

BS EN 6072:2010



BSI Standards Publication

Aerospace series — Metallic materials — Test methods — Constant amplitude fatigue testing

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW

National foreword

This British Standard is the UK implementation of EN 6072:2010.

The UK participation in its preparation was entrusted to Technical Committee ACE/61, Metallic materials for aerospace purposes.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© BSI 2010

ISBN 978 0 580 69120 1

ICS 49.025.05

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 September 2010.

Amendments issued since publication

| Date | Text affected |
|------|---------------|
|------|---------------|

ICS 49.025.05

English Version

**Aerospace series - Metallic materials - Test methods - Constant
amplitude fatigue testing**Série aérospatiale - Matériaux métalliques - Méthodes
d'essai - Essai de fatigue à amplitude constanteLuft- und Raumfahrt - Metallische Werkstoffe -
Prüfverfahren - Ermüdungstest mit konstanter Amplitude

This European Standard was approved by CEN on 25 December 2009.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG**Management Centre: Avenue Marnix 17, B-1000 Brussels**

Contents

Page

| | |
|--|----|
| Foreword..... | 3 |
| 1 Scope | 4 |
| 2 Normative references | 4 |
| 3 Terms and definitions | 4 |
| 4 Principles of the method..... | 5 |
| 5 Apparatus | 5 |
| 6 Test specimens | 5 |
| 7 Procedure | 6 |
| 8 Analysis of test results | 7 |
| 9 Test report | 7 |
| Annex A (normative) Axial Fatigue - Cylindrical specimen | 13 |
| Annex B (normative) Axial Fatigue - Flat specimen ($K_t = 1,0$)..... | 17 |
| Annex C (normative) Axial Fatigue - Flat specimen - "T-Type" and mini "T-Type" specimen ($K_t = 2,3$) | 19 |
| Annex D (normative) Bending Fatigue - Flat specimen | 22 |
| Annex E (normative) Recommendations for machining procedure of specimen | 24 |
| E.1 Cylindrical specimens..... | 24 |
| E.2 Flat specimens | 27 |
| Annex F (normative) Indication of failure sites..... | 30 |
| Annex G (normative) Table of fatigue test results..... | 31 |
| Annex H (normative) Representation of fatigue data | 32 |
| Annex I (informative) Example of inspection card process..... | 33 |

Foreword

This document (EN 6072:2010) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2010, and conflicting national standards shall be withdrawn at the latest by December 2010.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard defines a method to determine constant amplitude fatigue data of metallic materials and the S-N curve (or Wöhler curve).

2 Normative references

The following referenced documents are indispensable for the application 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 286-1, *ISO system of limits and fits — Part 1: Bases of tolerances, deviations and fits*

ISO 965-1, *ISO general-purpose metric screw threads — Tolerances — Part 1: Principles and basic data*

ISO 1101, *Geometrical Product Specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out*

ASTM E 466, *Standard practice for conducting force controlled constant amplitude axial fatigue tests of metallic materials*¹⁾

ASTM E 1823, *Standard terminology relating to fatigue and fracture testing*¹⁾

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ASTM E 1823 and the following apply.

3.1 Direction of test samples

3.1.2

cylindrical specimens

the direction of the sample is identified by the following symbols:

- L : Long (grain flow direction);
- LT : Long Transverse;
- ST : Short Transverse.

The directions of semi-finished products of rectangular cross section for rolled or extruded products and forgings are identified on Figure 1.

The directions of semi-finished products of circular cross section for rolled products and forged rings are identified on Figure 2.

3.1.2

flat specimens

designation for direction of these specimens is identical to ASTM designation:

Two letters separated by a dash:

- First letter : direction of load
- Second letter : direction of crack propagation

The directions of semi-finished products of rectangular cross section for rolled or extruded products and hand forgings are identified on Figure 3.

¹⁾ Published by: American Society for Testing and Materials (ASTM), 1916 Race Street, Philadelphia, PA 19103, USA.

The directions of semi-finished products of circular cross section for drawn or extruded products and hand forgings are identified on Figure 4.

4 Principles of the method

See ASTM E 466.

5 Apparatus

See ASTM E 466 (calibrating to ISO 7500-1 is also acceptable).

6 Test specimens

6.1 General

Test specimens shall be prepared according to the requirements of the relevant Process or Material Standard.

6.2 Geometry

The geometry of test specimens is described in Annexes A to D.

6.3 Machining

6.3.1 Dimensional tolerances

Machining tolerances (according to ISO 286-1) on transverse dimensions: ISO js 12.

Form tolerances (according to ISO 1101) = ISO IT9.

Specimens shall be machined cold, without generating surface hardening nor appreciable heating of the metal.

Recommendations for machining procedure of specimens are given in Annex E for each type of specimen.

Final machining to comply with the tolerances and to obtain the surface finish required on the calibrated section (see Annexes A to D).

6.3.2 Specimens to be heat-treated

The heat treatment should preferably be applied to the specimen blanks to avoid distortion, which cannot be corrected by machining.

Final machining after heat treatment, in accordance with 6.3.1.

NOTE For steels treated to obtain a high UTS, it may be necessary to machine the specimens to the final dimensions in the as-delivered condition and then protect them before heat treatment.

In general, the surface of steel and aluminium alloys specimens shall be:

- either protected against corrosion by an appropriate product,
- or machined only shortly before carrying out the test.

6.3.3 Grinding

Grinding of steel and titanium specimens shall only be carried out when a process is available which guarantees no detrimental effects to the specimen surface, for example contamination.

6.4 Straightening

It is strictly forbidden to straighten a distorted specimen.

Such distortion can arise from heat treatment on specimens machined to their final dimensions.

The surface hardening generated by the mechanical equipment used to straighten the specimens affects the mechanical properties and gives unrepresentative results.

7 Procedure

7.1 Number of specimens

A minimum of 10 fatigue specimens with valid results is necessary to determine a Wöhler curve.

Upon request, a static loaded specimen shall be performed.

7.2 Measurements of specimen dimensions

The dimensions of the test specimens shall be measured before testing and the results reported in the test report (see Clause 9).

7.3 Test procedure

Load ratio R and K_t factor are given in the relevant Process or Material Standard.

The test frequency shall be not more than 170 Hz. For frequency greater than 50 Hz, it is advisable to carry dynamic calibrations on test work.

The choice of load levels shall be done in order that test results can be regularly positioned on the S-N curve between at least 10^4 and $3 \cdot 10^6$ cycles, so that a Wöhler curve can be raised. For qualification of materials, cycling must not be stopped before $3 \cdot 10^6$ cycles, unless other conditions are specified. In case of non-failure at $3 \cdot 10^6$ cycles (or more), specimen can be tested again at a higher load level that will lead to failure before 10^5 cycles. Test results must mention that specimen has been tested after a non-failure so that analysis can take it into account.

NOTE For load ratio $R < 0$, it is recommended to use anti buckling equipment.

The breaking near the grip and the associated number of cycles shall be mentioned in the test report (see Clause 9). In this case the specimen should be clamped again (if possible) and the test should be continued at the same load level.

In order to check the reproducibility and friability of test machine, an example of inspection card is given in Annex I.

8 Analysis of test results

8.1 Failure of specimens

After testing, specimens shall be examined. Failure type and sites shall be indicated (see Annex F).

8.2 Presentation of fatigue data

All the values measured and calculated from the specimens shall be reported in a table (see Annex G).

The cross section of the specimen, which has been used for calculation, shall be indicated.

8.3 Plot of the Wöhler curve

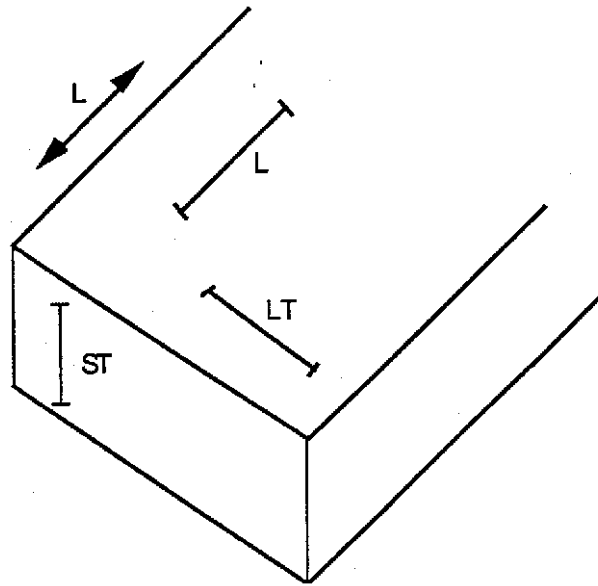
All the individual results shall be represented in a log (or semi-log) scale scheme: max. stress in MPa, σ , versus Fatigue life, number of cycles, N (see Annex H).

