BS EN ISO 6892-3:2015

BSI Standards Publication

Metallic materials — Tensile testing

Part 3: Method of test at low temperature

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National foreword

This British Standard is the UK implementation of EN ISO 6892-3:2015.

The UK participation in its preparation was entrusted to Technical Committee ISE/101/1, Uniaxial testing.

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

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Foreword

This document (EN ISO 6892-3:2015) has been prepared by Technical Committee ISO/TC 164 “Mechanical testing of metals” in collaboration with Technical Committee ECISS/TC 101 “Test methods for steel (other than chemical analysis)” the secretariat of which is held by AFNOR.

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of an identical text or by endorsement, at the latest by October 2015, and conflicting national standards shall be withdrawn at the latest by October 2015.

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.

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Endorsement notice

The text of ISO 6892-3:2015 has been approved by CEN as EN ISO 6892-3:2015 without any modification.

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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).

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

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 164, *Metallic materials*, Subcommittee SC 1, *Uniaxial testing*.

This first edition cancels and replaces ISO 15579:2000.

ISO 6892 consists of the following parts, under the general title *Metallic materials — Tensile testing*:

— *Part 1: Method of test at room temperature*

— *Part 2: Method of test at elevated temperature*

— *Part 3: Method of test at low temperature*

— *Part 4: Method of test in liquid helium*

Introduction

In this edition, there are two methods of testing speeds available. The first one, Method A, is based on strain rates (including crosshead separation rate) with narrow tolerances (±20 %) and the second, Method B, is based on conventional strain rate ranges and tolerances. Method A is intended to minimize the variation of the test rates during the moment when strain rate sensitive parameters are determined and to minimize the measurement uncertainty of the test results.

Mechanical properties determined by tensile test at low temperatures have been determined at the same rates at room temperature. This revised part of ISO 6892 incorporates the new set of testing rates of ISO 6892-1 and ISO 6892-2, developed to reduce the variability of test results.

Metallic materials — Tensile testing —

Part 3:
Method of test at low temperature

WARNING — This International Standard calls for the use of substances and/or procedures that can be injurious to health if adequate safety measures are not taken. This International Standard does not address any health hazards, safety or environmental matters associated with its use. It is the responsibility of the user of this International Standard to establish appropriate health, safety and environmentally acceptable practices and take suitable actions for any national and international regulations. Compliance with this International Standard does not in itself confer immunity from legal obligations.

1 Scope

This part of ISO 6892 specifies a method of tensile testing of metallic materials at temperatures between +10 °C and -196 °C.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6892-1:2009, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

ISO 9513, *Metallic materials — Calibration of extensometer systems used in uniaxial testing*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6892-1:2009 and the following apply.

In general, all test piece geometries/dimensions are based on measurements taken at room temperature. The exception can be the extensometer gauge length (see 3.3).

NOTE The following properties are generally not determined at low temperature unless required by relevant specifications or agreement:

— permanent set strength (R_r);

— percentage permanent elongation;

— percentage permanent extension;

— percentage yield point extension (A_e);

— percentage total extension at maximum force (A_{gt});

— percentage plastic extension at maximum force (A_g);

— percentage total extension at fracture (A_t).

3.1
original gauge length
L_o
gauge length measured at room temperature before cooling of the test piece and before application of force

3.2
percentage elongation after fracture
A
permanent elongation of the gauge length, measured at room temperature, after fracture (L_u-L_o), expressed as a percentage of the original gauge length (L_o)

Note 1 to entry: For further details, see ISO 6892-1:2009.

3.3
extensometer gauge length
L_e
initial extensometer gauge length used for measurement of extension by means of an extensometer

3.4
extension
increase in the extensometer gauge length (L_e) at a given moment during the test

3.4.1
percentage extension
extension (3.4) expressed as a percentage of the extensometer gauge length (L_e)

3.5
percentage reduction of area
Z
maximum change in cross-sectional area which has occurred during the test (S_o-S_u), expressed as a percentage of the original cross-sectional area (S_o), where S_o and S_u are calculated from the dimensions at room temperature

3.6
stress
R
force at any moment during the test divided by the original cross-sectional area (S_o) of the test piece

Note 1 to entry: All stresses referenced in this part of ISO 6892 are engineering stresses, calculated using the cross-sectional area of the test piece derived from dimensions measured at room temperature.

3.7
soaking time
t_s
time taken to stabilize the temperature of the test piece prior to mechanical loading

4 Symbols and designations

Additional symbols to ISO 6892-1:2009, Table 1 used throughout this International Standard and their designation are given in Table 1.

Table 1 — Symbols and designations

Symbol	Unit	Designation
T	°C	Specified temperature or nominal temperature at which the test should be performed
T_i	°C	Indicated temperature or measured temperature on the surface of the parallel length of the test piece
t_s	min	Soaking time

5 Principle

The test involves straining a test piece by tensile force for the determination of one or more of the mechanical properties defined in ISO 6892-1:2009, Clause 3.

The test is carried out at a specified temperature between +10 °C and -196 °C.

6 Test piece

For requirements concerning test pieces, see ISO 6892-1:2009, Clause 6.

NOTE Additional examples of test pieces are given in Annex A.

7 Determination of original cross-sectional area (S_o)

For requirements concerning the determination of the original cross-sectional area, see ISO 6892-1:2009, Clause 7.

NOTE This parameter is calculated from measurements taken at room temperature.

8 Marking the original gauge length (L_o)

For requirements concerning marking the original gauge length, see ISO 6892-1:2009, Clause 8.

9 Apparatus

9.1 Force measuring system

The force-measuring system of the testing machine shall be calibrated in accordance with ISO 7500-1, class 1 or better.

9.2 Extensometer

For the determination of proof strength (plastic or total extension), the extensometer used shall be in accordance with ISO 9513, class 1 or better, in the relevant range. For other properties (with higher extension), an ISO 9513, class 2 extensometer can be used in the relevant range.

