
**Cold-reduced carbon steel strip with a
mass fraction of carbon over 0,25 %**

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

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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.

ISO 4960 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 12, *Continuous mill flat rolled products*.

This third edition cancels and replaces the second edition (ISO 4960:1999), which has been technically revised.

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Cold-reduced carbon steel strip with a mass fraction of carbon over 0,25 %

1 Scope

1.1 This International Standard applies to cold-reduced carbon steel strip with a mass fraction of carbon over 0,25 % made from the 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 6.1 or Clause 5, and is predominantly used for springs, but also for other highly stressed parts of many different types. Steel designations CS55 to CS95 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:

- a) 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);
- b) annealed, which is intended for applications requiring moderate cold forming;
- c) 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;
- d) intermediate hardness, which is intended for applications where cold forming is slight or where a moderately stiff, springy product is needed.

1.4 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 referenced documents are indispensable for the application 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 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

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

ISO 6892, *Metallic materials — Tensile testing — Method of testing at ambient temperature*

3 Terms and definitions

For the purposes of this document, 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 an improved surface, greater uniformity in thickness and improved mechanical properties compared to hot-rolled strip. Cold-reduced strip is also characterized by tighter thickness tolerances than cold-reduced sheet, as well as specified edges.

3.2

skin pass

light cold rolling of the product

NOTE 1 The purpose of skin passing is 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 2 Some increase in hardness and some loss in ductility will result from skin passing.

3.3 Edges

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 Specified qualities appropriate to the particular grade

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

- a) full-hard quality: material rolled to the final thickness with a minimum hardness;
- b) annealed quality: annealed to a hardness or tensile strength;
- c) quenched and tempered quality: quenched and tempered steel strip for steel designations of CS55 and over, tempered to properties;
- d) intermediate quality: temper rolled to a hardness range by a controlled amount of cold rolling after annealing.

5 Conditions of manufacture

5.1 Steelmaking

Unless otherwise agreed, 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.

5.2 Chemical composition

The chemical composition (heat analysis) shall not exceed the values given in Tables 1 and 2.

5.3 Heat analysis

An analysis of each heat of steel shall be made by the manufacturer, in order to determine compliance with the requirements of Tables 1 and 2. When requested at the time of ordering, this analysis shall be reported to the purchaser or to his representative. Each of the elements listed in Table 1 shall be included in the report of the heat analysis. If one or more of the elements in Table 2 is/are specified, the analysis shall be reported.

5.4 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. The product analysis tolerances shall be in accordance with Table 3.

Table 1 — Chemical composition (heat analysis)

Mass fractions in percent

Designation	Carbon	Manganese ^a	Phosphorus ^b max.	Sulfur ^b max.	Silicon ^c
CS30	0,28 to 0,34	0,60 to 0,90	0,035	0,03	0,10 to 0,35
CS35	0,32 to 0,38	0,60 to 0,90	0,035	0,03	0,10 to 0,35
CS40	0,37 to 0,44	0,60 to 0,90	0,035	0,03	0,10 to 0,35
CS45	0,43 to 0,50	0,60 to 0,90	0,035	0,03	0,10 to 0,35
CS50	0,48 to 0,55	0,60 to 0,90	0,035	0,03	0,10 to 0,35
CS55	0,50 to 0,60	0,60 to 0,90	0,035	0,03	0,10 to 0,35
CS60	0,55 to 0,65	0,60 to 0,90	0,035	0,03	0,10 to 0,35
CS65	0,60 to 0,70	0,60 to 0,90	0,035	0,03	0,10 to 0,35
CS70	0,65 to 0,75	0,60 to 0,90	0,035	0,03	0,10 to 0,35
CS75	0,70 to 0,80	0,40 to 0,70	0,035	0,03	0,10 to 0,35
CS85	0,80 to 0,93	0,70 to 1,00	0,035	0,03	0,10 to 0,35
CS95	0,90 to 1,03	0,30 to 0,50	0,035	0,03	0,10 to 0,35

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

^b When specified, phosphorus and sulfur may be ordered to 0,020 % maximum by heat analysis.

^c Closer silicon ranges can be provided upon agreement at the time of ordering.

