INTERNATIONAL STANDARD 1352

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Steel — Torsional stress fatigue testing

Acier — Essais de fatigue par contrainte de torsion

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 1352 was developed by Technical Committee ISO/TC 17, *Steel*, and was circulated to the member bodies in November 1976. Subsequently, responsibility for this document has been transferred to ISO/TC 164, *Mechanical testing of metals*, which was set up in 1975.

It has been approved by the member bodies of the following countries :

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The member bodies of the following countries expressed disapproval of the document on technical grounds :

France
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Steel — Torsional stress fatigue testing

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies the conditions for carrying out torsional stress fatigue tests on test pieces having a nominal diameter between 5 and 12,5 mm without deliberately introduced stress concentrations. The tests are carried out at room temperature in air, by applying to the test piece a pure couple about its longitudinal axis.

The form, preparation and testing of test pieces of circular cross-section are specified, but component testing and other specialized forms of test are not included. Similarly, high strain torsional fatigue tests, which lead to failure in a few thousand cycles, are also excluded.

2 REFERENCES

ISO/R 373, *General principles for fatigue testing of metals.*

ISO/R 468, *Surface roughness.*

ISO 554, *Standard atmospheres for conditioning and/or testing.*

3 PRINCIPLE

Nominally identical test pieces are mounted in a torsional fatigue testing machine and subjected to the loading conditions required to induce cycles of torsional stress having the form of any one of the stress cycles illustrated in diagrams 4 to 7 of figure 3 in ISO/R 373.

NOTE — Diagrams 1 to 3 of figure 3 in ISO/R 373 are not relevant since in an axially symmetrical test piece, change of direction of mean torque does not induce a different type of stress system, and mean stress in torsion can always be regarded as positive in sign.

The purpose of the test is to determine fatigue properties such as the *S/N* curve as detailed in ISO/R 373, the test being continued until the test piece fails by complete fracture or until a pre-determined degree of cracking has been achieved or a predetermined number of stress cycles has been exceeded.

NOTES

1 The form of cracking experienced as a result of torsional fatigue testing may be of different configurations. Cracks may be parallel to the longitudinal axis of the test piece, or perpendicular to the longitudinal axis, or at any angle between these two.

2 Results of fatigue tests may be affected by atmospheric conditions, and if, by agreement, controlled conditions are required, these shall be as detailed in 2.1 of ISO 554 [see clause 11, paragraph e)].

4 SYMBOLS AND DEFINITIONS

In this International Standard the following symbols (see figures 1 and 2) are used.

Symbol	Definition
D	The diameter or width across flats of the gripped ends of the test piece. The value of D may be different for each end of the test piece
d	The diameter of the test piece where the stress is a maximum
L_c	The parallel length of the test piece
r	The transition blending radius at the ends of the test section which starts the transition from the test diameter d to the end diameter D [see figure 1a)], or the single radius between the gripped ends [see figure 1b)]

Further symbols and definitions relating to fatigue testing are given in ISO/R 373.

5 TEST PIECES

5.1 Form

The test section shall be either :

a) cylindrical with tangentially blending radii at each end of a parallel length, L_c [see figure 1a)], or

b) of continually varying circular cross-section, its surface formed by a single radius r, there being no central parallel portion.

The ends of the test piece shall be of a form to suit the holders of the machine being used and the material being tested. Screwed and plain cylindrical ends are not recommended. Typical test piece ends are shown in figure 2.

5.2 Dimensions

The nominal value of the diameter d shall be between 5 and 12,5 mm; the tolerance on diameter d shall be ± 0,05 mm.

For the purpose of calculating the torque to be applied to obtain the required stress, the actual diameter of each test piece shall be measured to an accuracy of 0,01 mm. Care should be taken during the measurement of the test piece prior to testing that the surface is not damaged.

In the case of a cylindrical test piece having a parallel test section, this test section shall have a length not greater than $5d$ and it shall be parallel within 0,02 mm. The transition blending radius at the end of the parallel test section shall have a radius not less than $3d$.