The extensometer gauge length shall be not less than 10 mm and shall correspond to the central portion of the parallel length.

NOTE When using an extensometer to measure extension up to fracture, the extensometer gauge length, L_e, should be approximately equal to the original gauge length, L_o, otherwise, the extensometer gauge length, L_e, should be at least half as long as the marked original gauge length, L_o, but cover no more than 90 % of the parallel length, L_c. This will ensure that the extensometer detects all yielding events that occur in the test piece. Further, for measurement of parameters “at” or “after reaching” maximum force, L_e will be approximately equal to L_o.

Any part of the extensometer projecting beyond the cooling device shall be designed or protected from air currents so that fluctuations in the room temperature have only a minimal effect on the readings. It is advisable to maintain reasonable stability of the temperature and air currents surrounding the testing machine.

9.3 Cooling device

9.3.1 General

The cooling device shall be capable of cooling the test piece to the specified temperature, *T*.

The means of cooling can be, for example,

— by refrigeration unit,

— by expansion of compressed gas (e.g. CO_2 or N_2), and

— by immersion in a liquid maintained at its boiling point (e.g. N_2) or in a refrigerated liquid (e.g. alcohol).

Tensile tests at low temperatures are performed using gaseous or liquid cooling media. The type of cooling medium has a significant influence on the cooling time and on the heat transfer during the test (isothermal and/or adiabatic) and might have a significant influence on the test result.

Examples for cooling curves can be found in Annex B.

9.3.2 Permitted deviations of temperature

The cooling device for the test piece shall be such that the test piece can be cooled to the specified temperature, T.

The indicated temperatures, T_i, are the temperatures measured on the surface of the parallel length of the test piece or measured in the agitated liquid with corrections applied for any known systematic errors, but with no consideration of the uncertainty of the temperature measurement equipment.

The permitted deviation between the specified temperature, T, and the indicated temperature, T_i, is ±3 °C. The temperature gradient along the surface of the test piece shall not exceed 3 °C.

The temperature along the parallel length (L_c) shall be controlled within the permitted tolerances until the final proof strength is reached.

NOTE When the final proof strength is reached, temperature control should be attempted but experience has shown that it can be very difficult to control the temperature within the permitted range especially if a gaseous cooling medium is used.

9.3.3 Measurement of temperature

When the gauge length is less than 50 mm, one temperature sensor shall measure the temperature at each end of the parallel length directly. When the gauge length is equal to or greater than 50 mm, a third temperature sensor shall measure near the centre of the parallel length.

This number can be reduced if the general arrangement of the cooling device and the test piece is such that, from experience, it is known that the variation in temperature of the test piece does not exceed the permitted deviation specified in 9.3.2. However, at least one sensor shall be measuring the test piece temperature directly.

Temperature sensor junctions shall make good thermal contact with the surface of the test piece.

NOTE Use of the proper type and class of thermocouple is important to ensure accuracy of the measured temperature.

If the test piece is in an agitated liquid medium which can be assumed to be homogeneous, the temperature measurement can be made at any point within the cooling media.

If testing is carried out in liquid nitrogen, no temperature measurement is needed. In this case, the absence of temperature recording equipment shall be recorded in the test report.

9.3.4 Verification of the temperature-measuring system

The temperature-measuring equipment shall have a resolution equal to or better than 1 °C and an accuracy of ±2 °C for the range +10 °C to -40 °C and ±3 °C for the range -41 °C to -196 °C.

NOTE The temperature-measuring system includes all components of the measuring chain (sensor, cables, indicating device, and reference junction).

All components of the temperature-measuring system shall be verified and calibrated over the working range at intervals not exceeding 1 year. Errors shall be recorded on the verification report. The components of the temperature-measuring system shall be verified by methods traceable to the international unit (SI unit) of temperature.

10 Test conditions

10.1 Setting the force zero point

The force measuring system shall be set to zero after the testing equipment has been assembled but before the test piece is actually placed in the gripping jaws. Once the force zero point has been set, the force measuring system cannot be changed in any way during the test.

NOTE The use of this method ensures that the weight of the gripping system is compensated in the force measurement and that any force resulting from the clamping operation does not affect the force zero point.

10.2 Gripping of the test piece, fixing of the extensometer and cooling of the test piece, not necessarily in the following sequence

10.2.1 Method of gripping

For requirements concerning the method of gripping, see ISO 6892-1:2009, 10.2.

10.2.2 Fixing of the extensometer and establishing the gauge length

10.2.2.1 General

Different methods of establishing the extensometer gauge length are used in practice. This may lead to minor differences in the test results. The method used shall be documented in the test report.

NOTE Because there is only a temperature range of about 200 °C, the influence of (negative) thermal expansion on the test result is less significant than in the wider temperature range available in ISO 6892-2.

10.2.2.2 L_e based on room temperature (Method 1)

The extensometer is set on the test piece at room temperature with nominal gauge length. The extension is measured at test temperature and the percentage extension is calculated with the gauge length at room temperature. The thermal extension is not considered.

10.2.2.3 L_e based on test temperature (Method 2)

The methods below consider thermal expansion of the test piece and possibly the extensometer.

10.2.2.3.1 Nominal L_e at test temperature (Method 2a)

The extensometer is set on the test piece at the test temperature with nominal gauge length before mechanical loading.

10.2.2.3.2 Extended L_e at room temperature (Method 2b)

An extensometer with extended gauge length is set on the test piece at room temperature such that, at test temperature, the nominal gauge length is achieved.

For the calculation of percentage extension, the nominal gauge length is used.

10.2.2.3.3 Corrected L_e at test temperature (Method 2c)

The extensometer is set on the test piece at room temperature with the nominal gauge length.

For the calculation of percentage extension, the corrected nominal gauge length at test temperature (gauge length at room temperature + thermal expansion) is used.