The analysis of the test results shall generate a mean Wöhler curve with 50 % probability of failure, in addition two curves for minimum and for maximum probability of failure.

9 Test report

The test report shall refer to the test method and shall include the following:

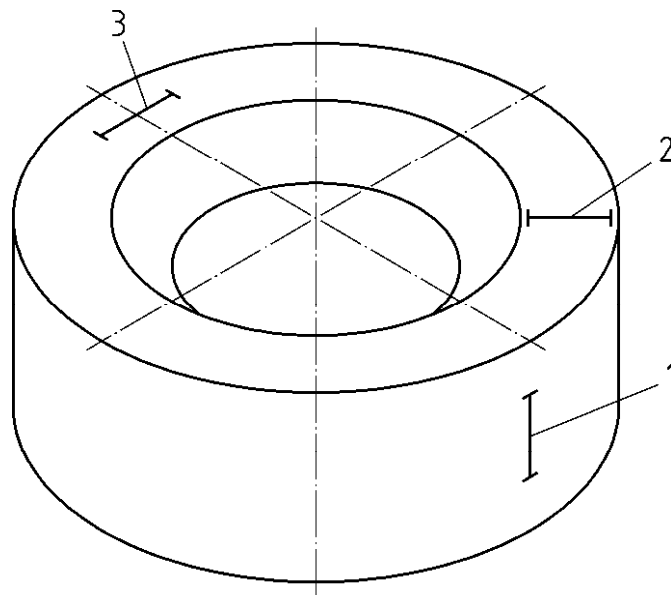
- Complete identification of the tested material including the manufacturers Name, Designation, and Batch Number.
- All details relating to the preparation of the specimens.
- All relevant dimensions of the specimens.
- Date of test and traceability to the individual performing the test work.
- Conditioning.
- Equipment used and test parameters (R ratio, test frequency, orientation ...).
- Recorded plots/graphs (with all the points).
- Individual test results and type of failure (see Annex F and Annex G).
- Any incident which may have affected the results, and any deviation from the test method.



Key

- L : Long (grain flow direction)
- LT : Long Transverse
- ST : Short Transverse

Figure 1 — Cylindrical specimens - Direction of semi-finished products of rectangular cross section



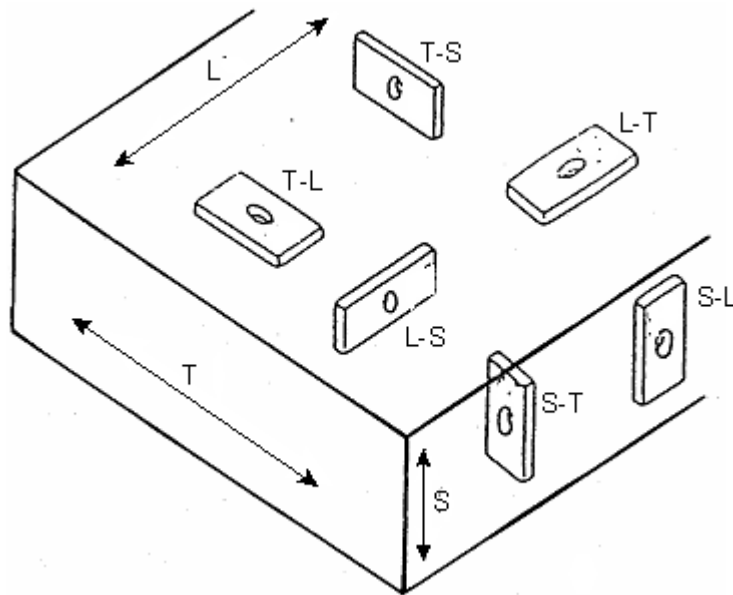
Key

- 1 Axial: corresponds to LT direction
- 2 Radial: corresponds to ST direction
- 3 Tangential: corresponds to L direction (grain flow direction)

Depending on the forging axis, the LT and ST directions can change.

Figure 2 — Cylindrical specimens - Direction of semi-finished products of circular cross section

BS EN 6072:2010



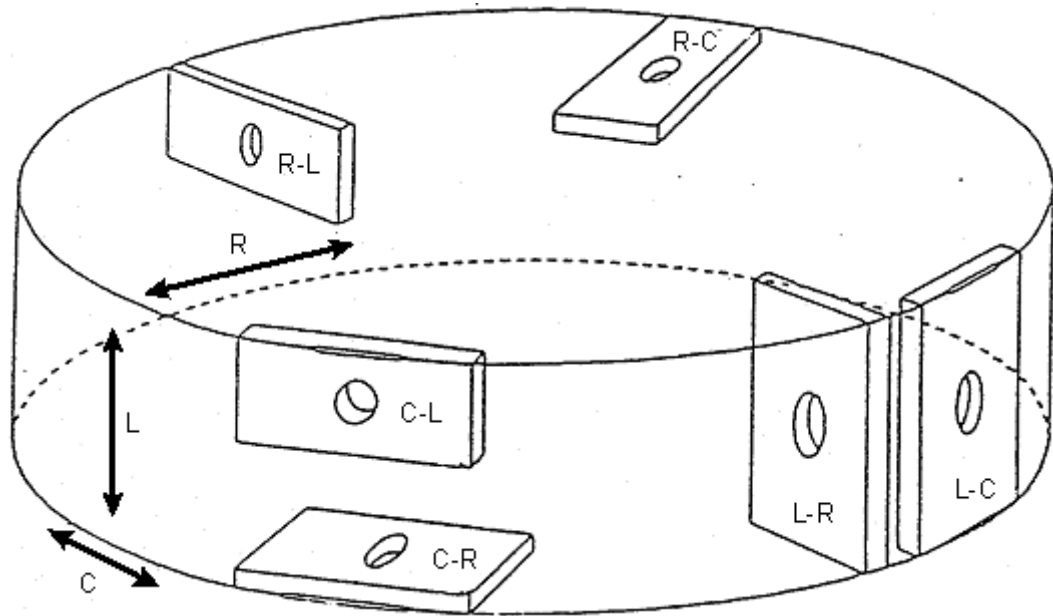
Key

- L : Long (grain flow direction)
- LT : Long Transverse
- ST : Short Transverse

Two letters separated by a dash:

- First letter : direction of load
- Second letter : direction of crack propagation

Figure 3 — Flat specimens - Direction of semi-finished products of rectangular cross section



Key

- L: direction of grain flow
- R: radial direction
- C: circumferential direction

Figure 4 — Flat specimens - Direction of semi-finished products of circular cross section

