INTERNATIONAL STANDARD

ISO 204

First edition
1997-03-15

Metallic materials — Uninterrupted uniaxial creep testing in tension — Method of test

Matériaux métalliques — Essai ininterrompu de fluage uniaxial en traction — Méthode d'essai

Reference number
ISO 204:1997(E)

Contents

Page

Annex

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet central@iso.ch
X.400 c=ch; a=400net; p=iso; o=isocs; s=central

Printed in Switzerland

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 204 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 1, *Uniaxial testing*.

Annex A of this International Standard is for information only.

This page intentionally left blank

Metallic materials — Uninterrupted uniaxial creep testing in tension — Method of test

1 Scope

This International Standard specifies an uninterrupted creep test (however, see 7.3) and defines the mechanical properties of metallic materials which can be determined, in particular the creep elongation and the time of creep rupture, at a specified temperature.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 286-2:1988, *ISO system of limits and fits — Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts.*

ISO 7500-2:1996, *Metallic materials — Verification of static uniaxial testing machine — Part 2: Tensile creep testing machines — Verification of the applied load.*

ISO 9513:—[1], *Metallic materials — Verification of extensometers used in uniaxial testing.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 reference length, L_r: Base length used for the calculation of elongation.

NOTE — Examples of reference lengths for several types of test pieces are given in figure 1.

Distinction is made between the reference lengths defined in 3.1.1 and 3.1.2.

3.1.1 original reference length, L_{ro}: Reference length determined at ambient temperature before the test.

L_{ro} shall not exceed the parallel length L_c (3.4) by more than 10 % L_c for circular test pieces, or by more than 15 % L_c for square or rectangular test pieces.

1) To be published. (Revision of ISO 9513:1989)

3.1.2 final reference length, L_{ru}**:** Reference length determined at ambient temperature after rupture, the two pieces having been carefully fitted back together so that their axes lie in a straight line.

3.2 original gauge length, L_o**:** Length between gauge length marks on the piece measured at ambient temperature before the test.

3.3 final gauge length after rupture, L_u**:** Length between gauge marks on the test piece measured after rupture, at ambient temperature, the two pieces having been carefully fitted back together so that their axes lies in a straight line.

3.4 parallel length, L_c**:** Length of the parallel reduced section of the test piece.

3.5 extensometer gauge length, L_e**:** Distance between the measuring points of extensometer; shall be as near as possible to the reference length.

3.6 original cross-sectional area, S_o**:** Cross-sectional area of the parallel length determined at ambient temperature prior to testing.

3.7 cross-sectional area after rupture, S_u**:** Minimum cross-sectional area of the parallel length determined at ambient temperature after rupture, the two pieces having been carefully fitted back together so that their axes lie in a straight line.

3.8 initial stress, σ_o**:** Applied force divided by the original cross-sectional area S_o of the test piece.

3.9 elongation: Increase of the reference length at any moment during the test.

Distinction is made between the elongations defined in 3.9.1 and 3.9.2.

3.9.1 percentage creep elongation, A_f**:** At a given moment t during the test, the increase in the reference length between this moment and the zero moment (ΔL_{rt}) at a specified temperature expressed as a percentage of the original reference length:

$$A_f = \frac{\Delta L_{rt}}{L_{ro}} \times 100$$

NOTE — The symbol A_f may have as superscript the specified temperature T in degrees Celsius and as subscript the stress in megapascals[2], and the time t, in hours.

By convention the zero moment (start of time) is the moment at which the initial stress (σ_o) is applied to the test piece. The origin of the elongation is the value of the reference length at the zero moment.

3.9.2 percentage elongation after creep rupture, A_{fu}**:** Permanent elongation of the reference length after rupture ($L_{ru} - L_{ro}$) expressed as a percentage of the original reference length:

$$A_{fu} = \frac{L_{ru} - L_{ro}}{L_{ro}} \times 100$$

NOTE — The symbol A_{fu} may have as superscript the specified temperature T in degrees Celsius and as subscript the stress in megapascals[2].

2) 1 MPa = 1 N/mm^2

3.10 percentage reduction of area after creep rupture, Z_u**:** Maximum change in cross-sectional area measured after rupture ($S_o - S_u$) expressed as a percentage of the original cross-sectional area (S_o):

$$Z_u = \frac{S_o - S_u}{S_o} \times 100$$

NOTE — The symbol Z_u may have as superscript the specified temperature T in degrees Celsius and as subscript the stress in megapascals[2)].

3.11 creep rupture time, t_u**:** Time required for the test piece, maintained at the specified temperature T and strained by the specified tensile force, to rupture.

NOTE — The symbol t_u may have as superscript the specified temperature T in degrees Celsius and as subscript the stress in megapascals[2)].

