
International Standard



4960

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

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 %

First edition — 1986-09-15

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UDC 669.14-418

Ref. No. ISO 4960-1986 (E)

Descriptors : steels, unalloyed steels, iron- and steel products, steel strips, specifications, chemical compositions, mechanical properties, dimensional tolerances, marking.

Foreword

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International Standard ISO 4960 was prepared by Technical Committee ISO/TC 17, *Steel*.

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

1 Scope and field of application

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 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 properties shown in table 4 a) or b);

d) intermediate quality : temper rolled to hardness range shown in table 5 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 a) and b), and 5].

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 References

- ISO/R 1024, *Rockwell superficial hardness test (N and T scales) for steel*.
- ISO 6507/1, *Metallic materials — Hardness test — Vickers test — Part 1 : HV 5 to HV 100*.
- ISO 6508, *Metallic materials — Hardness test — Rockwell test — Scales A, B, C, E, F, G, H*.¹⁾
- ISO 6892, *Metallic materials — Tensile testing*.
- ISO 7438, *Metallic materials — Bend test*.

3 Definitions

3.1 cold-reduced carbon steel strip : A product produced from a hot-rolled pickled coil which has been given substantial cold reduction.

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

3.2 skin pass : A light cold rolling of cold-reduced and annealed steel strip.

1) At present at the stage of draft. (Revision of ISO/R 80-1968 and ISO 2713-1973.)

4 Other information

4.1 General

Cold-reduced carbon steel strip shall be furnished in the qualities shown in 1.3.

4.2 Skin pass

The purpose of skin passing is one or more of the following :

- a) to minimize the appearance of coil breaks;
- b) to obtain the required surface finish;
- c) to control the shape.

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

The purchaser should state whether skin passing is required.

4.3 Edges

Material is normally supplied as described in 4.3.1 and 4.3.2. Other edges may be supplied as agreed between the manufacturer and purchaser.

4.3.1 Mill edge

A normal side edge without any definite contour produced in hot rolling. Mill edges may contain some irregularities such as cracked or torn edges or thin (feathered) edges. A square mill edge can be produced by hot edge rolling (with the corners not as square as a square edge bar).

4.3.2 Sheared edge

A normal edge obtained by shearing, slitting, or trimming a mill edge product. Normal processing does not necessarily provide a definite positioning of the slitting burr.

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).

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 cold-reduced carbon steel strip, but strip may be furnished not oiled if required. The oil is not intended as a drawing or forming lubricant and should be easily removable with degreasing chemicals.

5 Conditions of manufacture

5.1 Steelmaking

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 (cast 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.

Table 1 — Chemical composition (cast analysis)

Values as percentages by mass

| Designation | Carbon (C) | Manganese (Mn) ¹⁾ | Phosphorus (P) ²⁾ max. | Sulfur (S) ²⁾ max. | Silicon (Si) ³⁾ |
|-------------|--------------|------------------------------|--------------------------------------|----------------------------------|----------------------------|
| CS 30 | 0,27 to 0,34 | 0,60 to 0,90 | 0,040 | 0,050 | 0,10 to 0,35 |
| CS 35 | 0,31 to 0,38 | 0,60 to 0,90 | 0,040 | 0,050 | 0,10 to 0,35 |
| CS 40 | 0,36 to 0,44 | 0,60 to 0,90 | 0,040 | 0,050 | 0,10 to 0,35 |
| CS 45 | 0,42 to 0,50 | 0,60 to 0,90 | 0,040 | 0,050 | 0,10 to 0,35 |
| CS 50 | 0,47 to 0,55 | 0,60 to 0,90 | 0,040 | 0,050 | 0,10 to 0,35 |
| CS 55 | 0,52 to 0,60 | 0,60 to 0,90 | 0,040 | 0,050 | 0,10 to 0,35 |
| CS 60 | 0,55 to 0,66 | 0,60 to 0,90 | 0,040 | 0,050 | 0,10 to 0,35 |
| CS 65 | 0,59 to 0,70 | 0,60 to 0,90 | 0,040 | 0,050 | 0,10 to 0,35 |
| CS 70 | 0,65 to 0,76 | 0,60 to 0,90 | 0,040 | 0,050 | 0,10 to 0,35 |
| CS 75 | 0,69 to 0,80 | 0,40 to 0,70 | 0,040 | 0,050 | 0,10 to 0,35 |
| CS 85 | 0,80 to 0,94 | 0,70 to 1,00 | 0,040 | 0,050 | 0,10 to 0,35 |
| CS 95 | 0,90 to 1,04 | 0,30 to 0,60 | 0,040 | 0,050 | 0,10 to 0,35 |

