

*Withdrawn**Replaced by ISO 9328-1 : 1991*

Steel products for pressure purposes — Quality requirements —

Part 7 : Carbon steel plate (thicknesses over 100 to 250 mm)

Produits en acier pour appareils à pression — Spécifications de qualité — Partie 7 : Tôles en aciers au carbone (épaisseur supérieure à 100 mm et inférieure ou égale à 250 mm)

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ISO/TR 2604/7 was prepared by Technical Committee ISO/TC 17, *Steel*.

The reasons which led to the decision to publish this document in the form of a technical report type 2 are explained in the Introduction.

0 Introduction

Plates with thicknesses of up to 250 mm are manufactured by only a few companies. Therefore, international standardization of these products seemed more appropriate than their national standardization. This was the reason why in 1969 ISO/TC 17/SC 10 agreed to prepare an International Standard for plates for pressure purposes with thicknesses of over 100 to 250 mm manufactured from carbon steels, in addition to the International Standard for plates for pressure purposes with thicknesses up to 100 mm (ISO 2604/4). The

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subject had been discussed in four meetings and by correspondence. However, the discussions proved difficult, in particular because in certain areas of the world, grades with relatively low carbon and higher manganese contents are used, while in other areas those with higher carbon and lower manganese contents are used. But in 1984, a Draft International Standard, ISO/DIS 2604/7, could be prepared. However, intensive objections were expressed on this draft by several member bodies, and therefore certain doubts were recognized as to the advisability of publishing it as an International Standard.

After the agreement of ISO/TC 17/SC 10 to extend the scope of ISO 2604/4 to plates with thickness up to 150 mm, the scope of ISO 2604/7 will be limited to plates with thickness over 150 mm, which are only manufactured by a limited number of companies in a small amount. It was also foreseen that most of the steel types, particularly the grades with specified maximum Al content of 0,010 %, would be deleted at the time of revision of ISO 2604/4.

There also existed different views on the replacement of the normalizing treatment by controlled rolling and specific inspections; especially inspection on elevated temperature properties.

Some of those members who brought forward these objections indicated, however, that they were not against publication of the document as a Technical Report of type 2. It is expected that by such a publication a larger number of manufacturers and customers of thick plates will be incited to contribute ideas and data for the amendment of the specifications for these products.

1 Scope and field of application

This part of ISO 2604, ISO/TR 2604/7, specifies the quality requirements for plates for pressure purposes of thicknesses over 100 to 250 mm manufactured from the steel types listed in table 1.

NOTE — International Standards ISO 2604/4 and 2604/8 cover quality requirements for plates for pressure purposes of thicknesses up to or under 100 mm manufactured from other types of steel than those given in table 1. It is intended to combine these International Standards into one at a later date.

2 References

ISO 83, *Steel — Charpy impact test (U-notch).*

ISO 148, *Steel — Charpy impact test (V-notch).*

ISO 377, *Selection and preparation of samples and test pieces for wrought steel.*

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

ISO 643, *Steel — Micrographic determination of the ferritic or austenitic grain size.*

ISO/R 783, *Mechanical testing of steel at elevated temperatures — Determination of lower yield stress and proof stress and proving test.*

ISO 2566/1, *Steel — Conversion of elongation values — Part 1 : Carbon and low alloy steels.*

ISO 2604/4, *Steel products for pressure purposes — Quality requirements — Part 4 : Plates.¹⁾*

ISO 2604/8, *Steel products for pressure purposes — Quality requirements — Part 8 : Plates of weldable fine grain steels with high proof stress supplied in the normalized or quenched and tempered condition (thicknesses from 3 to 70 mm).*

ISO 2605/1, *Steel products for pressure purposes — Derivation and verification of elevated temperature properties — Part 1 : Yield or proof stress of carbon and low alloy steel products.*

ISO 2605/3, *Steel products for pressure purposes — Derivation and verification of elevated temperature properties — Part 3 : An alternative procedure for deriving the elevated temperature yield and proof stress properties when data are limited.*

ISO 6892, *Metallic materials — Tensile testing.*

ISO/TR 7468, *Summary of average stress rupture properties of wrought steels for boilers and pressure vessels.*

1) At present at the stage of draft. (Revision of ISO 2604/4-1975.)

