INTERNATIONAL STANDARD

ISO 11692

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Ferritic-pearlitic engineering steels for precipitation hardening from hot-working temperatures

Aciers pour construction mécanique de type ferrite-perlite apte au durcissement par précipitation à partir des températures de formage à chaud

Reference number
ISO 11692:1994(E)

Foreword

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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 11692 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 4, *Heat treatable and alloy steels*.

Annex A forms an integral part of this International Standard. Annex B is for information only.

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Ferritic-pearlitic engineering steels for precipitation hardening from hot-working temperatures

1 Scope

1.1 This International Standard specifies the technical delivery requirements for billets and bars made of the alloyed steels listed in tables 3 and 5. The steel grades listed in table 3 are characterized by chemical composition requirements and are intended for hot forging. The steel grades listed in table 5 are characterized by tensile requirements and are intended for machining. The products are supplied in the heat-treatment conditions given in table 1, lines 2 to 4, and in one of the surface conditions given in table 2.

1.2 In special cases, variations in these technical delivery requirements or additions to them may form the subject of an agreement at the time of enquiry and order (see annex A).

1.3 In addition to this International Standard, the general technical delivery requirements of ISO 404 are applicable.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 377-1:1989, *Selection and preparation of samples and test pieces of wrought steels — Part 1: Samples and test pieces for mechanical test.*

ISO 377-2:1989, *Selection and preparation of samples and test pieces of wrought steels — Part 2: Samples for the determination of the chemical composition.*

ISO 404:1992, *Steel and steel products — General technical delivery requirements.*

ISO 1035-1:1980, *Hot-rolled steel bars — Part 1: Dimensions of round bars.*

ISO 1035-3:1980, *Hot-rolled steel bars — Part 3: Dimensions of flat bars.*

ISO 1035-4:1982, *Hot-rolled steel bars — Part 4: Tolerances.*

ISO 4948-1:1982, *Steels — Classification — Part 1: Classification of steels into unalloyed and alloy steels based on chemical composition.*

ISO/TR 4949:1989, *Steel names based on letter symbols.*

ISO 6506:1981, *Metallic materials — Hardness test — Brinell test.*

ISO 6892:1984, *Metallic materials — Tensile testing.*

ISO 6929:1987, *Steel products — Definitions and classification.*

ISO 9443:1991, *Heat-treatable and alloy steels — Surface quality classes for hot-rolled round bars and wire rods — Technical delivery conditions.*

ISO/TR 9769:1991, *Steel and iron — Review of available methods of analysis.*

ISO 10474:1991, *Steel and steel products — Inspection documents.*

3 Definitions

For the purposes of this International Standard, the definitions for the product forms given in ISO 6929 apply. The term "alloyed steel" is as defined in ISO 4948-1.

4 Ordering and designation

The designation of the product in an order shall cover the following.

a) The designation of the product form (bar, billet) followed by

   — either the designation of the dimensional standard and the dimensions and tolerances selected from it (see 5.6); or

   — the designation of the drawing or any other document covering the dimensions and tolerances required for the product.

b) If a surface condition other than "hot worked" or a special surface quality is required

   — the surface condition (see table 2), and

   — the surface quality (see 5.5).

c) A description of the steel, comprising

   1) a reference to this International Standard;

   2) the designation of the steel type given in table 3 or 5;

   3) the standard designation for the required type of inspection document (see ISO 10474), if an inspection document is required;

   4) the symbol and, where necessary, the details of this supplementary requirement (see annex A), if any supplementary requirement shall be complied with.

EXAMPLE

The following are to be ordered.

Hot-rolled round bars

— in accordance with ISO 1035-1;

— with a nominal diameter of 25,0 mm;

— a nominal length of 8 000 mm;

— a tolerance on diameter of $\pm$ 0,25 mm (= class S of ISO 1035-4);

— a tolerance on length of $^{0}_{+100}$ mm (= class L2 of ISO 1035-4);

— all other tolerances as given in ISO 1035-4, for normal cases.

Surface

— as hot worked (symbol HW, see table 2).

Steel

— in accordance with this International Standard, type 38 MnVS 6 (see table 3);

— heat-treatment condition: untreated (symbol TU, see table 1);

— with an inspection certificate 3.1B (see ISO 10474).

