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Steel products for pressure purposes — Quality requirements — Part IV : Plates

Produits en acier pour appareils à pression — Spécifications de qualité
Partie IV : Tôles

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up has the right to be represented on that Committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 2604/IV (originally ISO/DIS 2607) was drawn up by Technical Committee ISO/TC 17, *Steel,* and circulated to the Member Bodies in October 1971.

It has been approved by the Member Bodies of the following countries :

Australia	France	Romania
Austria	Germany	South Africa, Rep. of
Belgium	Hungary	Spain
Bulgaria	India	Switzerland
Canada	Japan	Thailand
Czechoslovakia	Korea, Rep. of	Turkey
Denmark	Netherlands	United Kingdom
Egypt, Arab Rep. of	New Zealand	U.S.S.R.
Finland	Portugal	

The Member Bodies of the following countries expressed disapproval of the document on technical grounds :

Norway
Sweden
U.S.A.

Printed in Switzerland

Steel products for pressure purposes — Quality requirements — Part IV : Plates

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies the quality requirements for plates of 3 to 100 mm thickness manufactured from the steel types listed in table 1, for pressure purposes.

2 REFERENCES

ISO 82, *Steel — Tensile testing.*

ISO/R 83, *Charpy impact test (U-notch) for steel.*

ISO/R 85, *Bend test for steel.*

ISO 148, *Steel — Charpy impact test (V-notch).*[1)]

ISO/R 205, *Determination of proof stress and proving test for steel at elevated temperatures.*

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

ISO/R 404, *General technical delivery requirements for steel.*

ISO/R 643, *Micrographic determination of the austenitic grain size of steels.*

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

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

ISO 2605/I, *Steel products for pressure purposes — Derivation and verification of elevated temperature properties — Part I : Yield or proof stress of carbon and low alloy steel products.*[2)]

ISO 2605/II, *Steel products for pressure purposes — Derivation and verification of elevated temperature properties — Part II : Proof stress of austenitic steel products.*[2)]

ISO/DATA No. 1, *Summary of average stress rupture properties for wrought boiler and pressure vessel steels for times of 10 000 hours to 250 000 hours and master curves.*

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 Certain alternatives are permitted by this International Standard 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 :

d) the deoxidation practice (see 3.2.3);

e) if plates for hot-forming are required, the heat-treatment condition of supply (see 3.3.2 and 3.5.1.2);

f) if a product (check) analysis is required (see 3.4.2);

g) if additional mechanical tests are required (see 3.5.1.2);

h) any special requirements for freedom from defects (see 3.6.2);

i) the number of room temperature impact tests (1 or 3) required (see 3.10.1.6);

j) the details of non-destructive tests, if required (see 3.10.3 and 3.11.4);

k) if elevated temperature proof stress tests are required and if so, the testing temperature selected from table 3 (see 4.2.1);

l) if low temperature V-notch impact tests are required and, if so, the testing temperature selected from table 5 (see 5.2.3);

m) if a maximum copper content is required (see table 1, note 1).

1) At present at the stage of draft. (Revision of ISO/R 148.)

2) At present at the stage of draft.

3.2 Manufacture of the steel

3.2.1 Unless otherwise stated on the enquiry and order, the steelmaking process and the deoxidation practice within the provisions of 3.2.2, 3.2.3 and table 1 will 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 parties[1]. If he so requests, the purchaser shall be informed of the steelmaking process used.

3.2.3 Deoxidation practice shall be as defined in table 1 for the steel type specified.

NOTE – ISO documents covering the use of plates for pressure purposes place additional limitations on deoxidation practice for certain applications. For such applications, the purchaser shall ensure that these limitations are stated on the enquiry and order.

3.3 Heat treatment

3.3.1 The plates shall be supplied in the heat-treated condition given in table 1 for the particular steel type ordered.

For the steel types P3 to P18, the application of controlled temperatures during and after rolling or forming may take the place of normalizing provided the specified properties are obtained.

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.

3.4 Chemical composition

3.4.1 *Ladle analysis*

The steel shall show on ladle analysis 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 3.2 and 3.3 of ISO/R 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 ISO document is available, the method to be used shall be agreed between the interested parties.

3.5 Mechanical and technological properties

3.5.1 *Mechanical properties*

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 International Standard provided 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 :

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 International Standard 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

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.

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 Any special requirements for freedom from defects shall be agreed between the interested parties at the time of the enquiry and order.

3.6.3 The requirements for surface defects, rectification and internal defects given in 8.1, 8.2 and 8.3 of ISO/R 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 (possibly 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 covered electrodes and following a procedure suitable for the composition of the steel used for the plate and further heat treatments. His 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) For plate which has to be delivered in a heat-treated condition, the repair of the defects shall be carried out before the final test 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 ISO documents 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 8.4 of ISO/R 404 shall apply.

3.8 Inspection procedures

The purchaser shall indicate on his enquiry and order which of the five inspection procedures listed in clause 4 of ISO/R 404 is to be followed.

NOTE – The inspection procedure selected shall, if appropriate, be compatible with the requirements of the ISO document covering the use of the product.

3.9 General rules for carrying out acceptance tests

The requirements of clause 5 of ISO/R 404 covering the following shall apply :

a) place of acceptance;

b) submission for inspection;

c) rights of the inspector;

d) acceptance.

3.10 Number, selection and preparation of samples and testpieces

3.10.1 *Mechanical tests at room temperature*

3.10.1.1 The requirements of 2.3 and 2.4 of ISO/R 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 rolled[1] (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 the final heat treatment. If the plates are to be delivered in a condition different from the specified final heat-treatment condition, the test samples shall be in the reference heat-treatment condition required by table 1

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 82. The width of the parallel portion shall not exceed 40 mm. The thickness shall be that of the plate, except that for plates over 30 mm thick, the thickness of the test piece may be reduced to 30 mm by planing or milling of one face only.

Alternatively, for plates over 30 mm thick, and by agreement between the interested parties, a proportional round test piece, having dimensions in accordance with the requirements of ISO 82 and with the axis located one-sixth of the thickness from the outer surface, may be used.

b) One bend test piece – this shall be of the dimensions specified in 4.1 and 4.2.2 of ISO/R 85, except that the test piece shall be of the full thickness of the plate for plates up to 30 mm thick. For plates over 30 mm thick, the thickness of the test piece may be reduced to 30 mm by machining on one face only.

c) One or, if specified on the order, three transverse ISO V-notch test pieces – these shall be of the dimensions specified in ISO 148 and shall be taken from a position close to one of the rolled surfaces. For plates thicker than 40 mm the axis of the test piece shall be one-quarter of the 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.

