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October 1991

Cold rolled flat steel products for cold forming

Technical delivery conditions

English version of DIN EN 10 130

DIN EN 10 130

Kaltgewalzte Flacherzeugnisse aus weichen Stählen zum Kaltumformen; technische Lieferbedingungen

Supersedes DIN 1623 Part 1, February 1983 edition.

European Standard EN 10 130 : 1991 has the status of a DIN Standard.

A comma is used as the decimal marker.

National foreword

This standard has been prepared by ECISS/TC 13.

The responsible German body involved in the preparation of this standard was the *Normenausschuß Eisen und Stahl* (Steel and Iron Standards Committee), Technical Committee 01 *Flacherzeugnisse; Gütenormen*.

Besides the principal amendments made to the standard now superseded, as listed on page 2, the following should be noted.

a) **Classification of steel grades**

Grade USt 13 has been dropped, grades FE P05 and FE P06 have been introduced. The following table correlates the steel grades covered in this standard and the equivalent grades previously covered in DIN 1623 Part 1.

Steel grade as in		
	DIN 1623 Part 1 Material	
DIN EN 10 130	designation	number
Fe P01	St 12	1.0330
–	USt 13	1.0333
Fe P03	RRSt 13	1.0347
Fe P04	St 14	1.0338
Fe P05	– [1]	– [1]
Fe P06	– [2]	– [1]

[1] In practice, referred to as St 15 and 1.0312 respectively.

[2] Comparable to grade IF 18 as in *Stahl-Eisen-Werkstoffblatt* 095 (July 1987 edition).

b) **Designation of steel grades**

The specifications for standard designations (cf. clause 4 and table 2) still conform with those given in EURONORM 27, which is in the process of being adopted as a European Standard (EN 10 027 Part 1). Since that European Standard will include changes to the symbols, it is not recommended that the symbols used hitherto be replaced by those specified in EURONORM 27 but, pending the publication of EN 10 027 Part 1, that the material designations or numbers from DIN 1623 Part 1 given in the above table be used for a transitional period.

c) **Chemical composition and mechanical properties**

The specifications regarding chemical composition have been supplemented by specifying maximum P, S, Mn and (for grade Fe P06) Ti contents.

The yield strength, tensile strength and elongation values specified agree with the relevant specifications of DIN 1623 Part 1.

The requirements regarding hardness, and the behaviour of material in the cupping test, have been dropped since the majority of CEN members did not deem the results obtained in the cupping test to be meaningful in the assessment of the formability of the material. Instead, minimum values for the plastic strain ratio, r, and the strain hardening exponent, n, have been specified in table 2, the methods of determining these parameters being described in annnexes A and B (these methods reflect the stage of work in ISO/TC 164/SC 2).

d) **Surface characteristics**

The specifications for surface finish and quality have been adopted from DIN 1623 Part 1 almost unchanged.

The DIN Standards corresponding to the European Standards referred to in clause 2 of the EN are as follows:

European Standard/ EURONORM	DIN Standard
EN 10 002-1	DIN EN 10 002 Part 1
EN 10 002-2	DIN EN 10 002 Part 2 (at present at the stage of draft)
EN 10 020	DIN EN 10 020
prEN 10 021	DIN EN 10 021 (at present at the stage of draft)
EN 10 079	DIN EN 10 079
EN 10 131	DIN EN 10 131
EN 10 204	DIN 50 049

There are no DIN Standards corresponding to the EURONORMs referred to.

Continued overleaf.

EN comprises 9 pages.

Standards and other documents referred to

(and not included in **Normative references**)

Stahl-Eisen-Werkstoffblatt (Iron and steel materials sheet) 095

Kaltgewalztes Band und Blech zum Kaltumformen aus weichem mikrolegiertem Stahl; technische Lieferbedingungen (Cold rolled microalloyed low carbon steel sheet and strip; technical delivery conditions)

Previous editions

DIN 1623: 05.32; DIN 1623 Part 1: 01.61, 11.72, 02.83.