3 General requirements

3.1 Information to be supplied by the purchaser

3.1.1 The purchaser shall state on his enquiry and order the requirements given below :

- a) the plate dimensions and tolerances (see 3.7);
- b) the steel type (see table 1);
- c) the inspection procedures and type of documents (see 3.8, 3.13, 4.2 and 5.2).

3.1.2 The details for non-destructive tests (see 3.6.2, 3.10.3 and 3.11.3) shall be stated in the enquiry and order.

3.1.3 Certain alternatives are permitted by this Technical Report and the purchaser may also state on his enquiry and order his requirements as follows, but if no such statement is made, supply will be at the option of the manufacturer :

- a) if plates for hot-forming are required, the heat-treatment condition of supply (see 3.3.2 and 3.5.1.2);
- b) if a maximum copper content is required (see table 1, note 2);
- c) if a product (check) analysis is required (see 3.4.2);
- d) if additional mechanical tests are required (see 3.5.1.2);
- e) if elevated temperature proof stress tests are required and, if so, the testing temperature selected from table 3 (see 4.2.1);
- f) if the verification of the elevated temperature proof stress values of table 3 without specific tests is required and, if so, the procedure to be applied (see 4.2.1.3);
- g) if low-temperature V-notch impact tests are required and if so, the testing temperature selected from table 5 (see 5.2 and 5.2.3).

3.2 Manufacture of the steel

3.2.1 Unless otherwise stated on the enquiry and order, the steelmaking process within the provisions of 3.2.2 shall be at the option of the steel manufacturer.

3.2.2 The steel shall be produced by the open hearth, electric or one of the basic oxygen processes. Other processes may be used by agreement between the interested parties¹⁾. If he so requests, the purchaser shall be informed of the steelmaking process used.

3.2.3 All steels shall be fully killed.

3.3 Heat treatment

3.3.1 The plates shall be supplied in the normalized condition (see table 1). The application of controlled temperatures during and after rolling or forming may take the place of normalizing, provided that the specified properties are obtained.

NOTE — For thick plates, a higher cooling rate than the rate achieved by cooling in calm air may be necessary to receive a normalized structure with the mechanical properties specified in this Technical Report.

3.3.2 By agreement between the interested parties, the plates may be delivered in a condition other than the final heat-treated condition according to table 1, for example for hot-forming. Test samples shall be given a heat treatment complying with the requirements of table 1 (see 3.10.1.5) and the purchaser shall be informed of the actual heat treatment. Alternatively, see 3.5.1.2.

1) Such as the user, purchaser, and manufacturer of the equipment, the producer of the supplied construction material and the inspection and/or certifying authority.

3.4 Chemical composition

3.4.1 Ladle analysis

On ladle analysis, the steel shall show the composition given in table 1 appropriate to the steel types specified.

3.4.2 Product analysis

3.4.2.1 If a check analysis on the product is required, the permissible deviations given in table 2 shall apply to the ladle analysis specified in table 1 for samples taken from the standard position (see 3.4.2.2).

If a check analysis for acceptance purposes is required, this shall be stated on the enquiry and order.

3.4.2.2 If a check analysis on the product is required, the number of samples to be taken shall be agreed between the interested parties.

The samples shall be taken either from the test pieces used for the verification of the mechanical properties, or from drillings through the whole thickness of the plate at the same location as for the mechanical test samples. The requirements of ISO 377, covering the method of selection and preparation of the samples for chemical analysis, shall apply.

3.4.3 Cases of dispute *

In cases of dispute, the methods for chemical analysis shall be in accordance with the relevant ISO documents. If no International Standard is available, the methods to be used shall be agreed between the interested parties.

3.5 Mechanical and technological properties

3.5.1 Mechanical properties at room temperature

3.5.1.1 The mechanical properties at room temperature to be obtained on test pieces selected, prepared and tested in accordance with 3.10.1 and 3.11 are given in table 1.

3.5.1.2 If heat treatments different from, or additional to, the normal reference heat treatment are to be carried out after the delivery of the plates (which may have an adverse effect on the mechanical properties), the purchaser may require, at the time of enquiry and order, additional mechanical tests on additional samples which have been given heat treatments different from, or additional to, those in table 1. In this case, the heat treatment of the samples and the mechanical properties to be obtained on them shall be agreed between the interested parties at the time of enquiry and order.

