TECHNICAL REPORT

ISO/TR 15461

First edition
1997-12-15

Steel forgings — Testing frequency, sampling conditions and test methods for mechanical tests

Pièces forgées en acier — Fréquence des essais, conditions d'échantillonnage et méthodes d'essai pour essais mécaniques

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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 eletrotechnical standardization.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

- type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

- type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 15461, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 17, *Steel* Subcommittee SC 10, *Steel for pressure purposes*.

This document is being issued in the Technical Report (type 2) series of publications (according to subclause G.3.2.2 of part 1 of the ISO/IEC Directives, 1995) as a "prospective standard for provisional application" in the field of mechanical testing of steel forgings because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an "International Standard". It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the ISO Central Secretariat.

A review of this Technical Report (type 2) will be carried out not later than three years after its publication with the options of: extension for another three years; conversion into an International Standard; or withdrawal.

Annexes A and B form an integral part of this Technical report. Annexes C and D are for information only.

Steel forgings — Testing frequency, sampling conditions and test methods for mechanical tests

1 Scope

1.1 This Technical Report is intended to provide possibilities for the simplification and harmonization of the specifications for mechanical testing of open die and closed die forgings in ISO Standards and other technical delivery conditions for forgings of steel.

For this purpose this Technical Report

a) offers various options for

— the frequency of testing and

— sampling conditions;

b) introduces a designation system for the options, mentioned under (a);

c) specifies the test methods for

— room temperature tensile tests

— elevated temperature tensile tests

— impact tests and

— uniformity checks by hardness tests.

1.2 Unless otherwise specified in this Technical Report the general conditions given in ISO 377 for the marking and preparation of samples and test pieces apply.

1.3 Where the conditions specified in this Technical Report differ from the conditions specified in the product standard or order, then the conditions of the product standard or order apply.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Technical Report. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Technical Report 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 83:1976, *Steel - Charpy impact test (U-notch).*

ISO 148:1983, *Steel - Charpy impact test (V-notch).*

ISO 377:1997, *Steel and steel products - Location and preparation of samples and test pieces for mechanical testing.*

ISO 404:1992, *Steel and steel products - General technical delivery requirements*.

ISO 783:—[1], *Metallic materials - Tensile testing at elevated temperature*.

ISO 2566-1:1984, *Steel - Conversion of elongation values - Part 1: Carbon and low alloy steels*.

ISO 2566-2:1984, *Steel - Conversion of elongation values - Part 2: Austenitic steels*.

ISO 3785: —[2], *Metallic materials - Designation of test piece axes*.

ISO 6506:1981, *Metallic materials - Hardness test - Brinell test*.

ISO 6507-1:—[3], *Metallic materials - Vickers hardness test - Part 1: Test method*.

ISO 6508:1986, *Metallic materials - Hardness test - Rockwell test (scales A-B-C-D-E-F-G-H-K).*

ISO 6892:—[4], *Metallic materials - Tensile testing at ambient temperature*.

3 Definitions

For the purposes of this Technical Report the following definitions apply.

3.1 specific inspection and testing:
inspection and testing carried out before delivery, according to the technical requirements of the order, on the products to be supplied or on test units of which the product supplied is part, in order to verify whether these products comply with the requirements of the order.

[ISO 404:1992, 3.5]

3.2 test unit:
the number of pieces or the tonnage of products to be accepted or rejected together, on the basis of the tests to be carried out on sample products in accordance with the requirements of the product standard or order.

[ISO 404:1992, 3.7]

3.3 sample product:
item (e.g. bar, sheet, coil) selected for inspection and/or testing.

[ISO 377:1997, 3.2]

1) To be published. (Revision of ISO 783:1989)
2) To be published. (Revision of ISO 3785:1976)
3) To be published. (Revision of ISO 6501-1:1982, ISO 6507-2:1983, ISO 6507-3:1987, ISO 409-1:1982, ISO 409-2:1983 and ISO/DIS 409-3)
4) To be published. (Revision of ISO 6892:1984)

3.4 sample:
a sufficient quantity of material taken from the sample product for the purpose of producing one or more test pieces.

[ISO 377:1997, 3.3]

NOTE - In certain cases, the sample may be the sample product.

3.5 test piece:
part of the sample, with specified dimensions, machined or unmachined, brought to a required condition for submission to a given test.

[ISO 377:1997, 3.5]

NOTE - In certain cases the test piece may be the sample.

3.6 Ruling section:
that section for which the mechanical properties are specified.

4 Testing frequency

4.1 For the testing frequency of room temperature tensile tests and of impact tests, the requirements given in 4.1.1 to 4.1.3 apply.

4.1.1 The product standard or order shall specify, by reference to the appropriate symbol(s) in table 1, column 1,

— the composition of the test unit as defined in table 1, columns 2 to 8;

— whether uniformity checks by hardness tests in accordance with annex A are required and, if so, the percentage of products to be subjected to the hardness tests, and

— the number of sample products to be taken from the test unit. (See in this respect the explanations in table 1, footnote 1), for replacing the letter “*n*” of the symbol by the mass of the test unit up to which the taking of one sample product is sufficient.)

