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# International Standard



# 4954

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INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

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## Steels for cold heading and cold extruding

*Aciers pour refoulement et extrusion à froid*

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 4954 was developed by Technical Committee ISO/TC 17, *Steel*, and was circulated to the member bodies in February 1978.

It has been approved by the member bodies of the following countries :

Austria	Iran	Romania
Belgium	Ireland	South Africa, Rep. of
Bulgaria	Italy	Spain
Canada	Japan	Sweden
Czechoslovakia	Korea, Dem. P. Rep. of	Switzerland
Denmark	Korea, Rep. of	Turkey
France	Mexico	United Kingdom
Germany, F. R.	Netherlands	USSR
Hungary	Norway	
India	Poland	

The member bodies of the following countries expressed disapproval of the document on technical grounds :

Australia  
Finland  
New Zealand

# Steels for cold heading and cold extruding

## 1 Scope and field of application

1.1 This International Standard applies to wrought unalloyed and alloyed steels which are intended for cold heading or cold extruding and are delivered as wire or bars. It covers the following steel groups and diameter ranges :

- a) steels not intended for heat treatment with diameters from 2 to 100 mm (see section two);
- b) case hardening steels with diameters from 2 to 100 mm (see section three);
- c) steels for quenching and tempering including boron treated steels, with diameters from 2 to 100 mm (see section four);
- d) stainless steels with diameters of 2 mm up to 25 mm for ferritic and up to 100 mm for martensitic and austenitic steels (see section five).

1.2 This International Standard (except section two) is not applicable as regards the properties of cold headed or cold extruded parts which have not been subjected to a subsequent heat treatment. As the properties of the parts in the cold headed or cold extruded and subsequently not heat treated condition are largely dependent on the applied cold heading or cold extruding conditions, these should, if necessary, be a matter of agreement between the purchaser and the manufacturer of the parts.

NOTE — If stainless steels supplied to this International Standard are used for the manufacture of fasteners to the requirements of ISO 3506,

Stainless steel and corrosion resistant steel fasteners — Specifications<sup>1)</sup>, see table 1 of ISO 3506, concerning the identification of steel type and strength as applied to cold headed/extruded fasteners.

## 2 References

- ISO/R 79, *Brinell hardness test for steel.*
- ISO/R 80, *Rockwell hardness test (B and C scales) for steel.*
- ISO 82, *Steel — Tensile testing.*
- ISO 83, *Steel — Charpy impact test (U-notch).*
- ISO 89, *Steel — Tensile testing of wire.*
- ISO 148, *Steel — Beam impact test (V-notch)<sup>1)</sup>*
- ISO/R 377, *Selection and preparation of samples and test pieces for wrought steel.*
- ISO/R 404, *General technical delivery requirements for steel.*
- ISO/R 642, *Hardenability test by end quenching steel (Jominy test).*
- ISO/R 643, *Micrographic determination of the austenitic grain size of steels.*
- ISO 3887, *Steel, non-alloy and low-alloy — Determination of depth of decarburization.*

1) At present at the stage of draft.

**3 Ordering**

**3.1** The purchaser shall state in his enquiry and order

- a) the dimensions and tolerances of the product (see 4.10);
- b) the steel type (see tables 7, 11, 18, 19 and 29);
- c) the treatment condition (see 4.9.1);

- d) the surface coating treatment, if any (see 4.9.2);
- e) the requirement class (see 4.3);
- f) the required type of document (see 5.6).

**3.2** Certain options in ordering are permitted by this International Standard and the purchaser may also state in his enquiry and order his related requirements as shown in table 1.

