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**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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# Contents

	Page
Foreword .....	iv
<b>1 Scope</b> .....	<b>1</b>
<b>2 Normative references</b> .....	<b>1</b>
<b>3 Terms and definitions</b> .....	<b>1</b>
<b>4 General</b> .....	<b>2</b>
<b>5 Testing frequency</b> .....	<b>3</b>
<b>6 Uniformity checks on test units by hardness tests</b> .....	<b>6</b>
<b>7 Sampling conditions</b> .....	<b>7</b>
<b>8 Designation and determination of the direction of the test piece axis</b> .....	<b>16</b>
8.1 General .....	16
8.2 Designation for the main direction of strain during forming .....	16
8.3 Determination of X, Y and Z .....	17
<b>9 Test methods</b> .....	<b>20</b>
9.1 Tensile test at room temperature .....	20
9.2 Impact tests .....	20
9.3 Verification of the elevated temperature proof strength .....	21
<b>Annex A (informative) Presentation of the specifications for the testing frequency and the sampling conditions in tabulated form</b> .....	<b>22</b>
<b>Bibliography</b> .....	<b>24</b>

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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](http://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](http://www.iso.org/patents)).

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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](http://www.iso.org/iso/foreword.html). (standards.iteh.ai)

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This first edition of ISO 15461 is based on Technical Report ISO/TR 15461:1997, which has been withdrawn. The main changes are as follows:

- [Figures 3](#) a) and b) have been revised;
- [Table 3](#) has been revised;
- [Table 5](#) has been extended to steels for pressure purposes;
- the text of the document has been generally revised.

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

## 1 Scope

This document gives guidelines for the simplification and harmonization of the specifications for mechanical testing of open die and closed die forgings in International Standards and other technical delivery conditions for forgings of steel.

This document

- a) offers various options for
  - 1) the frequency of testing, and
  - 2) sampling conditions,
- b) introduces a designation system for the options, mentioned under (a), and
- c) specifies the test methods for
  - 1) room temperature tensile tests,
  - 2) elevated temperature tensile tests,
  - 3) impact tests, and
  - 4) uniformity checks by hardness tests.

## 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 148-1, *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

ISO 377:2017, *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing*

ISO 404, *Steel and steel products — General technical delivery requirements*

ISO 3785, *Metallic materials — Designation of test specimen axes in relation to product texture*

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

ISO 6892-2, *Metallic materials — Tensile testing at elevated temperature — Part 2: Method of test at elevated temperature*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

— IEC Electropedia: available at <https://www.electropedia.org/>

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

**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

[SOURCE: ISO 404:2013, 3.4, modified — “and testing” has been added and the wording has been altered.]

**3.2  
test unit**

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

[SOURCE: ISO 404:2013, 3.6, modified — the wording has been altered slightly and the notes to entry have been deleted.]

**3.3  
sample product**

item (e.g. bar, sheet, coil) selected for inspection or testing

[SOURCE: ISO 377:2017, 3.2]

**3.4  
sample**

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

Note 1 to entry: In certain cases, the sample can be the sample product.

[SOURCE: ISO 377:2017, 3.3, modified — a note to entry has been deleted.]

**3.5  
test piece**

part of a sample, with specified dimensions, machined or unmachined, brought to a required condition for submission to a given test

[SOURCE: ISO 377:2017, 3.5, modified — the wording has been altered slightly and a note to entry has been deleted.]

Note 1 to entry: In certain cases the test piece can be the sample.

**3.6  
ruling section**

section for which the mechanical properties are specified

## 4 General

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

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

## 5 Testing frequency

**5.1** For the testing frequency of room temperature tensile tests and of impact tests, the requirements given in [5.1.1](#) to [5.1.3](#) apply.

**5.1.1** The product standard or order shall specify, by reference to the appropriate symbol(s) in [Table 1](#), column 1, the following:

- a) the composition of the test unit as defined in [Table 1](#), columns 2 to 8;
- b) whether uniformity checks by hardness tests in accordance with [Table 1](#), column 9 are required and, if so, the percentage of products to be subjected to the hardness tests;
- c) the number of sample products to be taken from the test unit. (See the explanations in [Table 1](#), footnote <sup>a</sup>, 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 can be regarded as equivalent to a test unit characterized by the symbol CHD10 or CFHD15 and the test unit CU100 can be regarded as equivalent with CFHDU10. Consequently, it seems possible and reasonable to specify in the product standards or orders not only one distinct test unit, but to leave various equivalent test units to the choice of the manufacturer or to an agreement at the time of enquiry and order, as shown in the example in [Table A.1](#), column 5.

**5.1.2** 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.

**5.1.3** 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.

**5.2** 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 A.1](#), column 9).

**5.3** For simplifying comparisons the data for the frequency of testing should preferably be specified in the form of a table. (See the example in [Table A.1](#).)

