
Metallic materials — Fatigue testing — Axial plane bending method

*Matériaux métalliques — Essais de fatigue — Méthode par flexion
plane axiale*

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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 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 4, *Fatigue, fracture and toughness testing*.

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.

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Metallic materials — Fatigue testing — Axial plane bending method

1 Scope

This document specifies the conditions for conducting the plane bending fatigue test on an axial machine, constant-amplitude, force or displacement controlled, at room temperature (ideally between 10 °C and 35 °C) on metallic specimens, without deliberately introduced stress concentrations. This document does not include the reversed/partially loading test. The purpose of the test is to provide relevant results, such as the relation between applied stress and number of cycles to failure for a given material condition, expressed by hardness and microstructure, at various stress ratios.

Although the shape, preparation and testing of specimens of rectangular and bevelled cross-section are specified, component testing and other specialized forms of testing are not included in this document.

Fatigue tests on notched specimens are not covered by this document since the shape and size of notched test pieces have not been specified in any standard so far. Guidelines are given in [Annex A](#). However, the fatigue-test procedures described in this document can be used for testing such notched specimens.

It is possible for the results of a fatigue test to be affected by atmospheric conditions. Where controlled conditions are required, ISO 554:1976, 2.1 applies.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

ASTM E2309/E2309M, *Standard Practices for Verification of Displacement Measuring Systems and Devices Used in Material Testing Machines*

3 Terms and definitions

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

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

thickness of test section

δ

thickness of reduced section of rectangular test specimen

Note 1 to entry: See [Figure 1](#).

3.2
width of test section

w
width of reduced section of rectangular test specimen

Note 1 to entry: See [Figure 1](#).

3.3
specimen length

L_z
overall length of test specimen

3.4
specimen cross-section

S
surface of the specimen cross-section

3.5
corner radius

r_c
radius of the corner of rectangular cross-section specimen

3.6
distance between inner loading points

d_1
distance between the axes of the two inner rollers

Note 1 to entry: See [Figure 3](#).

3.7
distance between outer loading points

d_2
distance between the axes of the two outer rollers

Note 1 to entry: See [Figure 3](#).

3.8
roller diameter

D_R
diameter of the four rollers

3.9
stress cycle

smallest segment of stress-time that is repeated identically

Note 1 to entry: See [Figure 4](#).

3.10
maximum stress

$\sigma_{\max}$
greatest algebraic value of stress in a stress cycle

Note 1 to entry: See [Figure 4](#).

3.11
mean stress

σ_m
one-half the algebraic sum of the maximum stress and the minimum stress in a stress cycle

Note 1 to entry: See [Figure 4](#).

3.12 minimum stress

$\sigma_{\min}$
least algebraic value of stress in a stress cycle

Note 1 to entry: See [Figure 4](#).

3.13 stress amplitude

σ_a
one-half the algebraic difference between the maximum stress and the minimum stress in a stress cycle

Note 1 to entry: to entry:

$$\sigma_a = \Delta\sigma/2$$

Note 2 to entry: See [Figure 4](#).

3.14 stress range

$\Delta\sigma$
arithmetic difference between the maximum and minimum stress

Note 1 to entry: to entry:

$$\Delta\sigma = \sigma_{\max} - \sigma_{\min}$$

Note 2 to entry: See [Figure 4](#).

3.15 stress ratio

R_σ
ratio of minimum to maximum stress during any single cycle of fatigue operation

Note 1 to entry: to entry:

$$R_\sigma = \sigma_{\min}/\sigma_{\max}$$

Note 2 to entry: See [Figure 5](#).

3.16 load ratio

R_F
ratio of minimum to maximum load during any single cycle of fatigue operation

Note 1 to entry: to entry:

$$R_F = F_{\min}/F_{\max}$$

Note 2 to entry: See [Figure 5](#).

3.17 number of cycles

N
number of smallest segments of the force-time, stress-time, strain-time, etc., function that is repeated periodically

3.18 fatigue life

N_f
number of applied cycles to achieve a defined failure criterion

3.19 applied force

F
force applied during the test (for force-controlled test)

3.20 bending moment

M
constant moment between the inner rollers, calculated with the applied force and the distances between the rollers (d_1 and d_2)

Note 1 to entry: to entry:

$$M = \frac{F}{4}(d_2 - d_1)$$

4 Symbols

4.1 Symbols related to specimen geometry

Symbol	Designation	Unit
δ	Thickness of test section	mm
δ_1	Reduced thickness of the bevelled specimen	mm
w	Width of test section	mm
w_1	Reduced width of the bevelled specimen	mm
L_z	Specimen length	mm
I	Second moment of area	mm ⁴
d_{nba}	Maximum distance from the neutral bending axis	mm
S	Specimen cross-section	mm ²
r_c	Corner radius	mm