**Table 1 — Permitted options in ordering**

For steels of table	Permitted options	For steels of table	Permitted options
7, 11, 18, 19, 29	g) whether a product analysis is required (see 5.2.1);	11, 18, 19	l) whether impact properties are to be tested on ISO V-notch test pieces, in which case the values shall be agreed;
7, 11, 18, 19, 29	h) whether special specifications for the results and the testing conditions for the cold heading test and the surface inspection are required (see 4.7.2);	11, 18, 19	m) whether, in cases where the requirement classes 7r, 8r or 9r or 7v, 8v and 9v or 7w, 8w or 9w are specified, coarse or fine grain steel is required (see 4.6.1);
7	i <sub>1</sub> ) whether cast separation is required (if no such statement is made, the manufacturer is permitted to supply the steel without cast separation; see 4.2);	11, 18, 19	n) whether special specifications for testing the degree of spheroidization of the carbides are required (see 4.6.2);
	i <sub>2</sub> ) whether the mechanical properties for the cold drawn condition are to be specified (see 8.3);	11, 18, 19, 29	o) whether, in the case where simulated case hardening tests are required (requirement classes 5r, 9r, 5v, 9v, 5w, or 9w), a reference test bar of 16, 30 or 63 mm shall be used (see table 6, footnote 5);
11, 18, 19, 29	j) whether, for products with diameters < 4 mm in cases where the requirement classes 3r, 4r, 5r, 9r or 3v, 4v, 5v, 9v and 10v or 3w, 4w, 5w or 9w are specified, the elongation after fracture for a gauge length of 200 mm is required, in which case the values shall be agreed (see tables 14, 23 and 32, footnote 2);	18, 19, 29	p) whether special specifications for the permissible depth of the ferritic-pearlitic decarburization are required (see 4.7.4.1);
11, 18, 19	k) whether, in cases where impact values are specified for the relevant steel type and the requirement classes 3r, 4r, 5r, 9r or 3v, 4v, 5v, 9v or 3w, 4w, 5w, 9w are ordered and normal ISO U-notch test pieces (55 mm X 10 mm X 10 mm) can be prepared from the product, one impact test instead of three is sufficient (see table 6, footnote 6);	29	q) whether, in the case of a stainless steel, a test on corrosion resistance is required (see 4.8);
		7, 11, 18, 19, 29	r) whether, for products with diameters ≥ 6 and ≤ 30 mm, cold heading tests shall be carried out, in which case test conditions shall be agreed (see 4.7.2);
		11, 18, 19	s) whether a lower silicon content is required (see note 3 to tables 11 and 18 and note 4 to table 19).

## Section one : General

### 4 Requirements

#### 4.1 Manufacture of the steel and of the product

**4.1.1** Unless otherwise agreed in the order, the process used in making the steel and the product are left to the discretion of the manufacturer. When he so requests, the user shall be informed what steelmaking process is being used.

**4.1.2** The steels of table 7 with the suffix R in the designation shall be rimming, those with the suffix Si shall be silicon-killed and those with the suffix Al shall be killed with aluminium. The steels of tables 11, 18, 19 and 29 shall be killed.

#### 4.2 Cast separation

The steels of tables 11, 18, 19 and 29 are delivered by casts. For the steels of table 7, cast separation, if required, must be especially agreed at the time of enquiry and order.

#### 4.3 Requirement class

When a steel is ordered in accordance with this International Standard, one of the requirement classes indicated for the relevant steel type and treatment condition in 8.1, 10.1, 12.1 and 14.1 (see also table 4) shall be agreed at the time of enquiry and order.

**NOTE** — The requirement class indicates, as shown in table 5, the requirements to be observed. If, for example, the requirement class 2v is ordered (which according to table 4 is only applicable for the steel types B 10 to B 41, C 12 to C 43 and E 10 in a condition other than untreated), then, as marked by an "x" in column 3 of table 5, the delivery must fulfil the requirements given in lines 1, 2a, 3a, 6a, 6b and 6c of table 5.

#### 4.4 Chemical composition

**4.4.1** The chemical composition of the steels, as given by the cast analysis, shall be in accordance with the specifications in tables 7, 11, 18, 19 and 29 (see 4.4.3).

**4.4.2** If ordered to the requirement classes 1r, 1v, 1w, 7r, 7v or 7w (see tables 4 and 5), the deviations between the values specified in tables 7 (not applicable to rimming steels), 11, 18, 19 and 29 and the product analysis shall be within the limits specified in tables 8, 12, 20, 21 or 30.

**4.4.3** If ordered to other requirement classes than indicated under 4.4.2, the specified mechanical properties or hardenability values shall be regarded as the governing criteria for acceptance. In such cases the cast analysis may deviate slightly from the values shown in tables 7, 11, 18, 19 and 29.

#### 4.5 Hardenability and mechanical properties

The products shall, as far as this is required by the agreed requirement class (see 8.3, 10.3, 12.3 and 14.3), fulfil the specifications of 8.3, 10.3, 12.3 and 14.3.

#### 4.6 Structure

**4.6.1** If, for the steels of section two or section three, a controlled austenitic grain size is required, as indicated by the requirement classes 7r, 8r, 9r, 21r, 7v, 8v, 9v, 21v, 7w, 8w, 9w or 21w (see tables 4 and 5), then the austenitic grain size of the steel determination in accordance with clause 5.3.5.1 shall be 5 and finer for fine grain steels and 5 and coarser for coarse grain steels. The portion of grains of other sizes in the micro-section shall be smaller than 30 %.

