AS 2291:2020

AS 2291:2020
ISO 6892-2:2018

Australian STANDARD®

Metallic materials — Tensile testing — Method of test at elevated temperature

STANDARDS Australia

AS 2291:2020

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Metallic materials — Tensile testing — Method of test at elevated temperature

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Preface

This Test Method was prepared by the Standards Australia Committee MT-006, Mechanical Testing Of Metals to supersede AS 2291—2007, *Metallic materials — Tensile testing at elevated temperatures*.

The objective of this Test Method is to specify a method of tensile testing of metallic materials at temperatures higher than room temperature.

This Test Method is identical with, and has been reproduced from, ISO 6892-2:2018, *Metallic materials — Tensile testing — Part 2: Method of test at elevated temperature*.

As this document has been reproduced from an International Test Method, a full point substitutes for a comma when referring to a decimal marker.

Australian or Australian/New Zealand Standards that are identical adoptions of international normative references may be used interchangeably. Refer to the online catalogue for information on specific Standards.

The terms "normative" and "informative" are used in Standards to define the application of the appendices or annexes to which they apply. A "normative" appendix or annex is an integral part of a Standard, whereas an "informative" appendix or annex is only for information and guidance.

Contents

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 on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 1, *Uniaxial testing.*

This second edition cancels and replaces the first edition (ISO 6892-2:2011), of which it constitutes a minor revision.

The main changes compared to the previous edition are as follows:

— a note has been added after the first sentence of 10.2.1;

— some references to subclauses of ISO 6892-1 have been deleted.

A list of all parts in the ISO 6892 series can be found on the ISO website.

Introduction

In this document, two methods of testing speeds are described. The first, 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.

The influence of the testing speed on the mechanical properties, determined by the tensile test, is normally greater at an elevated temperature than at room temperature.

Traditionally, mechanical properties determined by tensile tests at elevated temperatures have been determined at a slower strain or stressing rate than at room temperature. This document recommends the use of slow strain rates but, in addition, higher strain rates are permitted for particular applications, such as comparison with room temperature properties at the same strain rate.

During discussions concerning the speed of testing in the preparation of this document, it was decided to consider deleting the stress rate method in future revisions.

NOTES

Australian Standard®

Metallic materials — Tensile testing — Method of test at elevated temperature

WARNING — This document calls for the use of substances and/or procedures that can be injurious to health if adequate safety measures are not taken. This document does not address any health hazards, safety or environmental matters associated with its use. It is the responsibility of the user of this document to establish appropriate health, safety and environmentally acceptable practices.

1 Scope

This document specifies a method of tensile testing of metallic materials at temperatures higher than room temperature.

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

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*

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 apply with the following exceptions and supplements.

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

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

In general, all test piece geometries/dimensions are based on measurements taken at room temperature. The exception may be the extensometer gauge length (see 3.3 and 10.2.2).

NOTE The following properties are generally not determined at elevated 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 heating of the test piece and before application of force

3.2
percentage elongation after fracture
A
permanent elongation at room temperature of the gauge length after fracture ($L_u - L_o$)

Note 1 to entry: It is expressed as a percentage of the *original gauge length* (L_o) (3.1).

Note 2 to entry: For further details, see ISO 6892-1.

3.3
extensometer gauge length
L_e
length within the parallel portion of the test piece used for the measurement of *extension* (3.4) by means of an extensometer

3.4
extension
increase in the *extensometer gauge length* (L_e) (3.3) at a given moment during the test

3.5
percentage extension
extension (3.4) expressed as a percentage of the *extensometer gauge length* (L_e) (3.3)

3.6
percentage reduction of area
Z
maximum change in cross-sectional area which has occurred during the test ($S_o - S_u$)

Note 1 to entry: It is 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.

3.7
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 referred to in this document are engineering stresses, calculated using the cross-sectional area of the test piece derived from dimensions measured at room temperature.

3.8
soaking time
t_s
time taken to stabilize the temperature of the test piece prior to mechanical loading

4 Symbols and designations

ISO 6892-1 provides an extensive listing of symbols and their related designations.

The additional symbols used in this document 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 Clause 3.

The test is carried out at a temperature higher than 35 °C, which means at temperatures higher than room temperature as specified in ISO 6892-1.

6 Test piece

For requirements concerning test pieces, see ISO 6892-1.

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

7 Determination of original cross-sectional area (S_o)

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

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.

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 used extensometer 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 in the relevant range may be used.

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

Any part of the extensometer projecting beyond the furnace shall be designed or protected from draughts 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 speed of the air surrounding the testing machine.

9.3 Heating device.

9.3.1 Permitted deviations of temperature

The heating device for the test piece shall be such that the test piece can be heated 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 with corrections applied for any known systematic errors, but with no consideration of the uncertainty of the temperature measurement equipment.

The permitted deviations between the specified temperature, T, and the indicated temperatures, T_i, and the maximum permissible temperature variation along the test piece are given in Table 2.

For specified temperatures greater than 1 100 °C, the permitted deviations shall be defined by previous agreement between the parties concerned.

Table 2 — Permitted deviations between T_i and T and maximum permissible temperature variations along the test piece

Specified temperature, T °C	**Permitted deviation between T_i and T** °C	**Maximum permissible temperature variation along the test piece** °C
$T \leq 600$	±3	3
$600 < T \leq 800$	±4	4
$800 < T \leq 1\,000$	±5	5
$1\,000 < T \leq 1\,100$	±6	6

9.3.2 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 may be reduced if the general arrangement of the furnace 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 9.3.1. 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 and be suitably screened from direct radiation from the furnace wall.

9.3.3 Verification of the temperature-measuring system

The temperature-measuring system shall have a resolution equal to or better than 1 °C and an accuracy of ±0,004 T °C or ±2 °C, whichever is greater.