NOTES

1 The mechanical properties can be affected by heating or reheating during fabrication. Purchasers who intend to heat or reheat any of the steels are advised to discuss the application and proposed heating or reheating treatment with the supplier.

2 If the plates are hot-formed, they shall have the same mechanical properties as specified in this Technical Report, provided that the steel has not been heated to more than 1 100 °C and that, after forming, it has been cooled to a temperature below the transformation temperature and then normalized at the specified temperature.

However, the final normalizing may be omitted provided that :

- a) the hot-forming is done in one operation at the normalizing temperature;
- b) if hot-forming is done in more than one operation, the plate is cooled to a temperature below the transformation temperature before the last operation, and this operation is then carried out at the normalizing temperature.

3.5.2 Weldability

The steels covered by this Technical Report are generally regarded as being weldable. However, the general weldability of any of the steels, but especially of the steels with relatively high carbon content or relatively high alloy content, cannot be guaranteed as the behaviour of the steel during and after welding is dependent not only on the steel, but also on the welding conditions and the final use for which the steel is employed. Therefore, where appropriate, the welding procedure shall be agreed between the interested parties at the time of enquiry and order.

3.6 Surface condition and soundness

3.6.1 The plates shall have a workmanlike finish and shall be clean and free from surface and internal defects likely to have an adverse effect.

3.6.2 The plates shall comply with the acceptance standards agreed for the ultrasonic tests (see 3.10.3 and 3.11.3).

3.6.3 The requirements for surface defects, rectification and internal defects given in ISO 404 shall apply.

3.6.4 Before delivery or submission for acceptance, the surface defects shall be removed by the supplier by grinding, provided that the final thickness complies with the minimum tolerance and that the resulting depression is properly smoothed off in relation to the remainder of the surface. If the thickness has to be reduced below the minimum accepted value, this repair shall be carried out only with the agreement of the user or his representative. Larger surface defects may, by agreement with the user or his representative, be repaired by grinding (possible by chiselling), followed by welding and levelling of the weld. This operation shall be carried out under the following conditions :

- a) The defects shall be completely eliminated before any filler metal is applied.
- b) The total surface to be repaired shall not exceed 2 % of the surface area of the face of the plate in question.
- c) The complete removal of the defects shall not reduce the thickness of the plate by more than 20 % of the nominal thickness.
- d) It shall be verified that, after the total elimination of the defect, the two above conditions are complied with. Every facility shall be given to the accepting agent (or to the representative of the user) to enable him if necessary to carry out the same verification.
- e) The repair shall be carried out by qualified welders accepted by the user or his delegate, using a low-hydrogen welding process and following a procedure suitable for the composition of the steel used for the plate and further heat treatments. This procedure shall be accepted by the user (or his representative). The welds shall be sound, without discontinuity or break. The filler metal, which shall be completely melted and joined throughout to the base metal shall finally present an excess thickness of at least 1,5 mm. This excess shall then be levelled by grinding (possibly preceded by chiselling) to give the repaired plate a technically smooth and uniform surface.
- f) An examination of the quality of the repair shall be carried out ultrasonically, magnetoscopically, by dye penetration or, where applicable, by radiography. The technique used for the examination and the qualification of the operator shall be agreed by the user or his representative.
- g) The repair of the defects shall be carried out before the final heat treatment.
- h) In cases where plates are delivered untreated, repair by means of welding shall be followed by a post-weld heat treatment.

3.6.5 The position of repairs of defects shall be carefully marked and pointed out to the user. These marks shall be mentioned in the acceptance report.

3.7 Dimensions and tolerances

3.7.1 The dimensions of the plates shall be stated on the enquiry and order.

3.7.2 Until the relevant International Standards are available, the tolerances on dimensions and mass shall be agreed between the interested parties and stated on the enquiry and order.

3.7.3 The requirements of ISO 404 shall apply.

3.8 Inspection procedures

The purchaser shall indicate on his enquiry and order which of the inspection procedures listed in ISO 404 is to be followed.

NOTE — The inspection procedure selected shall, if appropriate, be compatible with the requirements of the International Standard covering the use of the product.

In cases where specific inspection and testing is ordered, the specifications in 3.9 to 3.12 apply.

3.9 General rules for carrying out specific inspection and testing

The requirements of ISO 404 covering the following shall apply :

- a) place of inspection and testing;
- b) submission for inspection and testing;
- c) rights of the inspector.