For plates with a thickness between 5 and 10 mm, the impact test pieces shall be reduced to test pieces of a width equal to the thickness of the plate. The impact strength values to be obtained, increased in proportion to the difference in cross-sectional area between the test piece used and a normal test piece, are the same as for normal test pieces.

NOTE – Until 31st December 1975, U-notch test pieces with dimensions as specified in ISO/R 83 may be used instead of V-notch specimens.

3.10.2 *Visual inspection*

Every plate shall be inspected.

3.10.3 *Non-destructive testing*

If non-destructive testing is required by the order, every plate shall be tested unless otherwise agreed between the interested parties.

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 82.

3.11.1.2 The tensile strength R_m, the lower yield stress R_{eL} or proof stress R_p, and elongation A shall be determined. The results obtained shall meet the requirements given in table 1.

For acceptance purposes, the proof stress (total elongation) R_t may be determined. The 0,5 % proof stress (total elongation) $R_{t0,5}$ shall be used for ferritic steels having a specified lower yield stress R_{eL} or 0,2 % proof stress (non-proportional elongation) $R_{p0,2}$. The 1,0 % proof stress (total elongation) $R_{t1,0}$ should be used for austenitic steels having a specified 1,0 % proof stress (non-proportional elongation). However, in cases of dispute, the lower yield stress R_{eL}, or proof stress (non-proportional elongation) $R_{p0,2}$ ($R_{p1,0}$ for austenitic steels), shall be determined.

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

3.11.2 *Bend test*

3.11.2.1 The bend test shall be carried out in accordance with ISO/R 85.

The test piece shall be bent through 180° to an internal diameter not exceeding that given in table 1.

If the test piece is reduced in thickness by machining (see 3.10.1.6), the remaining original rolled surface shall be placed in tension.

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 govern.

3.11.2.2 The outer surface of the bent test piece shall not show any cracks or splits.

3.11.3 *Impact test at room temperature*

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

3.11.3.2 If one test piece is used, the value obtained shall meet the requirements given in table 1.

3.11.3.3 If three test pieces are used, 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.

3.11.4 *Non-destructive testing*

If non-destructive tests for internal soundness, by methods such as radiography, ultrasonics, magnetic particle detection, or dye penetrants, are required by the purchaser, this shall be the subject of agreement at the time of the enquiry and order. Any such agreement shall include details of the test procedure.

3.12 Retests

The requirements of 6.5 and 7.6 of ISO/R 404 shall apply except in the case of impact tests, where the average of the results on three test pieces is taken. 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 the enquiry and order which of the documents permitted by clause 4 of ISO/R 404 are to be provided (see also 3.8).

3.14 Marking

3.14.1 The plates shall be legibly marked to show :

a) the identification symbols for the type of steel, as given in table 1;

b) the brand of the manufacturer of the plates;

c) symbols, letters or numbers which relate the test certificates, test pieces and products to each other.

3.14.2 Unless the provisions of 3.14.4 are valid, 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.

3.14.4 On plates which are bundled or boxed, the information in 3.14.1 may be marked on the box, or on a tag securely attached to the bundle or box in which they are shipped.

4 SPECIAL REQUIREMENTS FOR PLATES IN STEEL TYPES HAVING SPECIFIED ELEVATED TEMPERATURE PROPERTIES

4.1 Mechanical properties

4.1.1 For the steel types which have specified elevated temperature properties, the minimum elevated temperature proof stress values, derived in accordance with clause 2 of ISO 2605/I (in the case of austenitic steels, ISO 2605/II) are given in table 3.

4.1.2 For the same steel types, 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 The elevated temperature proof stress values shall be verified either by elevated temperature acceptance testing or by the procedure given in clause 3 of ISO 2605/I or, in the case of austenitic steels ISO 2605/II.

4.2.1.2 VERIFICATION BY ACCEPTANCE TESTS

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 205 or 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 6.5 of ISO/R 404 shall apply.

4.2.1.3 VERIFICATION WITHOUT ACCEPTANCE TESTS

The elevated temperature proof stress values shall be verified by the procedure given in clause 3 of ISO 2605/I or, in the case of austenitic steels, ISO 2605/II. The 95 % lower confidence limits of the elevated temperature proof stress values which are necessary for the application of that procedure are given in figures 1 to 14 for the various steel types.

4.2.2 *Stress rupture properties*

For steel plates supplied to this International Standard, 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 International Standard, to ensure that the stress rupture requirements are complied with;

b) the producer of the steel supplies a statement to this effect, which shall be agreed by the interested parties.

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, and if the thickness of the plate is greater than or equal to 5 mm.

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 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, mechanical properties at room temperature and heat treatments

