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**Cold-reduced carbon steel strip  
with a carbon content over 0,25 %**

*Feuillards en acier au carbone laminés à froid à teneur en carbone  
supérieure à 0,25 %*

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## Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 4960 was prepared by ISO Technical Committee TC17, *Steel*, Subcommittee SC12, *Continuous mill flat rolled products*.

This second edition cancels and replaces the first edition (ISO 4960:1986) which has been technically revised.

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# Cold-reduced carbon steel strip with a carbon content over 0,25 %

## 1 Scope

1.1 This International Standard applies to cold-reduced carbon steel strip with a carbon content over 0,25 % (*m/m*) made from steels specified in Table 1. It is commonly produced in thicknesses of 6 mm and under, and in widths up to 600 mm exclusive, in coils and cut lengths. The strip is ordered in the as-delivered condition, as specified in 1.4 or clause 5, and is predominantly used for springs, but also for other highly stressed parts of many different types. Steel designations CS 55 to CS 95 may be supplied in the quenched and tempered condition.

1.2 This International Standard does not apply to alloy steels or stainless steels.

1.3 Cold-reduced carbon steel strip is furnished in the following types:

- full hard, where a very stiff, springy product is produced to obtain full hardness after the final rolling (it is intended for flat work not requiring the ability to withstand cold forming);
- annealed, which is intended for applications requiring moderate cold forming;
- quenched and tempered, which is intended generally for the production of steel springs where the appropriate combination of strength, hardness, toughness and ductility can be achieved;
- intermediate hardness, which is intended for applications where cold-forming is slight or where a moderately stiff, springy product is needed.

The cold-reduced carbon steel strip qualities appropriate to the particular grade shall be:

- a) full hard quality: material rolled to the final thickness with a minimum hardness as shown in Table 2;
- b) annealed quality: annealed to the hardness or tensile strength shown in Table 3;
- c) quenched and tempered quality: quenched and tempered steel strip for steel designations of CS 55 and over, tempered to the properties shown in Table 4 or Table 5;
- d) intermediate quality: temper rolled to the hardness range shown in Table 6 by a controlled amount of cold rolling after annealing.

1.4 The material shall be ordered to either hardness or tensile strength requirements, but not to both (see Tables 2, 3, 4, 5, and 6).

1.5 Cold-reduced carbon steel strip is characterized by close dimensional tolerances and good surface finish and, in the cold-rolled and quenched and tempered condition, it is possible to attain high values for hardness and tensile strength.

## 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 1024:1989, *Metallic materials — Hardness test — Rockwell superficial test (scales 15N, 30N, 45N, 15T, 30T and 45T)*.

ISO 6507-1:1997, *Metallic materials — Vickers hardness test — Part 1: Test method*.

ISO 6508-1:1999, *Metallic materials — Rockwell hardness Test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*.

ISO 6892:1998, *Metallic materials — Tensile testing at ambient temperature*.

ISO 7438:1985, *Metallic materials — Bend test*.

## 3 Terms and definitions

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

### 3.1

#### **cold-reduced carbon steel strip**

product produced from a hot-rolled pickled coil which has been given substantial cold reduction

NOTE The product is characterized by improved surface, greater uniformity in thickness and improved mechanical properties compared to hot-rolled strip.

### 3.2

#### **skin pass**

light cold rolling of the product, the purpose being one or more of the following:

- a) to minimize the appearance of coil breaks, stretcher strains and fluting;
- b) to control the shape;
- c) to obtain the required surface finish

NOTE Some increase in hardness and some loss in ductility will result from skin passing.

### 3.3

#### **edges**

NOTE Material is normally supplied as described in 3.3.1 and 3.3.2. Other edges may be supplied as agreed between the manufacturer and purchaser.

#### 3.3.1

##### **mill edge**

normal side edge without any definite contour produced in hot rolling

NOTE Mill edges may contain some irregularities such as cracked or torn edges or thin (feathered) edges.

#### 3.3.2

##### **sheared edge**

normal edge obtained by shearing, slitting, or trimming a mill edge product

NOTE Normal processing does not necessarily provide a definite positioning of the slitting burr.