Designation

Rounds ISO 1035-1 - 25,0 S × 8 000 L2
Surface HW
Steel ISO 11692 - 38 MnVS 6 TU - 3.1.B

5 Requirements

5.1 Manufacturing process

5.1.1 General

The manufacturing process of the steel and the products is left to the discretion of the manufacturer, with the restrictions given in 5.1.2 to 5.1.4.

5.1.2 Deoxidation

All steels shall be fully killed.

5.1.3 Heat-treatment condition and surface condition on delivery

5.1.3.1 Heat-treatment condition

Products of steels listed in table 3 shall be delivered in the untreated condition or in the condition "treated to improve shearability". Products of steels listed in table 5 shall be delivered in the precipitation-hardened condition.

5.1.3.2 Surface condition

Unless otherwise agreed (see table 2, lines 3 to 6) at the time of enquiry and order, the products shall be delivered in the as-hot-worked condition.

5.1.4 Cast separation

The steels shall be delivered separated by casts.

5.2 Chemical composition and mechanical properties

5.2.1 Where the steels are ordered with the designations given in table 3 and the products are to be delivered in the untreated condition, the requirements for chemical composition given in tables 3 and 4 apply. In addition, for products to be delivered in the condition "treated to improve shearability", a maximum Brinell hardness of 255 applies.

NOTE 1 Guidance data for mechanical properties after precipitation hardening are given in table B.1.

5.2.2 Where the steels are ordered with the designations given in table 5, the requirements for mechanical properties given in this table apply.

NOTE 2 Guidance data for chemical composition of the steels listed in table 5 are given in table 3.

5.3 Structure

5.3.1 The steels in table 5 are control/cooled from the hot-working temperature to produce a ferritic-pearlitic structure. Under certain circumstances, small portions of bainite and/or martensite may be present.

5.3.2 For the content, of non-metallic inclusions, see A.2.

5.4 Internal soundness

The steels shall be free from internal defects likely to have an adverse effect (see A.3).

5.5 Surface quality

5.5.1 All products shall have a workmanlike finish.

5.5.2 At the time of enquiry and order, agreements may be made concerning the required surface quality.

In the case of round bars, such agreements should be made in accordance with ISO 9443.

5.5.3 Removal of surface discontinuities by welding is not permitted.

If surface discontinuities are removed by other methods, the kind of surface discontinuities and permissible depth for their removal should, where appropriate, be agreed upon at the time of enquiry and order.

5.6 Shape, dimensions and tolerances

The shape, dimensions and tolerances of the products shall comply with the requirements agreed upon at the time of enquiry and order. The agreements shall, as far as possible, be based on corresponding International Standards or, otherwise, on suitable national standards.

NOTE 3 For flat and round bars, the following International Standards cover dimensions and/or tolerances for products included in this International Standard:

ISO 1035-1, ISO 1035-3 and ISO 1035-4.

6 Inspection, testing and conformance of products

6.1 Inspection and testing procedures and types of inspection documents

6.1.1 For each delivery, the issue of any inspection document according to ISO 10474 may be agreed upon at the time of enquiry and order.

6.1.2 If, in accordance with the agreements made at the time of enquiry and order, a test report is to be provided, this shall cover:

a) the statement that the material complies with the requirements of the order;

b) the results of the cast analysis for all elements specified for the type of steel supplied. (This also applies to the grades of table 5.)

6.1.3 If, in accordance with the agreements in the order, an inspection certificate 3.1.A, 3.1.B or 3.1.C or an inspection report 3.2 (see ISO 10474) is to be provided, the specific inspections and tests described in 6.2 shall be carried out and their results shall be certified in the document.

In addition the document shall cover

a) the results of the cast analysis provided by the manufacturer for all elements specified for the steel type concerned (this also applies to the grades of table 5);

b) the results of all inspections and tests ordered by supplementary requirements (see annex A);

c) the symbol letters or numbers connecting the inspection documents, the test pieces and products to each other.

6.2 Specific inspection and testing

6.2.1 Verification of the mechanical properties

6.2.1.1 Unless otherwise agreed, only the mechanical properties according to table 5 shall be verified for steels ordered with the designation given in this table.

6.2.1.2 The amount of testing, the sampling conditions and the test methods used for the verification of the requirements shall be as given in table 6.