Table 2 — Limits on additional chemical elements

Mass fractions in percent

Elements	Heat analysis	Product analysis
	max.	max.
Cu ^a (CS30–CS75)	0,30	0,33
(CS85–CS95)	0,25	0,28
Ni ^a (CS30–CS75)	0,20	0,23
(CS85–CS95)	0,25	0,28
Cr ^{a, b, c} (CS30–CS75)	0,20	0,24
(CS85–CS95)	0,30	0,34
Mo ^{a, b}	0,06	0,07
Nb ^d	0,008	0,018
V ^d	0,008	0,018
Ti ^d	0,008	0,018

^a The sum of copper, nickel, chromium and molybdenum shall not exceed 0,50 % on heat analysis. When one or more of these elements are specified, the sum does not apply; in which case, only the individual limits on the remaining elements will apply.

^b The sum of chromium and molybdenum shall not exceed 0,16 % on heat analysis. When one or more of these elements are specified, the sum does not apply; in which case, only the individual limits on the remaining elements will apply.

^c A higher value of Cr may be supplied after agreement between the producer and consumer.

^d An analysis greater than 0,008 % may be supplied after agreement between the producer and consumer.

Table 3 — Product analysis

Tolerances in percent

Element	Maximum of specified element	Tolerance over maximum specified
Carbon	> 0,15 to ≤ 0,40	0,04
	> 0,40 to ≤ 0,80	0,05
	> 0,80	0,06
Manganese	≤ 0,60	0,03
	> 0,60 to ≤ 1,15	0,04
Silicon	> 0,30 to ≤ 0,60	0,05
Phosphorus	≤ 0,04	0,01
Sulfur	≤ 0,04	0,01

NOTE The above maximum tolerances are the allowable excesses over the specified requirements, and not the heat analysis.

5.5 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 lacquer 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 colored (blue or bronze).

5.6 Oiling

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

5.7 Weldability

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

5.8 Application

It is desirable to identify the specified product 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.

5.9 Mechanical properties

5.9.1 Hardness ranges

When required [see 6.1 and Clause 16 h)] the hardness shall be as stated in Tables 4, 5 or 7. Intermediate hardness ranges shall be as shown in Table 8, or shall be as agreed upon between the manufacturer and the purchaser.

HV is the Vickers hardness.

HR is the Rockwell hardness. HRB is the Rockwell hardness (type B).

5.9.2 Tensile properties

When required [see 6.1 and Clause 16 h)] the tensile properties shall be as stated in Tables 5 and 6, at the time the steel is made available for shipment if the mechanical property designation is specified.

Table 4 — Minimum hardness requirements for full-hard cold-reduced carbon steel strip

Specified thickness, mm	Hardness min.			
	HV	HV	HV	HR
	CS30 to CS45	CS50 to CS70	CS75 to CS95	CS30 to CS95
< 0,36	240	250	260	15T92
≥ 0,36 < 1	230	240	250	30T83
≥ 1	220	230	240	B98

Table 5 — Hardness, tensile strength and elongation requirements for annealed cold-reduced carbon steel strip

Designation	Hardness max. ^{a, b}				R_m max. ^b MPa	A min. ^{b, c}	
	HR15T	HR30T	HRB	HV		$L_0 = 50$ mm	$L_0 = 80$ mm
CS30	85	67	76	160	585	18	16
CS35	86	68	78	170	590	17	15
CS40	87	70	80	170	595	16	14
CS45	88	72	83	175	600	16	14
CS50	88	72	84	180	605	15	13
CS55	88	73	85	180	610	15	13
CS60	89	74	87	185	620	14	12
CS65	89	75	88	185	630	13	11
CS70	90	76	89	190	640	12	10
CS75	90	76	90	190	640	12	10
CS85	91	78	93	205	670	12	10
CS95	92	80	94	210	680	12	10

NOTE 1 Material may be ordered in terms of hardness; or tensile strength, and elongation requirements, but not of both (see 6.1).

NOTE 2 R_m = tensile strength;
 A = percentage elongation after fracture;
 L_0 = gauge length on test piece;
 1 MPa = 1 N/mm².