**4.6.2** If, for the steels of sections two or three, the spheroidization of the carbides is required, as indicated by the requirement classes 1w to 9w, 20w and 21w, then the steels shall have a structure which is characterized by a high degree of spheroidization of the carbides.

**NOTE** It should be taken into account that the spheroidization of the cementite is more difficult for steels with lower carbon content.

#### 4.7 Inner and outer soundness

**4.7.1** The steel shall be free from inner and outer defects likely to have an adverse effect during cold heading or cold extruding and heat treatment. For the verification of the absence of these inner and outer defects, the requirements specified in 4.7.2 to 4.7.4 must be fulfilled.

**4.7.2** If, at the time of enquiry and order, a cold heading test was agreed, test pieces subjected to a cold heading test under the conditions given in 5.3.6 and 5.4.6.1 shall not show any imperfections which are detrimental to the end product.

However, in the case of cold headed test pieces with a hot rolled surface, grooves which result from rolling scores, and also, in the case of the martensitic stainless steels (see table 29), shear cracks which are characterized by a declination angle of 45° between the crack plane and the axis of the test piece, are not to be considered as being cause for rejection.

**4.7.3** The surface inspection shall reveal all defects which would lead to a rejection of the material when the cold heading test mentioned under 4.7.2 is applied. Bars and wire which according to the order were peeled or ground must be free from outer defects. Grooves originating from the machining operation are not to be considered as defects.

**4.7.4** For the decarburization the following applies :

**4.7.4.1** Bars and wire of the steels in tables 18 and 19 or of the martensitic stainless steels (see table 29) which are delivered in the hot rolled or cold drawn surface condition must, independent of their heat treatment condition, be free from completely ferritic decarburized zones.

For such products, the values given in table 2 apply for the permissible depth of the ferritic-pearlitic decarburization.

**Table 2 — Permissible depth of ferritic-pearlitic decarburization**

Diameter <i>d</i> mm	Permissible depth of ferritic-pearlitic decarburization in the condition <sup>1)</sup>	
	C + AC or C + AC + LC mm	untreated or AC mm
≤ 8	≤ 0,10	≤ 0,12
> 8 ≤ 12	≤ 0,12	≤ 0,15
> 12 ≤ 17	≤ 0,16	≤ 0,20
> 17 ≤ 23	≤ 0,20	≤ 0,25
> 23 ≤ 27	≤ 0,24	≤ 0,29
> 27	≤ (0,007 × <i>d</i> ) + 0,05	≤ (0,009 × <i>d</i> ) + 0,05

1) See 10.4 and 12.4.

If in special cases other values for the permissible depth of the ferritic-pearlitic decarburization are required, these shall be specially agreed at the time of the enquiry and order.

**4.7.4.2** Bars and wire of the steels in tables 11, 18 or 19 or of the martensitic stainless steels of table 29 which, according to the order, were peeled or ground must be free from decarburization.

**4.7.5** The general conditions given in ISO/R 404 for surface defects, rectification and internal defects are valid.

**4.8 Corrosion resistance of the stainless steels**

See 14.4.

**4.9 Treatment condition at the time of delivery**

**4.9.1** The treatment and heat treatment condition (if any) at the time of delivery must comply with the condition agreed in the order and shall be one of the conditions indicated in 8.4, 10.4, 12.4 and 14.4.

**4.9.2** Surface treatments which facilitate the cold heating and the cold extruding operation and which, in part, may also delay the formation of rust, such as descaling, copper coating, liming, phosphate coating, greasing or oiling etc., shall, if required, be agreed at the time of enquiry and order.

**4.10 Dimensions, tolerances on dimensions and masses**

The products shall, if possible, be ordered in accordance with existing International Standards for dimensions, tolerances on dimensions and masses.

If corresponding International Standard for dimensions and tolerances are not yet available or if the tolerances given in the corresponding International Standard are (for example in the

case of the stainless steels) not applicable, then the dimensions and tolerances shall be agreed at the time of enquiry and order.

**5 Acceptance testing**

**5.1 General**

**5.1.1** For all requirement classes acceptance tests can be agreed.

**5.1.2** If acceptance tests have been agreed, the general conditions of ISO/R 404 regarding

- the place of acceptance,
- the submission for inspection,
- the rights of the inspector,
- the acceptance,

and, furthermore, the conditions given in 5.2 to 5.5 (as far as these are applicable according to the ordered requirement class) are to be observed.

