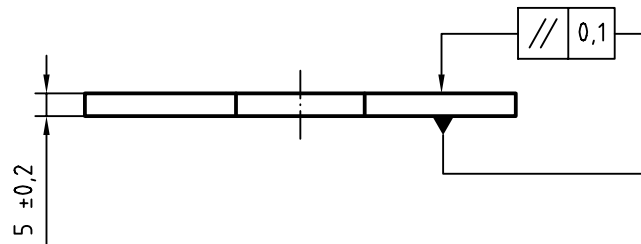
Use progressively lighter machining passes to minimize residual stresses. Diameter in gauge length should be uniform within $\pm 0,025$ mm.

5 Identification of test pieces

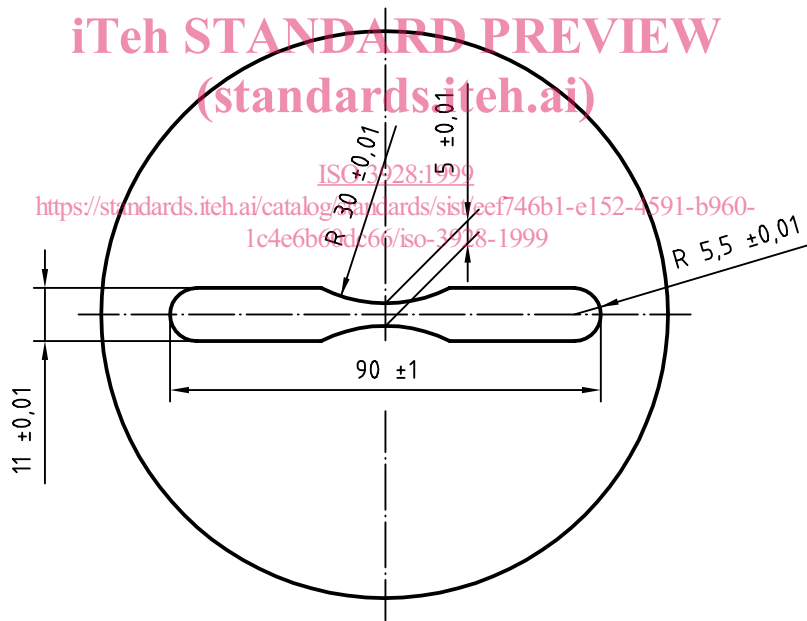
For the identification of test pieces, the following shall be stated:

- a) reference to this International Standard, i.e. ISO 3928;
- b) type of material;
- c) density of test piece;
- d) dimensions of test piece (thickness);
- e) when pressed and sintered test pieces are made according to clause 2, the nature of any finishing treatment shall be stated and also, preferably, the material and surface finish of the compacting tool;
- f) form of test piece, i.e. figure number;
- g) die material, i.e. tool steel or hardmetal/carbide;
- h) whether as-sintered or heat treated;
- i) hardness of test piece according to heat treatment;
- j) bottom of notch radius used on notched test piece, Figure 2.