Steel No.	Chemical composition %[1,2]									Mechanical properties specified for		Mechanical properties at room temperature[11]								Heat treatment				
	C	Si	Mn	P max.	S max.	Cr	Mo	Ni	Others[7]	low temperature in table	high temperature in table	Thickness mm	R_{eL} or $R_{p0,2}$[14] min.[18] N/mm²	$R_{p1,0}$[14] min. N/mm²	R_m N/mm²	A min. %	KCU min. J	KV min. J	Bend test D max.	Reference[12] heat treatment	Austenitizing or solution temperature °C	Cooling condition[17]	Tempering temperature °C	Cooling condition[17]
P3R[3]	⩽ 0,17	–	0,40 – 1,00	0,050	0,050	–	–	–	N ⩽ 0,009		–	> 3 ⩽ 16	205		360 – 480	26	30		1*a*	N	900 – 940	a	–	–
P3[3]	⩽ 0,17	⩽ 0,35	0,40 – 1,00[5]	0,050	0,050				N⩽ 0,009[4] Al[16]	–	3, 4	> 3 ⩽ 16 > 16 ⩽ 40 > 40 ⩽ 63 > 63 ⩽ 100	205 195 185 175	– – –	360 – 480	26 26 25 24	30		1*a*	N	900 – 940	a		
P5	⩽ 0,17	⩽ 0,35	0,40 – 1,00[5]	0,040	0,040	–	–	–	Al_{met} ⩾ 0,015[6,7,8]	5	3, 4	> 3 ⩽ 16 > 16 ⩽ 40 > 40 ⩽ 63 > 63 ⩽ 100	235 215 195 Note[13]	– – –	360 – 480	26 26 25 24	30		1*a*	N	900 – 940	a	–	–
P7[3]	⩽ 0,20	⩽ 0,35	0,50 – 1,30	0,050	0,050	–	–	–	N ⩽ 0,009[4] Al[16]	–	3, 4	> 3 ⩽ 16 > 16 ⩽ 40 > 40 ⩽ 63 > 63 ⩽ 100	235 225 215 205	– – –	410 – 530	24 24 23 22	25		2*a*	N	890 – 930	a	–	–
P9	⩽ 0,20	⩽ 0,35	0,50 – 1,30	0,040	0,040	–	–	–	Al_{met} ⩾ 0,015[6,7,8]	5	3, 4	> 3 ⩽ 16 > 16 ⩽ 40 > 40 ⩽ 63 > 63 ⩽ 100	265 245 235 Note[13]	– – – –	410 – 530	24 24 23 22	25		2*a*	N	890 – 930	a	–	–
P11	⩽ 0,20	⩽ 0,40	0,60 – 1,40[10]	0,050	0,050	–	–	–	N ⩽ 0,009[4] Al[16]	–	3, 4	> 3 ⩽ 16 > 16 ⩽ 40 > 40 ⩽ 63 > 63 ⩽ 100	285 255 245 235	– – – –	460 – 580	22 22 21 20	20		2,5*a*	N	880 – 920	a	–	–
P13	⩽ 0,20[9]	⩽ 0,40	0,60 – 1,40[10]	0,040	0,040		–		Al_{met} ⩾ 0,015[6,7,8]	–	3, 4	> 3 ⩽ 16 > 16 ⩽ 40 > 40 ⩽ 63 > 63 ⩽ 100	295 285 275 Note[13]	– – – –	460 – 580	22 22 21 20	20	VALUES UNDER CONSIDERATION	2,5*a*	N	880 – 920	a	–	–
P15	⩽ 0,20[9]	⩽ 0,40	0,60 – 1,50	0,040	0,040	–	–	–	Al_{met} ⩾ 0,015[6,7,8]	5		> 3 ⩽ 16 > 16 ⩽ 40 > 40 ⩽ 63 > 63 ⩽ 100	295 285 275 Note[13]	– – – –	460 – 580	22 22 21 20	20		2,5*a*	N	880 – 920	a	–	–
P16	⩽ 0,20[9]	0,10 – 0,50	0,90 – 1,60	0,050	0,050	–	–	–	N ⩽ 0,009[4] Al[16]	–	3, 4	> 3 ⩽ 16 > 16 ⩽ 40 > 40 ⩽ 63 > 63 ⩽ 100	305 275 265 255	– – –	490 – 610	21 21 20 19	20		3*a*	N	880 – 920	a	–	–
P18	⩽ 0,20[9]	0,10 – 0,50	0,90 – 1,60	0,040	0,040	–	–		Al_{met} ⩾ 0,015[6,7,8]	5	3, 4	> 3 ⩽ 16 > 16 ⩽ 40 > 40 ⩽ 63 > 63 ⩽ 100	315 315 305 Note[13]	– – –	490 – 610	21 21 20 19	20		3*a*	N	880 – 920	a	–	–
P26	0,12 – 0,20	0,15 – 0,35	0,50 – 0,80	0,030	0,040	⩽ 0,30	0,25 – 0,35	–	Al_{met} ⩽ 0,012[7]	–	3, 4	> 3 ⩽ 16 > 16 ⩽ 40 > 40 ⩽ 63 > 63 ⩽ 100	260 250 250 Note[13]	– – –	440 – 590	24 24 23 22	30		3*a*	N (+ T)	900 – 940	a	(600 – 650)	(a)
P28	0,12 – 0,20	0,15 – 0,35	0,50 – 0,80	0,035	0,035	⩽ 0,30	0,40 – 0,60	–	Al_{met} ⩽ 0,012[7]	–	3, 4	> 3 ⩽ 16 > 16 ⩽ 40 > 40 ⩽ 63 > 63 ⩽ 100	285 275 275 Note[13]	– – –	450 – 600	23 23 22 21	30		3*a*	N (+ T)	900 – 940	a	(600 – 650)	(a)
P30	0,12 – 0,20	0,15 – 0,35	0,90 – 1,40	0,040	0,040	⩽ 0,30	0,40 – 0,60	–	Al_{met} ⩽ 0,012[7]	–	3, 4	> 3 ⩽ 16 > 16 ⩽ 40 > 40 ⩽ 63 > 63 ⩽ 100	355 345 345 Note[13]	– – –	510 – 660	21 21 20 19	30		3*a*	N (+ T)	880 – 930	a	(600 – 720)	(a)
P32	0,10 – 0,18	0,15 – 0,35	0,40 – 0,80	0,040	0,040	0,70 – 1,30	0,40 – 0,60	–	Al_{met} ⩽ 0,020[7]	–	3, 4	> 3 ⩽ 16 > 16 ⩽ 40 > 40 ⩽ 63 > 63 ⩽ 100	305 305 305 Note[13]	– – –	470 – 620	20 20 19 18	30		3*a*	N + T	900 – 950	a	630 – 700	a
P33	0,08 – 0,18	0,15 – 0,35	0,40 – 0,70	0,040	0,040	0,30 – 0,60	0,50 – 0,70		V = 0,22 – 0,35 Al_{met} ⩽ 0,020[7]	–	3, 4	> 3 ⩽ 16 > 16 ⩽ 40 > 40 ⩽ 63 > 63 ⩽ 100	285 285 285 Note[13]	– – –	460 – 610	19 19 19 19	30 30 30 25		3,5*a*	N + T	930 – 980	a	670 – 720	a
P34	0,08 – 0,18	0,15 – 0,50	0,40 – 0,80	0,040	0,040	2,00 – 2,50	0,90 – 1,10	–	Al_{met} ⩽ 0,020[7]	–	3, 4	> 3 ⩽ 16 > 16 ⩽ 40 > 40 ⩽ 63 > 63 ⩽ 100	275 265 265 Note[13]	– – –	480 – 630	18 18 17 16	30 30 30 25		3*a*	N + T	900 – 950	a	650 – 720	a