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 may not 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 heating 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.

NOTE Maintaining a very small tensile load (e.g. test machine in load control) during heating period and soaking time can prevent possible compressive stresses due to thermal expansion.

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 can lead to minor differences in the test results. The method used shall be documented in the test report.

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)

This L_e includes the thermal extension of the test piece.

10.2.2.3.1 Nominal L_e at test temperature (Method 2 a)

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

10.2.2.3.2 Reduced L_e at room temperature (Method 2 b)

An extensometer with reduced 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 2 c)

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 and thermal expansion) is used.

10.2.3 Heating of the test piece

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

Quite often, longer times can be required to bring the entire cross-section of the material up to the specified temperature.

During heating, the temperature of the test piece shall not exceed the specified temperature with its tolerances, except by special 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.

It is not always the case that all properties of the tensile test at room temperature will be determined at elevated 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, but observe the following specified range:

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

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

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, but observe the following specified range:

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

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

See also Figure 1.

Recommended: crosshead control.

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, but observe the following specified range:

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

— 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: $\dot{e}_{L_c}$ = 0,001 4 s^{-1} (equal to 0,084 min^{-1}), with a relative tolerance of ±20 % (recommended unless otherwise specified);

— Range 4: $\dot{e}_{L_c}$ = 0,006 7 s^{-1} (equal to 0,4 min^{-1}), with a relative tolerance of ±20 %.

See also Figure 1.

Recommended: crosshead control.

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 3 may 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.

It should be taken into consideration that strain rate sensitivity of metals might be higher at elevated temperature than at room temperature. 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

This deals with upper and lower yield strengths and proof strength non-proportional extension.

The strain rate of the parallel length of the test piece, from the beginning of the test to the yield strength, shall be between 0,000 016 7 s^{-1} and 0,000 083 3 s^{-1} (0,001 min^{-1} and 0,005 min^{-1}).

When a test system is incapable of displaying strain rate, the stress rate shall be set so that a strain rate less than 0,000 05 s^{-1} (0,003 min^{-1}) is maintained throughout the elastic range. In no case shall the stress rate in the elastic range exceed 5 MPa s^{-1} (300 MPa min^{-1}).

10.4.3 Rate for the determination of tensile strength

If only the tensile strength is to be determined, the strain rate shall be between 0,000 33 s^{-1} and 0,003 3 s^{-1} (0,02 min^{-1} and 0,20 min^{-1}).

If a yield strength is also determined on the same test, the change of the test rate required in 10.4.2 to the rate defined above shall be smooth and avoid any overshoot (see ISO 6892-1).

10.5 Choice of the method and rates

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

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 6892-2 Annn or ISO 6892-2 Bn

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

EXAMPLE 1 ISO 6892-2 A113 defines a test based on strain rate control, using ranges 1, 1 and 3.

EXAMPLE 2 ISO 6892-2 B defines a test based on expanded strain rate ranges or stress rate, respectively, according to 10.4.2.

11 Determination or calculation of the properties

This step 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) a reference to this document extended with the test condition information specified in 10.6, e.g. ISO 6892-2 A113;

b) identification of the test piece;

c) specified material, if known;

d) the type of test piece;

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

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

g) the soaking time;

h) the test temperature;

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

j) test results.

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

— strength values, in megapascals, to the nearest whole number;

— percentage yield point extension values, A_e, to 0,1 %;

— all other percentage elongation values to 0,5 %;

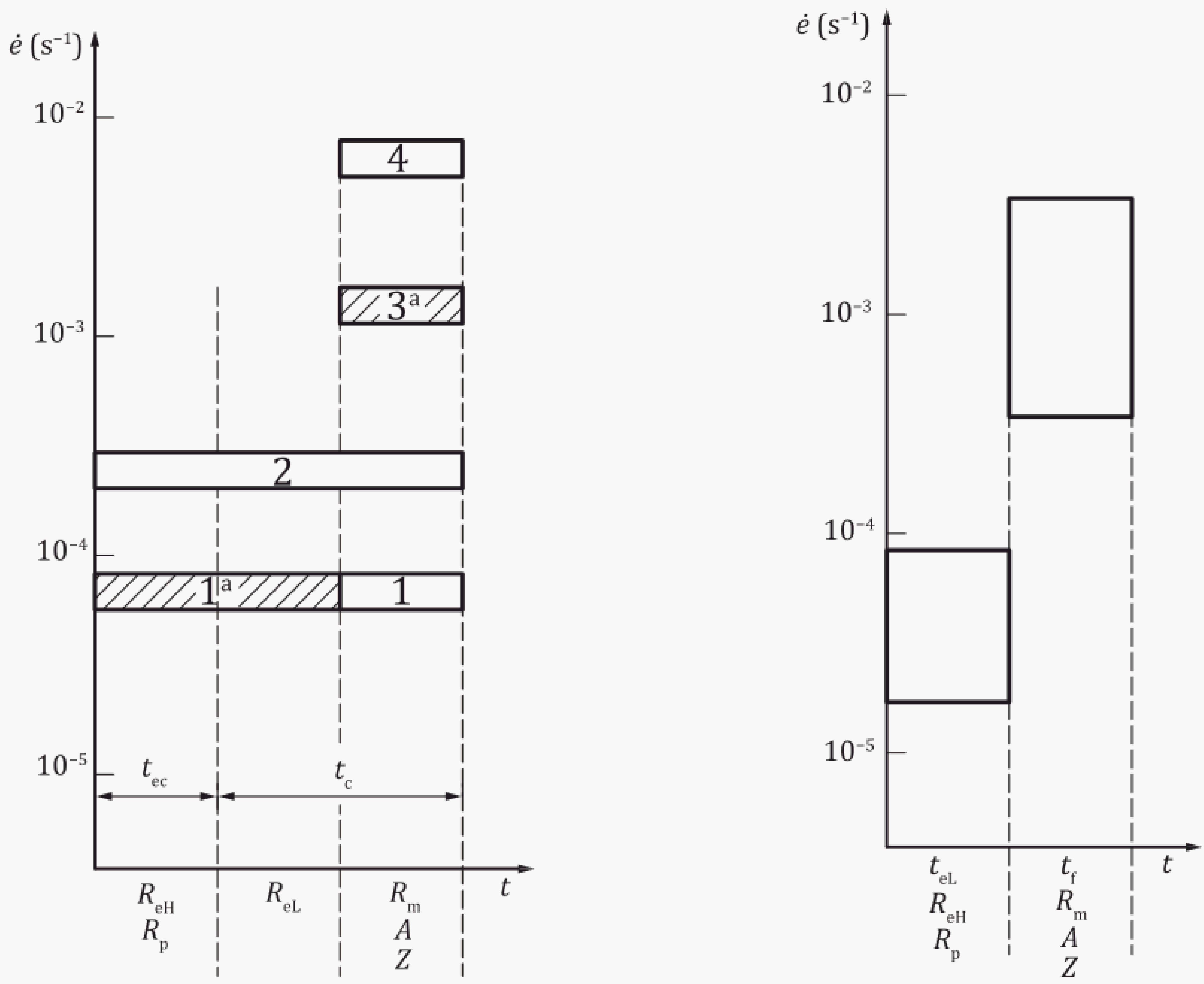
— percentage reduction of area, Z, to 1 %.