4.2 Symbols related to testing device

Symbol	Designation	Unit
d_1	Distance between inner loading points	mm
d_2	Distance between outer loading points	mm
D_R	Roller diameter	mm

4.3 Symbols related to fatigue test

Symbol	Designation	Unit
β_{hi}	Stress homogeneity for load i	
$\sigma_{\max}$	Maximum stress	MPa

Symbol	Designation	Unit
σ_m	Mean stress	MPa
σ_{min}	Minimum stress	MPa
σ_a	Stress amplitude	MPa
$\Delta\sigma$	Stress range	MPa
σ	Test stress	MPa
R_σ	Stress ratio	
R_F	Load ratio	
N	Number of cycles	cycles
N_f	Fatigue life	cycles
F	Applied force	N
M	Bending moment	N-m

5 Principle of test

The principle of the test is to place a specimen between four rollers as shown in [Figure 3](#). Then a constant amplitude cyclic force is applied so that a constant amplitude tension stress is applied to the tested surface of the specimen. The test is then continued until the specimen fails or until a predetermined number of stress cycles is reached.

Nominally identical specimens are mounted on a fatigue testing machine and subjected to the loading condition required to introduce cycles of plane bending stress. Any one of the types of cyclic stress illustrated in [Figure 5](#) may be used. The test waveform shall be constant-amplitude sinusoidal.

6 Test plan

6.1 General outline

Before commencing testing, the following shall be agreed by the parties concerned, unless specified otherwise in the relevant product standard:

- The form of specimen to be used (see [7.1](#));
- The stress ratio(s) to be used;
- The objective of the tests, i.e., which of the following is to be determined:
 - the fatigue life at a specified stress amplitude;
 - the fatigue strength at a specified number of cycles;
 - a full Wöhler or S-N curve;
- The number of specimens to be tested and the testing sequence;
- The number of cycles at which a test on an unfailed specimen shall be terminated.

7 Specimen

7.1 Shape of specimens

The specimens are generally fully machined with a rectangular cross-section of uniform thickness over the test section. In order to avoid crack initiation from corners, two solutions may be considered:

- machining of a radius on each corner ([Figure 1](#));

- use of a bevelled cross-section specimen^[8] (Figure 2)

When it is desired to take account of the surface condition in which the metal will be used in actual application, the surface of maximum stress should remain unmachined.

7.2 Size of specimen

In order to have a minimum influence of the shear stress on the bending stress (lower than 5 %, expressed in Von Mises equivalent stress), the following ratio [Formula (1)] shall be respected:

$$\frac{\delta}{d_2 - d_1} < 0,5 \quad (1)$$

Due to the bending of the specimen, the distance between the contact points of the rollers on the specimen changes when the load is applied. This change affects the stress level in the specimen compared with the value calculated in Clause 9.

The error between the calculated stress, σ_{cal} , and the real stress, σ_{real} , is proportional to the roller diameter and can be approximated using Formula (2). This error shall be lower than 5 %.

$$\frac{\sigma_{\text{cal}} - \sigma_{\text{real}}}{\sigma_{\text{cal}}} = \frac{3D_R (d_2 + 3d_1)}{(d_2 - d_1)^2 (d_2 + 2d_1)} \Delta r \quad (2)$$

where the maximum displacement of the grips during the test, Δr , can be determined with Formula (3):

$$\Delta r = \frac{M}{12EI} (d_2 - d_1) (d_2 + 2d_1) \quad (3)$$

where

E is the Young modulus of the tested specimen material.

7.3 Preparation of specimens

7.3.1 General

In any fatigue-test programme designed to characterize the intrinsic properties of a material, it is important to observe the following recommendations in the preparation of specimens. A deviation from these recommendations is possible if the test programme aims to determine the influence of a specific factor (surface treatment, oxidation, etc.) that is incompatible with these recommendations. In all cases, these deviations shall be noted in the test report.

The surface conditions of the specimens have an effect on the test results. This effect is generally associated with one or more of the following factors:

- the specimen surface roughness;
- the presence of residual stresses;
- alteration in the microstructure of the material;
- introduction of contaminants.

The recommendations given in 7.3.2, 7.3.3 and 7.3.4 allow for the influence of these factors to be reduced to a minimum.