3.12 simple machine: Test machine that allows the straining of only one test piece at a time.

3.13 multiple machine: Test machine that allows simultaneous straining of more than one test piece at the same temperature.

4 Symbols and their meaning

The symbols and corresponding meanings are given in table 1.

5 Principle

A test piece is heated to the specified temperature and strained by means of a constant tensile force or constant tensile stress[3)], applied along its longitudinal axis for a period of time either to obtain a specified creep elongation or to rupture the test piece.

6 Apparatus

6.1 Testing machine

The machine shall be such that the load can be applied along the axis of the test piece while keeping to a minimum the inadvertent bending or torsion of the test piece.

The load shall be applied to the test piece without shock.

NOTE — It is recommended that the machine be isolated from external vibration and shock. The machine should be equipped with a device which minimizes shock when the test piece ruptures.

The machine shall be verified and shall meet the requirements of class 1 in ISO 7500-2.

6.2 Elongation measuring device

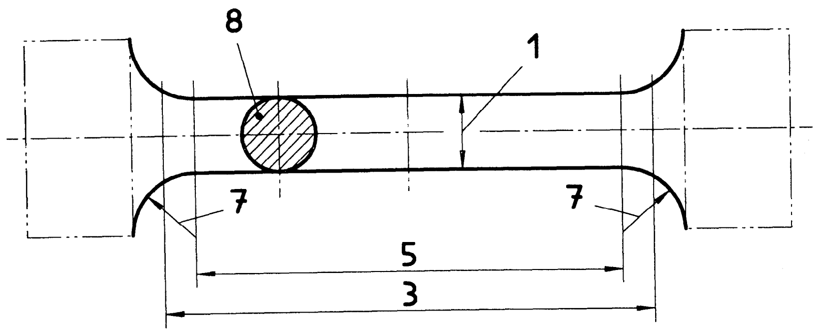
The elongation shall be measured using an extensometer which meets the requirements of at least class 1 in ISO 9513, or by other means which ensure the same accuracy without interruption of the test.

3) "Constant stress" is taken to mean that the ratio of the force to the instantaneous cross-section remains constant throughout the test.