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

2) When specified, phosphorus and sulfur may be ordered to 0,030 % maximum by cast or heat analysis.

3) Closer silicon ranges can be provided upon agreement at the time of ordering.

5.3 Chemical analysis

5.3.1 Cast analysis

A cast analysis of each cast of steel shall be made by the manufacturer to determine the percentage by mass of carbon, manganese, phosphorus, silicon and sulfur. On request, this analysis shall be reported to the purchaser or his representative.

5.3.2 Verification analysis

A verification analysis may be made by the purchaser to verify the specified analysis of the semi-finished or finished steel and shall take into consideration any normal heterogeneity. The sampling method and deviation limits shall be agreed upon between the manufacturer and purchaser at the time of ordering.

5.4 Weldability

This product can be welded if appropriate welding conditions are selected.

5.5 Application

It is desirable that cold-reduced carbon steel strip 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.

5.6 Mechanical properties

5.6.1 Hardness ranges

When required [see 1.4 and clause 15 h)], the hardness shall be as stated in tables 2 to 4. Intermediate hardness ranges shall be as shown in table 5 or shall be as agreed upon between the manufacturer and the purchaser.

5.6.2 Bend test requirements

The bend test piece shall withstand being bent as described in table 3 and in figure 1 a) and b) without cracking on the outside of the bent portion.

5.6.3 Tensile properties

At the time the steel is made available for shipment, the tensile properties, when required [see 1.4 and clause 15 h)] shall be as stated in tables 3 and 4 if the mechanical property designation is specified.

6 Dimensional tolerances

Dimensional tolerances applicable to cold-reduced carbon steel strip shall be as given in tables 6 to 10 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

7.1 Hardness or tensile test

One representative sample for the hardness or tensile test required in tables 2 to 5, as applicable, shall be taken from each lot of strip for shipment. The sample shall be taken midway between the edges. A lot consists of 25 t or less of strip of the same designation rolled to the same thickness and condition.

7.2 Bend test

One representative sample for the bend test shall be taken from each lot of strip for shipment. A lot consists of all strip 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/R 1024, ISO 6507/1 or ISO 6508.

8.2 Tensile test

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

8.3 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 to be visible, shall be disregarded.

9 Retests

9.1 Machining and flaws

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

9.2 Additional tests

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

10 Resubmission

10.1 The manufacturer may resubmit for acceptance the products that have been rejected during earlier inspection because of unsatisfactory properties, after he has subjected them to a suitable treatment (selection, heat treatment) which, on request, will be indicated to the purchaser. Tests shall be carried out as if they apply to a new batch.

10.2 The manufacturer has the right to present the rejected products to a new examination for compliance with the requirements for another quality.

11 Workmanship

The surface condition shall be that normally obtained in a cold-reduced product.

The steel strip in cut lengths shall be free from amounts of laminations, surface flaws and other imperfections that are detrimental to subsequent appropriate processing.

Processing for shipment in coils does not afford the manufacturer opportunity to observe readily or to remove defective portions as can be carried out on the cut length product.

12 Inspection and acceptance

12.1 While not usually required for products covered by this International Standard, when the purchaser specifies that inspection and tests for acceptance be observed prior to shipment from the manufacturer's works, the manufacturer shall afford the purchaser's inspector all reasonable facilities to determine that the steel is being furnished in accordance with this International Standard.