7.3.2 Machining procedure

7.3.2.1 General

The machining procedure selected can produce residual stresses on the specimen surface that are likely to affect the test results. These stresses can be induced by heat gradients at the machining stage, stresses associated with deformation of the material, or microstructural alterations. Their influence is less when tested at high stress levels because they can be partially or totally relaxed. However, they shall be reduced by using an appropriate final machining procedure, especially prior to a final polishing stage.

It is recommended to check for such surface residual stresses using X-ray diffraction techniques, for example.

The surface roughness is commonly quantified by the mean roughness value or equivalent (e.g. ten-point roughness or maximum height of irregularities)^[1]. An arithmetic mean deviation of less than 0,2 µm (or equivalent) shall be specified.

Because the fatigue life is more dependent on local roughness, maximum height of profile value gives additional information on the surface roughness and thus shall be measured and reported.

Another important parameter not covered by mean roughness is the presence of localized machining scratches. Final grinding followed by longitudinal mechanical polishing is particularly recommended. A low magnification check (approximately ×20) shall not show any transverse scratches within the gauge length.

Longitudinal grinding rather than tool operation (milling) followed by polishing may be preferred.

If heat treatment is to be carried out after rough finishing of the specimens, it is preferable to carry out the final polishing after the heat treatment. If this is not possible, the heat treatment should be carried out in a vacuum or in inert gas to prevent oxidation of the specimen. This treatment shall not alter the microstructural characteristics of the material under study. The specifics of the heat treatment and machining procedure shall be reported with the test results.

In order to avoid premature crack initiation for raw corners, it is recommended to round angles by polishing or even better to machine a given radius.

7.3.2.2 Alteration of the microstructure of the material

This phenomenon can be caused by an increase in temperature and/or by strain-hardening induced by machining or grinding. It can be a matter of a change in phase or, more frequently, of surface recrystallization. The immediate effect of this is to make a test invalid, as the material tested is no longer the initial material. Every precaution should therefore be taken to avoid this risk.

If there is any doubt, a microstructure of the surface of the specimen shall be completed.

7.3.2.3 Introduction of contaminants

The mechanical properties of certain materials deteriorate when in the presence of certain elements or compounds. An example of this is the effect of chlorine on steels and titanium alloys. These elements shall therefore be avoided in the products used (cutting fluids, etc.). Rinsing and degreasing of specimens prior to storage is also recommended.

7.3.3 Sampling and marking

The sampling of test materials from a semi-finished product or a component can have a major influence on the results obtained during the test. It is therefore necessary for this sampling to be carried out

with full knowledge of the situation. If necessary, a sampling drawing, attached to the test report, shall indicate clearly:

- the position of each specimen;
- the characteristic directions in which the semi-finished product has been worked (direction of rolling, extrusion, etc., as appropriate);
- the marking/identifying of each of the specimens.

The specimens shall carry a mark/identification during each different stage of their preparation. Such a mark/identification may be applied using any reliable method in an area not likely to disappear during machining or likely to adversely affect the quality of the test.

Before testing, identification shall be applied to each end of the specimen.

7.3.4 Dimensional checks

The dimensions should be measured on completion of the final machining stage using a method of metrology that does not alter the fatigue test result.

7.3.5 Storage and handling

After preparation, the specimens should be stored so as to prevent any risk of damage (scratching by contact, oxidation, etc.). The use of individual container is recommended. In certain cases, storage in a vacuum or in a desiccator filled with silica gel is necessary.

Handling should be reduced to the minimum necessary. Particular attention shall be given to avoid any mark or scratch.

8 Apparatus

8.1 Testing machine

8.1.1 Introduction

The tests shall be carried out on a tension-compression machine, designed for a smooth start-up. For a negative load ratio, no backlash when passing through zero is required. The machine shall have lateral rigidity and accurate alignment.

The testing machine and its control and measurement systems should be checked regularly.

Specifically, each transducer and associated electronics shall always be checked as a unit.

8.1.2 Force transducer

The force transducer shall have axial and lateral rigidity. Its capacity shall be suitable for the forces applied during the test. It shall be fatigue rated and suitable for the forces applied during the test. The indicated force as recorded at the output from the computer in an automated system, or from the final output recording device in any non-automated system, shall be within the specified permissible variation from the actual force. The load cell capacity shall be sufficient to cover the range of loads measured during a test to an accuracy of better than 1 % of the reading. The load cell shall be temperature-compensated and not have zero drift or sensitivity variation greater than 0,002 % of full scale per 1 °C.