6.2.2 Testing of the surface quality

For round bars, the verification of the surface quality shall be in accordance with ISO 9443, unless otherwise agreed. For flat bars and for billets, the details of verification are to be agreed upon at the time of enquiry and order.

6.2.3 Visual and dimensional inspection

A sufficient number of products shall be inspected to ensure compliance with the specification.

6.2.4 Retests

For retests, ISO 404 shall apply.

7 Marking

The manufacturer shall mark the products or the bundles or boxes containing the products in a suitable way, so that the identification of the cast, the steel type and the origin of the delivery is possible (see A.5).

Table 1 — Combinations of usual heat-treatment conditions on delivery, product forms (and their application) and requirements according to tables 3 to 5

1	2		3		4
1	Heat-treatment condition on delivery		x indicates applicable for		Applicable requirements
		Symbol	billets and bars for hot forging	bars for machining	
2	Untreated	None or TU	x	—	Chemical composition according to tables 3 and 4.
3	Treated to improve shearability	TS	x	—	Chemical composition according to tables 3 and 4 and maximum Brinell hardness according to 5.2.1.
4	Precipitation hardened	TP	—	x	Mechanical properties according to table 5. The chemical composition given in table 3 is given for guidance only.

Table 2 — Surface condition on delivery

1	2	3	4	5	6
1	Surface condition on delivery		Symbol	x indicates in general applicable for bars	billets
2	Unless otherwise agreed	As hot worked	None or HW	x	x
3	Particular conditions supplied by agreement	HW[1] + pickled	PI	x	x
4		HW + blast cleaned	BC	x	x
5		HW + surface removal[2]	—	x	—
6		Others			

1) HW: hot worked.

2) The type of surface removal may be agreed upon, for example, reference to the relevant dimensional standard.

Table 3 — Types of steel and specified chemical composition (applicable to cast analysis) for billets and bars for hot forging

Type of steel designation		Chemical composition [% (*m/m*)] [1]					
Number	Name[2]	C	Si max.	Mn	P max.	S[3]	V[4]
1	19 MnVS 6	0,15 to 0,22	0,80	1,20 to 1,60	0,035	0,020 to 0,060	0,08 to 0,20
2	30 MnVS 6	0,26 to 0,33	0,80	1,20 to 1,60	0,035	0,020 to 0,060	0,08 to 0,20
3	38 MnVS 6	0,34 to 0,41	0,80	1,20 to 1,60	0,035	0,020 to 0,060	0,08 to 0,20
4	46 MnVS 6	0,42 to 0,49	0,80	1,20 to 1,60	0,035	0,020 to 0,060	0,08 to 0,20
5	46 MnVS 3	0,42 to 0,49	0,80	0,60 to 1,00	0,035	0,020 to 0,060	0,08 to 0,20

1) Elements not quoted should not be intentionally added to the steel without the agreement of the purchaser, other than for the purpose of finishing the heat. All reasonable precautions should be taken to prevent the addition, from scrap or other material used in manufacture, of elements which affect the hardenability, mechanical properties and applicability.

2) The names are in accordance with ISO/TR 4949.

3) Other elements may be added to improve machinability (or to control sulfide morphology and oxide formation), subject to agreement. The sulfur range may also be subject to agreement.

4) Some or all of the vanadium content may be replaced by niobium or titanium, subject to agreement. In this case, the lower limit of vanadium shall also be subject to agreement.

Table 4 — Permissible deviations between specified analysis (see table 3) and product analysis

Element	Permissible maximum content according to cast analysis	Permissible deviation[1]
	% (*m/m*)	% (*m/m*)
C	⩽ 0,30	± 0,02
	> 0,30 and ⩽ 0,49	± 0,03
Si	⩽ 0,80	+ 0,05
Mn	⩽ 1,00	± 0,04
	> 1,00 and ⩽ 1,60	± 0,06
P	⩽ 0,035	+ 0,005
S	⩽ 0,060	± 0,005
V	⩽ 0,20	± 0,02

1) ± means that, in one cast, the deviation may occur over the upper value or under the lower value of the specified range in table 3, but not both at the same time.

Table 5 — Types of steel and mechanical properties of bars for machining

Type of steel designation		Mechanical properties[1] [2]			
Number	Name[3]	R_e min.	R_m	A min.	Z min.
		N/mm² [4]	N/mm² [4]	%	%
11	19 MnVS 6 TP	390	600 to 750	16	32
12	30 MnVS 6 TP	450	700 to 850	14	30
13	38 MnVS 6 TP	520	800 to 950	12	25
14	46 MnVS 6 TP	580	900 to 1 050	10	20
15	46 MnVS 3 TP	450	700 to 850	14	30

1) See ISO 6892.