In the case of a test piece having a test section formed by a continuous radius, this radius shall be not less than $5d$.

a)

b)

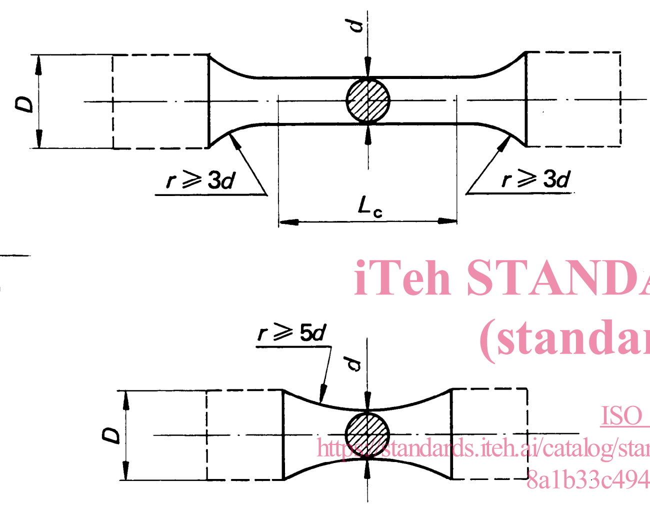

FIGURE 1 — **Forms of test piece**

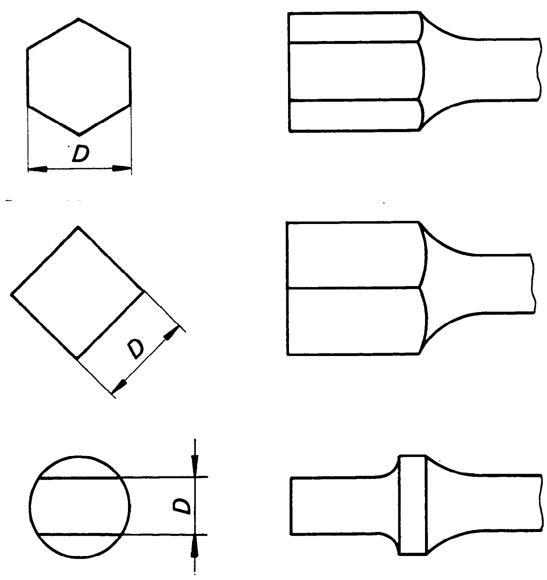

FIGURE 2 — **Typical test piece ends**

6 PREPARATION OF TEST PIECE

6.1 General

It is essential that any cutting or machining operation required, either to rough out the test piece from the blank, or to finish it to size, shall not alter the metallurgical structure or the mechanical properties of the test piece or induce substantial residual surface stress.

Care should be taken in the preparation of the ends of the test piece to ensure that the requirements of clause 7 can be met.

6.2 Turning

It is recommended that the following procedure be adopted :

6.2.1 In rough turning the test piece from a diameter $x + 5$ mm (x will generally be the diameter, d, plus a suitable allowance for surface finishing) to $x + 0{,}5$ mm, a succession of cuts of decreasing depth should be made, the recommended depths of cuts being :

1,25 mm, 0,75 mm and 0,25 mm.

6.2.2 From a diameter of $x + 0{,}5$ mm to x, a further succession of cuts of decreasing depths should be made, the recommended depths of cuts being :

0,125 mm, 0,075 mm and 0,05 mm,

using for these finishing cuts a feed not exceeding 0,06 mm per revolution.

6.3 Grinding

For test pieces in material which cannot be readily turned, it is recommended that the finishing operations be carried out by grinding. If the strength properties of the material are developed by heat treatment, this heat treatment may be carried out after rough turning to a diameter of $x + 0{,}5$ mm.

The test piece should then be ground to size. A succession of cuts of decreasing depth should be made, the recommended values being :

- 0,030 mm depth of cut to 0,1 mm oversize;
- 0,005 mm depth of cut to 0,025 mm oversize;
- 0,002 5 mm depth of cut to size.

6.4 Surface finishing

After the test section has been machined or ground to nominal dimensions, it shall be polished either by hand or by machine, using successively finer grades of abrasive papers or cloths. The polishing should generally be in a circumferential direction, although intermediate stages may be done in any direction, to ensure that scratches made by the coarser grades of abrasive papers, or cloths, are removed. The direction of the final polishing should mainly be circumferential.