NOTE The thermal expansion is negative in this case.

10.2.3 Cooling of the test piece

The test piece shall be cooled to the specified temperature, *T*, and shall be maintained at that temperature (soaking time) for at least 10 min before loading. The loading shall only be started after the output of the extensometer has stabilized.

NOTE Longer soaking times can be required to achieve the specified temperature throughout the cross section of larger test pieces (e.g. S_o > 100 mm^2).

During cooling, the temperature of the test piece shall not go below the specified temperature within its tolerances, except by agreement between the parties concerned.

10.3 Testing rate based on strain rate control (Method A)

10.3.1 General

This method is intended to minimize the variation of the test rates during the moment when strain rate sensitive parameters are determined and to minimize the measurement uncertainty of the test results.

For additional requirements concerning testing rate based on strain rate control (Method A), see ISO 6892-1:2009, 10.3.1.

It is not always the case that all properties of the tensile test at room temperature will be determined at low temperature. Hence, only the appropriate test rates/modes for the properties to be determined shall be used (see Figure 1).

10.3.2 Strain rate for the determination of the upper yield strength (R_{eH}) or proof strength properties (R_p and, if required, R_t)

For additional requirements concerning strain rate for the determination of the upper yield strength (R_{eH}) or proof strength properties (R_p and, if required, R_t), see ISO 6892-1:2009, 10.3.2 but observe one of the following specified ranges.

Range 1: $\dot{e}_{L_e}$ = 0,000 07 s^{-1} (equal to 0,004 2 min^{-1}), with a relative tolerance of ±20 %

Range 2: $\dot{e}_{L_e}$ = 0,000 25 s^{-1} (equal to 0,015 min^{-1}), with a relative tolerance of ±20 % (recommended unless otherwise specified; see also Figure 1)

10.3.3 Strain rate for the determination of the lower yield strength (R_{eL}) **and percentage yield point extension** (A_e) if required

For additional requirements concerning strain rate for the determination of the lower yield strength (R_{eL}) and percentage yield point extension (A_e) if required, see ISO 6892-1:2009, 10.3.3 but observe one of the following specified ranges

Range 2: $\dot{e}_{L_c}$ = 0,000 25 s^{-1} (equal to 0,015 min^{-1}), with a relative tolerance of ±20 % (recommended unless otherwise specified)

Range 3: $\dot{e}_{L_c}$ = 0,002 s^{-1} (equal to 0,12 min^{-1}), with a relative tolerance of ±20 % (see also Figure 1)

10.3.4 Strain rate for the determination of the tensile strength (R_m)**, percentage elongation after fracture** (A)**, percentage reduction area** (Z)**, and, if required, percentage total extension at the maximum force** (A_{gt})**, percentage plastic extension at maximum force** (A_g)

For additional requirements concerning strain rate for the determination of the tensile strength (R_m), percentage elongation after fracture (A), percentage reduction area (Z), and, if required, percentage total extension at the maximum force (A_{gt}), percentage plastic extension at maximum force (A_g), see ISO 6892-1:2009, 10.3.4 but observe one of the following specified ranges.

Range 2: $\dot{e}_{L_c}$ = 0,000 25 s^{-1} (equal to 0,015 min^{-1}), with a relative tolerance of ±20 %

Range 3: $\dot{e}_{L_c}$ = 0,002 s^{-1} (equal to 0,12 min^{-1}), with a relative tolerance of ±20 %

Range 4: $\dot{e}_{L_c}$ = 0,006 7 s^{-1} (equal to 0,4 min^{-1}), with a relative tolerance of ±20 % (recommended unless otherwise specified; see also Figure 1)

If the purpose of the tensile test is only to determine the tensile strength, then an estimated strain rate over the parallel length of the test piece according to range 4 can be applied throughout the entire test.

10.4 Method of testing with expanded strain rate ranges (Method B)

10.4.1 General

This method is based on conventional strain rate ranges.

NOTE The test rate, even within the specified range, can influence the values of the properties to be determined.

10.4.2 Rate for the determination of yield strength or proof strength properties

10.4.2.1 Rate for the determination of the upper yield strength (R_{eH})

Within the elastic range and up to the upper yield strength, the straining rate shall be between 0,000 03 s^{-1} and 0,000 30 s^{-1} and shall be kept as constant as possible.

If the testing machine is not capable of measuring and controlling the straining rate, a crosshead separation rate equivalent to a stress rate between 6 MPa·s^{-1} and 60 MPa·s^{-1} should be used.

10.4.2.2 Rate for the determination of the lower yield strength (R_{eL})

If only the lower yield strength is being determined, the test rate in the elastic range shall conform to 10.4.2.1 and the strain rate during yield shall be between 0,000 03 s^{-1} and 0,002 5 s^{-1} and shall be kept as constant as possible.

If this rate cannot be regulated directly, the test rate should be fixed by regulating the crosshead separation rate just before yield begins, the controls of the machine not being further adjusted until completion of yield.

10.4.2.3 Rate for the determination of the proof strength for plastic extension (R_p)

The crosshead separation rate of the machine shall be kept as constant as possible and within the limits corresponding to the stress rates in 10.4.2.1 for the elastic range. This crosshead separation rate shall be maintained up to the proof strength (plastic extension or total extension). In any case, the strain rate shall not exceed 0,002 5 s^{-1}.

10.4.3 Rate for the determination of tensile strength

In the plastic range, the straining rate shall not exceed 0,008 s^{-1}.

If the test does not include the determination of a yield strength or proof strength, the strain rate in the elastic range may reach the maximum permitted in the plastic range.

10.5 Choice of the method and rates

Unless otherwise agreed, the choice of method (A or B) and test rates are at the discretion of the producer or the test laboratory assigned by the producer, provided that these meet the requirements of this part of ISO 6892.