12.2 Steel that is reported to be defective after arrival at the user's works shall be set aside, properly and correctly identified and adequately protected. The supplier shall be notified in order that he may properly investigate.

13 Coil size

When cold-reduced steel strip is ordered in coils, a minimum or range of acceptable inside diameter (I.D.) shall be specified. In addition, the maximum outside diameter (O.D.) and the maximum acceptable coil mass shall be specified.

14 Marking

Unless otherwise stated, the following minimum requirements for identifying the steel shall be legibly stencilled on the top of each lift or shown on a tag attached to each coil or shipping unit :

- a) the manufacturer's name or identifying brand;
- b) the number of this International Standard;

- c) the quality designation;
- d) the order number;
- e) the product dimensions;
- f) the lot number;
- g) the mass.

15 Information to be supplied by the purchaser

To specify adequately the requirements of this International Standard, inquiries and orders shall include the following information :

- a) the number of this International Standard;
- b) the name, type, quality, and mechanical property designation (see 1.3 and 1.4);
- c) the dimensions of the product and quantity required;
- d) whether skin passing is required (see 4.2);
- e) whether oiled (see 4.5);
- f) the report of the cast analysis, if required (see 5.3.1);
- g) the application (name of part), if possible (see 5.5);
- h) whether strip is to be ordered to hardness values or tensile properties (see 5.6.1 and 5.6.3);
- i) the type of edge (see 4.3);
- j) the type of finish (see 4.4);
- k) inspection and tests for acceptance prior to shipment from the manufacturer's works, if required (see 12.1);
- l) limitations on mass and dimensions of individual coils or bundles, if applicable (see clause 13).

NOTE — Typical ordering description is as follows :

ISO 4960, cold-reduced carbon (over 0,25 %) steel strip, CS 30, annealed quality, HRB 76 max., 3 mm × 200 mm × 1 600 mm, 10 000 kg, to be used for warehouse resale, oiled, sheared edge with regular bright finish, maximum lift mass 1 000 kg, report of cast analysis required.

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

| Specified thickness, <i>e</i> | Hardness, min. | | | |
|-------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | Grades CS 30 to CS 45 | Grades CS 50 to CS 70 | Grades CS 75 to CS 95 | Grades CS 30 to CS 95 |
| mm | | HV | | HR |
| <i>e</i> < 0,36 | 240 | 250 | 260 | 15T 92 |
| 0,36 < <i>e</i> ≤ 1,00 | 230 | 240 | 250 | 30T 83 |
| <i>e</i> > 1,00 | 220 | 230 | 240 | B 98 |

Table 3 — Hardness, tensile strength, elongation, and bend test¹⁾²⁾³⁾ requirements for annealed cold-reduced carbon steel strip

| Designation | Hardness ⁴⁾⁵⁾ max. | | | | R_m max ⁵⁾ N/mm ² | A min. ⁵⁾⁶⁾ | | 180° bend mandrel diameter | | |
|-------------|-------------------------------|-------|-----|------------------------|----------------------------------------------|--------------------------|---------------|----------------------------|----------------|-------------------|
| | Hardness Rockwell | | | Hardness Vickers HV | | $L_o = 50$ mm | $L_o = 80$ mm | $e < 1$ | $1 \leq e < 2$ | $2 \leq e \leq 3$ |
| | HR15T | HR30T | HRB | | | | | | | |
| 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 |

- 1) R_m : tensile strength
- A : percentage elongation after fracture
- L_o : gauge length on test piece
- e : thickness, in millimetres, of steel strip
- a : thickness of bend test piece
- 1 N/mm² = 1 MPa

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- 2) 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).
- 3) 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.
- 4) 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.
- 5) Lower maximum values of hardness or lower maximum values of tensile strength and higher elongation values may be specified when ordering.
- 6) Elongation values apply only to thicknesses from 0,5 mm to and including 3 mm; for greater thicknesses, elongation values shall be as agreed upon at the time of ordering.