Table 1 — Options for the test units, the number of sample products to be taken per test unit and the percentage of products to be subjected to hardness tests for uniformity checks

1 Test unit symbol	2 The test unit shall be composed of products				3 The test unit shall be composed of products				4 The test unit shall be composed of products	5 The test unit shall be composed of products	6 The test unit shall be composed of products	7 The test unit shall be composed of products	8 The test unit shall be composed of products	9 The test unit shall be composed of products	10 Number of sample products to be taken from test units with an as heat-treated weight of				14 Notes	15 Notes	
	of the same cast	process	cycle <sup>b</sup>	of the same shape and dimensions	of similar <sup>c</sup> shape and dimensions	the same type <sup>d</sup> of heat treatment	the same conditions <sup>e</sup> of heat treatment	having been subjected to							≤ n <sup>a</sup>	> n	> 2n	> 4n			> 8n
t <sup>u</sup> a	C <sup>a</sup>	F <sup>a</sup>	D <sup>a</sup>	H <sup>a</sup>	U <sup>x</sup> a																
Cn	x	—	—	—	x	x	—	—	—	—	—	—	—	—	1	2	3	4	5	In general not for quenched and tempered products	
CHn	x	—	—	—	x	x	—	—	—	—	—	—	—	—	1	2	3	4	5		
CHDn	x	—	x	—	—	x	—	—	—	—	—	—	—	—	1	2	3	4	5		
CFHDn	x	x	x	x	—	x	—	—	—	—	—	—	—	—	1	2	3	4	5		
CUx	x	—	—	—	x	x	—	—	—	—	—	—	—	—	Independent 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)	
CHUx	x	—	—	—	x	x	—	—	—	—	—	—	—	—	Independent from the weight of the test unit, two sample products, namely the hardest and softest, shall be tested.						
CHDUx	x	—	x	—	—	x	—	—	—	—	—	—	—	—	Independent from the weight of the test unit, two sample products, namely the hardest and softest, shall be tested.						
CFHDUx	x	x	x	x	—	x	—	—	—	—	—	—	—	—	Independent from the weight of the test unit, two sample products, namely the hardest and softest, shall be tested.						
CnUx	x	—	—	—	x	x	—	—	—	—	—	—	—	—	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
CHnUx	x	—	—	—	x	x	—	—	—	—	—	—	—	—	Independent from the weight of the test unit, two sample products, namely the hardest and softest, shall be tested.						
CHDnUx	x	—	x	—	—	x	—	—	—	—	—	—	—	—	Independent from the weight of the test unit, two sample products, namely the hardest and softest, shall be tested.						
CFDnH	x	x	x	x	—	x	—	—	—	—	—	—	—	—	Independent from the weight of the test unit, two sample products, namely the hardest and softest, shall be tested.						
IND	The test unit sample product shall consist of the individual forging																			Not for small products	



Table 1 (continued)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Test unit symbol	The test unit shall be composed of products							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
	of the same forming		having been subjected to						$\leq n^a$	$> n$	$> 2n$	$> 4n$	$> 8n$		
	of the same cast	process	cycle <sup>b</sup>	of the same shape and dimensions	of similar <sup>c</sup> shape and dimensions	the same type <sup>d</sup> of heat treatment	the same conditions <sup>e</sup> of heat treatment		$\leq 2n$	$\leq 4n$	$\leq 8n$	$\leq 16n$			
tu <sup>a</sup>	C <sup>a</sup>		F <sup>a</sup>	D <sup>a</sup>			H <sup>a</sup>	Dx <sup>a</sup>							
<p><sup>a</sup> The symbols for the test unit in column 1 and in the headings of columns 2 to 10 have the following meaning:</p> <p>tu test unit;</p> <p>C products of the same cast;</p> <p>F same forming cycle;</p> <p>D same shape and dimensions;</p> <p>H same heat treatment conditions.</p> <p><sup>b</sup> 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 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 is preferred.)</p> <p><sup>c</sup> Ux for checking the uniformity of the test unit, x % of the products and at least the number of products given in Table 3 are to be subjected to a hardness test.</p> <p>EXAMPLE</p> <p>The symbol CHD10 would, in accordance with the indications in columns 2 to 15, mean the following:</p> <p>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 is 10 t one sample product is to be tested, if its weight is &gt; 4 n but ≤ 8 n, (that means in this example &gt; 40 t but ≤ 80 t) four samples are to be tested.</p> <p><sup>b</sup> 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 same forming process under the same conditions or, in other words, when they were produced in series.</p>															

**Table 2 — Conditions for taking two samples per sample product**

Symbols		Conditions for taking two samples per sample product <sup>b</sup>
in general numbers <sup>a</sup>	example	
ly	15	Forgings with a length or greatest dimension greater than y (5) metres.
wz	w4	Forgings with an as heat treated individual weight greater than z (4) tonnes.
ly+wz	15+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.
ly or wz	15 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.

<sup>a</sup> 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.

<sup>b</sup> The values given in parentheses apply for the example given in column 2.

## 6 Uniformity checks on test units by hardness tests

All test units bearing as last letter in their symbol a “U” followed, as indicated in [Table 1](#), by a value x = 5 to 100 shall be subjected as follows to uniformity checks by hardness tests.