TABLE 1 (*concluded*)

Steel No.	Chemical composition %[1,2]								Mechanical properties specified for		Mechanical properties at room temperature[11]								Heat treatment				
	C	Si	Mn	P max.	S max.	Cr	Mo	Ni	Others[7]	low / high temperature in table		Thickness	R_{eL} or $R_{p0,2}$[14] min.[18]	$R_{p1,0}$[14] min.	R_m	A min.	KCU min.	KV min.	Bend test D max.	Reference[12] heat treatment	Austenitizing or solution temperature	Cooling condition [17]	Tempering temperature	Cooling condition [17]
												mm	N/mm²	N/mm²	N/mm²	%	J	J			°C		°C	
P41	≤ 0,18	0,15 – 0,35	≤ 0,80	0,035	0,035	–	–	1,30 – 1,70	–	5	–	≥ 3 ≤ 30 > 30 ≤ 50	275 265	– –	490 – 640	22 21	25		2a	N N + T Q + T	850 – 880 850 – 880 850 – 880	a a o or w	– 600 – 690 600 – 690	– a or w a or w
P42	≤ 0,18	0,15 – 0,35	≤ 1,50	0 035	0,035	–	–	1,30 – 1,70	–	5	–	≥ 3 ≤ 30 > 30 ≤ 50	345 335	– –	490 – 640	22 21	25		2a	N	850 – 880	a	–	–
P43	≤ 0,15	0,15 – 0,35	≤ 0,80	0,035	0,035	–	–	3,25 – 3,75	–	5	–	≥ 3 ≤ 30 > 30 ≤ 50	275 265	– –	450 – 600	23 22	25		2a	N N + T	820 – 850 820 – 850	a a	– 580 – 630	– a or w
P44	≤ 0,18	0,15 – 0,35	≤ 0,80	0,035	0,035	–	–	3,25 – 3,75	–	5	–	≥ 3 ≤ 30 > 30 ≤ 50	345 335	– –	460 – 610	22 21	30		2a	N + T Q + T	810 – 840 810 – 840	a o or w	580 – 630 580 – 630	a or w a or w
P45	≤ 0,10	0,15 – 0,35	≤ 0,80	0,035	0,035	–	–	8,50 – 10,0	–	5	–	> 3 ≤ 30 > 30 ≤ 50	495 485	– –	690 – 840	19 18	30		3a	N + N + T Q + T	770 – 800[15] 770 – 800	a o or w	540 – 580 540 – 560	a or w a or w
P46	≤ 0,03	≤ 1,00	≤ 2,00	0,045	0 030	17,0 – 19,0	–	9,0 – 12,0	–	–	–	≥ 3 ≤ 30 > 30 ≤ 50	175 175	205 205	440 – 640	50 45	40		–	Q	1 000 – 1 050		–	–
P47	≤ 0,07	≤ 1,00	≤ 2,00	0,045	0,030	17,0 – 19,0	–	8,0 – 11,0	–	–	–	≥ 3 ≤ 30 > 30 ≤ 50	195 195	235 235	490 – 690	50 45	40		–	Q	1 000 – 1 050		–	–
P48	0,03 – 0,07	≤ 1,00	≤ 2,00	0,045	0,030	17,0 – 19,0	–	8,0 – 11,0	–	–	3, 4	≥ 3 ≤ 40 > 40 ≤ 63	195 195	235 235	490 – 690	50 45	40		–	Q	1 000 – 1 050		–	–
P49	≤ 0,07	≤ 1,00	≤ 2,00	0,045	0,030	17,0 – 19,0	≤ 0,50	9,0 – 11,5	–	5	–	≥ 3 ≤ 16	185	225	490 – 690	45	40		–	Q	1 050 – 1 100		–	–
P50	≤ 0,08	≤ 1,00	≤ 2,00	0,045	0,030	17,0 – 19,0	–	9,0 – 12,0	Nb ≥ 10 % C ≤ 1,0	–	–	≥ 3 ≤ 40 > 40 ≤ 63	205 205	245 245	490 – 690	40 35	35		–	Q	1 020 – 1 070		–	–
P52	≤ 0,10	≤ 1,00	≤ 2,00	0,045	0,030	17,0 – 19,0	≤ 0,50	10,0 – 12,0	Nb ≥ 8 % C ≤ 1,0	5	–	≥ 3 ≤ 16	205	245	490 – 690	35	35		–	Q	1 020 – 1 070		–	–
P53	≤ 0,08	≤ 1,00	≤ 2,00	0,045	0,030	17,0 – 19,0	–	9,0 – 12,0	Ti ≥ 5 % C ≤ 0,80	–	–	≥ 3 ≤ 40 > 40 ≤ 63	195 195	235 235	490 – 690	40 35	35		–	Q	1 020 – 1 070		–	–
P55	≤ 0,10	≤ 1,00	≤ 2,00	0,045	0 030	17,0 – 19,0	≤ 0,50	10,0 – 12,0	Ti ≥ 5 % C ≤ 0,80	5	–	≥ 3 ≤ 16	195	235	490 – 690	35	35		–	Q	1 020 – 1 070		–	–
P56	0,04 – 0,10	0,30 – 0,60	≤ 1,50	0,045	0,030	15,0 – 17,0	–	12,0 – 14,0	Nb ≥ 10 % C ≤ 1,20	–	3, 4	≥ 3 ≤ 40 > 40 ≤ 63	205 205	245 245	490 – 690	35 30	35		–	Q	1 050 – 1 100		–	–
P57	≤ 0,03	≤ 1,00	≤ 2,00	0,045	0,030	16,0 – 18,5	2,0 – 2,5	11,0 – 14,0	–	–	–	≥ 3 ≤ 40 > 40 ≤ 63	185 185	215 215	440 – 640	45 40	40		–	Q	1 050 – 1 100		–	–
P58	≤ 0,03	≤ 1,00	≤ 2,00	0,045	0,030	16,0 – 18,5	2,5 – 3,0	11,5 – 14,5	–	–	–	≥ 3 ≤ 40 > 40 ≤ 63	185 185	215 215	440 – 640	45 40	40		–	Q	1 050 – 1 100		–	–
P60	≤ 0,07	≤ 1,00	≤ 2,00	0,045	0 030	16,0 – 18,5	2,0 – 2,5	10,5 – 14,0	–	–	–	≥ 3 ≤ 40 > 40 ≤ 63	205 205	245 245	490 – 690	45 40	40		–	Q	1 050 – 1 100		–	–
P61	≤ 0,07	≤ 1,00	≤ 2,00	0,045	0 030	16,0 – 18,5	2,5 – 3,0	11,0 – 14,5	–	–	–	≥ 3 ≤ 40 > 40 ≤ 63	205 205	245 245	490 – 690	45 40	40		–	Q	1 050 – 1 100		–	–
P63	0,03 – 0,07	≤ 1,00	≤ 2,00	0,045	0,030	16,0 – 18,5	2,0 – 2,5	10,5 – 14,0	–	–	3, 4	≥ 3 ≤ 40 > 40 ≤ 63	205 205	245 245	490 – 690	40 35	40		–	Q	1 020 – 1 070		–	–
P67	0,04 – 0,10	0,20 – 0,60	≤ 1,50	0,045	0,030	15,5 – 17,5	1,6 – 2,0	15,5 – 17,5	Nb ≥ 10 % C ≤ 1,20	–	3, 4	≥ 3 ≤ 40 > 40 ≤ 63	215 215	255 255	530 – 730	35 30	35		–	Q	1 050 – 1 100		–	–
P69	≤ 0,12	≤ 1,00	≤ 2,00	0,045	0 030	19,0 – 23,0	–	30,0 – 35,0	Al = 0,15 – 0,60 Ti = 0,15 – 0,50	–	3, 4	≥ 3 ≤ 40 > 40 ≤ 63	165 165	205 205	430 – 680	25 20	35		–	Q	1 050 – 1 150		–	–