Amendments

In comparison with DIN 1623 Part 1, February 1983 edition, the following amendments have been made.

a) The specifications for standard designations have been changed.

b) Grade USt 13 has been dropped and grades Fe P05 and Fe P06 have been introduced.

c) The specifications regarding the chemical composition have been supplemented, new requirements for the plastic strain ratio and the strain hardening exponent have been specified.

d) The requirements regarding behaviour in cupping test and hardness have been deleted.

International Patent Classification

B 21 B 1/00

C 21 D 7/02

C 22 C 38/00

G 01 N 33/20

Editor's note

This standard reproduces the official text of the English version of EN 10 130 as issued by CEN. In its preparation for publication as DIN EN 10 130 (English version), certain points have been noted which we consider to be in need of correction. These have been marked $^{+}$*). The suggested amendments are given below and will be forwarded to the responsible CEN Secretariat for its consideration.*

In presentation, orthography, punctuation and hyphenation, the aim has been to implement the PNE Rules consistently. Obvious errors (e.g. redundancies and omissions) have been rectified without further reference.

Suggested amendments

1 *In subclause 5.7.2, 1st paragraph, 'affect' should be substituted for 'effect'.*

2 *In subclause 6.5.3, 'measurement' should be deleted.*

3 *In subclause 6.5.4, 'exponent' should be substituted for 'component'.*

4 *In A.1.2, A.2, A.7, B.1.3, B.2 and B.6, 'subscript x' and 'subscript y' should preferably be substituted for 'index (figure) x' and 'index (figure) y', respectively.*

5 *In the formula in annex A, 1.3,* r_a *should be substituted for* r_0*.*

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 10 130

March 1991

UDC 669.14.018.26-122.2-418

Descriptors: Iron and steel products, cold rolled products, metal plates, low carbon steels, cold working, cupping, foldings, delivery condition, acceptance testing.

English version

Cold rolled flat steel products for cold forming
Technical delivery conditions

Produits plats laminés à froid, en acier doux pour emboutissage au pliage à froid; conditions techniques de livraison

Kaltgewalzte Flacherzeugnisse aus weichen Stählen zum Kaltumformen; technische Lieferbedingungen

This European Standard was approved by CEN on 1991-02-20. CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Ref. No. EN 10 130 : 1991 E

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Foreword

The European Committee for Iron and Steel Standardization (ECISS) authorized Technical Committee 13 (Secretariat: Belgium) to convert EURONORM 130-1977, Cold rolled non-coated non-alloy mild steel flat products for cold forming; quality standard, published by ECSC, into European Standard EN 10 130.

This European Standard EN 10 130 was approved by CEN on 1991-02-20.

In accordance with the requirements of the CEN/CENELEC Internal Regulations, the following countries are bound to adopt this European Standard:

Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

This European Standard applies to cold rolled non-coated low carbon steel flat products in rolled widths equal to or over 600 mm for cold forming, with a minimum thickness of 0,35 mm, and unless otherwise agreed at the time of ordering, equal to or less than 3 mm, delivered in sheet, coil, slit coil, or cut lengths obtained from slit coil or sheet.

It does not apply to cold rolled narrow strip (rolling width < 600 mm) nor to flat cold rolled products for which there is a specific standard, in particular the following:

- cold rolled not grain-oriented magnetic steel sheet and strip (EURONORM 106);
- semi-processed steel strip for the construction of magnetic circuits (EURONORMs 126 and 165);
- blackplate in sheet form (EN 10 025);
- blackplate in coils (EN 10 025);
- sheets for welded steel gas bottles (EURONORM 120);
- flat products in high yield strength steels for cold forming (EURONORM 149);
- cold rolled uncoated non-alloy mild steel narrow strip for cold forming (EURONORM 139);
- cold rolled structural steels for general purposes.

It is not applicable to flat products which are to be enamelled.