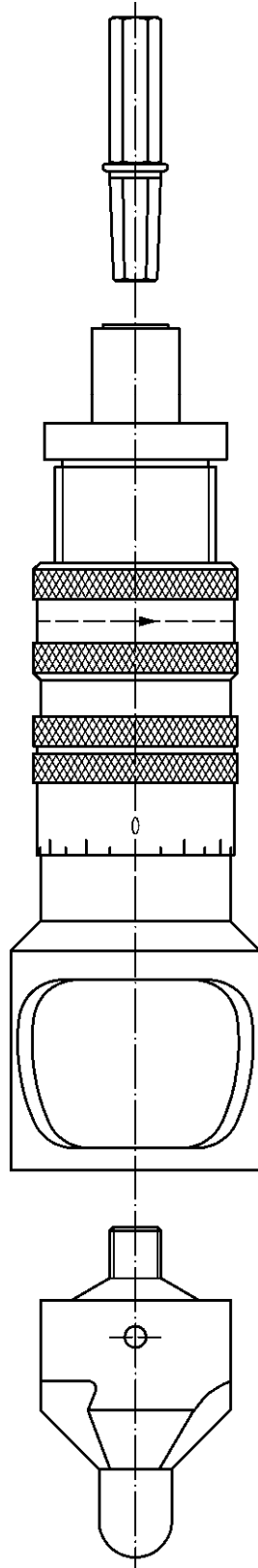
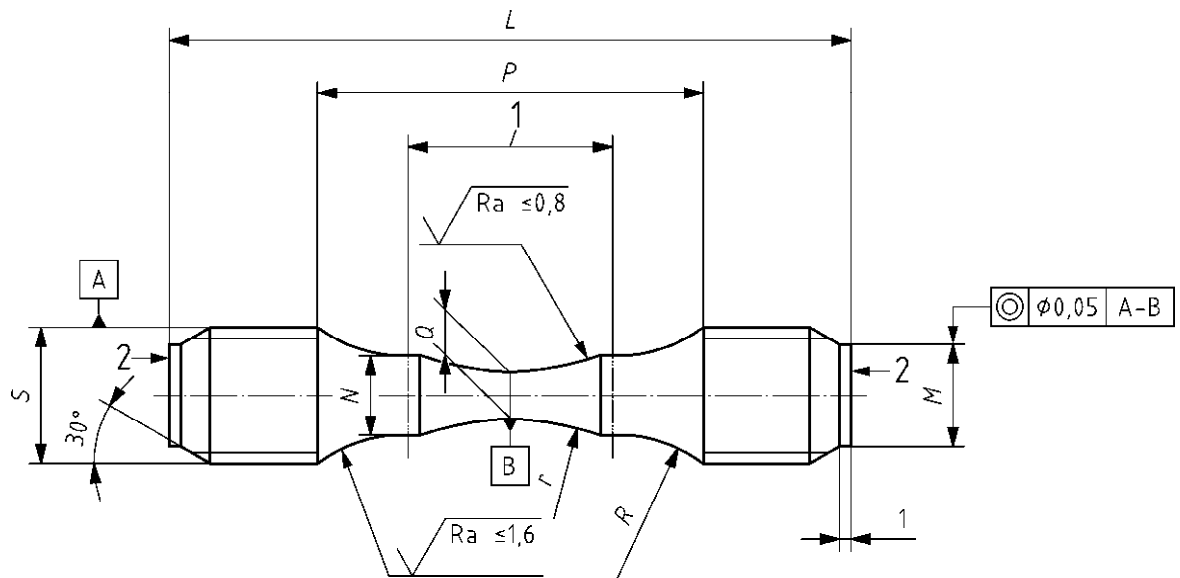


Figure 5 — Tool for chamfering
(can be ordered from Recoules Society or from Rexim Werkzeug GmbH)

Annex A
(normative)