^a The HRB values shown are applicable to thicknesses over 1 mm. HR30T should be used for thicknesses > 0,36 mm to ≤ 1 mm. HR15T should be used for thicknesses ≤ 0,36 mm.

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

^c Elongation values apply only to thicknesses > 0,5 mm to ≤ 3 mm: for greater thicknesses, elongation values shall be as agreed upon.

Table 6 — Tensile strength range for quenched and tempered cold-reduced carbon steel strip

Designation	Tensile strength, R_m range ^a MPa	Maximum thickness up to which the tensile values apply ^b mm
CS55	> 1 150 < 1 650	2
CS60	> 1 180 < 1 680	2
CS65	> 1 230 < 1 770	2,5
CS70	> 1 275 < 1 810	2,5
CS75	> 1 320 < 1 870	2,5
CS85	> 1 400 < 1 950	2,5
CS95	> 1 465 < 2 050	2

^a 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 equal to or greater than 200 N/mm² when ordering material.
1 MPa = 1 N/mm²

^b With greater thicknesses, the tensile strength values shall be as agreed upon at the time of ordering.

Table 7 — Hardness range for quenched and tempered cold-reduced carbon steel strip

Designation	Vickers hardness range ^a HV	Maximum thickness up to which the tensile values apply ^b mm
CS55	> 300 < 490	2
CS60	> 350 < 500	2
CS65	> 365 < 525	2,5
CS70	> 375 < 535	2,5
CS75	> 390 < 555	2,5
CS85	> 415 < 580	2,5
CS95	> 335 < 610	2

^a The purchaser should normally specify a hardness range equal to or greater than 66 HV when ordering material.

^b With greater thicknesses, the hardness values shall be as agreed upon at the time of ordering.

Table 8 — Hardness ranges for intermediate hard cold-reduced carbon steel strip

Specified thickness, mm	Rockwell hardness		Maximum of HR range	Vickers hardness	Maximum of HV range		
	Scale	Range	CS30 to CS95		CS30 to CS45	CS50 to CS70	CS75 to CS95
< 0,36	HR15T	4	89	40	240	250	260
≥ 0,36 > 1	HR30T	6	81	45	230	240	250
≥ 1	HRB	10	97	50	220	230	240

6 Ordering requirements and dimensional tolerances

6.1 Ordering requirements

The material shall be ordered in accordance with either hardness or tensile strength requirements, but not with both.

6.2 Dimensional tolerances

Dimensional tolerances shall be in accordance with Tables 9 to 13 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.

7 Sampling

One representative sample for the hardness or tensile test required in Tables 4 to 8, 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.

8 Mechanical property tests

8.1 Hardness test

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

8.2 Tensile test

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

Table 9 — Thickness tolerances for cold-reduced carbon steel strip, for coils and cut lengths

Values in millimetres

Specified thickness	Tolerance ^a for specified width					
	≤ 125 inclusive		> 125 ≤ 250		> 250 ≤ 600	
	N	F	N	F	N	F
≤ 0,15	± 0,01	± 0,01	± 0,02	± 0,015	—	—
> 0,15 ≤ 0,25	± 0,02	± 0,015	± 0,02	± 0,015	—	—
> 0,25 ≤ 0,4	± 0,02	± 0,015	± 0,03	± 0,02	± 0,03	± 0,02
> 0,4 ≤ 0,6	± 0,03	± 0,02	± 0,03	± 0,02	± 0,04	± 0,03
> 0,6 ≤ 0,8	± 0,04	± 0,03	± 0,04	± 0,03	± 0,05	± 0,035
> 0,8 ≤ 1	± 0,04	± 0,03	± 0,05	± 0,035	± 0,05	± 0,035
> 1 ≤ 1,5	± 0,05	± 0,035	± 0,06	± 0,045	± 0,07	± 0,055
> 1,5 ≤ 2,5	± 0,06	± 0,04	± 0,07	± 0,055	± 0,08	± 0,06
> 2,5 ≤ 4	± 0,07	± 0,05	± 0,08	± 0,06	± 0,10	± 0,08
> 4 ≤ 6	± 0,09	± 0,06	± 0,10	± 0,08	± 0,12	± 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.

^a N indicates normal tolerances; F indicates fine tolerances.