The testing machine force-measuring system shall be verified statically in accordance with ISO 7500-1, Class 1. It shall be ensured that incremental dynamic force-measurement errors do not exceed ± 1 % of the demanded force range.

NOTE 1 It is very important to recognize the importance of dynamic (inertia force) errors introduced by the mass between the load cell and the test specimen. Inertia force error = the grip mass multiplied by its local acceleration. Inertia force errors, expressed as a percentage of force range, can be expected to vary with the square of the frequency and are strongly influenced by specimen compliance. The testing machine (rigid body) resonance on its mountings can be a dominant error source.

The testing machine with the specific load cell, grips and couplings used for dynamic testing and a strain-gauged specimen or dynamometer, of similar conformance to the test specimens, should be verified for dynamic force measurement over the frequency range of interest.

NOTE 2 To avoid dynamic errors $> \pm 1$ % of force range, it can be necessary to create an error table to correct the dynamic force range of the testing machine (see ISO 4965-1 and ISO 4965-2).

8.1.3 Displacement transducer

If tests are performed under displacement control, the displacement measuring system shall be calibrated in accordance with ASTM E2309 class 1.

8.1.4 Cycle counter

The machine shall be equipped with a cycle-counting system accurate to 1 % and with error trips to shut down the machine when the specimen fails.

8.1.5 Instrumentation for test monitoring

It is common for fatigue test equipment nowadays to be computer controlled and equipped with digital data acquisition systems. Basic software platforms provided in modern digital systems provide accurate test control as well as report generation. They are typically equipped to provide real-time numerical displays in either the digital or analogue domain of test data as well as generation and storage of graphical and tabular test results.

In such a typical digital system, the sampling frequency of force-time data points shall be sufficient to ensure correct definition of the peak forces imposed upon the specimen.

Since there are a number of analogue systems still in use, the following shall be considered a minimum requirement for the analogue recording of data:

- a recorder for force – time;
- a peak-to-peak detector.

8.1.6 Anti-rotation system

To ensure the alignment of the two parts of the testing device during all the test duration, the test machine shall be equipped with an anti-rotation system.

8.2 Testing device

A general schematic drawing is given [Figure 3](#).

The gripping device shall ensure that the assembly of the specimen is reproducible.

The rollers are important parts of the test rig:

- their hardness shall be greater than 50 HRC in order to avoid any plastic deformation;
- their width shall be greater than the specimen width;

- their diameter shall be in accordance with [subclause 7.2](#);
- their diameter should not be too small for avoiding indentation of the specimen;
- their relative position (parallelisms) shall be in accordance with the stress homogeneity stress requirements (see [Clause 10](#)).

NOTE The diameter of the rollers generally have the same value.

9 Stress calculation

9.1 Introduction

The test stress is calculated according to [Formulae \(4\)](#) and [\(5\)](#):

$$\sigma = \frac{M}{I} d_{nba} \quad (4)$$

$$M = \frac{F(d_2 - d_1)}{4} \quad (5)$$

9.2 Rectangular cross-section

9.2.1 Angular corner

$$I = \frac{w\delta^3}{12} \quad (6)$$

$$d_{nba} = \frac{\delta}{2} \quad (7)$$

9.2.2 Rounded corner

$$I = \frac{w\delta^3}{12} - r_c^2 \left(\frac{4r_c^2}{3} + \delta^2 - 2\delta r_c \right) + 2r_c^2 \left(\frac{\pi r_c^2}{8} - \frac{8r_c^2}{9\pi} + \frac{\pi}{2} \left(\frac{4r_c}{3\pi} + \frac{\delta}{2} - r_c \right)^2 \right) \quad (8)$$

$$d_{nba} = \frac{\delta}{2} \quad (9)$$

9.3 Bevelled cross-section

$$S = w\delta - \frac{(\delta - \delta_1)(w - w_1)}{2} \quad (10)$$

$$I = \frac{(w - w_1)(\delta^3 + \delta^2\delta_1 + \delta\delta_1^2 + \delta_1^3)}{12} + \frac{w_1\delta^3}{3} - S(\delta - d_{nba})^2 \quad (11)$$

$$d_{nba} = \delta - \frac{1}{S} \left[\frac{(w - w_1)(\delta^2 + \delta_1^2 + \delta\delta_1)}{3} + \frac{w_1\delta^2}{2} \right] \quad (12)$$

10 Stress homogeneity check

10.1 Principle

Stress inhomogeneity is generally caused by the relative position of the rollers coming from machine misalignment or geometry imperfection of the system.