3.10 Number, selection and preparation of samples and test pieces

3.10.1 Mechanical tests at room temperature

3.10.1.1 The requirements of ISO 377, covering the identification and preparation of samples and test pieces, shall apply.

3.10.1.2 For plates not exceeding 5 000 kg in mass and 15 m in length, one test sample sufficient for the required test pieces shall be taken from one end of each plate as rolled¹⁾ (see 3.10.1.6, 4.2 and 5.2).

3.10.1.3 For plates exceeding 5 000 kg in mass or 15 m in length, one test sample sufficient for the required test pieces (see 3.10.1.6, 4.2 and 5.2) shall be taken from each end of each plate as rolled.¹⁾

3.10.1.4 The test samples shall be selected from a position halfway between the edge and the axis of the plate.

3.10.1.5 The test samples shall be cut from the plate after this has been heat treated in accordance with 3.3.1. If the plates are to be delivered in a condition different from the heat-treatment condition given in 3.3.1, the test samples shall be subjected to a reference heat treatment complying with the requirements in table 1 (see 3.3.2). See also 3.5.1.2.

3.10.1.6 From each test sample, the following test pieces shall be prepared, with the axis of the test pieces at right angles to the direction of final rolling :

- a) One tensile test piece — this shall be a rectangular section test piece, with dimensions in accordance with the requirements of ISO 6892. The width of the parallel portion shall not exceed 40 mm.

The thickness of the test piece shall be reduced to 30 mm by planing or milling of one face only.

Alternatively, a proportional round test piece, having dimensions in accordance with the requirements of ISO 6892 and with the axis located one fourth of the thickness from the outer surface, may be used.

- b) Where room temperature impact energy values are specified (see table 1) and no verification at the low temperature impact properties (see clause 5) is required, three transverse ISO V-notch test pieces — these shall be of the dimensions specified in ISO 148 (see the note), and shall be taken such that the axis of the test piece is situated in a distance of one quarter of the plate thickness from one of the rolled surfaces. The test piece shall not be closer than 25 mm from any flame-cut or sheared edge.

The axis of the notch shall be perpendicular to the rolled surface.

NOTE — Until sufficient data of V-notch specimens are available to specify minimum KV values, U-notch test pieces with dimensions as specified in ISO 83 may be used.

3.10.2 Visual and dimensional inspection

Every plate shall be inspected visually and appropriate checks shall be made for compliance with the dimensional tolerances.

1) The term "plate as rolled" refers to the unit plate from a slab, or rolled directly from an ingot, in its relation to the location and number of specimens, not to its condition. If the plate is sheared or otherwise cut into smaller pieces after rolling, the tests made on test samples taken from the original plate shall apply unless the pieces are heat treated separately, in which case each piece heat treated shall be tested separately. (Two test samples are required if the mass of the pieces exceeds 5 000 kg.)

3.10.3 Non-destructive testing

Every plate shall be ultrasonically tested.

3.11 Test methods and test results

3.11.1 Tensile test at room temperature

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

3.11.1.2 The tensile strength R_m , the yield strength R_e and elongation A shall be determined.

For the verification of the yield strength R_e the upper yield stress R_{eH} or the 0,5 % total elongation proof stress $R_{t0,5}$ or the 0,2 % proportional elongation proof stress $R_{p0,2}$ may be determined.

However, in cases of dispute, the upper yield stress value R_{eH} or, if no yield phenomenon occurs, the proof stress $R_{p0,2}$ shall be deciding.

The percentage elongation shall be reported with reference to a $5,65 \sqrt{S_0}$ gauge length. If other gauge lengths are used, the corresponding elongation on $5,65 \sqrt{S_0}$ shall be obtained by reference to ISO 2566/1. In cases of dispute, a gauge length of $5,65 \sqrt{S_0}$ shall be used.

3.11.2 Impact test at room temperature

3.11.2.1 The V-notch impact test shall be carried out in accordance with ISO 148 and the U-notch impact test in accordance with ISO 83.

3.11.2.2 The average value obtained shall meet the requirements given in table 1. One individual value may be below the specified value, provided that it is not less than 70 % of that value.