Axial Fatigue - Cylindrical specimen



Key

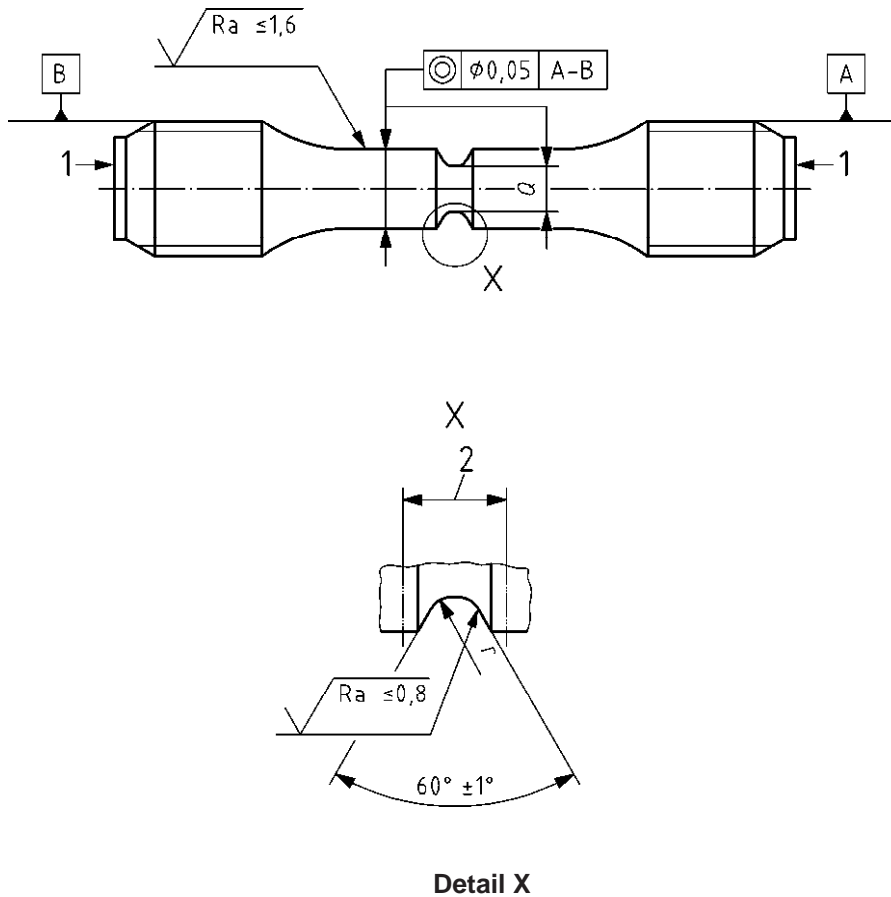
- 1 Calibrated section
- 2 Marking area

General tolerance = js 12

Form tolerance = IT 9

Thread tolerance = ISO 965-1 class 6g

Figure A.1 — Reference FCE type A



Key

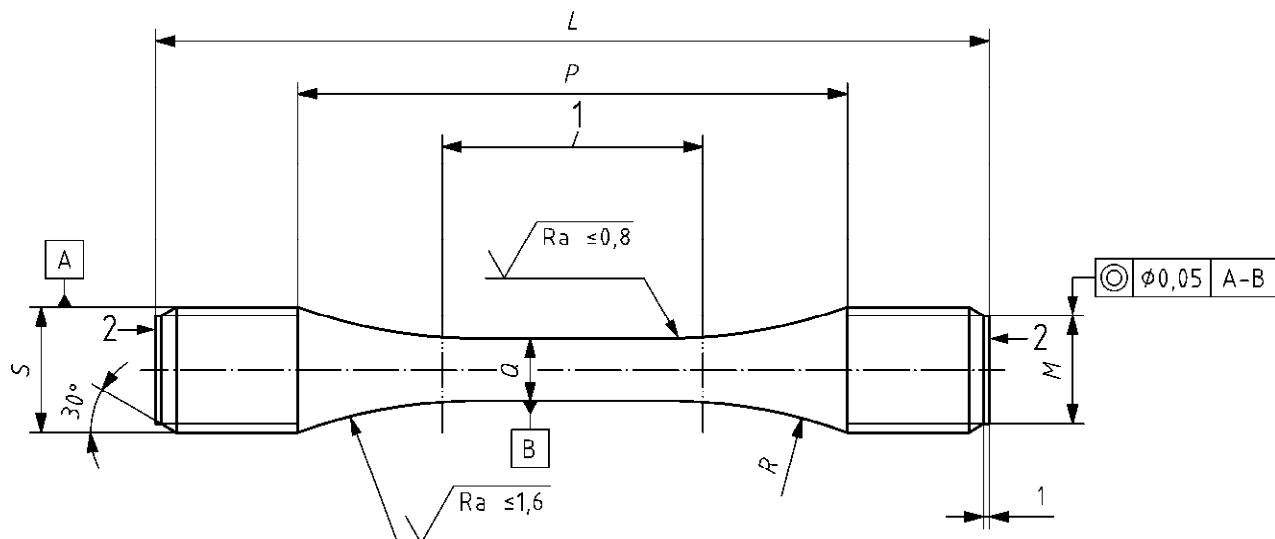
- 1 Marking area
- 2 Calibrated section

General tolerance = js 12

Form tolerance = IT 9

Thread tolerance = ISO 965-1 class 6g

Figure A.2 — Reference FCE type C to J



Key

- 1 Calibrated section
- 2 Marking area

General tolerance = js 12

Form tolerance = IT 9

Thread tolerance = ISO 965-1 class 6g

Figure A.3 — Reference FCE type B

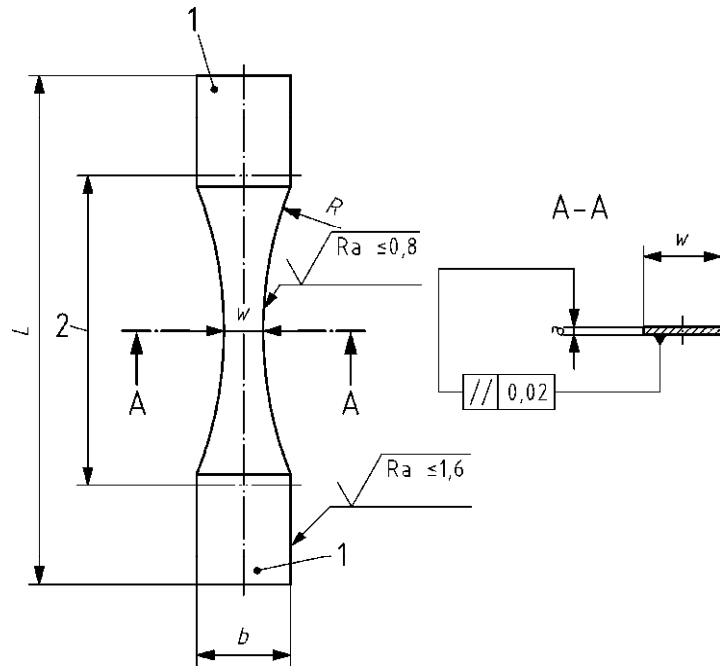
Table A.1 — Dimensions

Dimension in millimetres

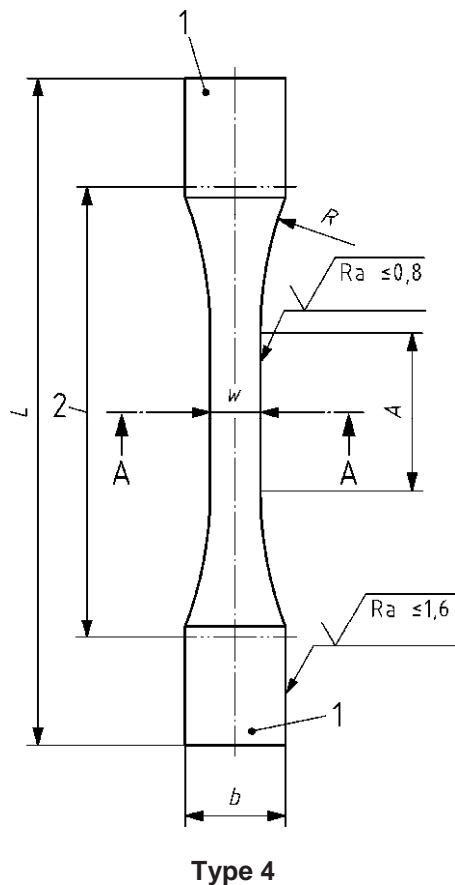
| Reference cross section mm ² | <i>L</i> | <i>M</i> | <i>N</i> | <i>P</i> | <i>Q</i> | <i>R</i> | <i>S</i> | Type | <i>K_t</i> | <i>r</i> | Tolerance on <i>r</i> |
|--|-----------------|----------|----------|----------|----------------|----------|-------------------|----------------|----------------------|--------------------------------------|--------------------------|
| 12,5 | 60 ¹ | 9 | 7 | 34 | 3,99 | 13 | M 12 Pitch 100 | A ² | 1,035 | 28 | ± 0,5 |
| | | | | | | | | C ² | 1,7 | 1 | ± 0,02 |
| | | | | | | | | D ² | 2,3 | 0,42 | |
| | | | | | | | | E ² | 3,3 | 0,18 | |
| | | | | | | | | I | 2,5 | 0,35 | |
| | | | | | | | | J | 3 | 0,22 | |
| 25 | 80 | 13 | 10 | 48 | 5,64 ± 0,03 | 20 | M 16 Pitch 100 | A ² | 1,035 | 40 | ± 1 |
| | | | | | | | | C ² | 1,7 | 1,41 | ± 0,02 |
| | | | | | | | | D ² | 2,3 | 0,60 | |
| | | | | | | | | E ² | 3,3 | 0,25 | |
| | | | | | | | | I | 2,5 | 0,49 | |
| | | | | | | | | J | 3 | 0,31 | |
| 50 | 110 | 19 | 14 | 68 | 7,98 ± 0,04 | 31 | M 22 Pitch 100 | A ¹ | 1,035 | 56 | ± 1 |
| | | | | | | | | C ² | 1,7 | 2 | ± 0,02 |
| | | | | | | | | D ² | 2,3 | 0,84 | |
| | | | | | | | | E ² | 3,3 | 0,36 | |
| | | | | | | | | I | 2,5 | 0,7 | |
| | | | | | | | | J | 3 | 0,44 | |
| 95 | 147 | 19 | - | 97 | 11 | 90 | M 22 Pitch 100 | B | 1 | Length of calibrated section = 35 mm | |
| ¹ Can be lengthened to 80 mm ² Recommended type | | | | | | | | | | | |

Annex B
(normative)

Axial Fatigue - Flat specimen ($K_t = 1,0$)



Type 1, 2, 3



Key

- 1 Marking area
- 2 Calibrated section

General tolerances = js12

Form tolerances = IT9

Figure B.1 — Types 1 to 4 ($K_t = 1,0$)

Table B.1 — Dimensions

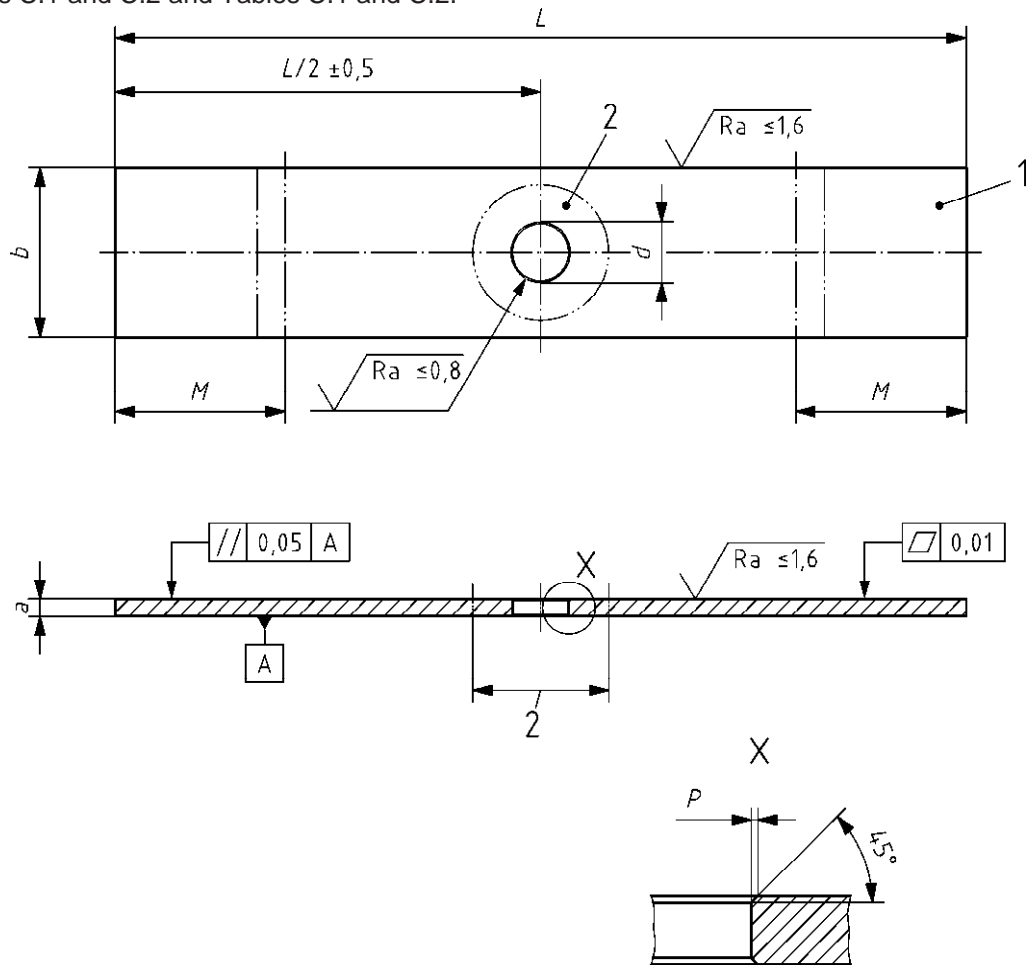
Dimensions in millimetres

| Reference cross section mm ² | Type | R | Tolerance on R | L | b | w | A |
|--|--------|-----|------------------|-----|------|------|-----|
| $w \times a$ | Type 1 | 100 | ± 1 | 130 | 24 | 10 | — |
| | Type 2 | 100 | ± 1 | 300 | 40 | 16 | — |
| | Type 3 | 50 | ± 1 | 200 | 80 | 50 | — |
| | Type 4 | 97 | ± 1 | 169 | 25,4 | 12,7 | 40 |

Annex C
(normative)

**Axial Fatigue - Flat specimen - "T-Type"
and mini "T-Type" specimen ($K_t = 2,3$)**

See Figures C.1 and C.2 and Tables C.1 and C.2.