R_e: upper yield stress or, if no yield phenomenon occurs, the 0,2 % proof stress $R_{p0,2}$
R_m: tensile strength;
A: percentage elongation after fracture on original gauge length $L_o = 5{,}65\sqrt{S_o}$ (where S_o is the original cross-sectional area);
Z: percentage reduction of area.

2) The values apply for sizes up to 120 mm.

3) The names are in accordance with ISO/TR 4949.

4) 1 N/mm² = 1 MPa

Table 6 — Test conditions for the verification of the requirements in column 2

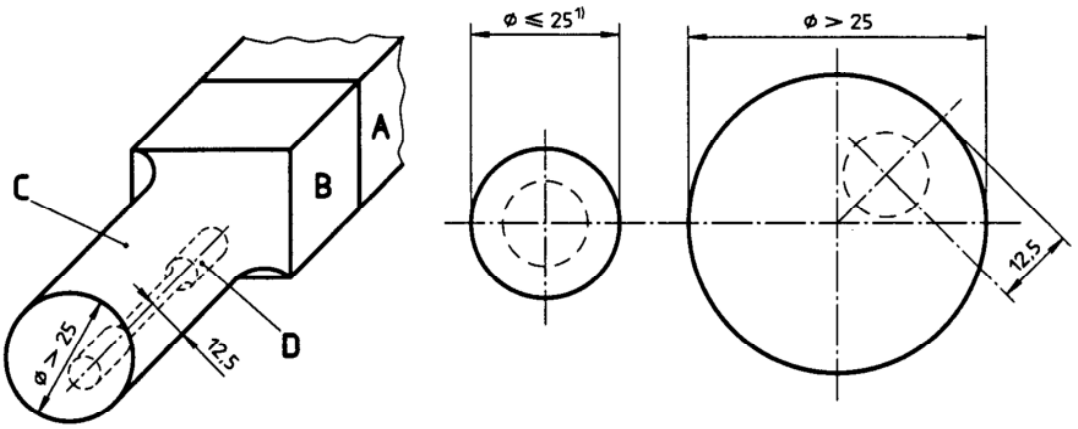
NOTE — Verification of the requirements is only necessary if an inspection certificate or an inspection report is ordered, and if the requirement is applicable according to table 1, column 4.

1	2		3	4	5	6	7
No.	**Requirements**		**Amount of testing**			**Sampling**[1]	**Test method**
		See	Test unit [2]	Number of sample products per test unit	Number of tests per sample product		
1	Chemical composition	tables 3 and 4	C	In each case, the cast analysis is provided by the manufacturer; for product analysis see A.4			According to appropriate International Standards listed in ISO/TR 9769
2	Hardness in the condition "treated to improve shearability"	5.2.1	C + D + T	1	1	In case of dispute, the hardness shall be measured, if possible, at the circumference of the product at a distance of 1 × thickness from one end and, in cases of products with square or rectangular cross-section, at a distance of 0,25 × b, where b is the width of the product, from one longitudinal edge.	According to ISO 6506
3	Mechanical properties in the precipitation hardened condition	table 5	C + D + T	1	1	The test pieces for the tensile test are to be taken in accordance with figure 1.	The tensile test shall be carried out in accordance with ISO 6892 on proportional test pieces having a gauge length of $L_o = 5{,}65\sqrt{S_o}$ where S_o is the cross-sectional area of the test piece.

1) The general conditions for selection and preparation of test samples and test pieces should be in accordance with ISO 377-1.