## 4 Conditions of manufacture

### 4.1 Steelmaking

Unless otherwise agreed upon, the processes used in making the steel and in manufacturing cold-reduced strip are left to the discretion of the manufacturer. On request, the purchaser shall be informed of the steelmaking process being used.

### 4.2 Chemical composition

The chemical composition (heat analysis) shall be as agreed upon between the interested parties at the time of ordering. The ranges or limits shall be in accordance with the requirements of Table 1 for the designation specified.

### 4.3 Chemical analysis

#### 4.3.1 Heat analysis

An analysis of each heat of steel shall be made by the manufacturer in order to determine compliance with the requirements of Table 1. When requested, at the time of ordering, this analysis shall be reported to the purchaser or to his representative.

#### 4.3.2 Product analysis

A product analysis may be made by the purchaser in order to verify the specified analysis of the semi-finished or finished steel and shall take into consideration any normal heterogeneity. For killed steels, the sampling method and deviation limits shall be agreed upon between the interested parties at the time of ordering.

**Table 1 — Chemical composition (heat analysis)**

Values as percentages by mass

Designation	Carbon	Manganese <sup>a</sup>	Phosphorus <sup>b</sup> max.	Sulfur max.	Silicon <sup>c</sup>
CS30	0,27 to 0,34	0,60 to 0,90	0,035	0,03	0,10 to 0,35
CS35	0,31 to 0,38	0,60 to 0,90	0,035	0,03	0,10 to 0,35
CS40	0,36 to 0,44	0,60 to 0,90	0,035	0,03	0,10 to 0,35
CS45	0,42 to 0,50	0,60 to 0,90	0,035	0,03	0,10 to 0,35
CS50	0,47 to 0,55	0,60 to 0,90	0,035	0,03	0,10 to 0,35
CS55	0,52 to 0,60	0,60 to 0,90	0,035	0,03	0,10 to 0,35
CS60	0,55 to 0,66	0,60 to 0,90	0,035	0,03	0,10 to 0,35
CS65	0,59 to 0,70	0,60 to 0,90	0,035	0,03	0,10 to 0,35
CS70	0,65 to 0,76	0,60 to 0,90	0,035	0,03	0,10 to 0,35
CS75	0,69 to 0,80	0,40 to 0,70	0,035	0,03	0,10 to 0,35
CS85	0,80 to 0,94	0,70 to 1,00	0,035	0,03	0,10 to 0,35
CS95	0,90 to 1,04	0,30 to 0,60	0,035	0,03	0,10 to 0,35

<sup>a</sup> Other manganese values can be specified upon agreement at the time of ordering provided a range of 0,30 % is maintained.

<sup>b</sup> When specified, phosphorus and sulfur may be ordered to 0,020 % maximum by heat analysis.

<sup>c</sup> Closer silicon ranges can be provided upon agreement at the time of ordering.

#### 4.4 Surface finish

Cold-reduced carbon steel strip is produced in a regular bright finish by rolling on rolls having a moderately smooth finish (it is not generally applicable to bright plating); or in a dull finish by rolling on rolls roughened by mechanical or chemical means. The dull finish is suitable for laquer or paint adhesion.

Quenched and tempered strip [see 1.3 c)] may be supplied with the following surface finishes:

- a) grey blue unpolished;
- b) bright tempered;
- c) rough, medium or fine polished;
- d) polished and temper coloured (blue or bronze).

NOTE The purchaser should state which surface finish is required.

#### 4.5 Oiling

As a deterrent to rusting, a coating of oil is usually applied to the product. The oil is not intended as a drawing or forming lubricant and should be easily removable using degreasing chemicals. The product may be ordered unoled, if required, in which case the supplier has limited responsibility if oxidation occurs.

#### 4.6 Weldability

This product is suitable for welding if appropriate welding conditions are selected.

#### 4.7 Application

It is desirable that the specified product be identified for fabrication by the name of the part or by the intended application. Proper identification of the part may include visual examination, prints or description, or a combination of these.