13 Measurement uncertainty

For requirements concerning measurement uncertainty, see ISO 6892-1 and Annex B.

14 Figures

ISO 6892-1:2016, Figures 1 to 8 and 10 to 15 remain valid; ISO 6892-1:2016, Figure 9 has been replaced by Figure 1.



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

Key

$\dot{e}$	strain rate
t	time progress of the tensile test
t_c	crosshead control time
t_{ec}	extensometer control time or crosshead control time
t_{el}	time range (elastic behaviour) for determination of the parameters listed (see ISO 6892-1 for designations)
t_f	time range (usually up to fracture) for determination of the parameters listed (see ISO 6892-1 for designations)
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: $\dot{e}$ = 0,001 4 s^{-1} (0,084 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 %
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 6892-1:2016 remain valid:

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

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

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

— Annex D: 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;

NOTE Exception: without Table D.2.

— Annex E: Types of test pieces to be used for tube;

— Annex F: Estimation of the crosshead separation rate in consideration of the stiffness (or compliance) of the testing equipment.

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

Annex A
(informative)

Addition to ISO 6892-1:2016, Annexes B and D

A.1 General

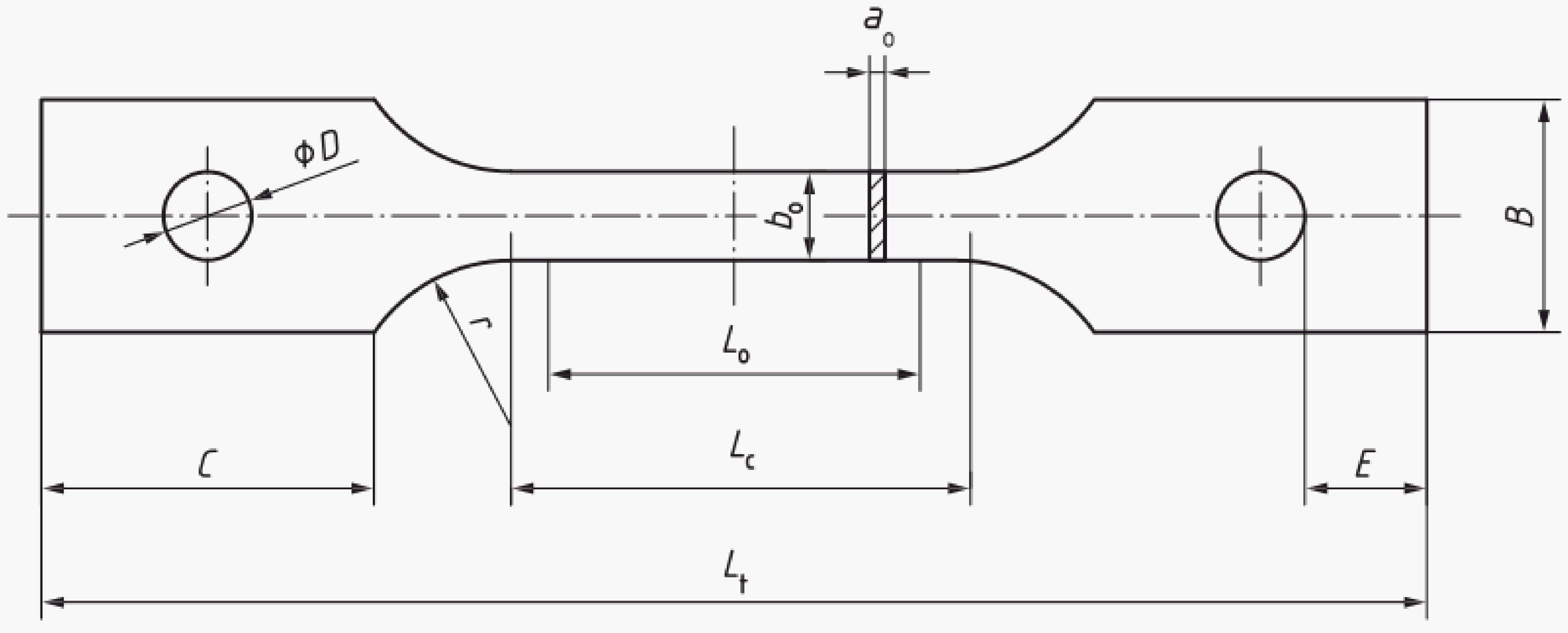
Generally, all test piece geometries which conform with the specifications given in ISO 6892-1:2016, Annexes B to E of can be used. In the following clauses, some examples are given with detailed information about test piece geometries.