3.11.3 Non-destructive testing

The plates shall be ultrasonically tested for internal soundness. The details of the method and the acceptance standard shall be agreed by the interested parties as long as no corresponding International Standard is available.

3.12 Retests

The requirements of ISO 404 shall apply except in the case of impact tests. In this latter case, the following procedure shall be used.

If the average of three impact values is lower than the specified value, or if any one value is lower than 70 % of this specified value, three additional test pieces shall be taken from the same sample and tested. The average value of the six tests shall be not less than the specified value. Not more than two of the individual values may be lower than the specified value and not more than one may be lower than 70 % of this value.

3.13 Documents

The purchaser shall state at the time of enquiry and order which of the documents permitted by ISO 404 are to be provided (see also 3.8).

3.14 Marking

3.14.1 The plates shall be marked legibly and, if requested, indelibly to show :

- the identification symbols for the type of steel, as given in table 1;
- the brand of the manufacturer of the plates;
- symbols, letters or numbers which relate the test certificates, test pieces and products to each other.

3.14.2 The symbols, letters or numbers shall be stamped or painted on a corner of each plate such that they read in the direction of rolling.

3.14.3 If paint is used for marking, it shall be free of lead, copper, zinc and tin.

4 Special requirements for plates in steel types having elevated temperature properties

4.1 Mechanical properties

4.1.1 Provisional minimum elevated temperature proof stress values are given in table 3.

4.1.2 Estimated average stress rupture properties are given in table 4.

4.2 Verification and testing

4.2.1 Elevated temperature proof stress

4.2.1.1 General

If so required, the elevated temperature proof stress values shall, according to the agreements at the time of enquiry and order, be verified either by specific tests (see 4.2.1.2) or without specific tests (see 4.2.1.3).

NOTE — The values given in table 3 are only provisional. International Standards now under preparation and covering the use of plates for pressure purposes will probably require, that, if it is intended to use such provisional values for design purposes under application of the normal safety factor, the compliance of the deliveries with the required provisional values is to be verified.

4.2.1.2 Verification by specific tests

When the verification by specific tests has been agreed, one test shall be made on each cast using a test sample prepared in accordance with 3.10.1 and with the test piece taken at a position adjacent to one of the test pieces used for the tensile test at room temperature. If plates of more than one thickness are to be supplied from one cast, then the test shall be made on the thickest plate.

The proof stress tests at elevated temperature shall be carried out in accordance with ISO/R 783 at a temperature selected from table 3 and agreed between the interested parties at the time of enquiry and order.

For retests, the requirements of ISO 404 shall apply.

NOTE — The results of such elevated temperature tensile tests, together with information on the product thickness, the room temperature tensile properties and the chemical composition of the material, should also be communicated to

Secretariat of ISO/TC 17/SC 18
British Standards Institution
3 York Street
Manchester M2 2AT
UNITED KINGDOM

so that at a future revision of this Technical Report enough data for the derivation of reliable minimum elevated temperature proof stress values are available.

4.2.1.3 Verification without specific tests

By the presentation of assessed data of earlier tests carried out on plates which were manufactured according to the same directives as the plates to be supplied, it shall be verified that such plates fulfil with sufficient confidence the requirements of table 3.

The details of the procedure shall be agreed between the interested parties as far as possible on the basis of the derivation and verification procedures described in ISO 2605/1 or ISO 2605/3.

4.2.2 Stress rupture properties

For steel plates supplied to this Technical Report, the average stress rupture properties at elevated temperatures given in table 4 are valid, provided that :

- a) the product has been manufactured strictly in accordance with the technical requirements of this Technical Report, to ensure that the stress rupture requirements are complied with;
- b) the producer of the steel supplies a statement to this effect.

5 Special requirements for plates in steel types having specified low-temperature properties

5.1 Mechanical properties

For the steel types which have specified low-temperature properties, the minimum longitudinal Charpy V-notch impact values are given in table 5 (see also 5.2.4).

5.2 Verification and testing

5.2.1 Tests shall only be carried out if so stated on the enquiry and order.

NOTE — International Standards covering the use of plates in the construction of pressure vessels include mandatory low-temperature test requirements.

5.2.2 If low-temperature impact tests are required, from one sample of each acceptance unit as specified in 3.10.1.2 and 3.10.1.3, three ISO V- notch test pieces shall be prepared in accordance with 3.10.1.6, except that longitudinal test pieces shall be taken.