VALUES UNDER CONSIDERATION

o, w, or rapidly in a

NOTES TO TABLE 1

1) 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 Cu content of 0,25 % may be imposed.

2) For permissible deviations on product (check) analysis, see table 2.

3) Steel P3R shall be rimmed, steels P3, P7 and P11 semi-killed or fully killed. All other steels shall be fully killed. See also note in 3.2.3.

4) For electric furnace steel, N ⩽ 0,012 %.

5) For steels P3 and P5, in thicknesses exceeding 40 mm, Mn = 0,40 to 1,20 %.

6) By agreement between the interested parties, aluminium may be replaced by other elements having a similar effect.

7) Where a maximum Al_{met} of 0,010 %, 0,012 % or 0,020 % 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_{met} of 0,015 % is specified, determination of the total aluminium content shall be deemed to meet this requirement, provided the total aluminium content value obtained is not less than 0,018 %.

In cases of dispute, the metallic aluminium content shall be determined.

8) Alternatively, an austenitic grain size of 6 or finer, determined in accordance with ISO/R 643, can be agreed.

9) For thicknesses > 30 mm but ⩽ 100 mm, C = 0,22 % max.

10) If the elevated temperature properties of table 4 are specified, the manganese content shall be 0,80 to 1,40 %.

11) R_{eL} = lower yield stress

$R_{p0,2}$ = 0,2 % proof stress (non-proportional elongation)

$R_{p1,0}$ = 1,0 % proof stress (non-proportional elongation)

R_m = tensile strength

A = percentage elongation after fracture on gauge length, $L_o = 5{,}65\sqrt{S_o}$

KCU = ISO U-notch impact strength

KV = ISO V-notch impact strength

D = maximum diameter of mandrel

a = thickness of test piece.

12) N = normalized, Q = quenched, T = tempered.

13) For thickness > 63 mm but ⩽ 100 mm, the values specified for the thickness range > 40 mm but ⩽ 63 mm are lowered by 1 % for each 5 mm of thickness over 63 mm.

14) For acceptance purposes, total elongation proof stress may be used (see 3.11.1.2).

15) Before this treatment, the material should be normalized as follows : 800 to 920 °C, air cooled.

16) If the elevated temperature properties of table 4 are specified, the Al_{met} content shall be ⩽ 0,010 %.

17) a = air, o = oil, w = water.

18) For design purposes, the values given in table 3 apply.

TABLE 2a) — **Permitted deviation from the specified composition for carbon and carbon-manganese steels**

Element	Maximum of specification range	Permissible deviation[1,2] from the specified composition
Carbon	⩽ 0,25	± 0,03
Silicon	⩽ 0,50	± 0,05
Manganese	⩽ 2,0	± 0,10
Sulphur specified max.	⩽ 0,050	+ 0,005
Phosphorus specified max.	⩽ 0,050	+ 0,005

TABLE 2b) — **Permitted deviation from the specified composition for low and medium alloy steels excluding manganese steels**

Element	Maximum of specification range	Permissible deviation[1,2] from the specified composition
Carbon	⩽ 0,25	± 0,03
Silicon	⩽ 0,50	± 0,05
Manganese	⩽ 2,0	± 0,10
Sulphur and Phosphorus specified max.	⩽ 0,050	+ 0,005
Nickel	⩽ 5,0 > 5,0 – 10,0	± 0,07 ± 0,10
Chromium	⩽ 2,5	± 0,10
Molybdenum	⩽ 0,35 > 0,35 – 1,5	± 0,04 ± 0,05
Vanadium	⩽ 0,35	± 0,03

TABLE 2c) — **Permitted deviation from the specified composition for high alloy and austenitic steels**

Element	Maximum of specification range	Permissible deviation[1,2] from the specified composition
Carbon	⩽ 0,03 > 0,03 – 0,25	± 0,005 ± 0,01
Manganese	⩽ 0,40 – 0,70 > 0,70 – 1,0 > 1,0 – 2,0	± 0,03 ± 0,04 ± 0,05
Silicon	⩽ 1,0	± 0,05
Sulphur and Phosphorus specified max.	⩽ 0,030 > 0,030 – 0,040 > 0,040 – 0,050	+ 0,003 + 0,004 + 0,005
Nickel	⩽ 1,0 > 1,0 – 2,0 > 2,0 – 5,0 > 5,0 – 10,0 > 10,0 – 20,0 > 20,0	± 0,03 ± 0,05 ± 0,07 ± 0,10 ± 0,15 ± 0,20
Chromium	⩽ 10,0 > 10,0 – 15,0 > 15,0 – 20,0 > 20,0	± 0,10 ± 0,15 ± 0,20 ± 0,20
Molybdenum	⩽ 1,0 > 1,0 – 2,0 > 2,0 – 3,0 > 3,0	± 0,04 ± 0,05 ± 0,08 ± 0,10
Titanium and Niobium	All ranges	± 0,05
Vanadium	⩽ 0,35	± 0,03

1) 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 the deviations are positive only. The values are valid only if the samples were selected according to 3.4.2.2.