The polishing sequences employed shall be such that the finished test section has a surface roughness R_a of less than 0,025 μm. It will usually be found satisfactory to arrange the sequence of polishing so that the last paper used is 600 grade.

6.5 Storage prior to testing

If deterioration of the surface has taken place during storage, the test piece shall be repolished to remove any surface defects, for example corrosion pits.

NOTE — The procedures given in 6.2, 6.3 and 6.4 represent standard practice for a wide range of materials. It should not be inferred that they are wholly applicable to all materials and to all heat-treated conditions of these materials. For example, the allowance of 0,5 mm on diameter x, for heat treatment prior to final grinding to size, may not be adequate. The purpose of this allowance is to permit the removal of surface phenomena associated with the heat treatment procedure such as decarburization, distortion, etc., and the allowance should be such as to ensure the complete removal of any features associated with such effects.

Some fatigue investigations may be undertaken to study the behaviour of material with particular surface finishes, for example rough machined or fine machined, or in the "as received" condition, in which case special conditions would apply.

7 MOUNTING OF TEST PIECE

The test piece shall be mounted in the testing machine in such a manner that stresses at the test section other than those imposed by the applied load are avoided and such that no bending stresses are introduced at the test section.

Care should be taken that the axis of the test piece lies along the axis of torsion of the testing machine.

8 SPEED OF TESTING

The frequency of the stress cycles will depend upon the type of testing machine employed and in many cases upon the stiffness of the test piece.

The testing speed chosen should be that which is most suitable for the particular combination of material, test piece and testing machine, having regard to the heating which can occur due to rapid dissipation of strain energy in the test piece.

9 APPLICATION OF TORQUE

The general procedure for attaining full torque running conditions should be the same for each test piece.

If frequencies are determined from the dynamic characteristics of the test piece and testing machine combination, it may be necessary to measure the stiffness of the test piece before commencement of testing.

In general, the application of the mean torque is followed by adjustment of the fluctuating torque.

During the early stages of the test, check the torque frequently to ensure that the required conditions are maintained. Then adjust and set the torque-maintaining devices and the test piece fracture cut-off switches.

At frequent intervals throughout the test period, monitor the torque to ascertain that the torque conditions have not changed.

The mean torque and the torque range, as determined by a suitable method of calibration, shall be accurate to within 3 % of their nominal values or to within 0,5 % of the maximum torque of the machine range employed, whichever is greater.

NOTE — Some users of torsional stress fatigue testing machines rely entirely on static calibration. However, the dynamic response of the machine may be appreciably different from the static behaviour, and for verifying the accuracy of the fluctuating torque a dynamic calibration is to be preferred. It is not considered feasible at the present time to attempt to standardize a method of calibration.

10 ENDURANCE

The *S/N* curve for certain materials shows a distinct change of slope after a given number of cycles, the curve becoming parallel to the horizontal axis. For other materials, the shape of the *S/N* curve may be continuous, becoming asymptotic with the horizontal axis. If *S/N* curves of the first type are experienced, it is recommended that the endurance used as a criterion of failure be 10^7 cycles. For *S/N* curves of the second type, the endurance should be 10^8 cycles.

11 TEST REPORT

The test report shall include the following :

a) the type and nominal dimensions of the test piece and surface finish of the test section;

b) the material tested, its metallurgical condition including details of any heat treatment and the references of any ISO publications to which the material was produced;

c) the frequency and the type of stress cycle, the minimum and maximum stress and the type of testing machine used;

d) where practicable, the temperature of the test piece, if this is significantly higher than that of the test environment;

e) the range of relative humidity, if this is outside the range of 50 to 70 % (the range of relative humidity should be measured every day throughout the duration of the test);

f) any deviation from the specified conditions during the test;

g) the criterion of failure, if other than complete failure of the test piece, for example 10^7 or 10^8 cycles.

NOTES

1 In the majority of fatigue determinations the criterion of failure is either the occurrence of visible fatigue cracks or a complete fracture. It should be noted, however, that for particular applications other criteria, for example plastic deformation of the test piece or rate of crack propagation, may be adopted to determine the end of the test.

If required, and particularly if low frequencies and high stresses are employed, the criterion of failure shall be the subject of agreement.

2 Test results may be presented graphically in one of the forms given in ISO/R 373.