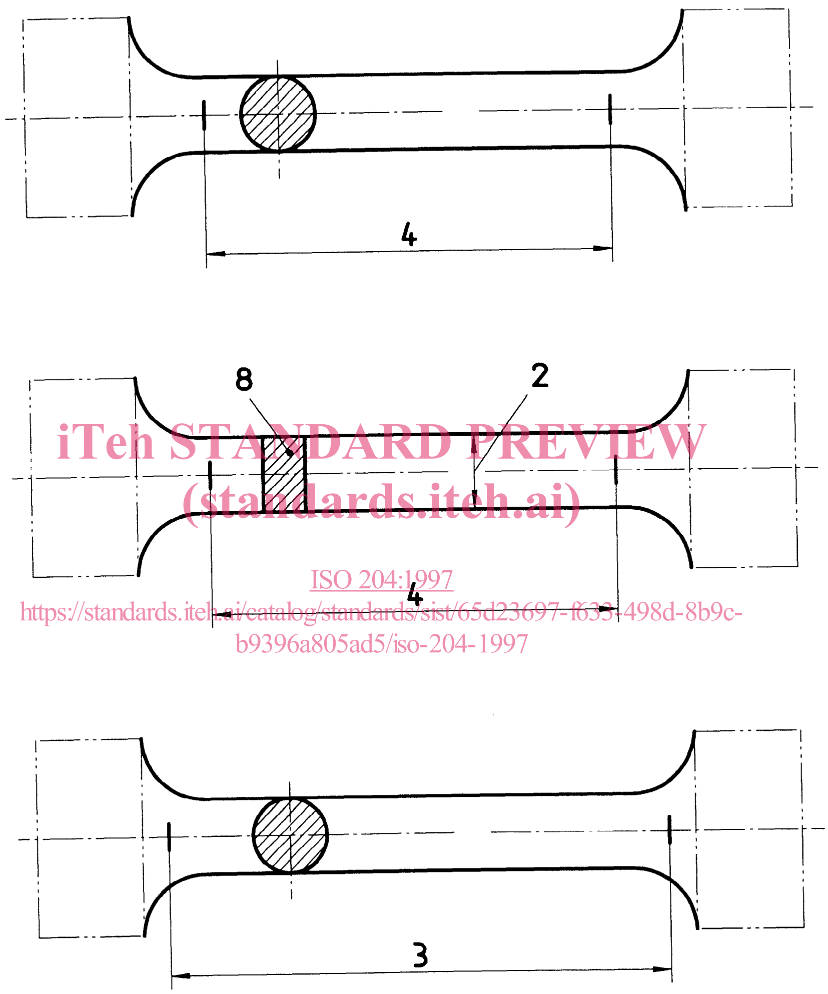
Table 1 — Symbols

Reference number[1)]	Symbol	Unit	Meaning
1	d	mm	Diameter of the cross-section of the parallel length of a cylindrical test piece
2	b	mm	Width of the cross-section of the parallel length of a test piece or square or rectangular cross-section
3	L_r	mm	Reference length
—	L_{ro}	mm	Original reference length
—	L_{ru}	mm	Final reference length
—	ΔL_{rt}	mm	Increase in the reference length between a moment t and the zero moment
4	L_o	mm	Original gauge length
—	L_u	mm	Final gauge length after rupture
5	L_c	mm	Parallel length
6	L_e	mm	Extensometer gauge length
7	r	mm	Transition radius
8	S_o	mm²	Original cross-sectional area of the parallel length
—	S_u	mm²	Cross-sectional area after rupture
—	σ_o	MPa	Initial stress
—	A_f	%	Percentage creep elongation: $A_f = \frac{\Delta L_{rt}}{L_{ro}} \times 100$ NOTE — As an example the symbol may be expressed as follows: $A_{f50/5\,000}^{375}$: percentage creep elongation with a stress of 50 MPa after 5 000 h at a specified temperature of 375 °C.
—	A_{fu}	%	Percentage elongation after creep rupture: $A_{fu} = \frac{L_{tu} - L_{ro}}{L_{ro}} \times 100$ NOTES 1 As an example the symbol may be expressed as follows: A_{fu50}^{375} : percentage elongation after creep rupture with a stress of 50 MPa at a specified temperature of 375 °C. 2 If a word processing machine is used, it is possible to write Afu 375/500 instead of A_{fu50}^{375}.
—	Z_u	%	Percentage reduction of area after creep rupture: $Z_u = \frac{S_o - S_u}{S_o} \times 100$ NOTE — As an example the symbol may be expressed as follows: Z_{u50}^{375} : percentage reduction of area after creep rupture with a stress of 50 MPa at a specified temperature of 375 °C
—	t_u	h	Creep rupture time NOTE — As an example the symbol may be expressed as follows: t_{u50}^{375} : creep rupture time with a stress of 50 MPa at a specified temperature of 375 °C.
—	t_{ue}	h	Creep rupture time of a notched test piece
—	T	°C	Specified temperature
—	T_i	°C	Indicated temperature

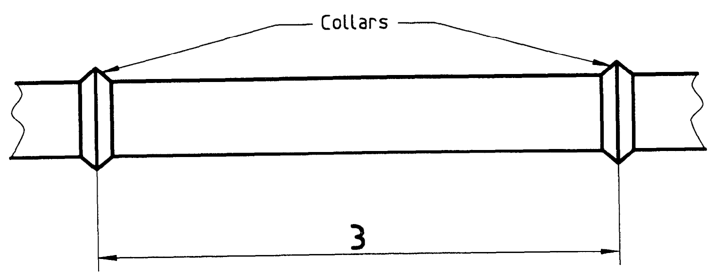
1) See figure 1.



a)

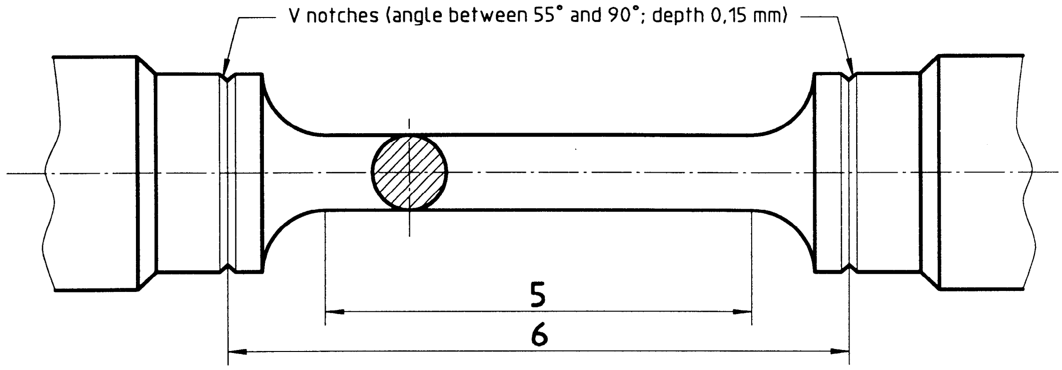


b)