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

In practice, different gripping systems are available, e.g. wedge grips, parallel grips, shoulder grips, etc. At higher temperatures (T > 250 °C), friction gripping (wedge grips, parallel grips) can be very problematic. Therefore, the test pieces are often gripped with a bolt or at the shoulders (form fit) such as the one in Figure A.1 (see Table A.1).

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

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



Key

a_0	original thickness	L_0	original gauge length (L_0 = 50 mm)
b_0	original width of the parallel length	L_c	parallel length ($L_c \geq L_0 + b_0$)
r	transition radius	L_t	total length of test piece
B	width of the gripped ends	D	diameter of the hole
C	length of the gripped ends	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 for test piece to be used for sheets, strips and flats with thickness between 0,1 mm and 3 mm

Dimensions in millimetres

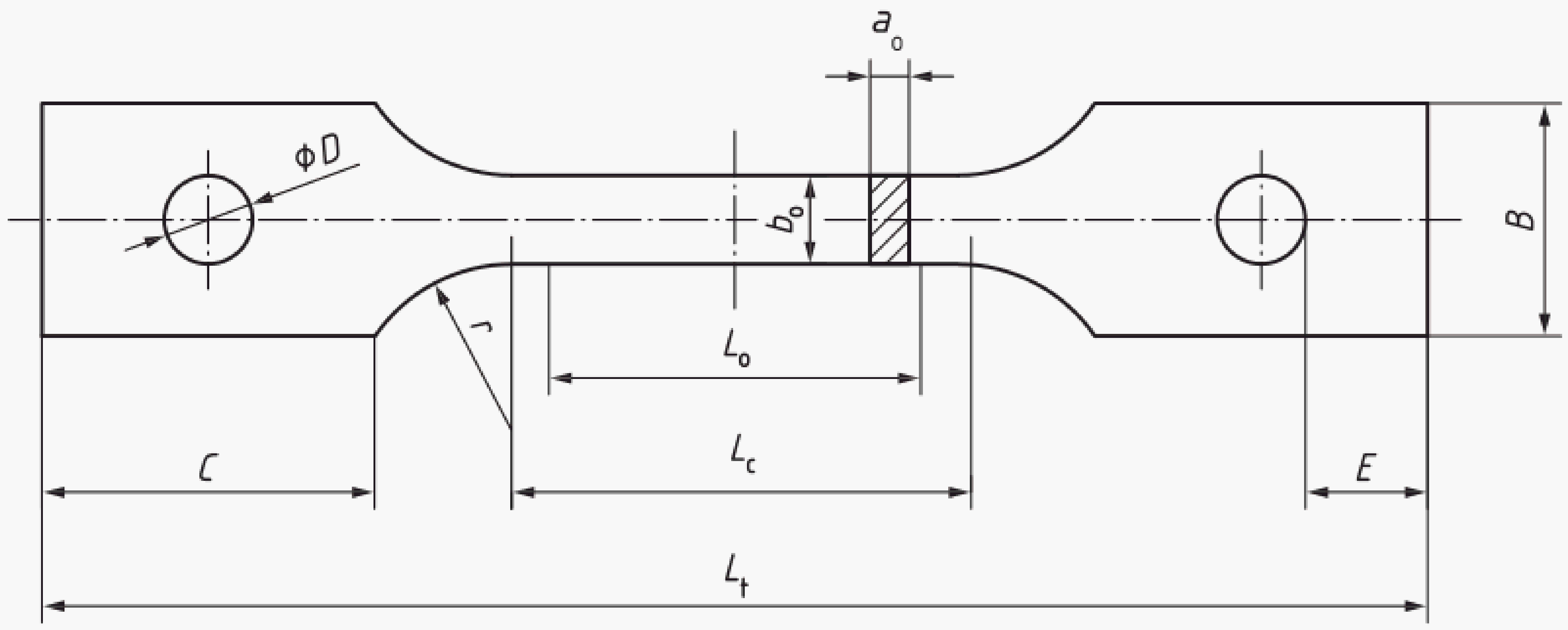
a_o		b_o	L_o	r	B	C	D	E	L_c	L_t
≥	≤								min.	min.[a]
0,1	3,0	12,5	50	25	35	50	15	17	62,5	205

[a] The minimum value is only sufficient when the parallel length, L_c, is the minimum value.

A.2.1 Test pieces to be used for sheets and flats with thickness equal to or greater than 3 mm

In practice, different gripping systems are available, e.g. wedge grips, parallel grips, shoulder grips, etc. At higher temperatures (T > 250 °C), friction gripping (wedge grips, parallel grips) can be very problematic. Therefore, the test pieces are often gripped with a bolt or at the shoulders (form fit) such as the one in Figure A.2 (see Table A.2).