10.6 Documentation of the chosen testing conditions

In order to report the test control mode and testing rates in an abridged form, the following system of abbreviation can be used:

ISO 6892-3 Annn, or ISO 6892-3 Bn

where ‘A’ defines the use of Method A (strain rate control), and ‘B’ the use of Method B (expanded strain rate ranges). The symbols ‘nnn’ are a series of up to 3 characters that refer to the rates used during each phase of the test, as defined in Figure 1, and ‘n’ can be added indicating the strain rate (in s^{-1}) selected.

EXAMPLE 1 ISO 6892-3, A224 defines a test based on strain rate control, using Ranges 2, 2, and 4.

EXAMPLE 2 ISO 6892-3 B defines a test based on expanded strain rates respectively stress rate according to 10.4.2.1.

11 Determination or calculation of the properties

This is done in accordance with ISO 6892-1.

12 Test report

The test report shall contain at least the following information unless otherwise agreed by the parties concerned:

a) reference to this part of ISO 6892 extended with the test condition information specified in 10.6 (e.g. ISO 6892-3:2015, A224);

b) identification of the test piece;

c) specified material, if known;

d) type of test piece;

e) location and direction of sampling of test pieces, if known;

f) testing control modes and testing rate respectively testing rate ranges (see 10.6) if different from the recommended methods and values given in 10.3 and 10.4;

g) cooling medium, cooling time, and soaking time;

h) test temperature;

i) method of establishing the extensometer gauge length, L_e;

j) test results

Results should be rounded to the following precisions (according ISO 80000-1[5]) or better, if not otherwise specified in product standards:

— strength values to the nearest whole number in MPa;

— percentage yield point extension values A_e to 0,1 %, all other percentage elongation values to 0,5 %;

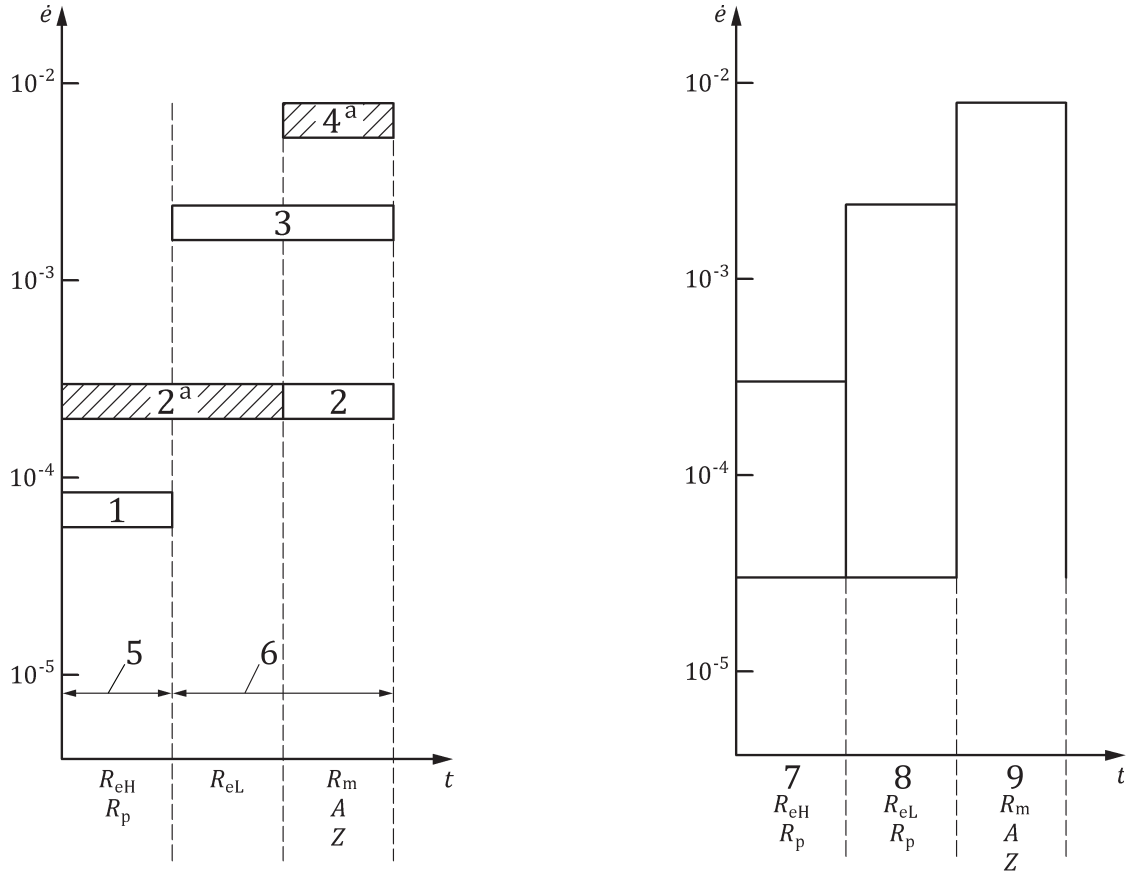
— percentage reduction of area to 1 %.

13 Measurement uncertainty

For requirements concerning measurement uncertainty, see ISO 6892-1:2009, Clause 23.