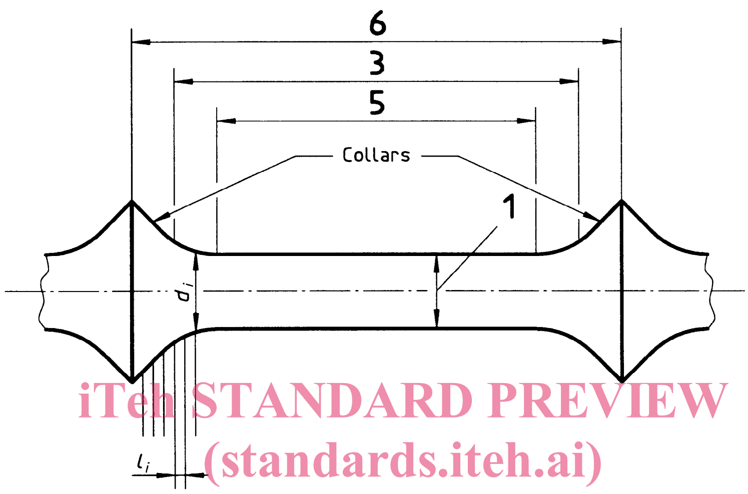


c)

NOTE — In general length 3 is equal to length 6 in d). (See following page.)



d)



e)

$$L_r = L_c + 2\sum_i \left[\left(d/d_i \right)^{2n} l_i \right]$$

where n is preferentially equal to 5.

Figure 1 — Examples of test pieces in relation with definitions in table 1
(The shape of the grip ends is only given as information)

The extensometer gauge length shall not be less than 10 mm. The extensometer shall be capable of measuring the average of the elongation on opposite sides of the test piece.

When the elongation is measured with an extensometer attached to the grip ends of the test piece, the ends shall be of such shape and size that it can be assumed that the observed elongation has occurred completely within the reference length of the test piece.

The increase in the extensometer gauge length is considered to be the increase in the reference length.

6.3 Heating device

6.3.1 Permissible temperature deviations

The heating device for the test piece shall be such that the test piece can be heated to the specified temperature T.

The permissible deviations between the specified temperature T and the indicated temperatures T_i are as follows:

± 3 °C for $T \leqslant 900$ °C;

± 4 °C for 900 °C < $T \leqslant 1\,000$ °C;

for specified temperatures greater than 1 000 °C, the permissible deviation shall be defined by a previous agreement.

The indicated temperature T_i are the temperatures which are measured at the surface of the parallel length of the test piece.

If an extensometer is used, the parts of this instrument outside the furnace shall be designed and protected in such a way that the temperature variations in the air around the furnace do not affect the measurements of the variations in length. In any case, the variations in temperature of the air surrounding the test machine shall be minimized.

6.3.2 Measurement of temperature

Temperature measurement equipment shall have a resolution of at least 0,5 °C and an accuracy of ± 1 °C.

6.3.2.1 For simple machines

For test pieces with a parallel length less than or equal to 50 mm, at least two thermocouples shall be used. For test pieces with a parallel length greater than 50 mm, at least three thermocouples shall be used. In all cases, a thermocouple shall be placed at each end of the parallel length and, if a third is used it shall be placed at the middle of the parallel length.

6.3.2.2 For multiple machines

It is recommended that at least one thermocouple be used for each test piece. Where only one thermocouple is used, it shall be positioned at the middle of the parallel length. However, the total number of thermocouples may be reduced to not less than three if thermocouples located at appropriate positions within the furnace show that conditions comply with the requirements of 6.3.1.

6.3.2.3 For notched test pieces

In the case of notched test pieces, it is recommended that one thermocouple shall be placed close to the notch.

6.3.2.4 Thermocouple junctions and wiring

In all cases, the thermocouple junctions shall make good thermal contact with the surface of the test piece and shall be suitably screened from direct radiation from the furnace wall. The remaining portions of the wires within the furnace shall be thermally shielded and electrically insulated by suitable covering.

6.3.3 Verification of the thermocouples and temperature measuring system

6.3.3.1 Verification of the thermocouple

Thermocouples in use for test durations of less than one year shall be verified at least every 12 months. Thermocouples in use for test durations greater than 12 months shall be verified before and after the test and the drift shall be noted on the test report.

NOTE — Thermocouple drift is dependent on the type of thermocouple used and the exposure time at temperature. It is recommended that more frequent verifications be carried out on thermocouples used at higher temperatures. It is further recommended that the verification be carried out either in the testing machine or in a calibration furnace having a similar depth of thermocouple immersion so that used on the testing machine. (For further information, see the reference in annex A.)

6.3.3.2 Verification of the temperature measuring system

The verification of the temperature measuring system shall be carried out by a method traceable to the international unit (SI) of temperature.

If practicable, this verification should be carried out annually over the working range of the measuring equipment and the readings shall be given in the verification report.