#### 4.8 Mechanical properties

##### 4.8.1 Hardness ranges

When required [see 1.4 and 14 h)], the hardness shall be as stated in Tables 2 to 5. Intermediate hardness ranges shall be as shown in Table 6 or shall be as agreed upon between the manufacturer and the purchaser.

##### 4.8.2 Bend test requirements

The bend test piece shall withstand being bent as described in Table 3 and in Figures 1 and 2 without cracking on the outside of the bent portion.

##### 4.8.3 Tensile properties

At the time the steel is made available for shipment, the tensile properties, when required [see 1.4 and 14 h)] shall be as stated in Tables 3 and 4 if the mechanical property designation is specified.

**Table 2 — Minimum hardness requirements for full hard cold-reduced carbon steel strip**

Specified thickness, <i>e</i> mm	Hardness, min.			
	HV CS30 to CS45	HV CS50 to CS70	HV CS75 to CS95	HR CS30 to CS95
$e < 0,36$	240	250	260	15T 92
$0,36 < e \leq 1$	230	240	250	30T 83
$e > 1$	220	230	240	B 98

**Table 3 — Hardness, tensile strength, elongation and bend test requirements for annealed cold-reduced carbon steel strip**

Designation	Hardness <sup>a, b</sup> max.				$R_m$ max. <sup>b</sup>	A min. <sup>b, c</sup>		180° bend mandrel diameter <sup>d</sup>		
	HR15T	HR30T	HRB	HV	N/mm <sup>2</sup>	$L_0 = 50$ mm	$L_0 = 80$ mm	$e < 1$	$1 \leq e < 2$	$2 \leq e \leq 3$
CS 30	85	67	76	160	585	18	16	1 mm	2a	3a
CS 35	86	68	78	170	590	17	15	1 mm	2a	3a
CS 40	87	70	80	170	595	16	14	1 mm	2a	3a
CS 45	88	72	83	175	600	16	14	1 mm	2a	3a
CS 50	88	72	84	180	605	15	13	1 mm	2a	3a
CS 55	88	73	85	180	610	15	13	1 mm	2a	3a
CS 60	89	74	87	185	620	14	12	1 mm	2a	3a
CS 65	89	75	88	185	630	13	11	1 mm	2a	3a
CS 70	90	76	89	190	640	12	10	2a	2a	3a
CS 75	90	76	90	190	640	12	10	2a	2a	3a
CS 85	91	78	93	205	670	12	10	2a	3a	4a
CS 95	92	80	94	210	680	12	10	2a	3a	4a

NOTE 1 Material may be ordered in terms of hardness and bend requirements; or tensile strength, elongation and bend requirements, but not to both (see 1.4).

NOTE 2  $R_m$  = tensile strength;

A = percentage elongation after fracture;

$L_0$  = gauge length on test piece;

$e$  = thickness, in millimetres, of steel sheet;

$a$  = thickness of bend test piece.

1 N/mm<sup>2</sup> = 1 MPa

<sup>a</sup> The HRB values shown are applicable to thicknesses over 1 mm. HR30T should be used for thicknesses over 0,36 mm up to and including 1 mm. HR15T should be used for thicknesses up to and including 0,36 mm.

<sup>b</sup> Lower maximum values of hardness or lower maximum levels of tensile strength and higher elongation values may be specified when ordering.

<sup>c</sup> Elongation values apply only to thicknesses from 0,5 mm up to and including 3 mm; for greater thicknesses, elongation values shall be as agreed upon.

<sup>d</sup> Normally the relation of the bend test piece to rolling direction shall be transverse, and the degree of bend requirement shall be 90°; however, if the finished strip width prohibits taking a transverse bend test piece, a test piece taken from the longitudinal direction may be substituted. The degree of bend requirement shall be 180° for longitudinal test pieces.