2 Normative references

EN 10 002-1 : 1990	Metallic materials; tensile testing. Part 1: Method of test at ambient temperature
EN 10 002-2 : 1990	Metallic materials; tensile testing. Part 2: Verification of the force measuring systems of testing machines
EN 10 020 : 1988	Definition and classification of grades of steel
prEN 10 021 : 1990	General technical delivery requirements for steel and iron and steel products
EN 10 079 : 1989	Definition of steel products
EN 10 131 : 1989	Cold rolled non-coated flat products in low carbon steel for cold forming; tolerances on dimensions and shape
EN 10 204 : 1989	Metallic materials; types of inspection documents
EURONORM 18-79	Selection and preparation of samples and test pieces for steel and iron and steel products [1]
EURONORM 49-72	Roughness measurement of cold rolled uncoated steel sheets and strip [1]
ISO 9513 : 1989	Metallic materials; verification of extensometers used in uniaxial testing

[1] Until these EURONORMs are transformed into European Standards, they can either be implemented or reference made to the corresponding national standards the list of which is given in annex C to this European Standard.

3 Definitions

For the purposes of this European Standard, the definitions of the cold rolled flat products listed in clause 1 are those given in European Standard EN 10 079.

4 Designation

NOTE: In this European Standard the old designations from EURONORM 130 are used. This is, because, at the time of publication of this European Standard, the transformation of EURONORM 27 into a European Standard was not completed.

The designation consists of the word: 'sheet', 'coil', 'slit coil' or 'cut length' followed in order by:

- reference to this European Standard (EN 10 130),
- the symbol Fe P,
- the grade designation (01-03-04-05 or 06),
- the symbol concerning the surface quality (A for surface quality A or B for surface quality B),
- if applicable, the symbol relating to the surface finish (see table 1).

EXAMPLES:

Designation of sheet made of steel grade Fe P01, surface quality A (A), surface finish 'normal' (m):

Sheet EN 10 130 – Fe P01 A m

Designation of coil made of steel grade Fe P06, surface quality B (B), surface finish 'semi-bright' (g):

Coil EN 10 130 – Fe P06 B g

5 Requirements

5.1 Steelmaking and manufacturing processes

Unless otherwise agreed at the time of ordering, the steelmaking and manufacturing processes are left to the discretion of the manufacturer. The purchaser shall be informed of these processes, if he specifies it.

5.2 Deoxidation

For grade Fe P01, the method of deoxidation shall be at the manufacturer's discretion.

Grades Fe P03, Fe P04, Fe P05 and Fe P06 shall be fully killed.

5.3 Chemical composition

The chemical composition based on ladle analysis shall be as given in table 2.

5.4 Delivery condition

5.4.1 Products specified in this standard are normally supplied in the skin-passed condition. By agreement at the time of ordering, not skin-passed products may be supplied.

5.4.2 The products are normally delivered oiled. In this case, both the surfaces are preserved by a layer of neutral non-drying oil, free of foreign matter and uniformly spread in such a way that, under normal conditions of packing, transportation, handling and storage, the products will show no corrosion for up to three months. If the conditions of transportation or storage are such that special protection against corrosion is required, the purchaser shall inform the manufacturer at the time of ordering.

The layer of oils shall be capable of being removed by alkaline solutions or normal solvents.

The choice of protective oils may be the subject of special agreement.

If the purchaser does not require the surfaces to be oiled, this shall be clearly indicated at the time of ordering.

NOTE: If the order is for unoiled products, the manufacturer is not responsible for the risk of rust. The purchaser is also advised that there is a greater risk of the appearance of light scratches during handling, transportation, and putting into application.

5.5 Choice of properties

The products covered by this European Standard shall comply with the requirements of tables 1 and 2. By agreement, they may be delivered as suitable for making a particular part; in this case, a maximum percentage of scrap may be agreed and acceptance on the basis of mechanical properties is not applicable.

5.6 Mechanical properties

The mechanical properties given in table 2 apply only to skin-passed products (see 5.8.2). The mechanical properties are valid for the period specified in table 2 from the date on which the products are made available.

For not skin-passed products (see 5.8.3), the mechanical properties should be agreed at the time of ordering.

The date of availability shall be notified to the purchaser with reasonable prior notice compatible with the validity of the mechanical properties. Prolonged storage of products of grade Fe P01 could result in some change in the mechanical properties leading to a reduction in formability.

5.7 Surface characteristics

5.7.1 General

The surface characteristics consist of the surface quality and the surface finish.

The surface quality and finish shall be specified by the purchaser at the time of ordering.

For not skin-passed products that have not been skin-passed, surface quality B is not applicable and no requirement for a particular surface finish can be made.