9 Decarburization

When specified, the steel strip shall have a maximum permissible depth of complete plus partial decarburization of 0,025 mm or 1,5 % of the thickness of the strip, whichever is greater, except that strip less than 0,03 mm thick shall show no complete decarburization.

10 Retests

10.1 Machining and flaws

If any test piece shows defective machining or develops flaws, it shall be discarded and another test piece substituted.

10.2 Additional tests

If a test does not give the specified results, two more tests shall be carried out on the same lot. Both retests shall conform to the requirements of this International Standard, otherwise, the lot may be rejected.

Table 10 — Width tolerances for cold-reduced carbon steel strip, for coils and cut lengths, mill edge

Values in millimetres

Specified width	Tolerance ^a
≤ 100	± 1,5
> 100 ≤ 200	± 2
> 200 ≤ 400	± 2,5
> 400 ≤ 500	± 3
> 500 ≤ 600	± 4

^a 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 with all plus tolerances, in which case the value is doubled.

Table 11 — Width tolerances for cold-reduced carbon steel strip, for coils and cut lengths sheared edge, not resquared

Values in millimetres

Specified width	Width tolerance ^a for specified thickness			
	≤ 1,5	> 1,5 ≤ 2,5	> 2,5 ≤ 4,5	> 4,5 ≤ 6
≤ 100	± 0,2	± 0,25	± 0,35	± 0,4
> 100 ≤ 200	± 0,25	± 0,3	± 0,45	± 0,5
> 200 ≤ 300	± 0,3	± 0,35	± 0,5	± 0,5
> 300 ≤ 450	± 0,4	± 0,45	± 0,6	± 0,7
> 450 ≤ 600	± 0,5	± 0,5	± 0,6	± 0,7

^a 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 12 — Length tolerances for cold-reduced carbon steel strip, for coils and cut lengths, not resquared

Values in millimetres

Specified length	Tolerance ^a for specified widths up to 600 mm
≤ 1 500	+15 0
> 1 500 ≤ 3 000	+20 0
> 3 000 ≤ 6 000	+25 0
> 6 000	+0,5 % of specified length

^a Closer tolerances are subject to agreement between the manufacturer and purchaser.

Table 13 — Camber tolerances for cold-reduced carbon steel strip, for coils and cut lengths, not resquared

Values in millimetres

Width	Camber tolerance ^a
>10 ≤ 40	25 max. in any 2 000 length
≥ 40 ≤ 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 1), 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:

$$t_2 = \frac{(2 \times l_2 \times t_1)}{l_1}$$

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.

^a The values do not apply to the uncropped ends of a mill-edge coil, within 7 m inclusive of both ends.

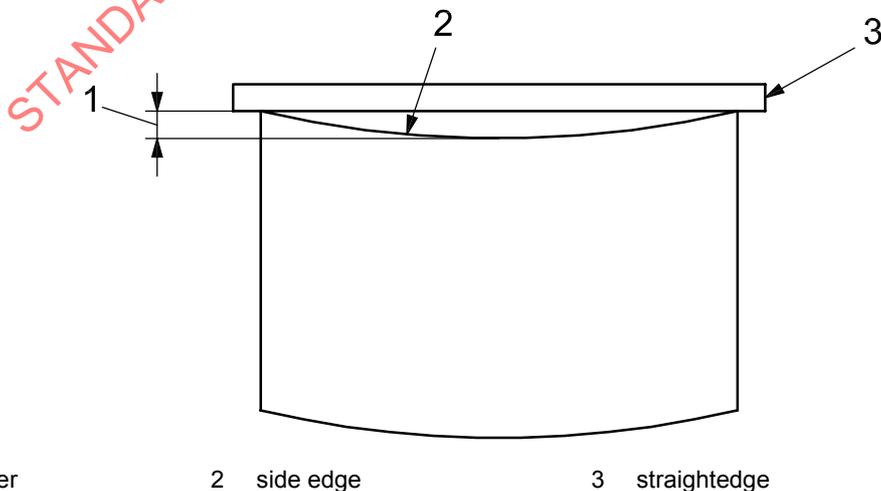


Figure 1 — Measurement of camber