**5.2 Test unit and number of sample products and tests**

**5.2.1 Chemical composition**

The cast analysis, if called for in the order, shall be provided by the manufacturer.

If a product analysis is required by the purchaser, and if not otherwise agreed at the time of enquiry and order, one sample product shall be taken from each cast.

If, for steels of table 7, no cast separation was agreed at the time of enquiry and order, then the product analysis shall be carried out separately for each steel type (see 4.4.2).

**5.2.2 Hardenability, mechanical properties, structure, inner and outer soundness**

If, according to the ordered requirement class (see tables 4 and 5) and the required type of document (see 5.6 and 5.1.2), the hardenability, the mechanical properties, the structure or the inner and outer soundness are to be verified, then the indications in table 6 apply for the test unit and the number of samples and test pieces.

**5.3 Selection and preparation of samples and test pieces**

**5.3.1 General**

**5.3.1.1** The general conditions given in ISO/R 377 for the selection and the preparation of samples and test pieces shall apply.

**5.3.1.2** In the case of coils, the samples shall be taken at least 300 mm from one of the ends of the coil. In cases of dispute, this distance shall be as indicated in table 3.

**Table 3 — Minimum distance from one of the ends of the coil**

Diameter mm	Minimum distance from one of the ends of the coil mm
≤ 6,5	5 000
> 6,5 ≤ 12,5	4 000
> 12,5 ≤ 18	3 000
> 18 ≤ 22,5	2 000
> 22,5 ≤ 27	1 500
> 27	1 000

### 5.3.2 Product analysis

For product analysis, the selection and preparation of samples shall be carried out in conformity with the requirements of ISO/R 377.

### 5.3.3 Hardenability test

**5.3.3.1** The bar from which the test piece for the end quench hardenability test is machined shall be a forged or rolled round piece 32 or 30 mm in diameter, representing the full cross-section of the product. Larger cross-sections shall be rolled or forged to these dimensions. By special agreement a cast test piece may be used instead of a rolled or forged test piece. The normalizing temperature must be 10 °C higher than the quenching temperature given for the end quench test in tables 16 or 28. Any other conditions to be observed when preparing the test pieces shall be as specified in ISO/R 642.

**5.3.3.2** The test piece for evaluation of the core hardenability shall have, as far as possible, the maximum diameter given in tables 26 or 27. Test bars with diameters larger than those given in table 26 or 27 are to be rolled or forged to the maximum diameters of tables 26 or 27. The length of the test piece shall be at least four times its diameter.

### 5.3.4 Tensile and impact tests

Where reference test bars are required these are to be manufactured by hot forging the test sample to the diameter prescribed for the reference test bars (see under column 2 of table 6, lines Nos. 3b to 3e). These test bars shall then be heat treated as follows :

- case hardening steels, according to table 16;
- steels for quenching and tempering, including boron treated steels, according to table 28;
- stainless steels, according to table 33.

With the following two exceptions, the test pieces for tensile tests and ISO U-notch (or ISO V-notch) impact tests shall be

taken according to figure 1 in the longitudinal direction of the products or the reference test bars.

**Exception 1 :** Test pieces for tensile tests in the usual condition for cold working (requirement 3a in table 6) shall be (as far as possible) tested with their original surface, i.e. without having been machined.

**Exception 2 :** The test pieces of simulated case hardened reference test bars with 30 mm diameters shall be taken as shown for diameters of < 25 mm in figure 1.

In cases of dispute, the tensile test pieces of products with > 4 mm diameter must have a gauge length of  $L_0 = 5 d_0$ . For products with a diameter < 4 mm, the gauge length shall be 200 mm.

Where three ISO U-notch (or ISO V-notch) impact test pieces are required, these should lie next to one another in the test sample or test bar. They must have the dimensions specified in ISO 83 (or ISO 148).

### 5.3.5 Structure

**5.3.5.1** For the selection and preparation of the test pieces determined for the verification of the austenitic grain size, the indications in ISO/R 643 apply. If not otherwise agreed at the time of enquiry and order, in cases of dispute the indications for the McQuaid-Ehn method shall be observed, if case hardening steels (see section three) are to be examined. In cases where steels for quenching and tempering (see section four) are to be examined, one of the other methods described in ISO/R 643 shall be applied and the austenitizing temperature shall correspond to the highest hardening temperature given in table 28 for the steel type concerned, and the holding time on this temperature shall be 1 h.

**5.3.5.2** For the examination of the spheroidization of the carbides, polished transverse micro-sections shall be prepared and these shall be etched in an appropriate solution.