Key

- 1 Marking area
- 2 Calibrated section

Figure C.1 — "T-Type" and "Mini T-Type" ($K_t = 2,3$)

M: area for clamping

Table C.1 — Dimensions

Dimensions in millimetres

| Specimen | L | b | \varnothing | M |
|-------------|-----|-----|---------------|-------|
| T-type | 150 | 30 | 10 | 25-35 |
| Mini T-type | 100 | 20 | 6,35 | 15-25 |

Table C.2 — Dimensions

Dimensions in millimetres

| Thickness a ¹ | Tolerance \varnothing bore | | Depth P | Concentricity between bore and chamfer |
|--|----------------------------------|--|-----------------|--|
| | Others materials ² | Aluminium alloys | | |
| $3 \begin{smallmatrix} 0 \\ -0,05 \end{smallmatrix}$ | $\varnothing \pm 0,1$ | $\varnothing \begin{smallmatrix} 0 \\ -0,04 \end{smallmatrix}$ | $0,30 \pm 0,05$ | $\leq 0,03$ |
| $1 \leq a < 3$ | $\varnothing \pm 0,1$ | $\varnothing \begin{smallmatrix} 0 \\ -0,04 \end{smallmatrix}$ | $0,15 \pm 0,05$ | $\leq 0,03$ |

¹ Specimens with thicknesses above 3 mm can be used on request.

² Specimen in titanium alloys, steels, nickel alloys...

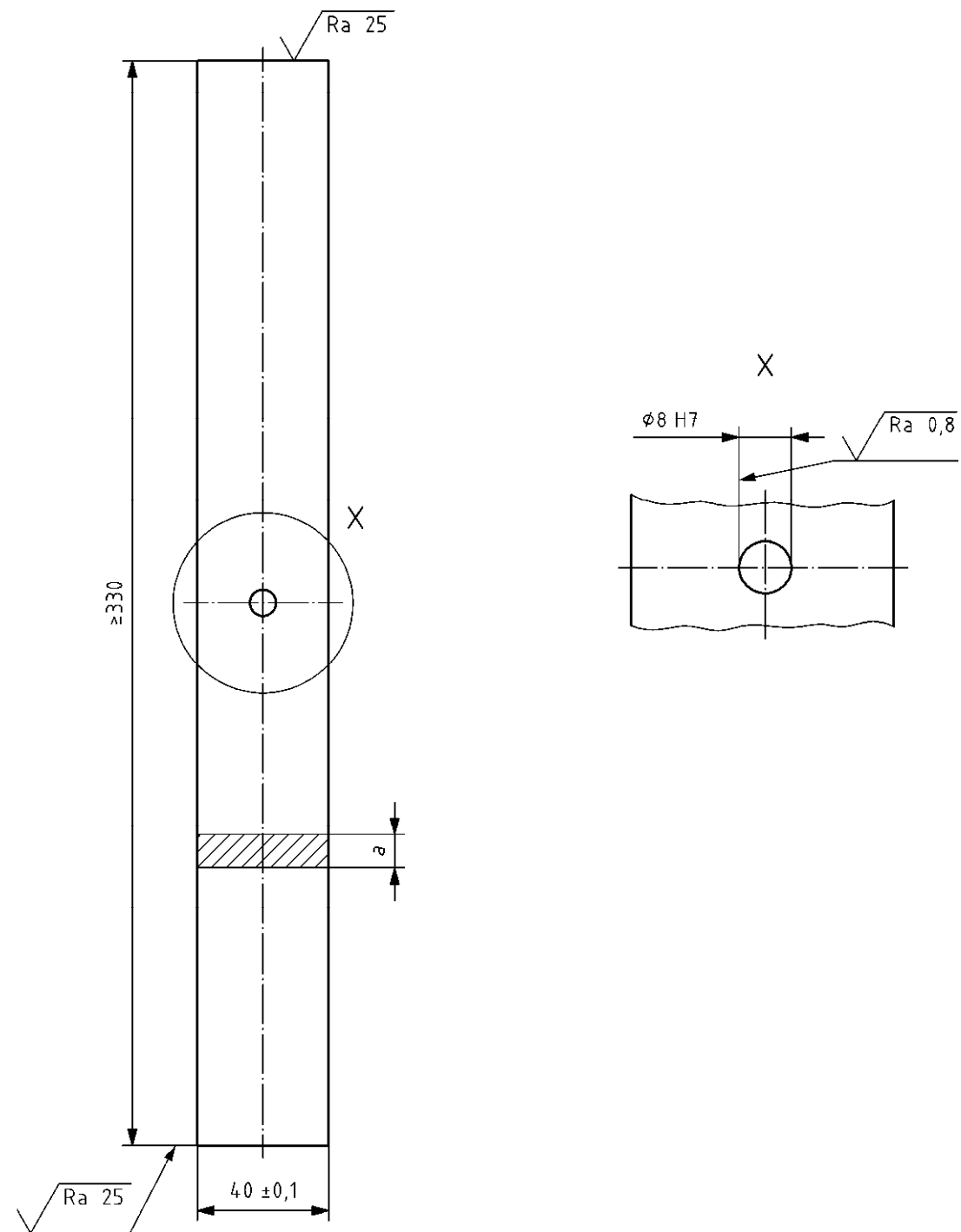
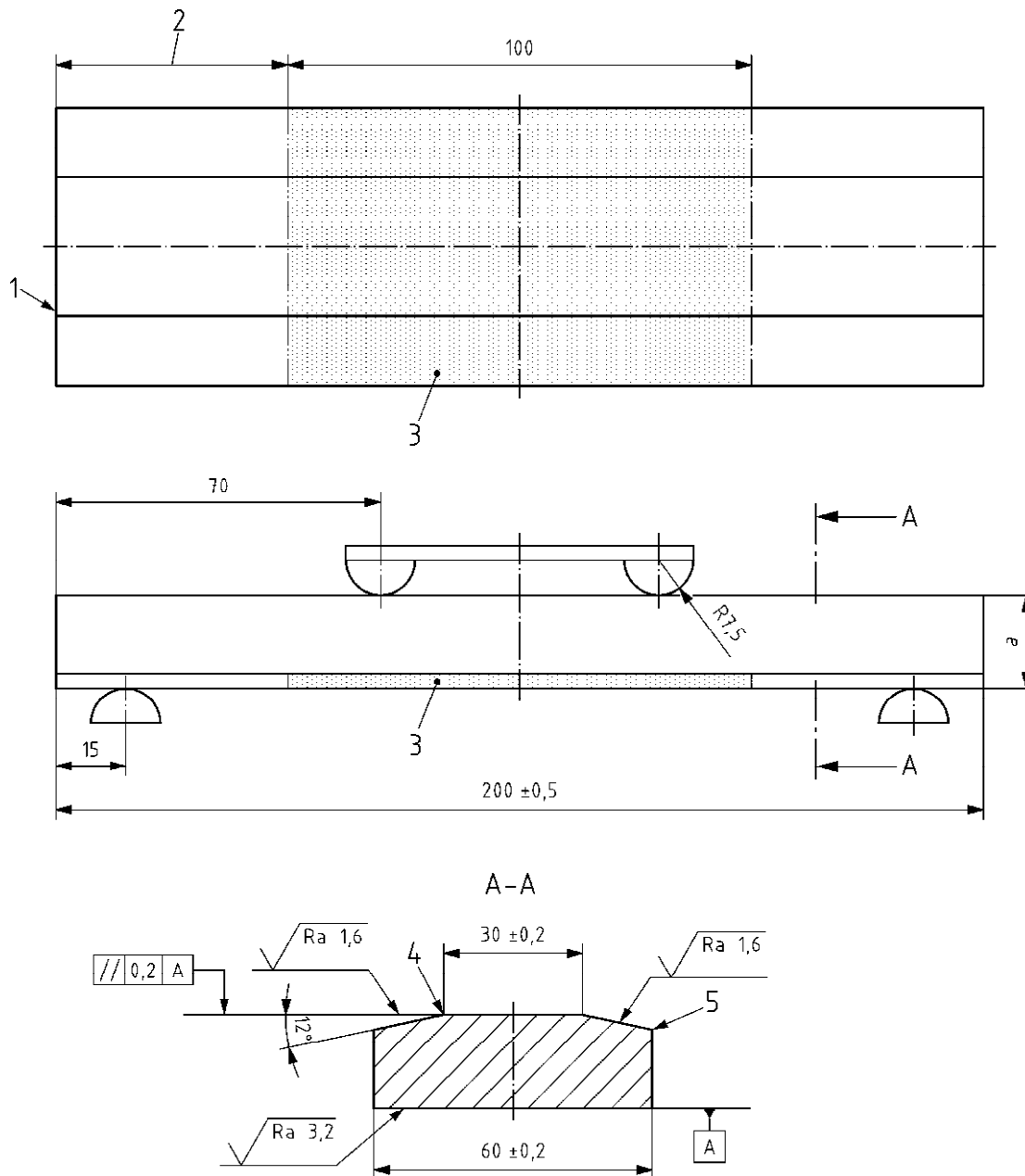