14 Figures

ISO 6892-1:2009, Figures 1 to 8 and 10 to 15 remain valid. ISO 6892-1:2009, Figure 9 is replaced by Figure 1.



a) **Method A** b) **Method B**

Key

$\dot{e}$ strain rate, in s^{-1}

t time

1 range 1: $\dot{e}$ = 0,000 07 s^{-1} (0,004 2 min^{-1}) with a relative tolerance of ±20 %

2 range 2: $\dot{e}$ = 0,000 25 s^{-1} (0,015 min^{-1}) with a relative tolerance of ±20 %

3 range 3: $\dot{e}$ = 0,002 s^{-1} (0,12 min^{-1}) with a relative tolerance of ±20 %

4 range 4: $\dot{e}$ = 0,006 7 s^{-1} (0,4 min^{-1}) with a relative tolerance of ±20 %

5 control mode: Extensometer control or crosshead control

6 control mode: Crosshead control

7 elastic range of the test

8 elastic range for the determination of R_{eL}, R_p

9 maximum strain rate for the determination of R_m, A, Z

a recommended

Figure 1 — Illustration of strain rates to be used during the tensile test, if R_{eH}, R_{eL}, R_p, R_m, A, and Z are determined

15 Annexes

The following Annexes of ISO 6892-1 remain valid:

— Annex A of ISO 6892-1:2009: Recommendations concerning the use of computer-controlled tensile-testing machines;

— Annex B of ISO 6892-1:2009: Types of test pieces to be used for thin products: sheets, strips, and flats between 0,1 mm and 3 mm thick;

— Annex C of ISO 6892-1:2009: Types of test pieces to be used for wire, bars, and sections with a diameter or thickness of less than 4 mm;

— Annex D of ISO 6892-1:2009: Types of test pieces to be used for sheets and flats of thickness equal to or greater than 3 mm and wire, bars, and sections of diameter or thickness equal to or greater than 4 mm

Exception: without Table D.2;

— Annex E of ISO 6892-1:2009: Types of test pieces to be used for tubes;

— Annex F of ISO 6892-1:2009: Estimation of the crosshead separation rate in consideration of the compliance of the testing machine.

Annex A gives additional information regarding test piece geometries and possible methods for gripping of the test pieces.

Annex A
(informative)

Addition to ISO 6892-1:2009, Annexes B and D

A.1 General

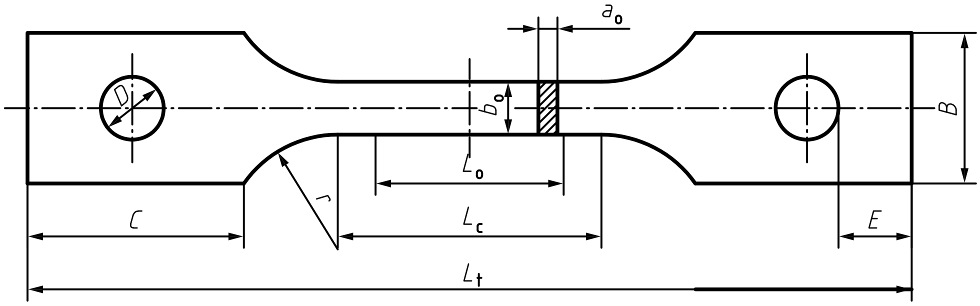
Generally, all test piece geometries can be used which conform with the specifications given in ISO 6892-1:2009, Annexes B to E. In the following, some examples are given with detailed information about test piece geometries.

A.2 Test pieces for thin products: sheets, strips, and flats with thickness between 0,1 mm and 3 mm

Several options are available for gripping the test piece, e.g. wedge grips, parallel grips, shoulder grips etc. However, friction gripping (wedge grips, parallel grips) can be unusable with a temperature chamber; therefore, test pieces are often gripped at the shoulders (form fit) or with a bolt such as the example in Figure A.1.

NOTE 1 If the test piece is gripped at the shoulders (form fit), a hole is not necessary. The tolerance of the radius is ±0,1 mm.

NOTE 2 It is good practice to reinforce the material around the pin holes to prevent hole tearing or localized buckling.



Key

a_0 original thickness

b_0 original width of the parallel length

r transition radius

B width of the gripped ends

C length of the gripped ends

L_0 original gauge length (L_0 = 50 mm)

L_c parallel length ($L_c \geq L_0 + b_0$)

L_t total length of test piece

D diameter of the hole

E distance from the test piece end to the hole

Figure A.1 — Example of test piece to be used for sheets, strips, and flats with thickness between 0,1 mm and 3 mm

Table A.1 — Example of test piece to be used for sheets, strips, and flats with thickness between 0,1 mm and 3 mm

Dimensions in mm

a_0		b_0	L_0	r	B	C	D	E	L_c	L_t
>	≤								min.	min.[a]
0,1	3,0	12,5	50	25	35[b]	50	15	17	62,5	205

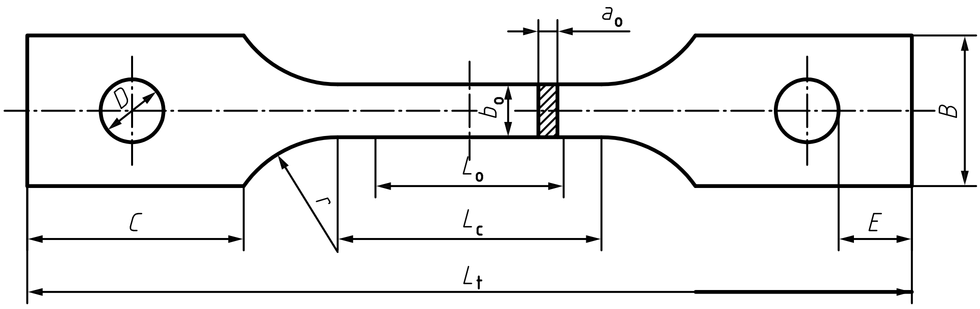
[a] Minimum value only sufficient, if the other geometries (especially the parallel length, L_c) are not greater than the given values.

[b] If the pin loaded system is used, for some materials it can be necessary to increase this value to 40 mm.

A.3 Test pieces to be used for sheets and flats with thickness equal to or greater than 3 mm

Several options are available for gripping the test piece, e.g. wedge grips, parallel grips, shoulder grips etc. However, friction gripping (wedge grips, parallel grips) can be unusable with a temperature chamber; therefore, test pieces are often gripped at the shoulders (form fit) or with a bolt such as the example in Figure A.2.

NOTE If the test piece is gripped at the shoulders (form fit), a hole is not necessary. The tolerance of the radius is ±0,1 mm.