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



Key

a_o original thickness

b_o original width of the parallel length

r transition radius

B width of the gripped ends

C length of the gripped ends

L_o original gauge length ($L_o = 5{,}65\sqrt{S_o}$)

L_c parallel length ($L_c \geq L_o + 1{,}5\sqrt{S_o}$)

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 a test piece to be used for sheets and flats with thicknesses equal to or greater than 3 mm

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

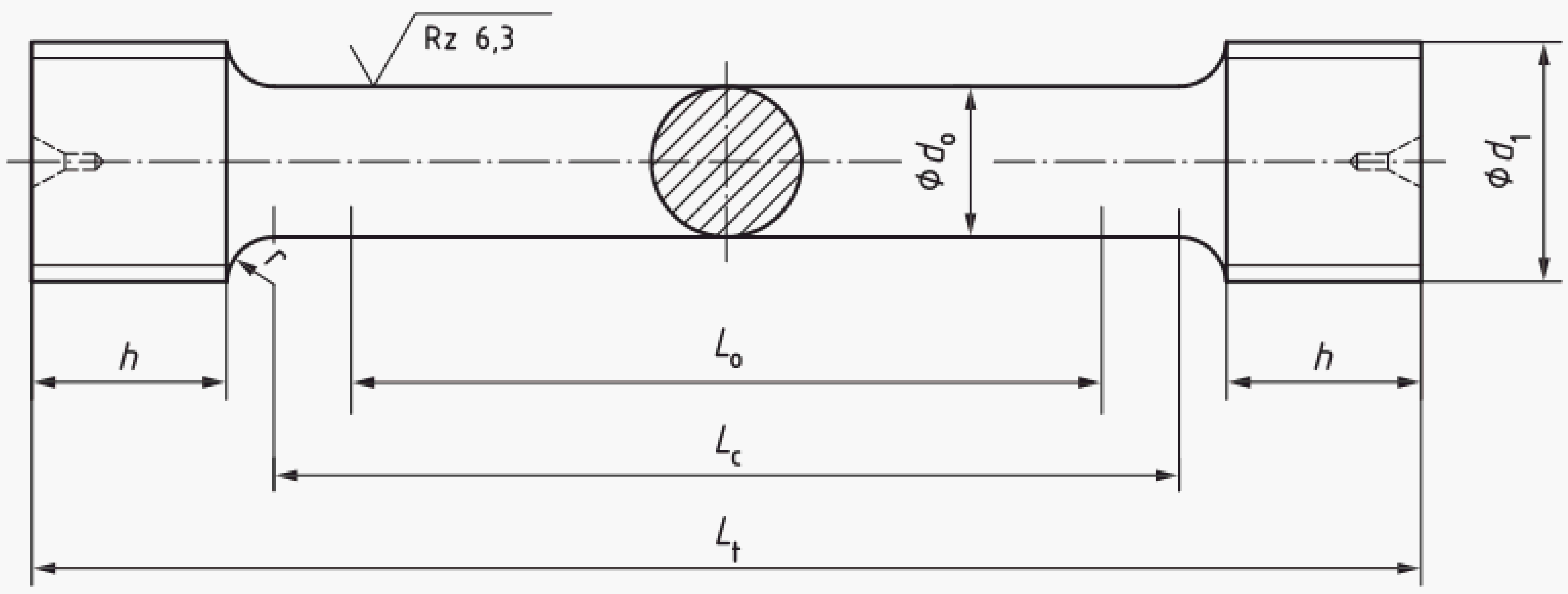
Dimensions in millimetres

a_o		b_o	L_o	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
4,5	5,7	12,5	45	25	35	50	15	17	61	203
5,7	6,9		50						67	209
6,9	8,3		55						73	215

[a] The minimum value is only sufficient when the parallel length, L_c, is the minimum value.

A.3 Test pieces to be used for wires, bars and sections with diameter or thickness equal to or greater than 4 mm

For these materials, threaded gripping ends are often 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 millimetres