Figure C.2 — "T-Type" ($K_t = 2,5$)

Annex D
(normative)

Bending Fatigue - Flat specimen

Dimensions in millimetres



Key

- | | | | |
|---|----------------------------|---|---|
| 1 | Marking area (on the edge) | 4 | Break sharp edge (abrasive cloth) |
| 2 | Long. direction | 5 | Break sharp edge (file + abrasive cloth $R = 2 \pm 0,5$) |
| 3 | Calibrated section | | |

Figure D.1 — Flat specimen

Table D.1 — Thicknesses

| | Aluminium alloys | Steel | Titanium and titanium alloys |
|-------------|------------------|-------|------------------------------|
| <i>a</i> mm | 20 | 10 | 10 |

www.bsigroup.com/standards

Annex E (normative)

Recommendations for machining procedure of specimen

E.1 Cylindrical specimens

E.1.1 Location

According to sampling drawing.

E.1.2 Cutting

Abundant lubrication should be used to ensure that heating is limited during cutting.

E.1.3 Identification of the blank specimens

Individual marking of identification with electric scriber.

E.1.4 Turning

E.1.4.1 Main methods to be used for machining

See Table E.1.

Table E.1 — Main methods to be used for machining

| | Cylindrical part | Thread | Groove | |
|--------------------------------|------------------|---------|-----------------|-----------|
| | | | Rough machining | Finishing |
| Aluminium and aluminium alloys | Turning | Turning | Turning | Turning |
| Titanium and titanium alloys | Turning | Turning | Turning | Turning |
| Steels | Turning | Turning | Turning | Grinding |
| Nickel & nickel alloys | Turning | Turning | Turning | Grinding |

E.1.4.2 Rough machining

- Production of centre holes to comply with concentricity tolerances.
- Lubrication mandatory during each phase; the cutting fluid must be suitable for the machined material.
- Rough machining of outside diameter: depth of pass $\leq 2,5$ mm on radius.

E.1.4.3 Finishing of calibrated section

See Table E.2.

- Machining of calibrated section with a good surface finish.
- Abundant lubrication.
- Sharpening of tool every 15 specimens recommended for notch cylindrical specimens.

Table E.2 — Machining parameters of calibrated section

| | Aluminium alloys | | Titanium and titanium alloys | | Steels | | Nickel and nickel alloys | |
|-----------------|------------------------|-----------------|------------------------------|-----------------|------------------------|-----------------|--------------------------|-----------------|
| | Cutting speed m/min | Feed mm/turn | Cutting speed m/min | Feed mm/turn | Cutting speed m/min | Feed mm/turn | Cutting speed m/min | Feed mm/turn |
| Rough machining | ≤ 40 | 0,3 | ≤ 30 | 0,1 | 40-60 | 0,15 | 20 | 0,2 |
| Finishing | 40 | 0,1 | 30 | 0,05 | 40 | 0,05-0,10 | 25 | 0,1 |

For other materials, conduct adjustment tests.

E.1.4.4 Machining of groove

E.1.4.4.1 Plunge-cutting

See Table E.3.

- Applicable for all radius in bottom of groove (r).
- Form tool in steel bar ground to 60°.
- Abundant lubrication.
- Sharpening of tool every 15 specimens is recommended.

Table E.3 — Machining parameters of groove by plunge-cutting

| | Aluminium alloys | | Titanium and titanium alloys | | Steels | |
|-----------------|------------------------|-----------------|------------------------------|-----------------|------------------------|-------------------|
| | Cutting speed m/min | Feed mm/turn | Cutting speed m/min | Feed mm/turn | Cutting speed m/min | Feed mm/turn |
| Rough machining | 40 | 0,05 | 30 | 0,05 | 40 | 0,15 |
| Finishing | 20 | 0,05 | 20 | 0,03 | 40 | 0,01 ¹ |

¹ Temporisation before stop: 2,5 s

E.1.4.4.2 Convoluted-cutting

See Table E.4.

- Applicable for radius in bottom of groove $r \geq 0,8$ mm.
- Lozenge tip tool (for example: VBMT 16 04 04 - F2)
 - in P15/K15 for aluminium alloys
 - in P 40/K40 for titanium and steels.
- Abundant lubrication (water + soluble oil at 3,5 %).
- Sharpening of tool every 15 specimens is recommended.

Table E.4 — Machining parameter of groove by convoluted-cutting

| | Aluminium alloys, titanium and titanium alloys | | | Steels | | |
|-----------------|--|-----------------|-------------|------------------------|-----------------|-------------|
| | Cutting speed m/min | Feed mm/turn | Depth mm | Cutting speed m/min | Feed mm/turn | Depth mm |
| Rough machining | 150 | 0,04 | 0,2 | 100 | 0,04 | 0,2 |
| Finishing | 150 | 0,01 | 0,2 | 100 | 0,01 | 0,2 |

E.1.5 Identification of test specimens

Individual marking of identification with electric scriber in zone reserved for this purpose. Provide trimming of marked face with grit 300 cloths to avoid oversize of this face needed for support.

E.1.6 Inspection

E.1.6.1 Procedure

- Geometrical tolerances of each test specimen.
- Visual inspection (binoculars magnification $\times 10$) to check for good surface finish in bottom of groove.
- Shadowgraph shall be used for checking the geometry of the groove.

Machining marks must be fine and homogeneous (even in rough machining phase), if not, the tool shall be resharpened.

E.1.6.2 Inspection report

The operator machining the test specimen must provide the person performing the test with a report giving the results of the inspections carried out in compliance with E.1.6.1.

E.2 Flat specimens

E.2.1 $K_t = 1,0$ Specimen and Flat Bending Fatigue Specimen

E.2.1.1 General

This process is applicable for these types of test specimens.

Calibrated section of $K_t = 1,0$ Specimen shall be produced using a form milling cutter (carbon-tipped edge mill).

E.2.1.2 Location

According to sampling drawing.

E.2.1.3 Cutting

Abundant lubrication should be used to ensure that heating is limited during cutting.

E.2.1.4 Identification of the blank specimens

Individual marking of identification with electric scribe in zone reserved for this purpose.

E.2.1.5 Milling of calibrated section

- When machining is required, to ensure flatness of the specimen to an oversize of 0,25 mm, material shall be rough machined symmetrically from each face (see Table E.4).
- The final finishing pass shall be 0,125 mm max. on each face.
- Lubrication mandatory during each pass; the cutting fluid must be suitable for the machined material.
- The edges in the calibrated section shall be finished by longitudinal polishing with fine emery cloth (grade 220) and then, if it is necessary, final polishing with grade 600 emery paper. The corners have to be rounded with a minimum radius of 0,5 mm and to be polished.