### 5.3.6 Examination of the inner and outer soundness

**5.3.6.1** The cold heading test applies only for products with a diameter > 6 and < 30 mm. If this test is required, and if not otherwise agreed at the time of enquiry and order, the cold heading test straight test pieces with parallel cut end faces and an initial height of  $h_0 = 1,5 \times d_0$  ( $d_0$  = diameter of the test piece) are to be prepared without altering the original surface of the sample product (see 5.4.6.1). Samples from products, which have not been heat treated after hot rolling may be transformed into the heat treatment condition indicated in table 4 as the usual condition for cold heading and cold extruding.

**5.3.6.2** In cases of dispute the surface inspection shall be carried out on the whole surface of the products to be tested. However, in normal cases the visual surface inspection of products with scaled surface can be restricted on samples of about 200 mm length, taken, in the case of coils, in accordance with 5.3.1.2, and pickled in an appropriate solution until the oxide layer has dissolved.

**5.3.6.3** Etched transverse micro-sections with sharp edges shall be prepared for a microscopic examination of decarburization.

In cases of dispute, however, the micro-section shall be hardened under conditions as given in 5.4.2.2, observing all measures to prevent a decarburization or carburization. After hardening the micro-sections shall be prepared for micro-hardness measurements by grinding and polishing. In all cases the requirements of ISO 3887 shall be observed.

## 5.4 Methods of test

### 5.4.1 Chemical analysis

In cases of dispute, the methods used for the chemical analysis shall be those established by the relevant International Standards. If no International Standards are available, the methods shall be agreed upon at the time of enquiry and order.

### 5.4.2 Hardenability test

**5.4.2.1** The end quench hardenability test is to be carried out in conformity with ISO/R 642. The temperature for quenching must be in accordance with tables 16 or 28.

**5.4.2.2** The test pieces for the core hardening test shall be heated, in a neutral or reducing furnace atmosphere, up to the hardening temperatures given for the hardenability test in table 28, and maintained at this temperature until they are completely austenitized. They shall then be taken out of the furnace and promptly quenched down to complete temperature equalization, in a high-duty quenching oil, at a bath temperature of 50 °C and with a speed of immersion of approximately 0,25 m/s. The samples shall then be centrally notched transverse to their longitudinal axis and broken. The fracture surface must be ground under conditions which do not lead to a temperature effect, so that the determination of the core hardness according to ISO/R 80 can be carried out.

### 5.4.3 Tensile test

The test shall be made in accordance with ISO 82 or ISO 89.

### 5.4.4 Impact test

The impact test shall be made in accordance with ISO 83. By special agreement between the purchaser and supplier the V-notch beam impact test according to ISO 148 may be carried out as an alternative test. In this case, the values to be guaranteed shall be agreed at the time of enquiry and order. Unless otherwise specified at the time of enquiry and order, the impact value shall be determined by taking the arithmetic mean of three test results.

### 5.4.5 Structure

**5.4.5.1** The austenitic grain size shall be tested in accordance with ISO/R 643 on test pieces prepared in accordance with 5.3.5.1.

**5.4.5.2** For testing the degree of the spheroidization of the cementite the micro-sections are usually examined at a magnification of 500 X and, if required, they shall be evaluated according to rating charts agreed upon at the time of the enquiry and order.

### 5.4.6 Examination of the inner and outer soundness

**5.4.6.1** The test pieces for the cold heading test shall be headed, at ambient temperature, to one-third of their initial height. The frequency and severity of imperfection that would justify rejection shall be determined at the time of enquiry and order.

If, because of over-large sample diameters or presses of insufficient power, the heading test cannot be carried out at ambient temperature, it should be carried out, after agreement, at approximately 500 °C. Where necessary, other requirements and test conditions can be agreed at the time of enquiry and order.

**5.4.6.2** Surface inspection on bars of the steel types of tables 7, 11, 18 and 19 and of the ferritic and martensitic steel types of table 29 may be carried out. The methods used are at the option of the manufacturer unless otherwise agreed at the time of enquiry and order.

If, at the time of enquiry and order, an agreement has been reached regarding the permissible depth of surface defects, any presumed defect shall be filled down until it disappears; the difference in the thickness before and after filling shall then be determined. Otherwise in cases of uncertainty with regard to the acceptability of the presumed defect a cold heading test according to 5.4.6.1 shall be carried out on a test piece containing the defect concerned or an equivalent defect.