5.7.2 Surface quality

The products are supplied with either of the surface qualities A or B.

Surface quality A

Defects such as pores, slight indentations, small marks, minor scratches and slight colouring which do not effect*) formability or the application of surface coatings are permitted.

Surface quality B

The better surface shall be free of defects which might affect the uniform appearance of a quality paint or an electrolytic coating (see 5.9). The other surface shall at least conform to surface quality A.

In the case of delivery of coil and slit coil, the percentage of defects may be greater than in the case of delivery in sheet or cut lengths. This should be taken into account by the purchaser, and the percentage of admissible surface defects may be agreed at the time of ordering.

Unless otherwise agreed, a single surface of the product shall comply with the specified requirements. The other surface shall be such that, during subsequent treatment, it does not have a deleterious effect on the better surface.

5.7.3 Surface finish

The surface finish may be bright, semi-bright, normal or rough. In the absence of a requirement on the order, products shall be supplied with the normal finish.

Limiting values for average surface roughness for the four types of finish are given in table 1. The measurement shall be made in accordance with EURONORM 49.

By agreement at the time of ordering, other ranges for surface roughness may be specified for specific end uses.

Table 1: Surface finish and roughness values

Surface finish	Symbol	Roughness, R_a, in µm
Bright	b	$\leq 0,4$
Semi-bright	g	$\leq 0,9$
Normal	m	$> 0,6 \leq 1,9$
Rough	r	$> 1,6$

5.8 Stretcher strain marks

5.8.1 General

All products are generally subjected to a light skin-pass after annealing at the manufacturer's works to avoid the formation of stretcher strain marks during subsequent forming.

The tendency to form such marks may reappear a certain time after the skin-pass. It is therefore in the purchaser's interest to form the products as soon as possible.

Products of grade Fe P06 do not exhibit stretcher strain marks whether delivered skin-passed or not skin-passed.

5.8.2 Skin-passed products

The manufacturer shall ensure the absence of stretcher strain marks:

- for 6 months, after products of grades Fe P03, Fe P04, and Fe P05 are made available, for surface appearances A and B,
- for 3 months, after products of Fe P01 are made available for surface appearance B.

5.8.3 Not skin-passed products

Stretcher strain marks are permitted in the condition of delivery and on drawn items.

5.9 Suitablility for surface coating

The products may be required for metallic coating by the hot dip coating, or electrolytic coating process, or organic coating or other coating. When such a coating is intended, it shall be specified at the time of ordering.

5.10 Weldability

The material is specified as suitable for normal welding procedures. It is, however, desirable to state the welding procedure at the time of ordering but essential to do so in the case of gas welding.

5.11 Tolerances on shape and dimensions

Tolerances on shape and dimensions are given in EN 10 031.

6 Tests

6.1 General

6.1.1 The purchaser shall specify at the time of ordering his requirements for

- type of inspection and testing: specific or non-specific; see EN 10 021 (in preparation);
- type of inspection document; see EN 10 204.

6.1.2 Specific inspection and testing shall be carried out in accordance with 6.2 to 6.6.

6.1.3 Specific inspection and testing may not be specified either for the product analysis or the surface finish.

6.2 Inspection units

The inspection unit is 30 t or a fraction of 30 t of products of the same grade and nominal thickness. When a coil exceeds 30 t, it constitutes a single inspection unit, as do its products.

6.3 Number of tests

For each inspection unit a tensile test shall be carried out and where appropriate a determination of n and r (see table 2 and annexes A and B).

6.4 Sampling

The requirements of EURONORM 18 and EN 10 021 are supplemented by the following specific requirements.

For sheet and cut lengths, the selection of products to be tested and the position of the samples in the products is left to the discretion of the inspection representative.

In the case of coil and slit coil, the sample should preferably be taken from the outer end.

If the width of the product permits, the test pieces for the tensile test shall be taken perpendicular to the direction of rolling.

6.5 Test methods

6.5.1 The products shall be tested in the condition of delivery.

The tests shall be carried out at ambient temperature.

6.5.2 The tensile test shall be carried out as described in EN 10 002-1 using type 2 specimens (initial gauge length, $L_0 = 80$ mm; width, $b = 20$ mm) as described in annex A of EN 10 002 Part 1.