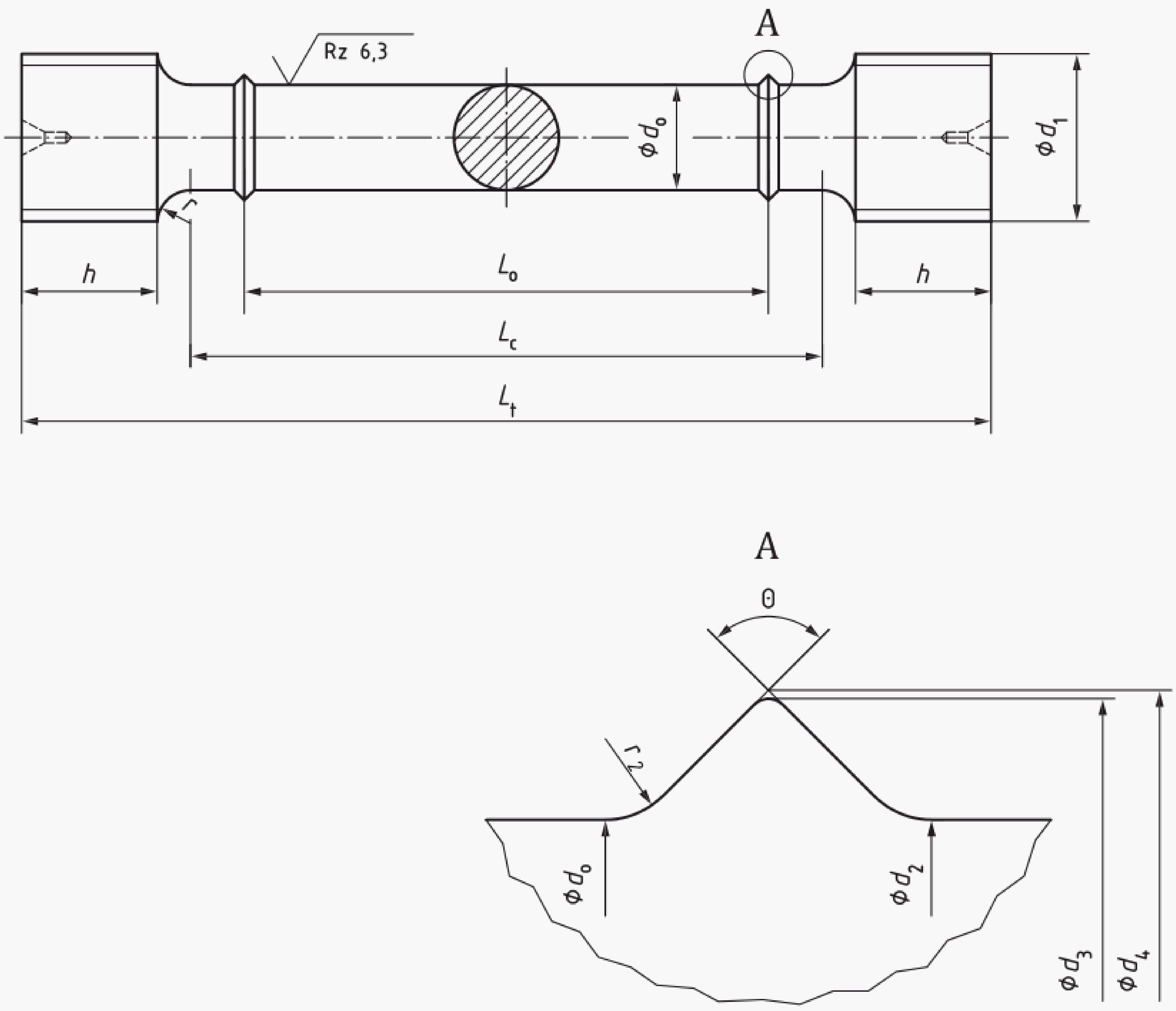
d_o	L_o	d_1	r min.	h min.	L_c min.	L_t min.[a]
4	20	M6	3	6	24	41
5	25	M8	4	7	30	51
6	30	M10	5	8	36	60
8	40	M12	6	10	48	77
10	50	M16	8	12	60	97
12	60	M18	9	15	72	116
14	70	M20	11	17	84	134
16	80	M24	12	20	96	154
18	90	M27	14	22	108	173
20	100	M30	15	24	120	191
25	125	M33	20	30	150	234

[a] The minimum value is only sufficient when the transition radius, r, the length of the gripped ends, h, and the parallel length, L_c, are minimum values.

Large test pieces can cause an invalid temperature gradient depending on the heating device. In such cases, smaller test piece geometries should be used.

A.4 Example of test piece with collars/annular knife-edge ridges

See Figure A.4 and Table A.4.



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 and collars/annular knife-edge ridges

Dimensions in millimetres

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.

[c] The minimum value is only sufficient when the transition radius, r, and the length of the gripped ends, h, are minimum values and the parallel length, L_c, is equal to 5,5 d_o.

Annex B
(informative)

Measurement uncertainty

See ISO 6892-1 and the following information when estimating the measurement uncertainty of test results.

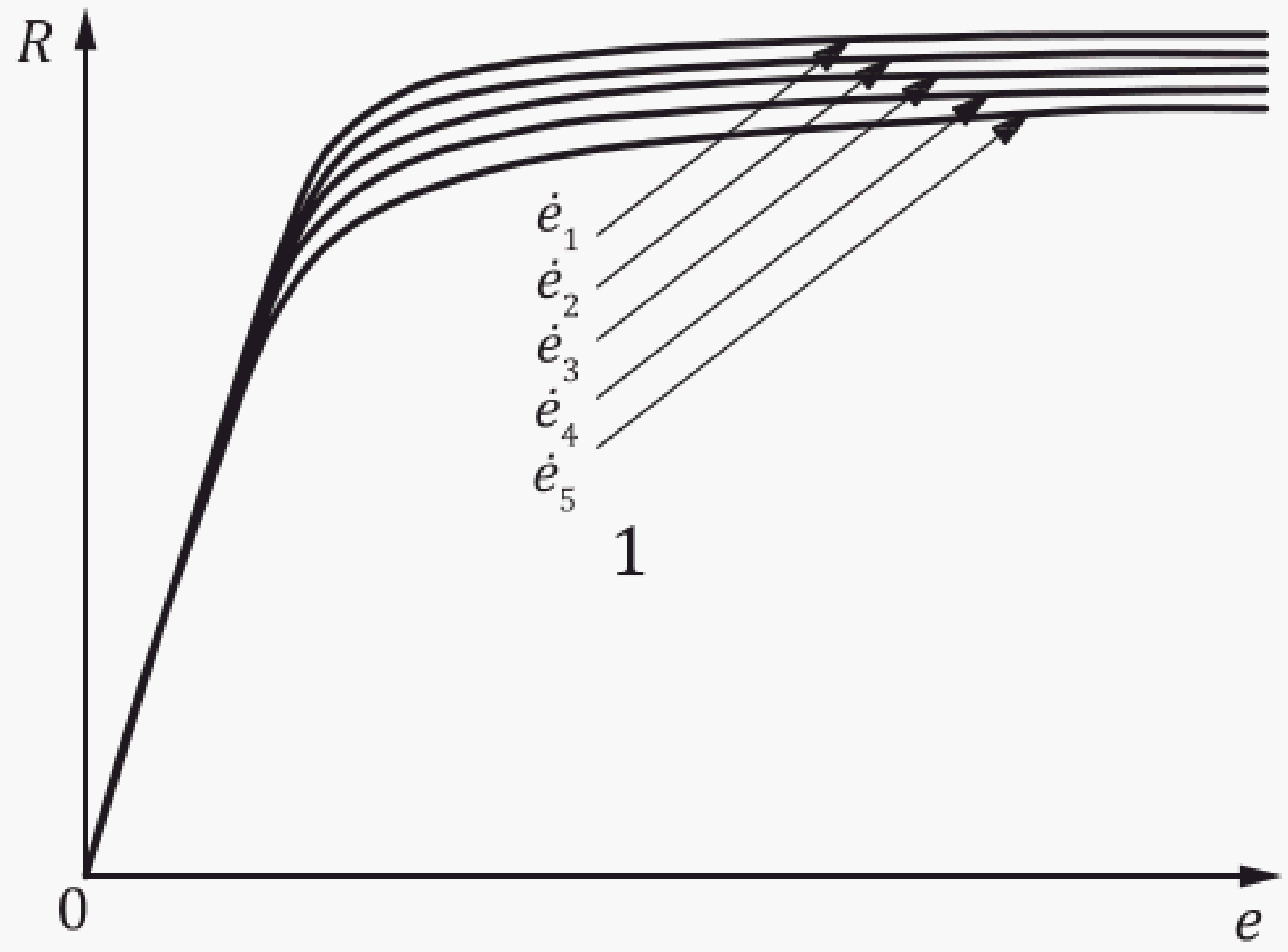
Table B.1 is a reproduction of ISO 6892-1 with the addition of temperature and strain rate components. The variations in temperature and strain rate have been found to have a larger potential effect on testing results at elevated temperatures than comparable effects at room temperature. Therefore, uncertainty components relative to temperature and strain rate variations should be considered when estimating measurement uncertainty of testing results. As shown in Table B.1, the temperature and the strain rate can affect the results of all listed material parameters.