2) These values apply only to fully killed and semi-killed steels and shall be considered as provisional until more confident data are available.

TABLE 3 – **Minimum lower yield stress (R_{eL}) or 0,2 % proof stress ($R_{p0,2}$) values at elevated temperature**

Steel No.	Reference heat treatment 1,2)	Thickness mm	R_{eL} min. or $R_{p0,2}$ min.3), N/mm²														
			Temperature, °C														
			20[5]	50[5,6]	100	150	200	250	300	350	400	450	500	550	600	650	700
P3	N	< 16	192	183	175	172	168	150	124	117	115	113	–	–	–	–	–
		> 16 ⩽ 40	176	173	171	169	162	144	124	117	115	113	–	–	–	–	–
		> 40 ⩽ 63	170	166	162	158	152	141	124	117	115	113	–	–	–	–	–
		> 63 ⩽ 100	160	155	150	148	144	136	124	117	115	113	–	–	–	–	–
P5	N	< 16	220	214	204	185	165	145	127	116	110	106	–	–	–	–	–
		> 16 ⩽ 40	202	200	196	183	164	145	127	116	110	106	–	–	–	–	–
		> 40 ⩽ 63	184	183	179	172	159	145	127	116	110	106	–	–	–	–	–
		> 63 ⩽ 100[7]															
P7	N	< 16	232	220	211	208	201	180	150	142	138	136	–	–	–	–	–
		> 16 ⩽ 40	209	204	201	198	191	171	150	142	138	136	–	–	–	–	–
		> 40 ⩽ 63	201	196	192	188	181	168	150	142	138	136	–	–	–	–	–
		> 63 ⩽ 100	189	183	178	175	170	162	150	142	138	136	–	–	–	–	–
P9	N	< 16	252	248	235	216	194	171	152	141	134	130	–	–	–	–	–
		> 16 ⩽ 40	239	235	228	213	192	171	152	141	134	130	–	–	–	–	–
		> 40 ⩽ 63	226	222	215	204	188	171	152	141	134	130	–	–	–	–	–
		> 63 ⩽ 100[7]															
P11	N	< 16	272	260	248	243	235	210	176	168	162	158	–	–	–	–	–
		> 16 ⩽ 40	241	235	230	227	220	198	176	168	162	158	–	–	–	–	–
		> 40 ⩽ 63	232	227	222	218	210	194	176	168	162	158	–	–	–	–	–
		> 63 ⩽ 100	218	212	206	203	197	188	176	168	162	158	–	–	–	–	–
P13	N	< 16	284	276	266	247	223	198	177	167	158	153	–	–	–	–	–
		> 16 ⩽ 40	277	271	260	242	220	198	177	167	158	153	–	–	–	–	–
		> 40 ⩽ 63	268	262	251	236	217	198	177	167	158	153	–	–	–	–	–
		> 63 ⩽ 100[7]															
P16	N	< 16	295	280	270	264	255	228	192	183	177	172	–	–	–	–	–
		> 16 ⩽ 40	261	255	248	245	237	214	192	183	177	172	–	–	–	–	–
		> 40 ⩽ 63	251	245	240	236	227	210	192	183	177	172	–	–	–	–	–
		> 63 ⩽ 100	236	229	222	219	212	203	192	183	177	172	–	–	–	–	–
P18	N	< 16	304	297	284	265	240	213	192	182	173	168	–	–	–	–	–
		> 16 ⩽ 40	300	293	279	260	237	213	192	182	173	168	–	–	–	–	–
		> 40 ⩽ 63	293	286	272	256	234	213	192	182	173	168	–	–	–	–	–
		> 63 ⩽ 100[7]															
P26	N + T		241	239	237	232	218	200	167	153	148	143	139	–	–	–	–
P28[4]	N + T																
P30[4]	N + T																
P32	N + T		298	284	270	259	248	237	216	203	199	194	188	181	174	–	–
P33	N + T		270	266	259	248	235	218	192	184	177	168	155	148	135	–	–
P34	N + T		259	255	249	241	233	224	219	212	207	194	180	160	137	–	–
P48	Q		195		132	120	109	100	93	87	84	81	79	78	76	–	–
P56	Q		205		171	162	153	147	139	133	129	125	123	122	120	–	–
P63	Q		205		155	144	132	121	113	107	101	98	95	92	90	89	88
P67[4]	Q		215														
P69[4]	Q		165														

1) N = normalized, Q = quenched, T = tempered.

2) For temperatures and cooling conditions, see table 1.

3) If a yield phenomenon is pronounced, R_{eL} is valid. If a yield phenomenon is not pronounced, $R_{p0,2}$ is valid.

4) Until values for lower yield stress and proof stress, derived in accordance with clause 2 of ISO 2605/I or, in the case of austenitic steels, ISO 2605/II, are available for these steels, the values shall be agreed between the interested parties at the time of enquiry and order.

5) Values at 20 °C and 50 °C are included for design purposes only, and are not subject to verification.

6) Values at 50 °C have been obtained by interpolation.

7) For thicknesses > 63 mm but < 100 mm, the values specified for thickness range > 40 mm but < 63 mm are lowered by 1 % for each 5 mm of thickness over 63 mm.

GENERAL NOTE – Values are subject to revision when more data become available.