5.2.3 The tests shall be carried out in accordance with ISO 148 at a temperature selected from table 5 and agreed between the interested parties at the time of enquiry and order.

5.2.4 The average value of the three tests shall meet the requirements given in table 5. One of the three individual values may be below the specified minimum average value of table 5, provided that it is not less than 70 % of that value.

5.2.5 For retests, the following procedure shall be used.

If the average of three impact values is lower than the specified value, or if any one value is lower than 70 % of this specified value, three additional test pieces shall be taken from the same sample and tested. The average value of the six tests shall be not less than the specified value. Not more than two of the individual values may be lower than the specified value, and not more than one may be lower than 70 % of this value.

Table 1 — Chemical composition, room temperature mechanical properties and heat treatment

Steel No. ¹⁾	Chemical composition, % (m/m) ²⁾³⁾					Mechanical properties specified for low high temperatures in table	Mechanical properties at room temperature ¹²⁾						Heat treatment			
	C	Si	Mn	P max.	S max.		Others	Thickness mm	R _e ¹¹⁾ min. N/mm ²	R _m N/mm ²	A min. %	KCU min. J	KV min. J	Refer- ence heat treat- ment ¹²⁾	Tem- perature °C	Cool- ing con- dition ¹³⁾
P7a	≤ 0,25	≤ 0,35	0,50-1,30	0,050	0,050	N < 0,009 4); Al ⁵⁾⁶⁾	3)4)	> 100 < 150	200	185	410-530	21	25	N	880-930	a
P7b	≤ 0,30	≤ 0,35	≤ 0,9	0,050	0,050	N < 0,009 4); Al ⁵⁾⁶⁾	3)4)	> 100 < 150	200	185	410-530	21	—	N	880-930	a
P9	≤ 0,22	≤ 0,35	0,60-1,40	0,040	0,040	Al _{met} > 0,015 6)7)8)	5)	> 100 < 150	220	210	410-530	21	25	N	880-930	a
P11a	≤ 0,22	≤ 0,40	0,80-1,60	0,050	0,050	N < 0,009 4); Al ⁵⁾⁶⁾	3)4)	> 100 < 250	220	204	460-580	19	20	N	880-930	a
P11b	≤ 0,31	≤ 0,40	≤ 0,9	0,050	0,050	N < 0,009 4); Al ⁵⁾⁶⁾	3)4)	> 100 < 150	220	204	460-580	19	—	N	880-920	a
P11c	≤ 0,33	≤ 0,40	≤ 0,9	0,050	0,050	N < 0,009 4); Al ⁵⁾⁶⁾	3)4)	> 150 < 250	220	204	460-580	19	—	N	880-920	a
P13	≤ 0,22	≤ 0,40	0,80-1,60	0,040	0,040	Al _{met} > 0,015 6)7)8)	5)	> 100 < 150	250	242	460-580	19	20	N	880-920	a
P16a	≤ 0,24	0,10-0,50	0,90-1,60	0,050	0,050	N < 0,009 4); Al ⁵⁾⁶⁾	3)4)	> 100 < 150	240	223	490-610	18	20	N	880-920	a
P16b	≤ 0,33	0,10-0,50	≤ 0,9	0,050	0,050	N < 0,009 4); Al ⁵⁾⁶⁾	3)4)	> 100 < 150	240	223	490-610	18	—	N	880-920	a
P16c	≤ 0,35	0,10-0,50	≤ 0,9	0,050	0,050	N < 0,009 4); Al ⁵⁾⁶⁾	3)4)	> 150 < 250	240	223	490-610	18	—	N	880-920	a
P18	≤ 0,24	0,10-0,50	0,90-1,60	0,040	0,040	Al _{met} > 0,015 6)7)8)	5)	> 100 < 250	280	268	490-610	18	20	N	880-920	a
P19	≤ 0,30	0,10-0,50	0,90-1,60	0,040	0,040	N < 0,009 4); Al ⁵⁾⁶⁾	3)4)	> 100 < 250	280	268	510-630	17	—	N	880-920	a