Table E.5 — Machining parameters

| Material | Aluminium alloys | Titanium and titanium alloys | Steels (UTS < 1 400 MPa) |
|-----------------------|------------------|------------------------------|-----------------------------|
| Feed (mm/tooth) | 0,1 | 0,1 | 0,1 |
| Cutting speed (m/min) | 300 | 50 | 100 |

For other alloys, conduct adjustments tests.

E.2.1.6 Identification of test specimens

Transfer initial markings to test specimen zones reserved for this purpose.

E.2.2 T-type and mini T-type specimen ($K_t = 2,3$) and T-type specimen ($K_t = 2,5$)

E.2.2.1 General

This process is applicable for all T-types of test specimens.

E.2.2.2 Location

According to sampling drawing.

E.2.2.3 Cutting

Abundant lubrication should be used to ensure that heating is limited during cutting.

E.2.2.4 Identification of the blank specimens

Individual marking of identification with electric scriber in zone reserved for this purpose.

E.2.2.5 Milling

- All milling will be made with carbide mills.
- When machining is required, to ensure flatness and residual stresses level of the specimen, to an oversize of 0,25 mm, material shall be rough machined symmetrically from each face. The final finishing pass shall be 0,125 mm maximum on each face.
- Diameter of milling cutter: 50 mm-80 mm
- Score orientation / load direction: perpendicular to the load
- Lubrication mandatory during each pass; the cutting fluid must be suitable for the machined material.

Table E.6 — Machining parameters

| Material | Aluminium alloys | Titanium and titanium alloys | Steels (UTS ≤ 1 400 MPa) |
|-----------------------|------------------|------------------------------|-----------------------------|
| Feed (mm/tooth) | 0,02 | 0,1 | 0,1 |
| Cutting speed (m/min) | 400 | 50 | 40 |

For other alloys, conduct adjustments tests.

E.2.2.6 Identification of test specimens

Transfer initial markings to test specimen zones reserved for this purpose.

E.2.2.7 Drilling-reaming

E.2.2.7.1 T-type and mini T-type specimen ($K_t = 2,3$)

- Clamping on back plate
- Drilling of a pilot hole to 7 mm (T-type) or 5 mm (mini T-type) diameter with a standard drill, only for aluminium alloys.
- Drilling and reaming of the final diameter mm

Table E.7 — Drilling-reaming

| Material | Aluminium alloys | Titanium and titanium alloys | Steels (UTS ≤ 1 400 MPa) |
|-----------------------|---------------------------|--------------------------------|--------------------------------|
| Tool | ∅ mm dia. finishing drill | ∅ mm dia. carbide-tipped drill | ∅ mm dia. carbide-tipped drill |
| Feed (mm/min) | 100 | 60 | 90 |
| Cutting speed (m/min) | 20 | 30 | 40 |
| Change of tool | Every 500 holes | Every 50 holes | Every 25 holes |

Continuous lubrication with cutting fluid qualified for the machined material.

For other alloys, conduct adjustments tests.

E.2.2.7.2 T-type specimen ($K_t = 2,5$)

- To avoid burring of the holes, use cover plates on both sides of the specimen. Take great care that the sharpening of the drill is sufficient. A large burr on the outgoing side shows that the sharpness is not sufficient. Specimens with large burr must not be used for testing, depending on hardening of the hole by the drilling process.
- Predrilling shall be done using a twist drill of HSS material (full carbide drill for titanium can be used) and with oil emulsion cutting fluid. The hole diameter shall be 7,7 mm. The drill speed shall be 600 rpm for aluminium alloys and steel, and 300 rpm for titanium and titanium alloys.
- The reaming of the hole shall be carried out using spiral groove reamer of HSS material (full carbide reamer for steel and titanium can be used) at a feed rate of 0,1 mm/turn and with oil emulsion cutting fluid.
A new reamer shall be used after preparation of 10 holes (50 holes if using a full carbide tool) for titanium, titanium alloys and steel and after 50 holes for aluminium alloys. The reaming speed shall be 90 rpm for titanium and titanium alloys, 100 rpm for steel and 400 rpm for aluminium alloys.
- Great care is to be taken during deburring of the hole and edges to avoid chamfering. Deburring by using a chamfering tool is not allowed.
- Grinding in longitudinal direction of the specimen with very fine paper is preferred.
- For grinding of titanium, titanium alloys and steel see 6.3.3.

E.2.2.8 Chamfering of T-type and mini T-type specimen ($K_t = 2,3$)

- To be carried out on a hand-controlled pillar drill with a micrometer stop and a milling cutter with a smooth pilot tip, ∅ 21 mm, speed 250 rpm. See Figure E.1.
- Preliminary tests shall be carried out to adjust the milling depth (i.e. the stop).

E.2.3 Inspection

E.2.3.1 Procedure

- Geometrical tolerances of each test specimen
- Visual inspection (binoculars magnification × 10) of the hole and chamfer area to check for good surface finish and identify score marks.

E.2.3.2 Inspection report

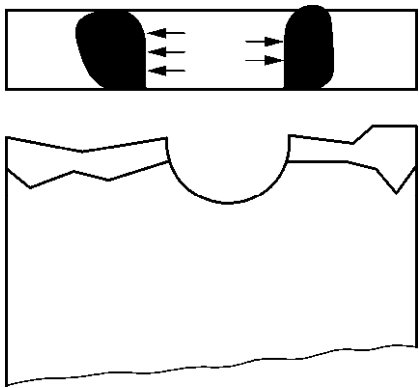
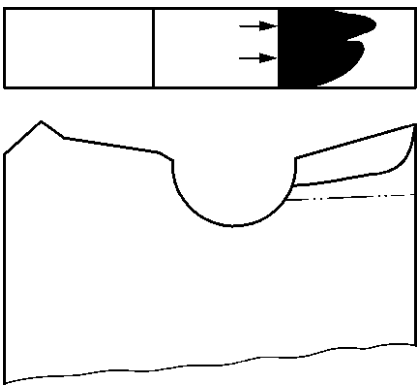
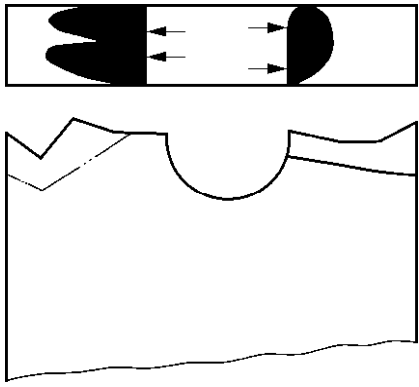
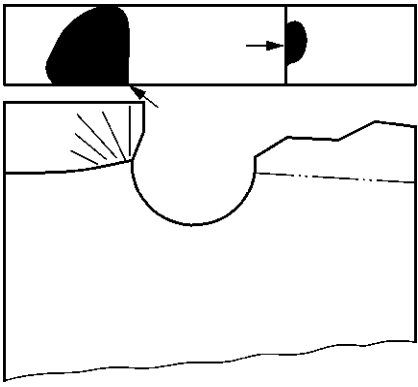
The operator machining the test specimen must provide the person performing the test with a report giving the results of the inspections carried out in compliance with E.2.3.1.

Annex F
(normative)

Indication of failure sites

See Table F.1.

Table F.1 — Example

| | |
|---|---|
| "T-Type" Specimen | |
| Material: | |
| Nett cross-section: | |
|  |  |
| <p>Specimen nb. = XXX - 1 s max = 220 MPa Number of cycles = 53 000</p> | <p>Specimen nb = XXX - 2 s max = 220 MPa Number of cycles = 99 000</p> |
|  |  |
| <p>Specimen nb = XXX - 3 s max = 220 MPa Number of cycles = 31 600</p> | <p>Specimen nb = XXX - 4 s max = 180 MPa Number of cycles = 241 400</p> |

© 2010 British Standards Institution

Annex G
(normative)

Table of fatigue test results

See Table G.1.