**5.4.6.3** When testing the products with regard to their decarburization (see ISO 3887), usually the depth of the ferritic completely decarburized zone and that of the ferritic-pearlitic partially decarburized zone are measured by microscope at a magnification of 100 X at the four ends of two diameters of the etched plane standing perpendicular to another. The inner starting point for the measurement of the depth of the ferritic-pearlitic decarburized zone shall be the point at which a marked decrease of the pearlite content begins. (This is usually at about two-thirds of the total depth of the ferritic-pearlitic decarburized zone.) The average of the four single values obtained in this way is to be calculated.

In cases of dispute the decarburization shall be checked by micro-hardness measurements (HV 0,3) along the two diameters. For the depth of the decarburized zone, the average of the distances  $e_1$ ,  $e_2$ ,  $e_3$ , and  $e_4$  (see figure 3) shall be calculated. The single values  $e_1$  to  $e_4$  represent, according to figure 3, the distance between the surface and the next point of the corresponding diameter, where the hardness is 80 % of the maximum hardness, which, in the case of a decarburization, is measured in the outer zone of the micro-section.

## 5.5 Retests

For retests ISO/R 404 shall apply.



## 5.6 Certification of the tests

ISO/R 404 is valid, acceptable documents being :

- statement of compliance with the order, or
- report based on quality control, or
- works certificate, or
- test certificate, or
- certificate of acceptance.

## 6 Complaints

**6.1** The conditions for dealing with complaints laid down in ISO/R 404 shall apply.

**6.2** Since it is not possible to detect, on coils, all surface imperfections which may be detrimental to cold heading or cold extruding, a certain portion of the length of the wire may have such imperfections. The maximum permissible percentage of length shall be agreed between the purchaser and supplier at the time of enquiry and order.

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Table 4 — Types of requirement classes applicable (x) for the different steels and/or treatment conditions

Type of steel	Treatment conditions <sup>1)</sup>	Types of requirement class <sup>2)</sup>																																	
		1r	2r	2cr	21r	3r	4r	5r	7r	8r	9r	1v	2v	20v	21v	3v	4v	5v	7v	8v	9v	10v	1w	2w	20w	21w	3w	4w	5w	7w	8w	9			
7	A 1 R to A 5 A 1	x										x																							
	U, P, C																																		
11	B 1 to B 3	x						x	x	x		x											x												
	AC, AC + P, C + AC or C + AC + LC 3)																																		
11	B 10 to B 41	x	x						x	x	x	x											x												
	AC, AC + P, C + AC or C + AC + LC 3)																																		
18	C 1 to C 2	x							x	x																									
	AC, AC + P, C + AC or C + AC + LC 3)																																		
18	C 3 to C 11	x	x	x					x	x																									
	AC, AC + P, C + AC or C + AC + LC 3)																																		
18	C 12 to C 43	x	x	x					x	x																									
	AC, AC + P, C + AC or C + AC + LC 3)																																		
29	D 1 to D 12																																		
	AC, AC + P, C + AC or C + AC + LC 3)																																		
29	D 20 to D 32																																		
	Q, Q + P, C + Q or C + Q + LC 3)																																		
19	E 1 to E 7	x							x	x	x																								
	AC, AC + P, C + AC or C + AC + LC 3)																																		
19	E 10	x	x	x					x	x																									
	AC, AC + P, C + AC or C + AC + LC 3)																																		

1) U = untreated (as rolled); P = peeled; AC = annealed in order to achieve a spheroidization of the carbides; LC = lightly cold reduced, for example with a reduction of 5%; Q = quenched; C = cold reduced.

2) The numbers of the requirement classes should be regarded as provisional until a system for the types of requirement classes has been established.

3) Treatment conditions in which the products are usually cold headed or cold extruded.