Table 4 — Tensile strength range for quenched and tempered cold-reduced carbon steel strip

Designation	Tensile strength, $R_m$ , range <sup>a</sup>	Maximum thickness up to which the tensile values apply <sup>b</sup>
	N/mm <sup>2</sup>	mm
CS 55	1 150 < $R_m$ < 1 650	2
CS 60	1 180 < $R_m$ < 1 680	2
CS 65	1 230 < $R_m$ < 1 770	2,5
CS 70	1 275 < $R_m$ < 1 810	2,5
CS 75	1 320 < $R_m$ < 1 870	2,5
CS 85	1 400 < $R_m$ < 1 950	2,5
CS 95	1 465 < $R_m$ < 2 050	2

<sup>a</sup> For a given tensile strength, the steel grade should be chosen with particular regard to thickness and the application of the materials. The purchaser should normally specify a tensile strength range of  $\geq 200$  N/mm<sup>2</sup> when ordering material. 1 N/mm<sup>2</sup> = 1 MPa.

<sup>b</sup> With greater thicknesses, the tensile strength values shall be as agreed upon at the time of ordering.

Table 5 — Hardness range for quenched and tempered cold-reduced carbon steel strip

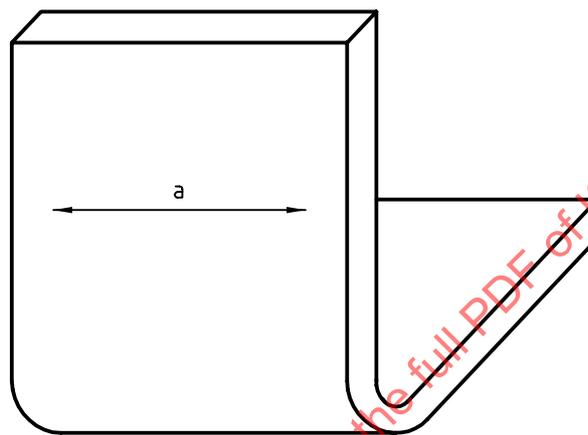
Designation	Hardness Vickers range <sup>a</sup>	Maximum thickness up to which the hardness values apply <sup>b</sup>
	HV	mm
CS 55	300 < HV < 490	2
CS 60	350 < HV < 500	2
CS 65	365 < HV < 525	2,5
CS 70	375 < HV < 535	2,5
CS 75	390 < HV < 555	2,5
CS 85	415 < HV < 580	2,5
CS 95	435 < HV < 610	2

<sup>a</sup> The purchaser should normally specify a hardness range of  $\geq 66$  HV when ordering material.

<sup>b</sup> With greater thicknesses, the hardness values shall be as agreed upon at the time of ordering.

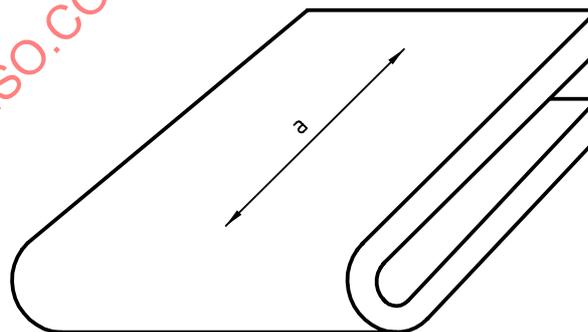
Table 6 — Hardness ranges for intermediate hard cold-reduced carbon steel strip

Specified Thickness, $e$ (mm)	Hardness Rockwell		Maximum of range (HR)	Hardness Vickers	Maximum of range (HV)		
	Scale	Range	CS30 to CS95		CS30 to CS45	CS50 to CS70	CS75 to CS95
$e \leq 0,36$	HR15T	4	89	40	240	250	260
$0,36 < e \leq 1$	HR30T	6	81	45	230	240	250
$e > 1$	HRB	10	97	50	220	230	240



<sup>a</sup> Rolling direction

Figure 1 — Transverse bend test piece (after bending)



<sup>a</sup> Rolling direction

Figure 2 — Longitudinal bend test piece (after bending)

## 5 Dimensional tolerances

Dimensional tolerances shall be in accordance with Tables 7 to 11 inclusive. When required, specified tolerances shall be as agreed between the manufacturer and purchaser. It has not been practicable to formulate flatness tolerances for material covered by this International Standard.