6.5.3 Surface roughness measurement+) shall be determined in accordance with EURONORM 49.

6.5.4 The determination of plastic strain ratio, r, and tensile strain hardening component+), n, shall be carried out in accordance with annexes A and B of this standard.

6.5.5 For the determination of the chemical composition, the corresponding European Standards and EURONORMs shall apply in cases of dispute.

6.6 Retests

The requirements of EN 10 021 shall apply.

For coils, in the event of the test results giving rise to dispute, the samples for retests shall be taken at intervals of at least one lap, but also at a maximum distance of 20 m from the appropriate end.

6.7 Inspection document

By agreement at the time of ordering, an inspection document chosen from those given in EN 10 204 shall be supplied (see also 6.1.2).

7 Marking

Unless otherwise agreed at the time of ordering, marking shall be carried out on the inspected surface by means of an easily removed non-corrosive ink.

8 Packing

The packing requirements shall be agreed when ordering.

9 Disputes

With regard to any claims and any action arising therefrom, EN 10 021 shall apply.

10 Information to be supplied by the purchaser at the time of ordering

To permit the manufacturer to supply products conforming to this standard, the following information should be given in the order.

a) The full designation as given in clause 4.

b) Nominal dimensions and quantities.

c) Whether the products are to be supplied not skin-passed.

d) Whether the products are to be delivered with mill edges or sheared edges.

e) Limits for mass and size of coils and individual bundles.

f) Intended application of the products, including surface coating.

g) Whether the products are to be welded; indication of the method to be used.

h) Whether the products are to be supplied as suitable for making a specific part.

i) Whether inspection documents are required; type of document.

j) Whether an external inspection is to be carried out at the manufacturer's works.

k) Whether oiling is not required.

l) Whether other protective coatings are required.

m) Detailed description of all other special requirements.

n) Any special requirements for packing and marking.

o) The position of the surface of better surface finish quality.

Table 2: Characteristics[1])

Grade	Definition and classification according to EN 10 020	Deoxidation properties	Validity of mechanical appearance	Surface marks	Absence of stretcher strain	R_e N/mm² [2)]	R_m N/mm²	A_{80} % min. [3)]	r_{90} min. [4),5)]	n_{90} min. [4)]	Chemical composition (ladle analysis, % max)				
											C	P	S	Mn	Ti
Fe P01 [6)]	Non-alloy quality steel[7)]	At manufacturer's discretion	— —	A B	— 3 months	[8),10)] —/280	270 to 410	28	—	—	0,12	0,045	0,045	0,60	
Fe P03	Non-alloy quality steel[7)]	Fully killed	6 months 6 months	A B	6 months 6 months	[8)] —/240	270 to 370	34	1,3	—	0,10	0,035	0,035	0,45	
Fe P04	Non-alloy quality steel[7)]	Fully killed	6 months 6 months	A B	6 months 6 months	[8)] —/210	270 to 350	38	1,6	0,180	0,08	0,030	0,030	0,40	
Fe P05	Non-alloy quality steel[7)]	Fully killed	6 months 6 months	A B	6 months 6 months	[8)] —/180	270 to 330	40	1,9	0,200	0,06	0,025	0,025	0,35	
									$\bar{r}$ [4),5)] min	$\bar{n}$ [4)] min.					
Fe P06	Alloy quality steel	Fully killed	6 months 6 months	A B	No limit No limit	[9)] —/180	270 to 350	38	1,8	0,220	0,02	0,020	0,020	0,25	0,3[11)]

[1)] The mechanical properties apply only to skin-passed products.

[2)] The values of yield stress are the 0,2 % proof stress for products which do not present a definite yield point and the lower yield stress R_{eL} for the others. When the thickness is less than or equal to 0,7 mm and greater than 0,5 mm, the value for yield stress is increased by 20 N/mm². For thicknesses less than or equal to 0,5 mm, the value is increased by 40 N/mm².

[3)] When the thickness is less than or equal to 0,7 mm and greater than 0,5 mm, the minimum value for elongation is reduced by 2 units. For thicknesses less than or equal to 0,5 mm, the minimum value is reduced by 4 units.