NOTE - Less stringent requirements for the composition of the test unit can be compensated by more stringent requirements for the number of sample products to be tested. Therefore, for example, a test unit characterized by the symbol CH5 may be regarded as equivalent to a test unit characterized by the symbol CHD10 or CMHD15 and the test unit CU100 may be regarded as equivalent with CMHDU10. Consequently, it seems possible and reasonable to specify in the product standards or orders not only one distinct test unit, but to leave, as in the example in table C.1, column 5, various equivalent test units to the choice of the manufacturer or to an agreement at the time of enquiry and order.

4.1.2 In general one sample is to be taken per sample product. The product standard or order may however, by reference to the symbols in table 2, specify that in the case of products with a length and/or mass greater than a certain limiting value two samples per sample product shall be taken.

4.1.3 If room temperature tensile tests are to be carried out, one tensile test piece shall be taken per sample. If impact tests are to be carried out, three impact test pieces shall be taken per sample.

4.2 If elevated temperature tensile tests are to be carried out, the product standard or order shall specify the number of test pieces to be taken for this test in relation to the number of test pieces to be taken for the room temperature tensile test (see example in table C.1, column 9).

4.3 For simplifying comparisons the data for the frequency of testing should preferably be specified in form of a table. (See the example in table C.1).

5 Sampling conditions

The product standard or order shall, preferably in the form of a table (see example in table C.2), specify the following:

— by reference to the symbols in table 3 the type of sample product and, where surplus material is required, the way of mounting this;

— by reference to the symbols in table 4, the distance of the test piece axis from the surface of the sample product in the as heat treated condition;

— by reference to the symbols in table 5, the direction of the longitudinal test piece axis and, in the case of impact test pieces, the direction of the notch of the test piece and the fracture plane determined by this to the direction of grain flow or strain.

6 Test methods

6.1 Tensile test at room temperature

6.1.1 Tensile tests at room temperature shall be carried out in accordance with ISO 6892 at a temperature of 20 °C ± 5 °C.

6.1.2 For the verification of the yield strength R_e of non-austenitic steels, where a yield phenomenon occurs, the upper yield strength $R_{eH,}$ or alternatively the 0,2 % proportional elongation proof strength $R_{p0,2}$ shall be determined.

In the case of austenitic steels depending on the characteristic specified in the product standard the 0,2 % and/or 1,0 % proportional elongation proof strength ($R_{p0,2}$ or $R_{p1,0}$) shall be determined.

The percentage elongation shall be reported with reference to a 5,65 $\sqrt{S_0}$ gauge length; (S_0 represents the area of the initial cross section of the test piece within the gauge length). If other gauge lengths are used, the corresponding elongation on 5,65 $\sqrt{S_0}$ should be obtained in accordance with ISO 2566-1 or ISO 2566-2. In cases of dispute, a gauge length of 5,65 $\sqrt{S_0}$ shall be used.

6.2 Impact tests

6.2.1 Impact tests shall be carried out according to the rules for sequential tests specified in ISO 404 and

— when values for Charpy V-notch impact test pieces are to be verified in accordance with ISO 148;

— when values for Charpy U-notch test pieces are to be verified in accordance with ISO 83.

6.2.2 If, for a steel, the impact properties are specified for several testing temperatures, unless otherwise agreed in the order, the test shall be carried out at the lowest temperature for which a value is specified.

6.3 Verification of the elevated temperature proof strength

6.3.1 The verification shall be carried out in accordance with the test method described in ISO 783.

6.3.2 Unless otherwise agreed at the time of enquiry and order the test temperature shall be

— for unalloyed steels and for weldable fine grain steels with high proof strength ..... 300 °C

— for other steels ..... 450 °C.

6.3.3 For non-austenitic steels the 0,2 % proof strength value and for austenitic steels, depending on the characteristic specified in the product standard, the 0,2 % and/or 1,0 % elevated temperature proof strength value shall be determined.

Table 1 — Options for the test units, the number of sample products to be taken per test unit

1	2	3	4	5	6	7	8	
Test unit symbol	**The test unit shall be composed of products**							
		of the same forming				**having been subjected to**		
	of the same cast	**process**	**cycle**[2]	**of the same shape and dimensions**	**of similar**[3] **shape and dimensions**	**the same type**[4] **of heat treatment**	**the same conditions**[5] **of heat treatment**	
tu[1]	C[1]		F[1]	D[1]			H[1]	
C*n*	×	×	—	—	×	×	—	
CH*n*	×	×	—	—	×	×	×	
CHD*n*	×	×	—	×	—	×	×	
CFHD*n*	×	×	×	×	—	×	×	
CU*x*	×	×	—	—	×	×	—	
CHU*x*	×	×	—	—	×	×	×	
CHDU*x*	×	×	—	×	—	×	×	
CFHDU*x*	×	×	×	×	—	×	×	
CnU*x*	×	×	—	—	×	×	—	
CH*n*U*x*	×	×	—	—	×	×	×	
CHD*n*U*x*	×	×	—	×	—	×	×	
CFHD*n*U*x*	×	×	×	×	—	×	×	
IND	The test unit sample product shall							