The stress homogeneity shall be checked before each series of tests or any time a change is made to the force train.

The recommended geometry and material of the homogeneity device used to measure the stress homogeneity should be as close as possible as the test specimen ones.

Four strain gauges (arranged in two sets of two) shall be numbered and positioned on the tensile surface as shown in [Figure 6](#). The strain gauges shall all be matched, i.e. from the same manufacturer's batch. It is recommended they have active lengths of approximately $0,1 d_1$ or less.

10.2 Measurement method

- 1) Connect the lead wires of the strain gauges to the conditioning equipment and allow the system to stabilise under power for at least 30 min.
- 2) Install the homogeneity device in test system so that the distance between the gauges and the closer roller is approximatively $0,25 d_1$.
- 3) Zero the strain gauges.
- 4) Apply a series of ten force increments equally spaced up to the maximum estimated force of the fatigue tests and record the corresponding readings of the strain gauges. Return to zero force.

10.3 Calculations

The quality of the stress homogeneity for each load, i , is given by [Formula \(13\)](#).

$$\beta_{hi} = \max_{(j=1 \text{ to } 4)} \left(\frac{\varepsilon_j - \varepsilon_{\text{mean}}}{\varepsilon_{\text{mean}}} \right) \quad (13)$$

Where $\varepsilon_1, \varepsilon_2, \varepsilon_3, \varepsilon_4$ are the readings of strain gauges.

$$\varepsilon_{\text{mean}} = \left(\frac{\varepsilon_1 + \varepsilon_2 + \varepsilon_3 + \varepsilon_4}{4} \right) \quad (14)$$

The global stress homogeneity is the maximum value of the stress homogeneity over the 10 load levels.

For meaningful measurements it is essential to establish the repeatability of specimen positioning in the test system.

To do so, calculate the mean and standard deviation values obtained from 5 measurements of the stress homogeneity for the maximum load. To assure a good repeatability, the standard deviation value shall not exceed 5 % of the mean value.

11 Test procedure

11.1 Mounting of testing device

The testing device should be mounted to ensure the parallelism and position of the rollers. A simple way to do so is to machine a specific specimen with V-grooves corresponding to the roller positions (See [Figure 7](#)).

The rotation of both parts of the testing device shall be avoided.

11.2 Mounting of specimen

Care should be taken to ensure that each test specimen is located symmetrically both in longitudinal and transversal directions.

During the specimen mounting, attention shall be given to avoid any mark or scratch on the tested surface.

11.3 Rate of testing

The frequency of the force cycle will depend upon the type of testing machine employed and, in many cases, upon the stiffness of the test piece.

The frequency chosen shall be that most suitable for the particular combination of material, test piece and testing machine. If the 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 testing is started.

NOTE 1 The frequency range of axial force-controlled fatigue-testing machines in common use is approximately 1 to 100 Hz.

At high frequencies, substantial heating of the specimen can occur, that can affect the test result of fatigue life and strength. If heating occurs, it is advisable to decrease the test frequency. If the specimen temperature exceeds 35 °C, the temperature shall be recorded.

NOTE 2 If the influence of the environment is significant, the test result is likely to be frequency dependent.

11.4 Application of force or displacement

The test procedure shall ensure that the number of cycles for attaining the aimed running conditions shall be the same for each specimen. This period should be as short as possible and shall not exceed 1 % of the fatigue life of specimen.

For load-controlled tests, the mean force and force range shall be maintained to within ± 1 % of the force range.

For displacement-controlled tests, the mean displacement and displacement range shall be maintained to within ± 1 % of the displacement range.

11.5 Recording of temperature and humidity

The test is typically conducted at ambient temperature (ideally between 10 °C and 35 °C). The maximum and minimum air temperature and humidity shall be recorded daily for the duration of the test.

11.6 Criterion of failure and test termination

11.6.1 Criterion of failure

Unless agreed otherwise, the criterion of failure shall be test piece separation.

In particular applications, another criterion such as occurrence of a visible fatigue crack, plastic deformation of the test piece or rate of crack propagation, may be adopted but shall be the same for all specimens of the batch.

11.6.2 Test termination

The test is terminated when either the specimen fails or a predetermined number of cycles has been applied, as agreed upon by the concerned parties.

11.7 Test validity

After a test is terminated and the tested specimen is broken, it is necessary to inspect the specimen in order to validate or invalidate the test result. A test shall be declared non-valid and the result not considered when:

- failure occurs outside the tested area (i.e. outside the inner rollers);
- crack initiates from the corner of the cross-section.