- 1) The designations are preliminary and will be finally fixed by ISO/TC 17/SC 2. They are identical with the designations for the corresponding steel types in ISO 2606/4.
- 2) Elements not quoted in the table shall not be intentionally added without the agreement of the purchaser, other than for the purpose of finishing the heat. All reasonable precautions shall be taken to prevent the addition of such elements from scrap or other materials used in the manufacture, but residual elements may be present provided the mechanical properties and applicability are not adversely affected.
- If the level of residual elements is important in relation to the properties or weldability of the steel, the cast (ladle) analysis for such elements shall be reported.
- If the purchaser so requires, for reasons of formability, etc., a maximum copper content of 0,25 % (m/m) may be imposed.
- 3) For permissible deviations on product (check) analysis, see table 2.
- 4) For electric furnace steel, $N \leq 0,012 \text{ \% (m/m)}$.
- 5) If the elevated temperature properties of table 4 are specified, the Al_{net} content shall be $\leq 0,010 \text{ \% (m/m)}$ (see notes 4 and 5 of table 4).
- 6) Where a maximum Al_{net} content of 0,012 % (m/m) or 0,020 % (m/m) is specified, determination of the total aluminium content, provided that it does not exceed the specified value, shall be deemed to meet this requirement. Where a minimum Al_{net} content of 0,015 % (m/m) is specified, determination of the total aluminium content shall be deemed to meet this requirement, provided that the total aluminium content value obtained is not less than 0,018 % (m/m).
- In case of dispute, the metallic aluminium content shall be determined.
- 7) Alternatively, an austenitic grain size of 6 or finer, determined in accordance with ISO 643, can be agreed.
- 8) Aluminium may be replaced by other elements having a similar effect.
- 9) Values for acceptance purposes, not for design (see note 10).
- 10) These values are included for design purposes only, and are not subject to verification.
- 11) For acceptance purposes, total elongation proof stress values may be used (see 3.11.1.2 in ISO 2604/4).

- 12) N = normalised
 R_e = yield strength (see 3.11.1.2)
 R_m = tensile strength
 A = percentage elongation after fracture on gauge length $L_o = 5,65 \sqrt{S_o}$
 KV = ISO V-notch impact energy
 KCU = ISO U-notch impact energy
- 13) a = air (see the note in 3.3.1)

Table 2 — Permissible deviations between specified analysis and product analysis

Element	Maximum of specification range	Permissible deviation from specified composition 1) 2)
	% (m/m)	% (m/m)
C	< 0,25	+ 0,03
	> 0,25 < 0,35	+ 0,04
Si	< 0,50	± 0,05
Mn	< 1,60	± 0,10
S, specified max.	< 0,050	+ 0,005
P, specified max.	< 0,050	+ 0,005

1) These values should be considered as provisional until more confident data are available.

2) The deviations, other than when maxima only are specified, apply either above or below the specified limits of the range but not both above and below for the same element from different sample products from the same cast. When maxima only are specified for the ladle analysis as given according to 3.4.1 by the manufacturer, the deviations are positive only. The values are valid only if the samples were selected according to 3.4.2.

Table 3 — Minimum 0,2 % proof stress ($R_{p0,2}$) values at elevated temperature

Steel No.	Reference heat treatment 1) 2)	Thickness mm	$R_{p0,2}$ min. ³⁾ , N/mm ²								
			Temperature, °C								
			20 ⁴⁾	50 ^{4) 5)}	100	150	200	300	350	400	450
P7a P7b	N	> 100 < 150	185	179	174	172	167	150	142	138	136
P9	N	> 100 < 150	210	206	200	190	175	141	131	125	121
P11a	N	> 100 < 250	204	199	194	191	185	176	168	162	158
P11b	N	> 100 < 150									
P11c	N	> 150 < 250									
P13	N	> 100 < 150	242	238	228	215	200	164	155	147	142
P16a	N	> 100 < 150	223	216	210	207	201	192	183	177	172
P16b	N	> 100 < 150									
P16c	N	> 150 < 250									
P18	N	> 100 < 250	268	262	250	235	217	179	169	161	156
P19	N	> 100 < 250	268	not specified ⁶⁾							

- 1) N = normalised
- 2) For temperatures and cooling conditions, see table 1.
- 3) The values are provisional and are subject to revision when more data become available.
- 4) Values at 20 and 50 °C are included for design purposes only and are not subject to verification.
- 5) Values at 50 °C have been obtained by interpolation.
- 6) This steel is because of lack of elevated temperature data for the time being considered as room temperature grade only.