Table 7 — Thickness tolerances for cold-reduced carbon steel strip, for coils and cut lengths

Values in millimetres

Specified Thickness, $e$	Tolerance <sup>a</sup> for specified width, $b$					
	$b \leq 125$		$125 < b \leq 250$		$250 < b < 600$	
	N	F	N	F	N	F
$e \leq 0,15$	$\pm 0,01$	$\pm 0,01$	$\pm 0,02$	$\pm 0,015$	—	—
$0,15 < e \leq 0,25$	$\pm 0,02$	$\pm 0,015$	$\pm 0,02$	$\pm 0,015$	—	—
$0,25 < e \leq 0,4$	$\pm 0,02$	$\pm 0,015$	$\pm 0,03$	$\pm 0,02$	$\pm 0,03$	$\pm 0,02$
$0,4 < e \leq 0,6$	$\pm 0,03$	$\pm 0,02$	$\pm 0,03$	$\pm 0,02$	$\pm 0,04$	$\pm 0,03$
$0,6 < e \leq 0,8$	$\pm 0,04$	$\pm 0,03$	$\pm 0,04$	$\pm 0,03$	$\pm 0,05$	$\pm 0,035$
$0,8 < e \leq 1$	$\pm 0,04$	$\pm 0,03$	$\pm 0,05$	$\pm 0,035$	$\pm 0,05$	$\pm 0,035$
$1 < e \leq 1,5$	$\pm 0,05$	$\pm 0,035$	$\pm 0,06$	$\pm 0,045$	$\pm 0,07$	$\pm 0,055$
$1,5 < e \leq 2,5$	$\pm 0,06$	$\pm 0,04$	$\pm 0,07$	$\pm 0,055$	$\pm 0,08$	$\pm 0,06$
$2,5 < e \leq 4$	$\pm 0,07$	$\pm 0,05$	$\pm 0,08$	$\pm 0,06$	$\pm 0,10$	$\pm 0,08$
$4 < e \leq 6$	$\pm 0,09$	$\pm 0,06$	$\pm 0,10$	$\pm 0,08$	$\pm 0,12$	$\pm 0,09$

NOTE Thickness is measured at any point on the strip not less than 20 mm from a side edge for mill edge strip and not less than 10 mm from a side edge for sheared edge strip. For widths of mill edge strip 40 mm or less and sheared edge strip 20 mm wide or less, measurements are made on the centre line of the strip. Measurement must not be made on top of the shear burr.

<sup>a</sup> N indicates normal tolerances; F indicates fine tolerances.

Table 8 — Width tolerances for cold-reduced carbon steel strip, for coils and cut lengths, mill edge

Values in millimetres

Specified width, $b$	Tolerance <sup>a</sup>
$b \leq 100$	$\pm 1,5$
$100 < b \leq 200$	$\pm 2$
$200 < b \leq 400$	$\pm 2,5$
$400 < b \leq 500$	$\pm 3$
$500 < b < 600$	$\pm 4$

<sup>a</sup> The values specified do not apply to the uncropped ends of a mill edge coil within 7 m inclusive of both ends. By agreement between the manufacturer and purchaser, material can be ordered to all plus tolerances, in which case the value is doubled.

**Table 9 — Width tolerance for cold-reduced carbon steel strip, for coils and cut lengths, sheared edge, not resquared**

Values in millimetres

Specified Width, <i>b</i>	Width tolerance <sup>a</sup> for specified thickness, <i>e</i>			
	$e \leq 1,5$	$1,5 < e \leq 2,5$	$2,5 < e \leq 4,5$	$4,5 < e \leq 6$
$b \leq 100$	± 0,2	± 0,25	± 0,35	± 0,4
$100 < b \leq 200$	± 0,25	± 0,3	± 0,45	± 0,5
$200 < b \leq 300$	± 0,3	± 0,35	± 0,5	± 0,5
$300 < b \leq 450$	± 0,4	± 0,45	± 0,6	± 0,7
$450 < b < 600$	± 0,5	± 0,5	± 0,6	± 0,7

<sup>a</sup> By agreement between the manufacturer and the purchaser, material can be ordered to all plus tolerances or to all minus tolerances, in which case the value is doubled.