1) In the symbols for the test unit in column 1 the individual letters have, as is additionally indicated in the headings of columns 2 to 10, the following meaning:

C products of the same Cast;

F same Forming cycle [2];

H same Heat treatment conditions [3];

D same shape and Dimensions;

n In the product standard or order the letter *n* of the symbol for the test unit given in column 1 is to be replaced by the mass of the test unit in tonnes up to

U*x* For checking the Uniformity of the test unit, *x* % of the products and at least the number of products given in table A.1, are to be subjected to a hardness test

EXAMPLE

The symbol CHD10 would, in accordance with the indications in columns 2 to 15, mean the following:

The test unit covers products of the same cast and the same dimensions and has been subjected to the same heat treatment condition. If the weight of the test unit

2) Forgings are regarded as being taken from the same forming cycle when they were, without any essential interruption, manufactured one after the other by the

3) The shape and dimensions of the forgings are regarded as similar when the following conditions are complied with:

a) the forgings have the same shape; round, hexagon or square bars may, however, be covered in one test unit;

b) the difference in the thickness of the ruling section of the forgings of the test unit is less than 30 % of the forging possessing the greatest thickness;

c) where, in the technical delivery conditions, the specifications for the tensile and/or impact properties of the forgings vary for different thicknesses, the

4) Different types of heat treatment are here considered e.g. normalizing, stress relieving, quenching and tempering.

5) The forgings shall be regarded as having been subjected to the same heat treatment conditions when they were subjected to the same temperature-time-cycle in

In the past a usual requirement was that the products covered in a test unit had to be taken from the same heat treatment batch. In the case of continuous or batch no longer justified. Where, however, the purchaser still regards this as appropriate he may specify in his enquiry and order that the test unit be composed of products

and the percentage of products to be subjected to hardness tests for uniformity checks

	9	10	11	12	13	14	15
	The test unit shall have been subjected to	**Number of sample products to be taken from test units with an as heat-treated weight of**					**Notes**
		$\leqslant n$ 1)	$> n$ $\leqslant 2n$	$> 2n$ $\leqslant 4n$	$> 4n$ $\leqslant 8n$	$> 8n$ $\leqslant 16n$	
	Ux1)	x 1000 kg					
	—						In general not for quenched and tempered products.
	— — —	1	2	3	4	5	
	an x % uniformity check by hardness tests (see annex A)	Independant from the weight of the test unit, two sample products, namely the hardest and softest, shall be tested.					Only applicable where the test pieces for the mechanical tests can be taken from the products themselves (no prolongations).
		1	2	3	4	5	Normally only applied where, for the tensile and impact tests, prolongations or integral surplus-material is provided. The product standard shall, in this case, include specifications for the maximum hardness range.
consist of the individual forging.							Not for small products.

which, in accordance with the indications in column 10, the testing of one sample product is sufficient. (For n the values 5, 10, 20 and 40 should be preferred).

in accordance with annex A. The value of x shall be specified in the product standard or order (e.g. CHU10).

is 10 t one sample product is to be tested; if its weight is $> 4\ n$ but $\leqslant 8\ n$, (that means in this example > 40 t but ⩽ 80 t) four samples are to be tested.

same forming process under the same conditions or, in other words, when they were produced in series.

thicknesses of all forgings of the test unit shall fall within one of the specified ranges.

the same heat treatment apparatus but not necessarily at the same time.

type furnaces with modern equipment for the steering and with registration of the time-temperature-cycle and the composition of the furnace atmosphere this is of the same heat treatment batch.

Table 2 — Conditions (s2) for taking two samples per sample product

Symbols, (s2)		**Conditions for taking two samples per sample product** [2]
in general numbers [1]	**example**	
l*y*	l5	Forgings with a length or greatest dimension greater than *y* (5) meters
w*z*	w4	Forgings with an as heat treated individual weight greater than *z* (4) tonnes.
l*y*+w*z*	l5+w4	Forgings with a length or greatest dimension greater than *y* (5) meters and an as heat treated individual weight greater than *z* (= 4) tonnes.
l*y* or w*z*	l5 or w4	Forgings with a length or greatest dimension greater than *y* (5) meters or an as heat treated individual mass greater than *z* (4) tonnes.

1) Replace as shown in the column “example” the letter *y* in the symbol by the appropriate value for the length in meters and the letter *z* by the appropriate value for the as heat treated individual mass of the forgings in tonnes.

2) The values given in parentheses apply for the example given in column 2.