Table 5 — Types of requirement classes and requirements specified by them

1	2	3													4				5				6				7				8									
		Requirement class <sup>1)</sup>													steels not intended for heat treatment				case hardening steels				steel for quenching and tempering				stainless steels				boron treated steels for quenching and tempering									
Line No.	Quality requirement	1r	2r	20r	21r	3r	4r	5r	7r	8r	9r	1r	2w	20w	21w	3w	4w	5w	7w	8w	9w	8.2	10.2	12.2	14.2	12.2	14.2	12.2	14.2	12.2	14.2	12.2	14.2	12.2	14.2					
1	Chemical composition	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
2	Hardenability	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
2a	End quench test	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(15)	(24)	-	-	-	-	-	-	-	-	-	-	-	-	-	(25)		
2b	Core hardenability	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(26)	-	-	-	-	-	-	-	-	-	-	-	-	-	(27)		
3	Mechanical properties	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(9)	(13)	(22)	(31)	(22)	(23)	(23)	(23)	(23)	(23)	(23)	(23)	(23)	(23)	(23)	(23)	(23)		
3a	in the usual condition for cold working <sup>2)</sup>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(14)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
3b	of simulated case hardened reference test bars of 16.30 or 63 mm diameter <sup>3)</sup>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
3c	of quenched and tempered reference test bars of 16 mm diameter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
3d	of quenched and tempered reference test bars with the ruling section <sup>4)</sup>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
3e	of a reference test bar of stainless steel <sup>5)</sup>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
4	Austenitic grain size	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.6.1	4.6.1	-	4.6.1	4.6.1	4.6.1	4.6.1	4.6.1	4.6.1	4.6.1	4.6.1	4.6.1	4.6.1	4.6.1	4.6.1	4.6.1		
5	Spheroidization	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.6.2	4.6.2	-	4.6.2	4.6.2	4.6.2	4.6.2	4.6.2	4.6.2	4.6.2	4.6.2	4.6.2	4.6.2	4.6.2	4.6.2	4.6.2		
6	Inner and outer defects	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
6a	Cold headability	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	4.7.2	4.7.2	4.7.2	4.7.2	4.7.2	4.7.2	4.7.2	4.7.2	4.7.2	4.7.2	4.7.2	4.7.2	4.7.2	4.7.2	4.7.2	4.7.2	4.7.2		
6b	Surface quality	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	4.7.3	4.7.3	4.7.3	4.7.3	4.7.3	4.7.3	4.7.3	4.7.3	4.7.3	4.7.3	4.7.3	4.7.3	4.7.3	4.7.3	4.7.3	4.7.3	4.7.3	4.7.3	
6c	Decarburization <sup>6)</sup>	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

- 1) The number of the requirement classes are to be regarded as provisional until a system for the type of requirement classes has been established.
- 2) See table 4, footnote 2.
- 3) The diameter for which the mechanical properties are required should be stated in the order. Otherwise, the manufacturer is permitted to use a sample having a diameter chosen from the three mentioned above. The chosen diameter shall be the smaller of those between which the diameter of the product lies.
- 4) In the selection of a steel, one of the most important considerations is whether the mechanical properties required can be obtained from the steel in the size and shape at the time of heat treatment. That portion, which is most important from the point of view of the mechanical properties obtained by heat treatment, is referred to as the ruling section, and the ruling section should always be expressed in terms of the diameter of an equivalent round bar (see figure 2).
- 5) In cases of dispute and if not otherwise stated in the order, the diameter of the reference test bar in the heat treatment condition given in table 33 shall be that of the product.
- 6) Only for the steels for quenching and tempering (see tables 18 and 19) and for the martensitic stainless steels (see table 29).

Table 6 — Test unit and number of samples and test pieces

Line No.	Quality requirement	Test unit <sup>1)</sup>	Number of sample products	Number of test pieces per sample product
1	Chemical composition	see 5.2.1	see 5.2.1	see 5.2.1
2	Hardenability			
2a	End quench test	C	1 per cast	1
2b	Core hardenability	C	1 per cast	1
3	Mechanical properties			
3a	in the usual condition for cold working <sup>2)</sup>	C <sup>3)</sup> + D <sup>4)</sup> + T	2 per 10 t or broken 10 t	1
3b	of simulated case hardened reference test bars of 16, 30 or 63 mm diameter <sup>5)</sup>	C	1 per cast	3 ISO U-notch <sup>6)</sup> and  1 tensile test piece  1 tensile test piece
3c	of quenched and tempered reference test bars of 16 mm diameter	C	1 per cast	
3d	of quenched and tempered reference test bars with the ruling section <sup>7)</sup>	C	1 per cast	
3e	of a reference test bar of stainless steel <sup>8)</sup>	C	1 per cast	
4	Austenitic grain size	C	1 per cast	1
5	Spheroidization	C + D <sup>4)</sup> + T	2 per 10 t or broken 10 t	1
6	Inner and outer defects			
6a	Cold headability	C <sup>3)</sup> + D + T	To be agreed at the time of enquiry and order	1
6b	Surface quality	C <sup>3)</sup> + D + T		
7	Decarburization <sup>9)</sup>	C + D + T	2 per 10 t or part thereof	1

1) The tests shall be carried out separately for each cast (symbol C), or, for each cast, each dimension and each treatment (symbol C + D + T).