Key

a_0 original thickness

b_0 original width of the parallel length

r transition radius

B width of the gripped ends

C length of the gripped ends

L_0 original gauge length ($L_0 = 5,65\sqrt{S_0}$)

L_c parallel length ($L_c \geq L_0 + 1,5\sqrt{S_0}$)

L_t total length of test piece

D diameter of the hole

E distance from the test piece end to the hole

Figure A.2 — Example of test piece to be used for sheets and flats with thickness equal to or greater than 3 mm

Table A.2 — Example of test pieces to be used for sheets and flats with thickness equal to or greater than 3 mm

Dimensions in mm

a_0		b_0	L_0	r	B	C	D	E	L_c	L_t
>	≤								min.	min.[a]
3	3,5		35						48	190
3,5	4,5		40						54	196

[a] Minimum value only sufficient, if the other geometries (especially the parallel length L_c) are not greater than the given values.

[b] If the pin loaded system is used, for some materials it can be necessary to increase this value to 40 mm.

Table A.2 *(continued)*

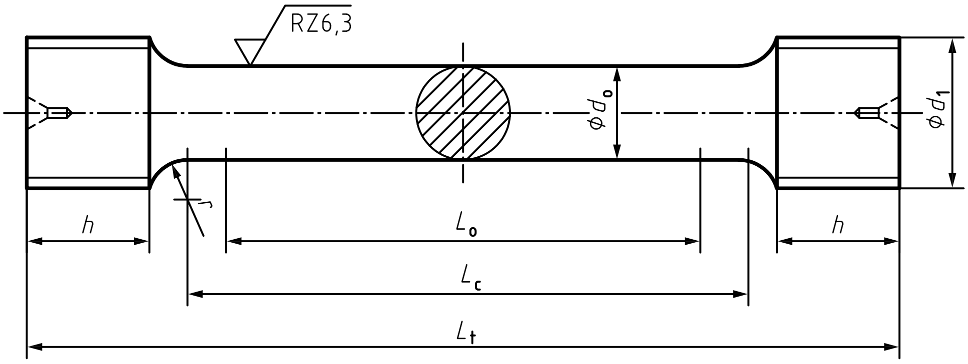
a_o		b_o	L_o	r	B	C	D	E	L_c	L_t
>	≤								min.	min.[a]
4,5	5,7	12,5	45	25	35[b]	50	15	17	61	203
5,7	6,9		50						67	209
6,9	8,3		55						73	215

[a] Minimum value only sufficient, if the other geometries (especially the parallel length L_c) are not greater than the given values.

[b] If the pin loaded system is used, for some materials it can be necessary to increase this value to 40 mm.

A.4 Test pieces to be used for wire, bars, and sections with diameter or thickness equal to or greater than 4 mm

For these materials, often threaded gripping ends are used (see Figure A.3 and Table A.3).



Key

d_o original diameter of the parallel length

d_1 metric ISO-thread

r transition radius

h length of the gripped ends

L_o original gauge length ($L_o = 5d_o$)

L_c parallel length ($L_c \geq L_o + d_o$)

L_t total length of test piece

Figure A.3 — Example of cylindrical test piece with threaded gripping ends

Table A.3 — Examples of cylindrical test pieces with threaded gripping ends

Dimensions in mm

d_o	L_o	d_1	r min.	h min.	L_c min.	L_t min.[a]
4	20	M6	3	6	24	41
5	25	M8	4	7	30	51
6	30	M10	5	8	36	60
8	40	M12	6	10	48	77
10	50	M16	8	12	60	97
12	60	M18	9	15	72	116
14	70	M20	11	17	84	134

[a] Minimum value only sufficient, if the other geometries (especially the transition radius, the length of the gripped ends, and the parallel length, L_c) are not greater than the given values.

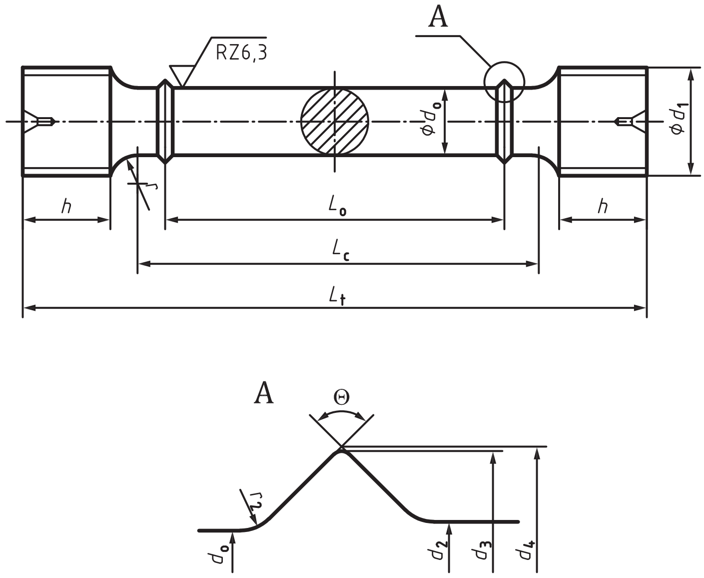
Table A.3 *(continued)*

d_o	L_o	d_1	r min.	h min.	L_c min.	L_t min.[a]
16	80	M24	12	20	96	154
18	90	M27	14	22	108	173
20	100	M30	15	24	120	191
25	125	M33	20	30	150	234

[a] Minimum value only sufficient, if the other geometries (especially the transition radius, the length of the gripped ends, and the parallel length, L_c) are not greater than the given values.

NOTE Longer test pieces can cause an invalid temperature gradient depending on the cooling device. In such cases, shorter test pieces should be used.