TABLE 4 — **Stress rupture properties at elevated temperature**

Steel No.	Reference heat treatment 1,2)	Rupture time h	Estimated average stresses for rupture[3], N/mm²												
			Temperature, °C												
			380	390	400	410	420	430	440	450	460	470	480	490	500
P3[6]	N	10 000	285	263	240	218	196	176	155	135	117	101	86	75	64
		30 000	251	228	205	181	160	139	120	103	88	76	64	53	(44)
		50 000	234	211	188	165	143	124	105	89	76	65	54	(45)	(36)
		100 000	211*	186*	164*	141*	122*	103	88	75	63	51	(42)*	–	–
		150 000	196*	173*	150*	127*	108*	91•	78*	66•	54•	(44)*	(36)•	–	–
		200 000	185*	163*	139*	118*	99*	85*	72*	60•	49*	(39)*	(31)•	–	–
		250 000	177*	155*	131*	111*	93*	80*	67*	55•	(45)*	(36)*	–	–	–
P5	N	10 000	221	201	181	164	148	132	118	104	91	79	69	59	51
		30 000	192	175	157	140	124	108	94	81	70	60	51*	43*	(36)*
		50 000	181*	163*	145*	128*	112*	97•	82*	70*	59*	50*	43*	(36)*	(30)*
		100 000	164*	145*	127*	110*	94*	79•	68*	56*	46*	39•	(33)*	–	–
		150 000	153*	135*	119*	101*	84*	71*	59*	49•	40*	(34)•	(28)•	–	–
		200 000	146*	128*	111*	93*	77*	64*	53*	44*	(36)*	(30)•	–	–	–
		250 000	140*	123*	104*	86•	72*	59•	49•	40*	(33)*	(27)*	–	–	–
P7[6]	N	10 000	285	263	240	218	196	176	155	135	117	101	86	75	64
		30 000	251	228	205	181	160	139	120	103	88	76	64	53	(44)
		50 000	234	211	188	165	143	124	105	89	76	65	54	(45)	(36)
		100 000	211*	186*	164*	141•	122*	103	88	75	63	51	(42)•	–	–
		150 000	196*	173*	150*	127*	108*	91•	78*	66*	54*	(44)•	(36)•	–	–
		200 000	185*	163*	139*	118*	99*	85•	72*	60*	49*	(39)*	(31)•	–	–
		250 000	177*	155*	131*	111*	93*	80•	67*	55•	(45)*	(36)•	–	–	–
P9	N	10 000	221	201	181	164	148	132	118	104	91	79	69	59	51
		30 000	192	175	157	140	124	108	94	81	70	60	51*	43*	(36)*
		50 000	181*	163*	145*	128*	112*	97•	82*	70*	59*	50*	43*	(36)*	(30)*
		100 000	164*	145*	127*	110*	94*	79*	68*	56•	46*	39*	(33)•	–	–
		150 000	153*	135*	119*	101*	84*	71•	59*	49*	40*	(34)*	(28)•	–	–
		200 000	146*	128*	111*	93*	77*	64*	53*	44•	(36)•	(30)*	–	–	–
		250 000	140*	123*	104*	86*	72*	59*	49*	40*	(33)*	(27)*	–	–	–
P11[4,6]	N	10 000	293	270	247	226	204	182	162	143	127	111	97	84	74
		30 000	259	235	214	191	170	150	132	116	101	87	75	64	(54)
		50 000	243	221	197	176	155	135	119	104	89	76	65	(54)	–
		100 000	221	198	176	154	134	117	102	87	75	63	(53)	–	–
		150 000	206*	183*	162*	142*	125*	107*	91*	77*	66*	(55)•	(46)*	–	–
		200 000	196*	174*	153*	134*	116*	99•	84*	72*	60*	(50)*	(42)•	–	–
		250 000	189*	167*	146*	128*	110*	93*	79*	67*	56*	(47)*	–	–	–
P13[4]	N	10 000	279	254	229	206	183	163	145	127	113	100	88	78	71
		30 000	251	224	197	174	152	133	117	101	88	77	68	60	(52)
		50 000	237	206	179	158	137	119	103	88	76	67	59	(52)	(45)
		100 000	211*	182*	157*	135*	117*	100*	85*	73*	62*	(53)•	(47)•	–	–
		150 000	196*	168*	144*	124*	104*	87•	75*	65*	56*	(48)*	–	–	–
		200 000	185*	157*	135*	114*	95*	79*	69*	59•	(51)*	–	–	–	–
		250 000	177*	150*	127*	106*	88•	75*	64*	(55)*	(46)•	–	–	–	–
P16[6]	N	10 000	293	270	247	226	204	182	162	143	127	111	97	84	74
		30 000	259	235	214	191	170	150	132	116	101	87	75	64	(54)
		50 000	243	221	197	176	155	135	119	104	89	76	65	(54)	–
		100 000	221	198	176	154	134	117	102	87	75	63	(53)	–	–
		150 000	206*	183*	162*	142*	125*	107*	91*	77*	66*	(55)•	(46)*	–	–
		200 000	196*	174*	153*	134*	116*	99•	84*	72*	60*	(50)*	(42)*	–	–
		250 000	189*	167*	146*	128*	110*	93*	79*	67*	56*	(47)*	–	–	–
P18	N	10 000	279	254	229	206	183	163	145	127	113	100	88	78	71
		30 000	251	224	197	174	152	133	117	101	88	77	68	60	(52)
		50 000	237	206	179	158	137	119	103	88	76	67	59	(52)	(45)
		100 000	211*	182*	157*	135*	117*	100*	85*	73*	62*	(53)*	(47)*	–	–
		150 000	196*	168*	144*	124*	104*	87*	75*	65*	56*	(48)•	–	–	–
		200 000	185*	157*	135*	114*	95*	79*	69*	59•	(51)*	–	–	–	–
		250 000	177*	150*	127*	106*	88*	75*	64*	(55)*	(46)•	–	–	–	–

TABLE 4 (*continued*)