12 Presentation of fatigue results

The design of the investigation, and the use to be made of the results, govern the choice of the most suitable method of presenting the results from the many available, graphically and otherwise. The results of fatigue tests are usually presented graphically. In reporting fatigue data, the test conditions should be clearly defined. In addition to graphical presentations, tabulated numerical data are desirable where the presentation format permits.

For all details, refer to ISO 12107.

13 Test report

The test report shall include the following information for the test series, if available:

- a) a reference to this document with its publication date, i.e. ISO 22407:2021;
- b) the tested material, its metallurgical characteristics, mechanical properties, and any heat treatment given to the test piece(s);
- c) the location of the test piece(s) in the parent material;
- d) the form and nominal dimensions of the test piece(s);
- e) the surface condition of the test piece(s);
- f) the reference of the load or displacement cell;
- g) the reference of the test device;
- h) the device characteristics (L_1 , L_2 , D);
- i) the waveform;
- j) the controlled parameter (i.e., force or displacement);
- k) the frequency of tests;
- l) the specimen geometry;
- m) the load ratio (i.e. force or displacement);
- n) criterion of failure

The test report shall include the following information for each individual test piece:

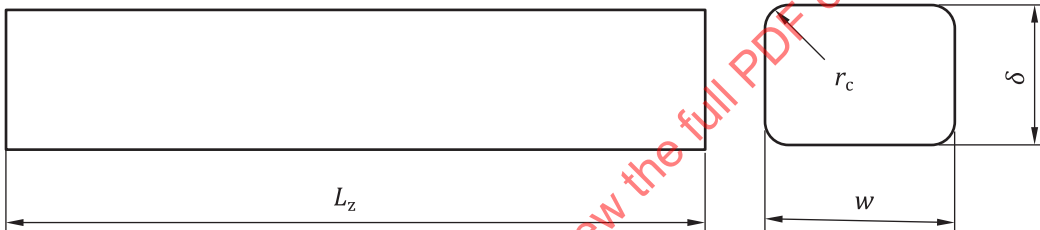
- 1) the specimen dimensions;

- 2) for force-controlled test, the applied stress conditions (maximum, minimum, amplitude);
- 3) the tests results (fatigue life, specimen broken or not, location of the crack initiation);
- 4) description of testing machine used: type, serial number, load cell and serial number, number and load train description;
- 5) the temperature of the test specimen if heating occurs (i.e. greater than 35 °C);
- 6) the maximum and minimum air temperature and relative humidity;
- 7) any special observations or deviations from the required test conditions;
- 8) the date of the test.

Additionally, the test results can be presented graphically.

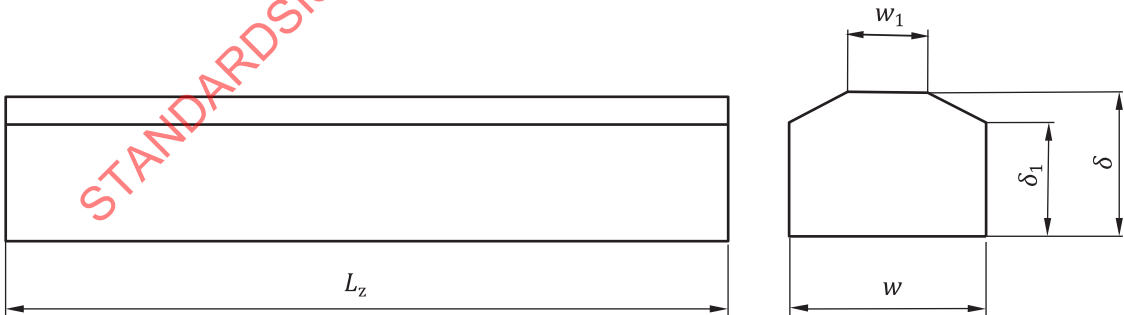
14 Measurement uncertainty

Uncertainty analysis is useful for identifying significant sources that may contribute to the uncertainty of the test results. Uncertainty estimation in accordance with GUM^[2]-based protocol is recommended.



- Key
- L_z specimen length
 - w specimen width
 - δ specimen thickness
 - r_c corner radius

Figure 1 — Rectangular cross-section specimen geometry



- Key
- L_z specimen length
 - w specimen width
 - δ specimen thickness
 - w_1 width of test section (see 3.2)
 - δ_1 thickness of reduced section of bevelled test specimen

Figure 2 — Bevelled cross-section specimen geometry^[8]