[4)] The values of r_{90} and n_{90} or $\bar{r}$ and $\bar{n}$ (see annexes A and B) only apply to products of thickness equal to or greater than 0,5 mm.

[5)] When the thickness is over 2 mm, the value for r_{90} or $\bar{r}$ is reduced by 0,2.

[6)] It is recommended that products in grade Fe P01 should be formed within 6 weeks from the time of their availability.

[7)] Unless otherwise agreed at the time of the ordering, Fe P01, Fe P03, Fe P04 and Fe P05 may be supplied as alloy steels (for example, with boron or titanium).

[8)] For design purposes, the lower limit of R_e for grade Fe P01, Fe P03, Fe P04 and Fe P05 may be assumed to be 140 N/mm².

[9)] For design purposes, the lower limit of R_e for grade Fe P06 may be assumed to be 120 N/mm².

[10)] The upper limit of R_e of 280 N/mm² for grade Fe P01 is valid only for 8 days from the time of the availability of the product.

[11)] Titanium may be replaced by niobium. Carbon and nitrogen shall be completely bound.

Annex A
Method of determination of the plastic strain ratio, r

NOTE: This annex is based upon the procedures being developed by ISO/TC164/SC2.

A.1 Definitions, symbols and designations

A.1.1 Plastic strain ratio, r, is defined as the ratio of true width and thickness strains in a test piece that has been submitted to unlaxial tensile stress.

$$r = \frac{\varepsilon_b}{\varepsilon_a}$$

where

ε_a is the true thickness strain;

ε_b is the true width strain.

The plastic strain shall be homogeneous.

A.1.2 Since measurements of length are more easily made than of thickness changes, the following relationship derived from the law of constancy of volume before and after plastic strain is normally used for calculation of r:

$$r = \frac{\ln \frac{b_0}{b}}{\ln \frac{L \cdot b}{L_0 b_0}}$$

The symbol r shall be completed by index figure+) x giving the orientation of the test piece relative to the rolling direction and by index figure+) y giving the strain level; example: $r_{45/20}$ (see table 3).

A.1.3 The weighted average $r_{x/y}$ value is calculated using the formula

$$\bar{r} = \frac{r_0 + r_{90} + 2r_{45}}{4}$$ +)

A.1.4 Symbols and designations used in measurement and calculations for determining the plastic strain ratio, r, are given in table 3.

Table 3

Symbol	Designation	Unit
b_0	Original gauge width of the test piece	mm
b	Gauge width of the test piece after straining to a specified elongation	mm
L_0	Original gauge length	mm
L	Gauge length after straining to a specified elogation	mm
r	Plastic strain ratio	–
$r_{x/y}$	Plastic strain ratio in direction x (in degrees) relative to the rolling direction for the strain level y (in %)	–
$\bar{r}$ [1])	Weighted average of $r_{x/y}$ values	–
ε_a	True thickness strain	–
ε_b	True width strain	–

[1]) In some countries, r_m is used instead of $\bar{r}$.

A.2 Principle

The method involves carrying out a tensile test to a specified strain level of 20 % and of determining the plastic strain ratio by calculation from measurements of the changes in length and width for a given test piece. As the determination shall be carried out in the range of homogeneous deformation, then, if the uniform elongation of the tested material is lower than 20 %, strain values of 15 % to 20 % can be applied. The strain level shall be given as index+) y. The orientation of the test piece relative to the rolling direction shall be given as index+) x (see A.1.2).

A.3 Testing equipment

A.3.1 The testing machine and method of gripping shall comply with the requirements of EN 10 002-1 and -2.

A.3.2 When the gauge length and width are determined by an extensometer, the class of the extensometer shall be 1 or better (according to ISO 9513).

A.4 Test piece

A.4.1 The sampling and preparation of the test piece shall be in accordance with EN 10 002-1. The test piece type shall be No. 2 (80/20 mm).

A.4.2 The gauge length shall be between 50 mm and 80 mm but preferably 80 mm. The gauge length shall be measured to within ±0,01 mm and the test piece width shall be measured to within ±0,005 mm, using devices having adequate accuracy.