Dimensions in millimetres



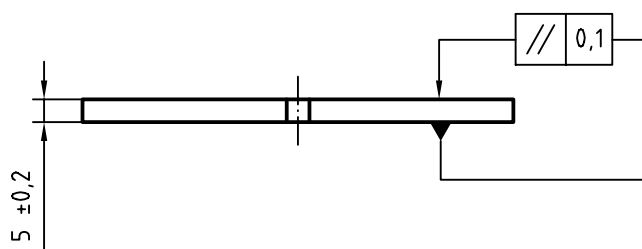
a) Test piece



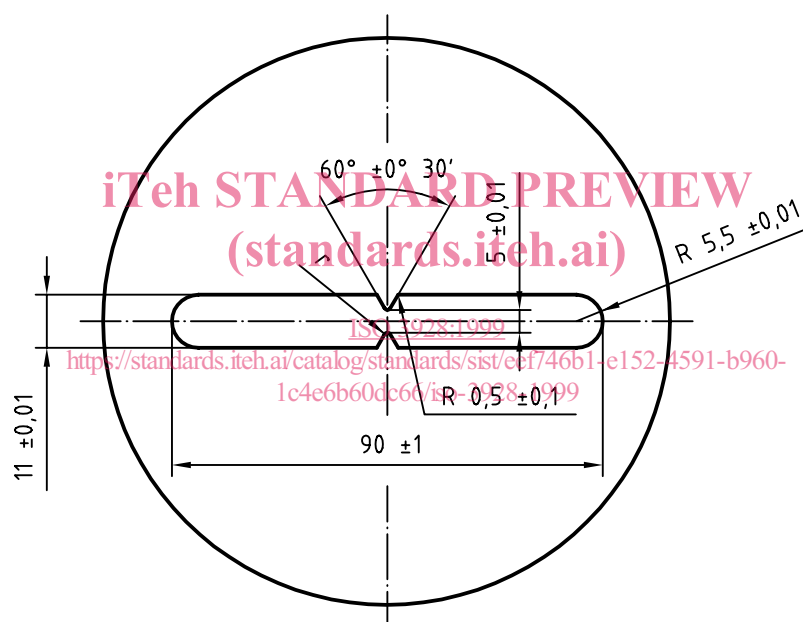
b) Die

Figure 1 — Unnotched test piece and compacting die for use with unnotched fatigue test pieces

Dimensions in millimetres



a) Test piece



b) Die

The stress concentration factor K_t depends upon radius R , as follows:

r	K_t axial loading	K_t reverse bending
0,9 ± 0,02	2,4	1,8
0,45 ± 0,02	3,2	2,4

Figure 2 — Notched test piece and compacting die for use with notched fatigue test pieces

Dimensions in millimetres

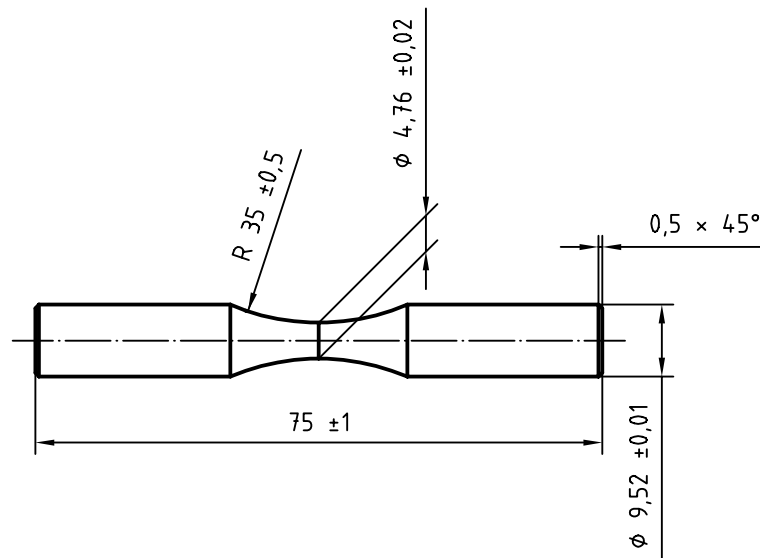


Figure 3 — Machined rotating beam fatigue test piece
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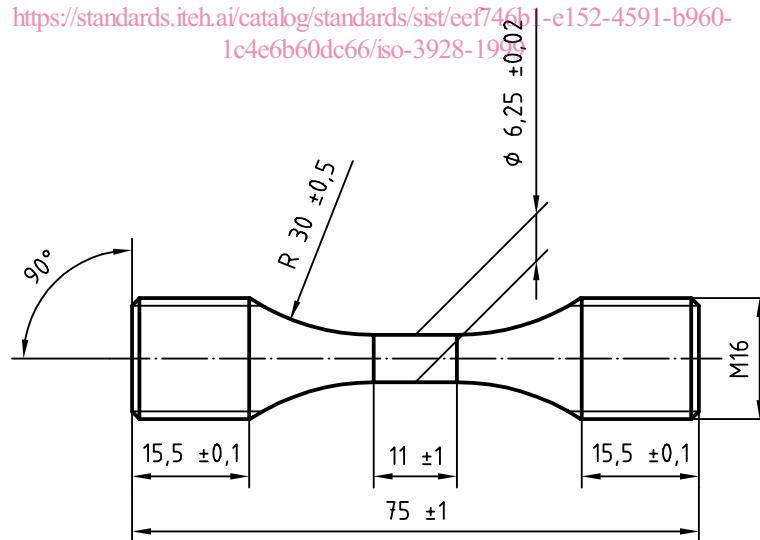


Figure 4 — Machined axial loading test piece

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.

Bibliography

- [1] ISO 296, *Machine tools — Self-holding tapers for tool shanks.*
- [2] ISO 1099, *Metals — Axial fatigue testing.*
- [3] ISO 1143, *Metals — Rotating bar bending fatigue testing.*
- [4] ISO 1352, *Steel — Torsional stress fatigue testing.*

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