Table B.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
X: relevant. —: not relevant.						

To determine the uncertainty of the test results listed in Table B.1, the uncertainty contribution related to test equipment can be derived from the calibration certificates for the devices used for the determination of the test results (see ISO 6892-1). However, the uncertainty of the test results influenced by temperature and strain rate variations should be determined experimentally since these uncertainty values are highly material dependent. For this reason, it is not possible at this time to assign predictable values for temperature and strain rate components to be used in an example. Figures B.1 and B.2 show examples of the possible effects of different strain rates on stress-strain curves at two different testing temperatures for one particular alloy.

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



Key

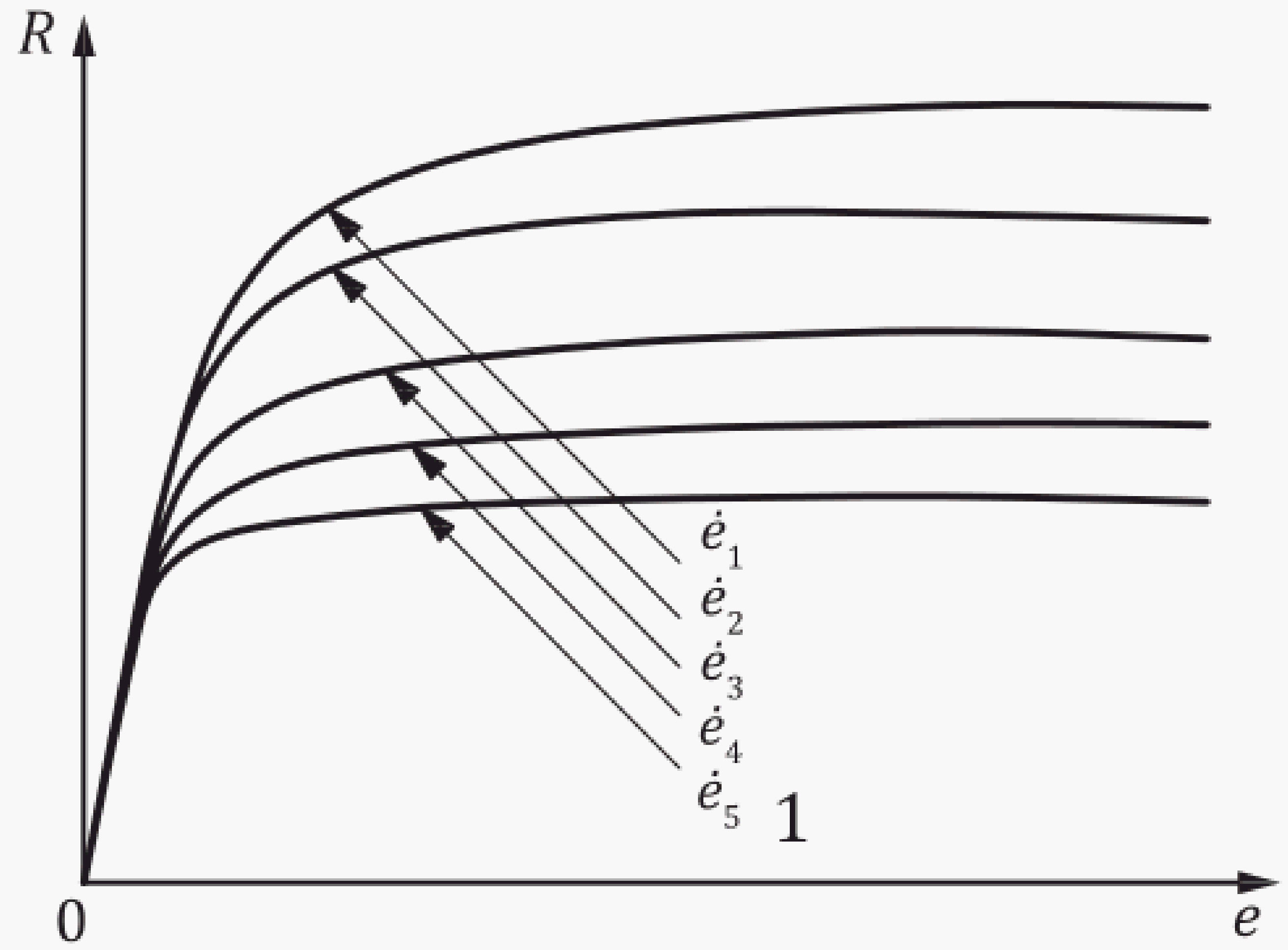
1 strain rate

R stress, MPa

e percentage extension (strain), %

Figure B.1 — Stress-strain curves at room temperature and different strain rates

Figure B.1 shows that for different strain rates at room temperature, there is relatively little difference in the material response ($\dot{e}_1 > \dot{e}_2 > \dot{e}_3 > \dot{e}_4 > \dot{e}_5$).