A.5 Procedure

A.5.1 In general, the test is carried out at ambient temperature between 10 °C and 35 °C. Tests carried out under controlled conditions shall be made at a temperature of (23 ± 5) °C.

A.5.2 If the measurement is made manually, the original width of the test piece shall be measured at at least three evenly distributed points within the gauge length (one measurement at each end of the gauge length). The mean value of the width shall be taken for calculations of plastic strain ratio, r.

A.5.3 If the measurements are made automatically, the original gauge length and at least one width measurement shall be set according to the requirements of class 1 extensometers or better as specified in ISO 9513.

A.5.4 The speed of the machine, as defined by the speed of separation of crossheads of the machine, expressed as a percentage of the parallel length per minute, shall in no case exceed 50.

A.5.5 Mount the test piece in the grips of the testing machine and apply the load in accordance with A.5.4:

a) to achieve the prescribed strain (manual determination);

b) to determine the width values at the prescribed strain level (automatic determination).

A.5.6 For manual determination after removing the load, measure the gauge length, L, and gauge width, b, in the same manner and to the same tolerance as for original values.

A.5.7 For automatic determination, the measurements of length and width at prescribed strain level are made according to A.4.2.

A.5.8 For manual determination, calculate the plastic strain ratio in accordance with A.1.2.

A.5.9 For automatic determination, the plastic strain ratio is obtained directly using an automatic tensile testing machine and data processing programme. The elastic strains (in both width and length directions) shall be considered.

A.5.10 Calculate the weighted average, $\bar{r}$, in accordance with A.1.3.

A.6 Interpretation of results

A.6.1 Determined values of plastic strain ratio, r, shall be rounded to 0,05.

A.6.2 If the test piece shows any transverse bow which could influence the test results, the test shall be considered invalid and a new test shall be carried out.

A.6.3 If the plastic strain was inhomogeneous, the test results shall be considered invalid and a new test shall be carried out.

A.6.4 In case of dispute, the testing shall be carried out with three test pieces of the specified orientation relative to the rolling direction. The average value of the 3 tests shall be considered.

A.7 Test report

The orientation of the applied strain relative to the rolling direction shall be added as an index figure+) x. The applied strain value, if not 20 %, shall be given as an index figure+) y.

Annex B
Method of determination of the tensile strain hardening exponent, n

NOTE: This annex is based upon the procedures being developed by ISO/TC 164/SC2.

B.1 Definitions, symbols and designations

B.1.1 Symbols and designations used in determining the strain hardening exponent are given in table 4.

B.1.2 The strain hardening exponent, n, is defined as an exponent in the mathematical equation of the relation between true stress and true strain (during uniaxial application of the force):

$$\sigma = K \varepsilon^n \qquad (1)$$

or in the logarithmic form:

$$\ln \sigma = \ln K + n \ln \varepsilon \qquad (2)$$

B.1.3 The symbol n shall be completed by an index figure+) x giving the orientation of the test piece relative to the rolling direction and by an index figure+) y giving the upper limit of the strain range if the latter is not the standard value of 20 %, i.e. $n_{45/18}$.

B.1.4 The weighted average of n_x values is calculated using the formula

$$\bar{n} = \frac{n_0 + n_{90} + 2n_{45}}{4}$$

B.2 Principle

The test involves uniaxial tensile straining of the test piece at the prescribed rate in the interval including the region of the uniform plastic strain.

The strain hardening exponent is determined within the strain range of 10 % to 20 %. As the determination shall be carried out in the range of homogeneous deformation, then, if the uniform elongation of the tested material is lower than 20 %, values for the upper limit of the strain range of 15 % to

Table 4

Symbol	Designation	Unit
L_0	Original extensometer gauge length of the test piece	mm
L	Instantaneous gauge length of the test piece after instantaneous action of the force F	mm
S_0	Original cross section of the gauge part of the test piece	mm^2
S	Instantaneous cross section of the gauge part of the test piece after instantaneous action of the force F $S = S_0 \frac{L_0}{L}$	mm^2
ε	Instantaneous true strain after instantaneous action of the force F $\varepsilon = \ln \frac{L}{L_0}$	
σ	Instantaneous true stress after instantaneous action of the force F $\sigma = \frac{F}{L_0} \cdot \frac{L}{S_0}$	$N \cdot mm^{-2}$
F	Instantaneous force applied to the test piece	N
n	Strain hardening exponent	

(continued)

Table 4 (concluded)

Symbol	Designation	Unit
K	Strength coefficient	$N \cdot mm^{-2}$
$n_{x/y}$	Strain hardening exponent ratio in direction x (in degrees) relative to the rolling direction for the strain level y (in %)	
$\bar{n}$ [1]	Weighted average of n_x values	
N	Number of measurements for determination of strain hardening exponent	

[1] In some countries, n_m is used instead of $\bar{n}$.