Depending on the value of x, given in the symbol for the test unit, the number of products stated in [Table 3](#) shall be selected at random for the hardness tests.

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**Table 3 — Number of products to be checked**

x <sup>a,b</sup>	Number of products to be checked
5	100 %
10	
20	
30	
50	
100	

<sup>a</sup> For x the values given above should be used.

<sup>b</sup> For test units of the type CU high values of x are normally specified, whereas for the more homogeneous test units of the type CHU, CHDU and CFH DU, lower values are normally applied.

On all products to be hardness tested, the same location shall be tested. This location shall lie at the surface of the product and where possible in an area where the thickness of the product corresponds to the thickness of the ruling section.

Decarburized zones and, as far as it may impair the measurement, scale shall be eliminated before the hardness tests are carried out.

All hardness tests on the products of one test unit shall be carried out using to the same method. If the hardness test method is not specified in the product standard or order, the manufacturer may choose the method. Acceptable methods are as follows:

- a) Brinell test in accordance with ISO 6506-1;

- b) Vickers test in accordance with ISO 6507-1;
- c) Rockwell test in accordance with ISO 6508-1;
- d) Shore test in accordance with ASTM E448 or JIS Z 2246;
- e) “Leeb” test in accordance with ISO 16859-1 or ASTM A956.

**7 Sampling conditions**

The product standard or order shall, preferably in the form of a table (see example in [Table A.2](#)), specify the following:

- a) by reference to the symbols in [Table 4](#), the type of sample product and, where surplus material is required, the way of mounting this;
- b) by reference to the symbols in [Table 5](#), the distance of the test piece axis from the surface of the sample product in the as heat treated condition;
- c) by reference to the symbols in [Table 6](#), 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.

**Table 4 — Options for the types of sample products (ts) and the positioning of prolongations, integral surplus material and heat buffers and the location of the test pieces**

Symbol ts	Type of sample product	Description of the type of sample product, the positioning of surplus material and the location of test pieces	Notes
pl	Complete products	The sample product consists of a complete product without prolongation or integral surplus material	the product is destroyed by taking of the test pieces
pc			the test pieces are taken by core drilling
ppl	Complete product with prolongations	The prolongation shall be positioned as indicated	<a href="#">Figure 1 a)</a>
ppld			d in <a href="#">Figure 1 a)</a>
pple			e in <a href="#">Figure 1 a)</a>
pp2			<a href="#">Figure 1 b)</a>
pp2d			d in <a href="#">Figure 1 b)</a>
pp2e			e in <a href="#">Figure 1 b)</a>
pp2f			f in <a href="#">Figure 1 b)</a>
pp0			in the order
pi1	Complete product with integral surplus material	The integral surplus material shall be positioned as indicated	in <a href="#">Figure 2 a)</a>
pi2			in <a href="#">Figure 2 b)</a>
pi0			in the order

<sup>a</sup> Only for small (closed die) forgings.

<sup>b</sup> The shape, dimensions and manufacturing conditions (including the heat treatment of the prolongations, of integral surplus material and of separately forged samples shall, as far as is possible and practical and unless otherwise specified, conform to the shape and dimensions and to the manufacturing conditions of the products in the area of their ruling section. Thus one can expect in the location from where the test pieces are to be taken the same principal direction of grain flow, the same degree of metal forming and the same heating and cooling rates as in the relevant location of the ruling section.

<sup>c</sup> Only applicable when the condition for taking two samples per sample product applies (see [Table 2](#)).

Table 4 (continued)

Symbol ts	Type of sample product	Description of the type of sample product, the positioning of surplus material and the location of test pieces		Notes
pl	Complete products	The sample product consists of a complete product without prolongation or integral surplus material	the product is destroyed by taking of the test pieces	a
pc			the test pieces are taken by core drilling	
pb1	Complete product with welded heat buffer	The buffer shall consist of unalloyed or low alloy steel and shall be positioned as indicated by a completely sealing weld	in <a href="#">Figure 3</a>	b
pb2			in <a href="#">Figure 4</a>	b, c
pb0			in the order	b
ss1	Separately forged samples	The samples shall be taken from the same cast as the forgings and shall be heat treated together with these (see also footnote b).  Dimensions of the sample.	T × 2T × 2T (T = thickness of the ruling section of the forging)	b
ss0			as agreed when ordering	
<p>a Only for small (closed die) forgings.</p> <p>b The shape, dimensions and manufacturing conditions (including the heat treatment of the prolongations, of integral surplus material and of separately forged samples shall, as far as is possible and practical and unless otherwise specified, conform to the shape and dimensions and to the manufacturing conditions of the products in the area of their ruling section. Thus one can expect in the location from where the test pieces are to be taken the same principal direction of grain flow, the same degree of metal forming and the same heating and cooling rates as in the relevant location of the ruling section.</p> <p>c Only applicable when the condition for taking two samples per sample product applies (see <a href="#">Table 2</a>).</p>				

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