**Table 10 — Length tolerances for cold-reduced carbon steel strip, for coils and cut lengths, not resquared**

Values in millimetres

Specified length, <i>l</i>	Tolerance <sup>a</sup> for specified widths < 600 mm
$l \leq 1\ 500$	+ 15 0
$1\ 500 < l \leq 3\ 000$	+ 20 0
$3\ 000 < l \leq 6\ 000$	+ 25 0
$l > 6\ 000$	+ 0,5 % × <i>l</i>

<sup>a</sup> Closer tolerances are subject to agreement between the manufacturer and purchaser.

**Table 11 — Camber tolerances for cold-reduced carbon steel strip, for coils and cut lengths, not resquared**

Values in millimetres

Width, <i>b</i>	Camber tolerance <sup>a</sup>
$10 \leq b < 40$	25 max. in any 2 000 length
$40 \leq b < 600$	10 max. in any 2 000 length

NOTE 1 Camber is the greatest deviation of a side edge from a straight line (see Figure 3), the measurement being taken on the concave side with a straightedge.

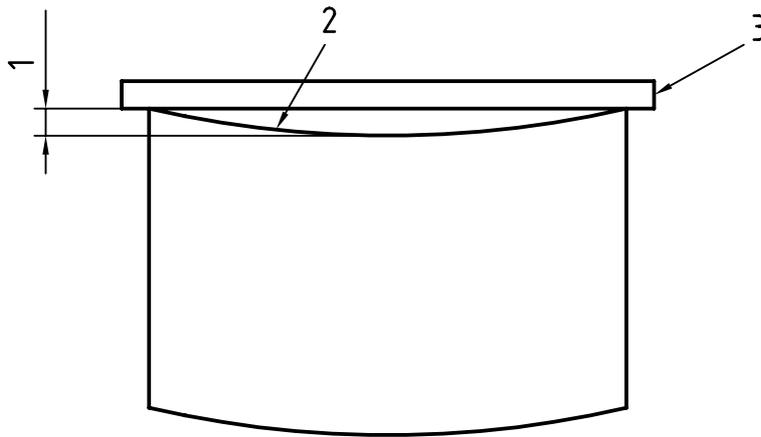
NOTE 2 In those cases where it is not practical to measure the tolerance as given in this Table, the camber tolerance,  $t_2$ , may be calculated from the equation:

$$t_2 = (l_2/l_1)^2 \times t_1$$

where:

- $l_1$  is the standard length in this Table (2 000 mm);
- $l_2$  is the non-standard length;
- $t_1$  is the camber tolerance in this Table.

<sup>a</sup> The values do not apply to the uncropped ends of a mill edge coil within 7 m inclusive of both ends

**Key**

- 1 Edge camber
- 2 Side edge (concave side)
- 3 Straight-edge

Figure 3 — Measurement of camber

## 6 Sampling

### 6.1 Hardness or tensile test sampling

One representative sample for the hardness or tensile test required in Tables 2 to 6, as applicable, shall be taken from each lot of sheet for shipment. The sample shall be taken midway between the edges. A lot consists of 25 t or less of material of the same designation rolled to the same thickness and condition.

### 6.2 Bend test sampling

One representative sample for the bend test shall be taken from each lot of strip for shipment. A lot consists of all material of the same designation rolled to the same thickness and condition.

## 7 Mechanical property tests

### 7.1 Hardness test

The hardness test shall be carried out in accordance with ISO 1024, ISO 6507-1 or ISO 6508-1.

### 7.2 Tensile test

The tensile test shall be carried out in accordance with ISO 6892.

### 7.3 Bend test

The bend test shall be carried out at ambient temperature and in accordance with ISO 7438.

Small cracks on the edges of test pieces, and cracks which require magnification in order to be visible, shall be disregarded.