20 % can be applied. In this case, the upper strain limit shall be given as index+) y (see B.1.3).

B.3 Testing equipment

B.3.1 The testing machine and method of gripping shall comply with the requirements of EN 10 002-1 and -2.

B.3.2 The accuracy of the extensometer used shall be class 1 or better (according to ISO 9513).

B.4 Test piece

B.4.1 The sampling and preparation of the test piece shall be in accordance with EN 10 002-1, the test piece type is No. 2 (80/20 mm).

B.4.2 The gauge length shall be between 50 mm and 80 mm but preferably 80 mm. The gauge length shall be measured to within ±0,01 mm using a device having adequate accuracy.

B.5 Procedure

B.5.1 In general, the test is carried out at ambient temperature between 10 °C and 35 °C. Tests carried out under controlled conditions shall be made at a temperature of (23 ± 5) °C.

B.5.2 The test piece shall be mounted in the testing machine so that the force can be applied axially in accordance with EN 10 002-1.

B.5.3 The speed of the machine, as defined by the speed of separation of the crossheads of the machine, expressed as a percentage of the parallel length per minute, shall in no case exceed 50. This speed shall be kept constant in the time interval over which the tensile hardening exponent is calculated.

B.5.4 The force and the corresponding strain shall be recorded at a minimum of 5 points, distributed at equal distances within the strain range of 10 % to 20 % (or 10 % to 15 ... 18 %; refer to B.2) for which the strain hardening exponent is calculated.

B.5.5 From the values of the force and the corresponding strain, the true stress shall be calculated using the formula

$$\sigma = \frac{F}{S_0} \cdot \frac{L}{L_0}$$

and the true strain shall be calculated using the formula

$$\varepsilon = \ln \frac{L}{L_0}$$

and the logarithms of these values shall be obtained.

B.5.6 The n value is calculated using the formula given below, the standard formula for calculating the inclination of a straight line using the statistical method of least squares:

$$n = \frac{N \Sigma x_i y_i - \Sigma x_i \Sigma y_i}{N \Sigma x_i^2 - (\Sigma x_i)^2}$$

where $y = Ax + B$

with $y = \ln \sigma$

$x = \ln \varepsilon$

$A = n$

$B = \ln K$

B.5.7 Calculated values of the strain hardening exponent, n, shall be rounded to 0,005.

B.5.8 In case of dispute, the testing shall be carried out with three test pieces of the specified orientation relative to the rolling direction. The average value from the 3 tests shall be considered.

B.6 Test report

The orientation of the applied strain relative to the rolling direction shall be added as an index figure+) x, the upper limit of the applied strain range, if not 20 %, shall be given as an index figure+) y.

Annex C

(informative)

List of national standards corresponding to referenced EURONORMs (see clause 2)

Until the following EURONORMs are transformed into European Standards, they can either be implemented or reference made to the corresponding national standard given in table 5.

Table 5: EURONORMs and corresponding national standards

EURO-NORM	Corresponding national standards						
	Germany DIN	France NF	UK BS	Italy UNI	Belgium NBN	Sweden SS	Spain UNE
18	–	A 03-111	1449 Part 1: 1983	EU 18	A 03-111	11 0120 11 0105	36-300
21	17 010 50 049	A 03-115	1449 Part 1: 1983	EU 21	A 02-001	11 0001 21 9301	36-007
49	–	–	–	–	–	ISO 4288	–
79	–	A 40-001	6562 Part 2: 1986	7272	A 01-102	01 6601	36-501
131	1541	–	1449 Part 1: 1983	–	A 43-401	21 1210	36-563