A.5 Example of test piece with collars/annular knife-edge ridges



Note For the different parts of detail A, the target values are as follows

$d_2 = d_o + 0{,}2$

$d_3 = d_o + 1{,}8$

$d_4 = d_o + 2{,}0$

$r_2 = 0{,}5$

$\Theta = 90°$

Figure A.4 — Example of cylindrical test piece with threaded gripping ends and collars/annular knife-edge ridges

Table A.4 — Examples of cylindrical test pieces with threaded gripping ends collars/annular knife-edge ridges

Dimensions in mm

d_o	L_o	d_1 [a]	r min.[b]	h min.	L_c	L_t min.[c]
6	30	M10	4,5	8	5,5 d_o to 7,5 d_o	57
8	40	M12	6	10	5,5 d_o to 7,5 d_o	73
10	50	M16	7,5	12	5,5 d_o to 7,5 d_o	91
12	60	M18	9	15	5,5 d_o to 7,5 d_o	110

[a] Minimum number of metric ISO-thread.

[b] Minimum value according to ISO 6892-1:2009.

[c] Minimum value only sufficient, if the other geometries (especially the transition radius and the length of the gripped ends) are not greater than the given values and the parallel length, L_c, is equal 5,5 d_o.

NOTE Use of this test piece geometry may result in reduced elongation results in comparison with other test piece geometries.

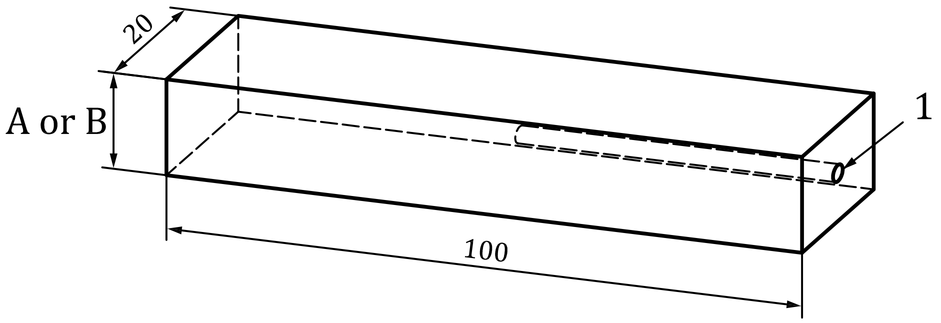
Annex B
(informative)

Example for cooling curves of steel depending on test piece dimensions and the specified test temperature in ethanol and liquid nitrogen

A drawing of the test piece blank used for generating the cooling curves B.2 to B.4 is shown in Figure B.1. They can give hints for the cooling times that can be required.

If gaseous cooling media are used, the necessary cooling times can be much longer.

NOTE There are health and safety concerns with the use of ethanol and its use should only be considered in a closed environment.