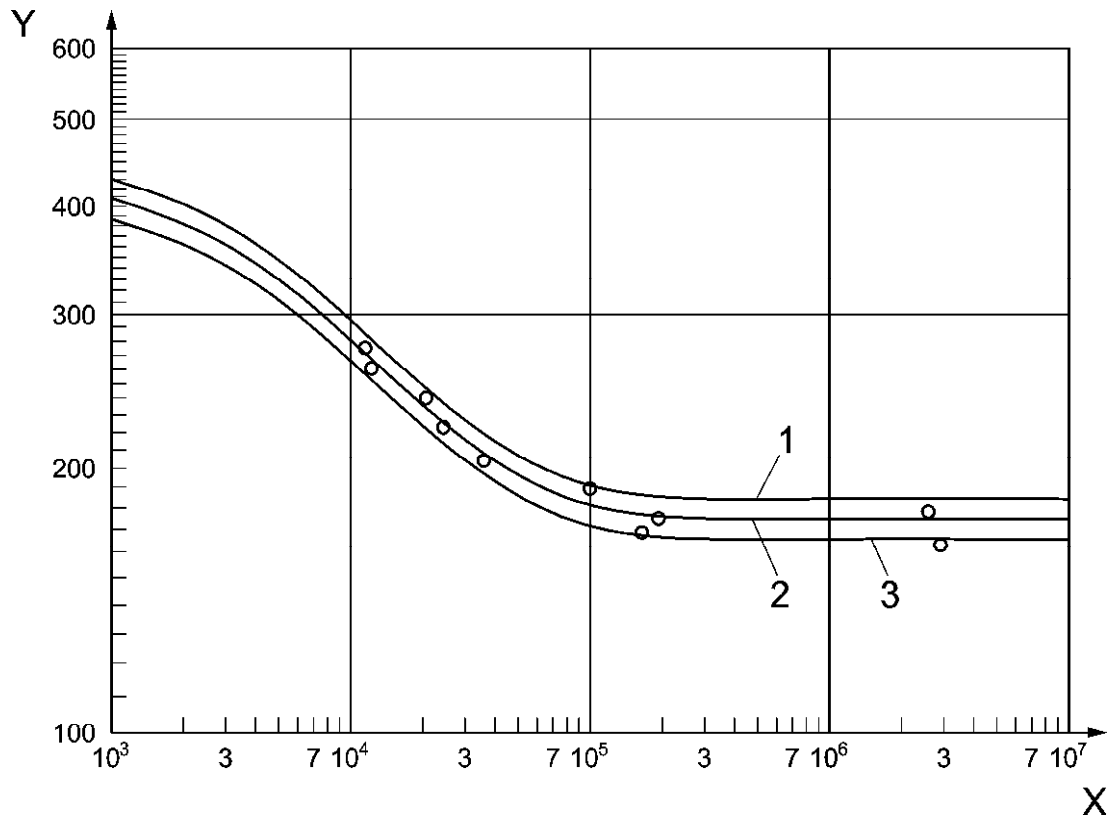
Table G.1 — Example

| Specimen | Thick-ness | Width | Hole | Cross section | Max. load | Min. load | Stress amplif. | Stress max. net. | Nb of cycles | Comments |
|----------|------------|-------|------|---------------|-----------|-----------|----------------|------------------|--------------|----------|
| N_o | a | b | d | mm^2 | P_o | P_u | σ_a | $\sigma_{max.}$ | N | |
| | mm | mm | mm | | N | N | MPa | MPa | | |
| XXX - 1 | 2,10 | 40,20 | 8,00 | 67,6 | 13 000 | 1 300 | 86,5 | 192 | 9 870 | |
| XXX - 2 | 2,00 | 40,20 | 8,00 | 64,4 | 8 000 | 800 | 55,9 | 124 | 98 020 | |
| XXX - 3 | 2,00 | 40,10 | 8,00 | 64,2 | 9 300 | 930 | 65,2 | 145 | 39 650 | |
| XXX - 4 | 2,00 | 40,00 | 8,00 | 64,0 | 5 700 | 570 | 40,1 | 89 | 3 000 000 | D A |
| XXX - 5 | 2,00 | 40,00 | 8,00 | 64,0 | 7 500 | 750 | 52,7 | 117 | 89 760 | |
| XXX - 6 | 2,00 | 40,10 | 8,00 | 67,4 | 7 100 | 710 | 47,4 | 105 | 31 2100 | |
| XXX - 7 | 2,00 | 40,00 | 8,00 | 64,0 | 6 700 | 670 | 47,1 | 108 | 831 300 | |
| XXX - 8 | 2,00 | 40,10 | 8,00 | 64,2 | 6 400 | 640 | 44,9 | 100 | 3 000 000 | B |
| XXX - 9 | 2,00 | 40,20 | 8,00 | 64,4 | 7 300 | 730 | 51,0 | 113 | 185 660 | |
| XXX - 4 | 2,00 | 40,00 | 8,00 | 64,0 | 11 500 | 1 150 | 80,9 | 180 | 17 000 | C |
| XXX - 8 | 2,00 | 40,10 | 8,00 | 64,2 | 10 000 | 1 000 | 70,1 | 156 | 7850 | D |

A = No failure, increased to $P_o = 11\,500\text{ N}$
 B = No failure, increased to $P_o = 10\,000\text{ N}$
 C = Failure initiation not at the hole
 D = Not taken into account for analysis

Annex H (normative)

Representation of fatigue data



Key

- 1 $P_{\ddot{u}} = 10\%$
- 2 $P_{\ddot{u}} = 50\%$
- 3 $P_{\ddot{u}} = 90\%$
- X Cycles to Failure
- Y Net Stress Amplitude δ_a (MPa)

Figure H.1 — Example

Annex I (informative)

Example of inspection card process

It is recommended to use an inspection card, or whatever similar system, to check the reproducibility of the process (mainly the machining of samples). This can be done as following:

- supply one plate in aluminium (or other material) long enough to enable machining samples during some years.
- testing of 20 or 25 samples machined from this plate, according to this EN: this will be the reference.
- for each campaign of machining samples, add 3 or 4 samples from this plate and test all of them for comparing results with the reference.

By this kind of method, any deviation in the process of machining or machine testing will be pointed out.

11/11/2023 10:11:11 AM

British Standards Institution (BSI)

BSI is the independent national body responsible for preparing British Standards and other standards-related publications, information and services.

It presents the UK view on standards in Europe and at the international level.

It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover.

Tel: +44 (0)20 8996 9001 Fax: +44 (0)20 8996 7001

BSI offers Members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Tel: +44 (0)20 8996 7669 Fax: +44 (0)20 8996 7001

Email: plus@bsigroup.com

Buying standards

You may buy PDF and hard copy versions of standards directly using a credit card from the BSI Shop on the website www.bsigroup.com/shop. In addition all orders for BSI, international and foreign standards publications can be addressed to BSI Customer Services.

Tel: +44 (0)20 8996 9001 Fax: +44 (0)20 8996 7001

Email: orders@bsigroup.com

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Knowledge Centre.

Tel: +44 (0)20 8996 7004 Fax: +44 (0)20 8996 7005

Email: knowledgecentre@bsigroup.com

Various BSI electronic information services are also available which give details on all its products and services.

Tel: +44 (0)20 8996 7111 Fax: +44 (0)20 8996 7048

Email: info@bsigroup.com

BSI Subscribing Members are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration.

Tel: +44 (0)20 8996 7002 Fax: +44 (0)20 8996 7001

Email: membership@bsigroup.com

Information regarding online access to British Standards via British Standards Online can be found at www.bsigroup.com/BSOL

Further information about BSI is available on the BSI website at www.bsigroup.com/standards

Copyright

Copyright subsists in all BSI publications. BSI also holds the copyright, in the UK, of the publications of the international standardization bodies. Except as permitted under the Copyright, Designs and Patents Act 1988 no extract may be reproduced, stored in a retrieval system or transmitted in any form or by any means – electronic, photocopying, recording or otherwise – without prior written permission from BSI. This does not preclude the free use, in the course of implementing the standard of necessary details such as symbols, and size, type or grade designations. If these details are to be used for any other purpose than implementation then the prior written permission of BSI must be obtained. Details and advice can be obtained from the Copyright & Licensing Manager.

Tel: +44 (0)20 8996 7070

Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

Tel +44 (0)20 8996 9001

Fax +44 (0)20 8996 7001

www.bsigroup.com/standards