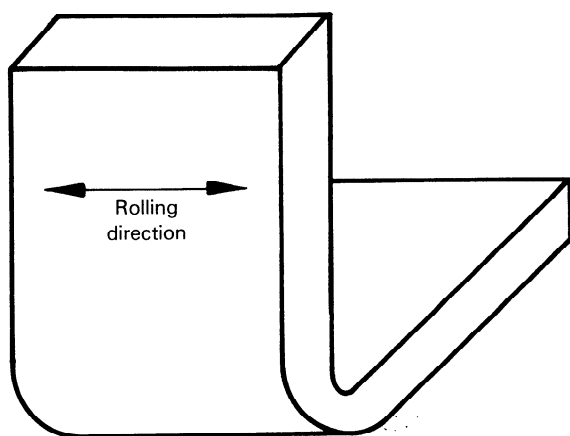


Figure 1 a) — Transverse bend test piece (after bending)

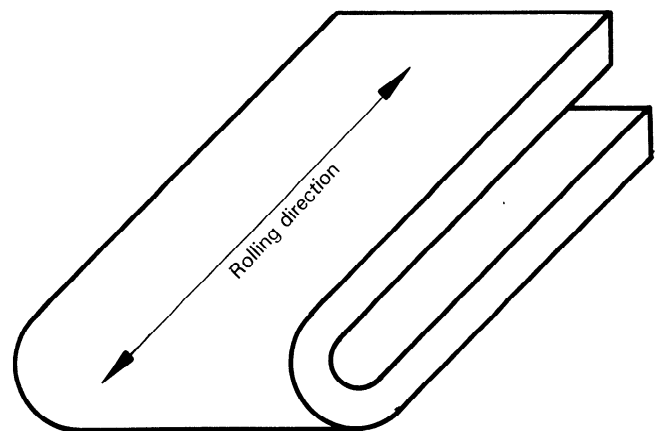


Figure 1 b) — Longitudinal bend test piece (after bending)

Table 4 a) – Tensile strength range for quenched and tempered cold-reduced carbon steel strip

| Designation | Tensile strength, R_m , range ¹⁾ | Maximum thickness up to which the tensile values apply ²⁾ |
|-------------|-----------------------------------------------|----------------------------------------------------------------------|
| | N/mm ² | mm |
| CS 55 | 1 150 < R_m < 1 650 | 2,0 |
| CS 60 | 1 180 < R_m < 1 680 | 2,0 |
| 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 | 2,0 |

1) 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 ≥ 200 N/mm² when ordering material.

1 N/mm² = 1 MPa

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

Table 4 b) – Hardness range for quenched and tempered cold-reduced carbon steel strip

| Designation | Hardness Vickers range ¹⁾ | Maximum thickness up to which the hardness values apply ²⁾ |
|-------------|--------------------------------------|-----------------------------------------------------------------------|
| | HV | mm |
| CS 55 | 300 < HV < 490 | 2,0 |
| CS 60 | 350 < HV < 500 | 2,0 |
| 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 | 2,0 |

1) The purchaser should normally specify a hardness range of ≥ 66 HV when ordering material.

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

Table 5 – Hardness ranges for intermediate hard cold-reduced carbon steel strip

| Specified thickness, e (mm) | Hardness Rockwell | | Maximum of range (HR) Grades CS 30 to CS 95 | Hardness Vickers | Maximum of range (HV) | | |
|----------------------------------|-------------------|-------|------------------------------------------------|------------------|-----------------------|-----------------------|-----------------------|
| | Scale | Range | | | Grades CS 30 to CS 45 | Grades CS 50 to CS 70 | Grades CS 75 to CS 95 |
| $e < 0,36$ | HR15T | 4 | 89 | 40 | 240 | 250 | 260 |
| $0,36 < e < 1,00$ | HR30T | 6 | 81 | 45 | 230 | 240 | 250 |
| $e > 1,00$ | HRB | 10 | 97 | 50 | 220 | 230 | 240 |

Table 6 – Thickness tolerances¹⁾ for cold-reduced carbon steel strip, for coils and cut lengths