Key

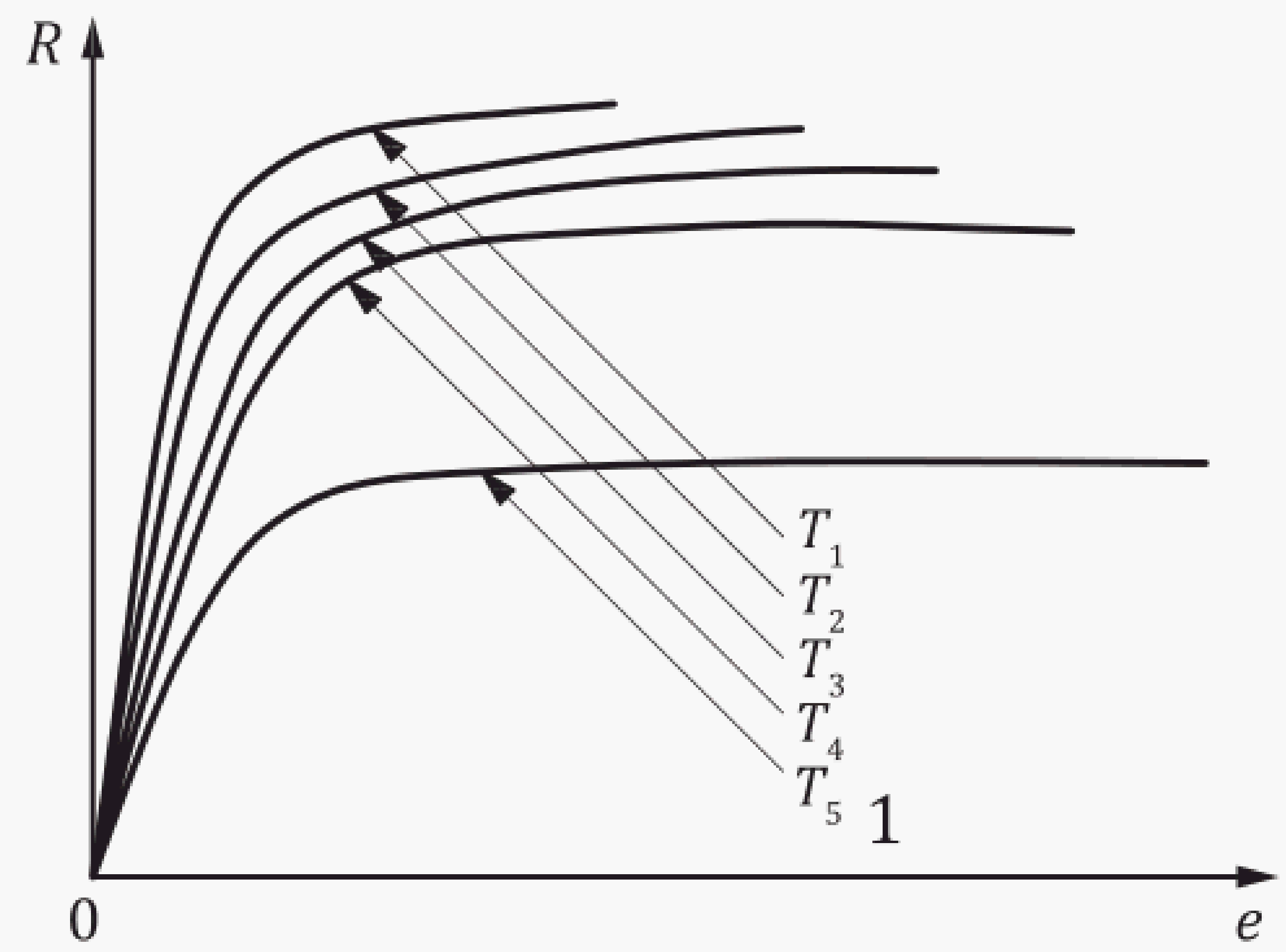
1 strain rate

R stress, MPa

e percentage extension (strain), %

Figure B.2 — Stress-strain curves at 850 °C and different strain rates

Figure B.2 shows that for different strain rates at elevated temperature, there are large differences in the material response ($\dot{e}_1 > \dot{e}_2 > \dot{e}_3 > \dot{e}_4 > \dot{e}_5$).



Key

1 temperature

R stress, MPa

e percentage extension (strain), %

Figure B.3 — Stress-strain curves at a given strain rate and different temperatures

Figure B.3 shows that for a given strain rate and different temperatures, there are large differences in the material response ($T_1 < T_2 < T_3 < T_4 < T_5$).

Bibliography

[1] ISO 377, *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing*

[2] ISO 2142[1)], *Wrought aluminium, magnesium and their alloys — Selection of specimens and test pieces for mechanical testing*

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

[4] ISO 2566-2, *Steel — Conversion of elongation values — Part 2: Austenitic steels*

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

1) Withdrawn.

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