2) See footnote 2 of table 4.

3) If, for steels of table 7, no cast separation was agreed at the time of enquiry and order, then the tests shall be carried out separately for each steel type.

4) If the consignment consists of bars or wire with cross sections which differ by not more than 3 : 1 these can be grouped into one test unit.

5) The diameter for which the mechanical properties are required should be stated in the order. Otherwise, the manufacturer is permitted to use a sample having a diameter chosen from the three mentioned above. The chosen diameter shall be the smaller of those between which the diameter of the product lies.

6) Where possible. If only one test piece was agreed at the time of enquiry and order, this requirement shall be modified accordingly.

7) In the selections of a steel, one of the most important considerations is whether the mechanical properties required can be obtained from the steel in the size and shape at the time of heat treatment. That portion which is most important from the point of view of the mechanical properties obtained by heat treatment, is referred to as the ruling section, and the ruling section should always be expressed in terms of the diameter of an equivalent round bar (see figure 2).

8) In cases of dispute and if not otherwise stated in the order, the diameter of the reference test bar in the heat treatment condition given in table 33 should be that of the product.

9) Only for the steels for quenching and tempering (see tables 18 and 19) and for the martensitic stainless steels (see table 29).

Dimensions in millimetres

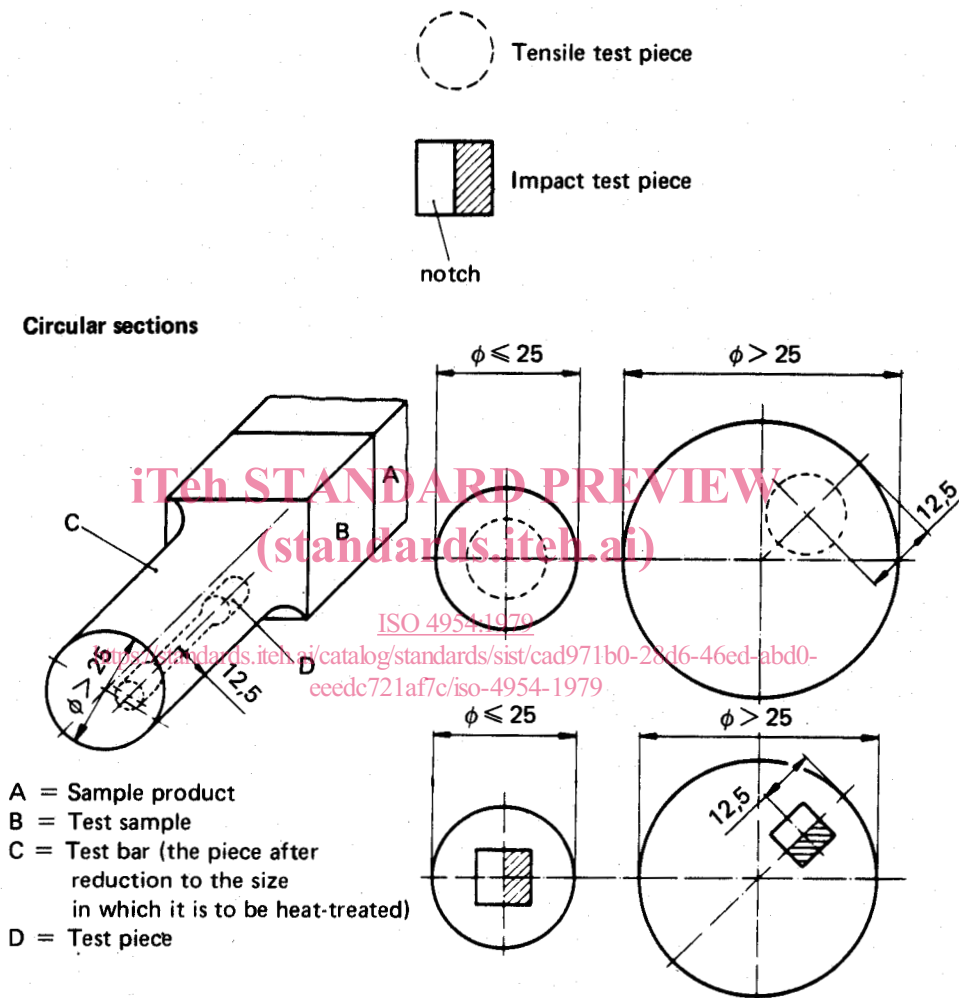


Figure 1 — Location of the tensile and impact test pieces in the products