Values in millimetres

| Specified thickness, <i>e</i> | Tolerance ²⁾ for specified width, <i>b</i> | | | | | |
|-------------------------------|-------------------------------------------------------|---------|----------------------|---------|----------------------|---------|
| | <i>b</i> < 125 | | 125 < <i>b</i> < 250 | | 250 < <i>b</i> < 600 | |
| | N | F | N | F | N | F |
| <i>e</i> < 0,15 | ± 0,01 | ± 0,01 | ± 0,02 | ± 0,015 | — | — |
| 0,15 < <i>e</i> < 0,25 | ± 0,02 | ± 0,015 | ± 0,02 | ± 0,015 | — | — |
| 0,25 < <i>e</i> < 0,40 | ± 0,02 | ± 0,015 | ± 0,03 | ± 0,02 | ± 0,03 | ± 0,02 |
| 0,40 < <i>e</i> < 0,60 | ± 0,03 | ± 0,02 | ± 0,03 | ± 0,02 | ± 0,04 | ± 0,03 |
| 0,60 < <i>e</i> < 0,80 | ± 0,04 | ± 0,03 | ± 0,04 | ± 0,03 | ± 0,05 | ± 0,035 |
| 0,80 < <i>e</i> < 1,00 | ± 0,04 | ± 0,03 | ± 0,05 | ± 0,035 | ± 0,05 | ± 0,035 |
| 1,00 < <i>e</i> < 1,50 | ± 0,05 | ± 0,035 | ± 0,06 | ± 0,045 | ± 0,07 | ± 0,055 |
| 1,50 < <i>e</i> < 2,50 | ± 0,06 | ± 0,04 | ± 0,07 | ± 0,055 | ± 0,08 | ± 0,06 |
| 2,50 < <i>e</i> < 4,00 | ± 0,07 | ± 0,05 | ± 0,08 | ± 0,06 | ± 0,10 | ± 0,08 |
| 4,00 < <i>e</i> < 6,00 | ± 0,09 | ± 0,06 | ± 0,10 | ± 0,08 | ± 0,12 | ± 0,09 |

1) 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.

2) N indicates normal tolerances; F indicates fine tolerances.

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Table 7 – Width tolerances for cold-reduced carbon steel strip, for coils and cut lengths, mill edge

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Values in millimetres

| Specified width, <i>b</i> | Tolerance ¹⁾²⁾ |
|---------------------------|---------------------------|
| <i>b</i> < 100 | ± 1,5 |
| 100 < <i>b</i> < 200 | ± 2,0 |
| 200 < <i>b</i> < 400 | ± 2,5 |
| 400 < <i>b</i> < 500 | ± 3,0 |
| 500 < <i>b</i> < 600 | ± 4,0 |

1) The values specified do not apply to the uncropped ends of a mill edge coil within 7 m inclusive of both ends.

2) By agreement between the manufacturer and purchaser, material can be ordered to all plus tolerances, in which case the value is doubled.

Table 8 – Width tolerances for cold-reduced carbon steel strip, for coils and cut lengths, sheared edge, not resquared

Values in millimetres

| Specified width, <i>b</i> | Tolerance ¹⁾ for specified thickness, <i>e</i> | | | |
|---------------------------|-----------------------------------------------------------|----------------------|----------------------|----------------------|
| | <i>e</i> < 1,5 | 1,5 < <i>e</i> < 2,5 | 2,5 < <i>e</i> < 4,5 | 4,5 < <i>e</i> < 6,0 |
| <i>b</i> < 100 | ± 0,20 | ± 0,25 | ± 0,35 | ± 0,40 |
| 100 < <i>b</i> < 200 | ± 0,25 | ± 0,30 | ± 0,45 | ± 0,50 |
| 200 < <i>b</i> < 300 | ± 0,30 | ± 0,35 | ± 0,50 | ± 0,50 |
| 300 < <i>b</i> < 450 | ± 0,40 | ± 0,45 | ± 0,60 | ± 0,70 |
| 450 < <i>b</i> < 600 | ± 0,50 | ± 0,50 | ± 0,60 | ± 0,70 |

1) 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.