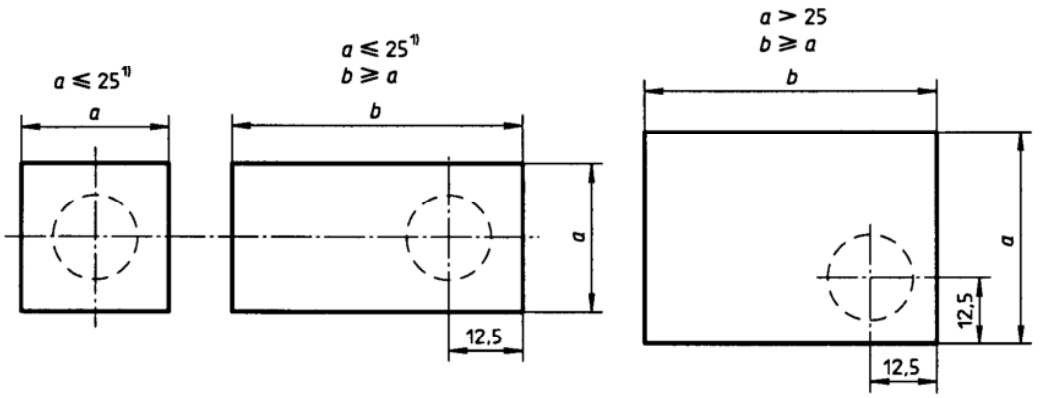
2) The tests shall be carried out separately for each cast as indicated by "C", each dimension as indicated by "D", and each heat-treatment batch as indicated by "T".

Dimensions in millimetres



A = Sample product
B = Test sample
C = Test bar (the piece after reduction to the size in which it is to be heat treated)
D = Test piece

Circular and similar shaped sections



Rectangular sections including squares

Tensile test piece

1) For small products (a or $b \leqslant 25$ mm), the test piece shall, if possible, consist of an unmachined part of the bar.

Figure 1 — Location of the test pieces in bars

Annex A
(normative)

Supplementary or special requirements

A.1 General

One or more of the following supplementary or special requirements shall be applied, but only when specified in the enquiry and order. Where necessary, details of these requirements shall be agreed upon by the manufacturer and purchaser at the time of enquiry and order.

A.2 Content of non-metallic inclusion

The content of non-metallic inclusions shall be within limits which have been agreed upon, when microscopically determined according to an agreed procedure (for example see ISO 4967:1979, *Steel — Determination of content of non-metallic inclusions — Micrographic method using standard diagrams*).

A.3 Ultrasonic tests

The products shall be ultrasonically tested under conditions, and according to an acceptance standard, agreed upon at the time of enquiry and order.

A.4 Product analysis

One product analysis shall be carried out per cast for elements for which values are specified for the cast analysis of the steel type concerned.

The conditions for sampling shall be in accordance with ISO 377-2. In the case of dispute about the analytical method, the chemical composition shall be determined in accordance with a reference method taken from one of the International Standards listed in ISO/TR 9769.

A.5 Special agreements for marking

The products shall be marked in a way specially agreed upon at the time of enquiry and order.

Annex B
(informative)

Guide to additional property values

B.1 Introduction

Property values which are contained in this International Standard are requirements of delivery unless otherwise stated (see table 1 and note 2 to 5.2.2). Property values which are only indicated in this annex are not requirements of delivery, because they are the result of processing after delivery. The data in this annex are provided only as a guide to the relative performance of the different steels enumerated in this International Standard. They are not intended for use in the purchase or design. For such purposes, the requirements shall be agreed between the supplier and his customer.

B.2 Mechanical properties

Table B.1 contains information on mechanical properties for "composition" grades after precipitation hardening.

Table B.1 — Guidance data for mechanical properties of billets and bars for hot forging after precipitation hardening

Type of steel designation	Mechanical properties[1) 2)]			
	R_e min.	R_m	A min.	Z min.
	N/mm² [3)]	N/mm² [3)]	%	%
19 MnVS 6	420	650 to 850	16	32
30 MnVS 6	470	730 to 930	14	30
38 MnVS 6	520	800 to 1 000	12	25
46 MnVS 6	570	880 to 1 080	8	20
46 MnVS 3	470	730 to 930	10	20

1) See B.1.

2) R_e: upper yield stress or, if no yield phenomenon occurs, the 0,2 % proof stress $R_{p0,2}$;

R_m: tensile strength;

A: percentage elongation after fracture on original gauge length $L_o = 5{,}65\sqrt{S_o}$ (where S_o is the original cross-area);

Z: percentage reduction of area.

3) 1 N/mm² = 1 MPa

ICS 77.140.10; 77.140.20

Descriptors: steels, alloy steels, metal bars, billets, iron and steel products, classification, specifications, mechanical properties, chemical composition, delivery condition, tests, inspection, marking.

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