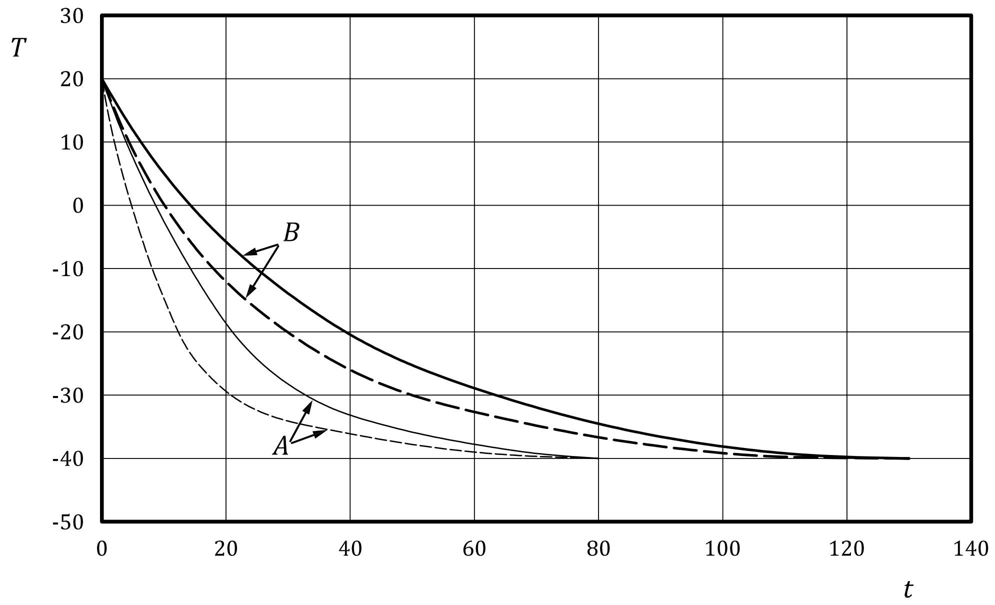
Key

1 thermocouple hole

A test piece thickness: 5 mm

B test piece thickness: 15 mm

Figure B.1 — Drawing of the test piece blank used



Key

A test piece thickness: 5 mm

B test piece thickness: 15 mm

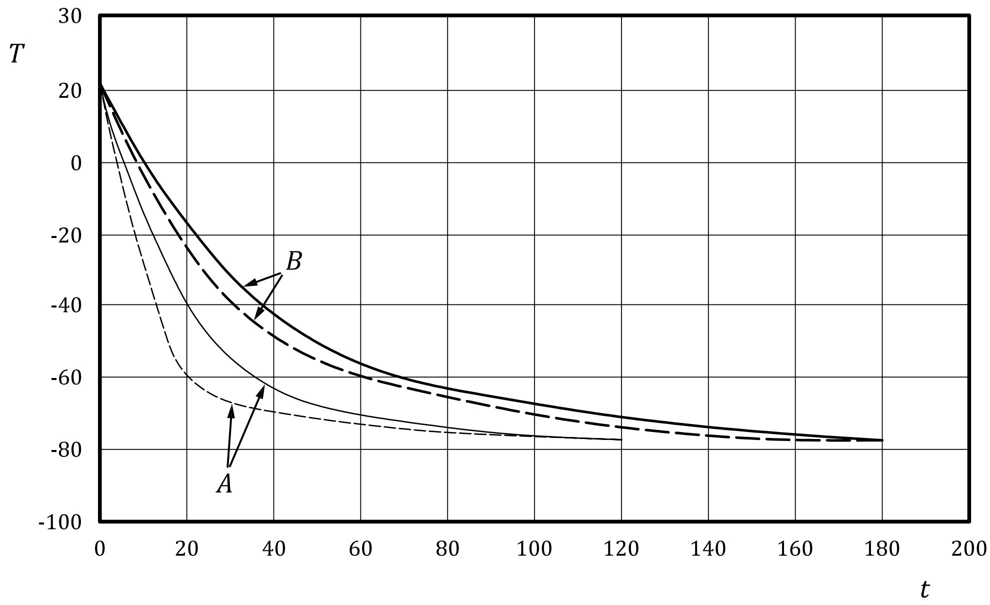
T temperature, in °C

t time, in s

---- surface of the test piece

— centre of the test piece

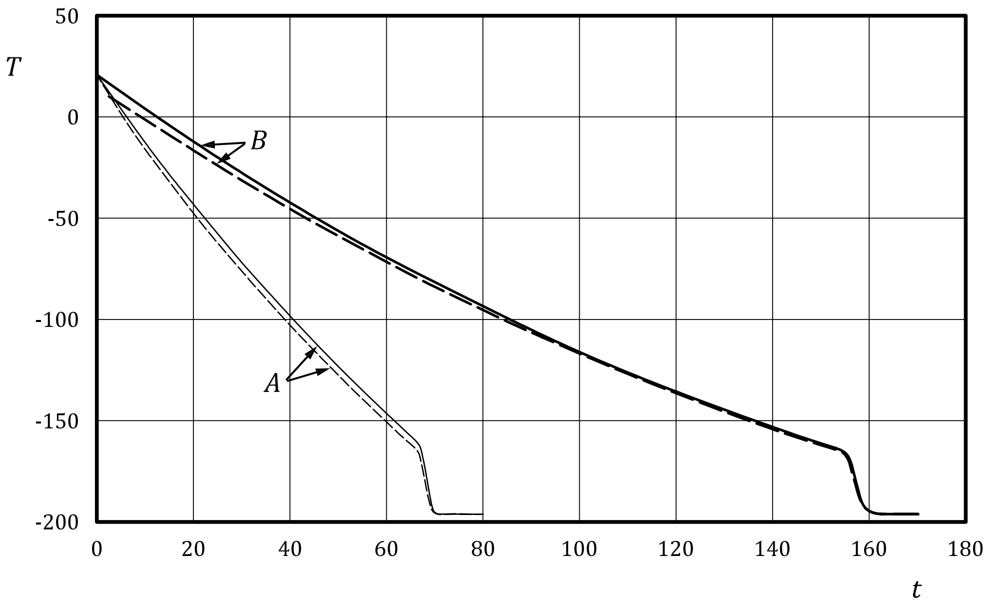
Figure B.2 — Cooling curves of the test piece blank used in ethanol at –40 °C



Key

A	test piece thickness: 5 mm
B	test piece thickness: 15 mm
T	temperature, in °C
t	time, in s
----	surface of the test piece
—	centre of the test piece

Figure B.3 — Cooling curves of the test piece blank used in ethanol at –78 °C



Key

A	test piece thickness: 5 mm
B	test piece thickness: 15 mm
T	temperature, in °C
t	time, in s
----	surface of the test piece
—	centre of the test piece

Figure B.4 — Cooling curves of the test piece blank used in liquid nitrogen at –196 °C

Annex C
(informative)

Measurement uncertainty

See ISO 6892-1:2009, Annex J and the following information when estimating the measurement uncertainty of test results.

Table C.1 is a reproduction of ISO 6892-1:2009, Table J.1 with the addition of temperature, type of cooling medium, and strain rate components. The variations in temperature and the type of cooling medium have been found to have a noticeable potential effect on testing results. The effect of the variation of the strain rate is comparable to the effect at room temperature. Therefore, uncertainty, components relative to temperature and strain rate variations, and the type of cooling medium should be considered when estimating measurement uncertainty of testing results. As shown in Table C.1, temperature, cooling medium, and strain rate can affect the results of the listed material parameters.

Table C.1 — Uncertainty contributors to the test results

Parameter	Test results					
	R_{eH}	R_{eL}	R_m	R_p	A	Z
Force	X	X	X	X	—	—
Extension	—	—	—	X	X	—
Gauge length	—	—	—	X	X	—
S_o	X	X	X	X	—	X
S_u	—	—	—	—	—	X
Temperature	X	X	X	X	X	X
Strain rate	X	X	X	X	X	X
Liquid cooling medium/ Gaseous cooling medium	—	—	X	X	X	X
X = relevant — = not relevant						

To determine the uncertainty of the test results listed in Table C.1, the uncertainty contribution related to test equipment may be derived from the calibration certificates for the devices used for the determination of the test results, see (ISO 6892-1:2009, J.3). However, the uncertainty of the test results influenced by temperature and strain rate variations and the type of cooling medium shall be determined experimentally since these uncertainty values are highly material dependant. For this reason, it is not possible at this time to assign predictable values for temperature, cooling medium, and strain rate components to be used in an example.

See ISO 6892-1:2009, Annex J for examples of how uncertainty components are determined, arithmetically combined and represented for an estimation of total expanded measurement uncertainty of testing results.

Bibliography

[1] ISO 2566-1, *Steel — Conversion of elongation values — Part 1: Carbon and low alloy steels*

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[3] ISO 80000-1, *Quantities and units — Part 1: General*

[4] ASTM E1012 REV A:1993, *Standard Practice for Verification of Specimen Alignment Under Tensile Loading*

[5] Tension and Compression Testing at Low Temperatures, ASM Handbook Vol 8, p 164

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