Steel No.	Reference heat treatment 1,2)	Rupture time h	Estimated average stresses for rupture[3], N/mm²															
			Temperature, °C															
			450	460	470	480	490	500	510	520	530	540	550	560	570	580	590	600
P26	N + T	10 000	298	273	247	222	196	171	147	125	102	82	64	–	–	–	–	–
		30 000	273	244	216	187	159	134	113	93	76	61	49	–	–	–	–	–
		50 000	260*	229*	200*	172	144	119	99	80	66	53	(42)	–	–	–	–	–
		100 000	239*	208*	178*	148	123	101	81	66	53*	(42)*	(34)*	–	–	–	–	–
		150 000	226*	197*	168*	139*	114*	91*	74*	60*	48*	(39)*	–	–	–	–	–	–
		200 000	217*	188*	159*	130*	105*	84*	69*	55*	45*	(36)*	–	–	–	–	–	–
		250 000	210*	180*	151*	124*	100*	80*	65*	52*	(42)*	(33)*	–	–	–	–	–	–
P28[5]	N + T																	
P30[5]	N + T																	
P32	N + T	10 000	–	–	–	304	273	239	209	179	154	129	109	91	76	64	53	44
		30 000	–	–	–	267	233	200	169	140	116	96	79	66	54	44	36	(29)
		50 000	–	–	–	239	207	177	149	124	101	82	68	55	45	–	–	–
		100 000	–	–	–	210	177	146	121	99	81	67	54	43	35	–	–	–
		150 000	–	–	–	194*	161*	132*	108*	87*	71	57	46	38	(31)	–	–	–
		200 000	–	–	–	180*	148*	122*	99*	79*	64*	52*	42*	34*	(28)*	–	–	–
		250 000	–	–	–	170*	139*	114*	91*	74*	59*	48*	39*	32*	(26)*	–	–	–
P33	N + T	10 000	–	–	–	299	268	241	219	198	179	164	148	134	121	108	95	78
		30 000	–	–	–	261	232	209	187	168	152	135	121	107	93	80	67	(50)
		50 000	–	–	–	243	217	193	172	153	136	121	107	92	78	66	–	–
		100 000	–	–	–	218	191	170	150	131	116	100	85	72	59	(46)*	–	–
		150 000	–	–	–	205	179	156	136	119	101*	85*	70*	57*	(45)*	(35)*	–	–
		200 000	–	–	–	194*	169*	146*	127*	109*	91*	76*	61*	(48)*	(37)*	(28)*	–	–
		250 000	–	–	–	185*	160*	138*	119*	101*	83*	68*	54*	(42)*	(32)*	–	–	–
P34	N + T	10 000	(309)*	(285)*	(263)*	240	219	196	176	155	137	122	108	96	85	76	68	61
		30 000	(276)*	(254)*	233*	213	192	172	152	134	118	103	90	79	70	61	54	48
		50 000	(257)*	236*	217*	197*	177*	158*	139*	123*	107	93	80	71	62	54	47	42
		100 000	221*	204*	186*	170*	153*	137*	122*	107*	93	79	69	59	51	44	(38)	(34)
		150 000	209*	192*	175*	158*	141*	126*	110*	95*	82*	73*	63*	54*	47	40	(35)	(30)
		200 000	203*	186*	169*	152*	135*	119*	103*	89*	77*	68*	58*	50*	43*	(37)*	(32)*	(28)*
		250 000	198*	181*	164*	147*	130*	113*	98*	84*	74*	64*	55*	47*	41*	(35)*	(30)*	(26)*

TABLE 4 (*concluded*)

Steel No.	Reference heat treatment 1, 2)	Rupture time h	Estimated average stresses for rupture[3], N/mm² — Temperature °C																															
			540	550	560	570	580	590	600	610	620	630	640	650	660	670	680	690	700	710	720	730	740	750	760	770	780	790	800	810	820	830	840	850
P48	Q	10 000	–	176	164	152	142	131	122	113	104	95	87	79	73	67	61	55	48	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		30 000	–	147*	135*	126*	115*	105*	96*	88*	80*	74	67	61	55	50	44*	(40)*	(35)*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		50 000	–	134*	123*	113*	103*	94*	85*	78*	72*	65*	58*	52*	47*	41*	(36)*	(32)*	(27)*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		100 000	–	115*	105*	98*	89*	81*	74*	68*	61*	55*	50*	45*	(40)*	(35)*	(30)*	(26)*	(23)*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		150 000	–	108*	99*	89*	81*	74*	67*	60*	54*	49*	43*	(39)*	(34)*	(30)*	(26)*	(23)*	(20)*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		200 000	–	102*	93*	84*	76*	69*	62*	56*	50*	45*	(40)*	(35)*	(31)*	(27)*	(24)*	(21)*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		250 000	–	97*	88*	79*	73*	66*	59*	53*	47*	42*	(37)*	(33)*	(29)*	(25)*	(22)*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P56	Q	10 000	243	228	215	200	186	173	159	146	134	124	114	104	95	86	77	69	61	54	46	–	–	–	–	–	–	–	–	–	–	–	–	–
		30 000	210*	197	184	172	159	146	133	123	112	102	92	83	74	66	58	51	44	38	(33)	–	–	–	–	–	–	–	–	–	–	–	–	–
		50 000	198*	185*	172*	159*	146	133	123	111	101	91	82	74	66	58	51	44	39	(33)	(28)	–	–	–	–	–	–	–	–	–	–	–	–	–
		100 000	181*	168*	154*	142*	129	118	106	96	86	77	69	61	53	46	40*	35*	(30)*	(25)*	(22)*	–	–	–	–	–	–	–	–	–	–	–	–	–
		150 000	171*	158*	145*	132*	121	109	98	88	79	71*	63*	55*	48*	42*	36*	(32)*	(28)*	(24)*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		200 000	164*	151*	138*	127*	114*	103*	93*	83*	75*	66*	58*	51*	44*	38*	(33)*	(29)*	(25)*	(22)*	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		250 000	159*	146*	133*	122*	110*	99*	88*	79*	71*	63*	55*	48*	41*	36*	(31)*	(27)*	(25)*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P63	Q	10 000	–	260	245	228	211	195	179	164	149	136	123	111	99	89	80	74	65	59	53	48	44	39	–	–	–	–	–	–	–	–	–	–
		30 000	–	243*	224*	204*	187	171	155	139	125	112	100	89	79	72	64	57	51	46	41	37*	33*	30*	–	–	–	–	–	–	–	–	–	–
		50 000	–	226*	208*	192*	175	158	142	128	115	103	91	80	72	63	56*	50*	45*	40*	36*	32*	29*	(26)*	–	–	–	–	–	–	–	–	–	–
		100 000	–	196*	180*	160*	147*	132*	118*	106*	96*	86*	76*	69*	60*	53*	46*	41*	37*	33*	30*	27*	(25)*	(23)*	–	–	–	–	–	–	–	–	–	–
		150 000	–	187*	171*	152*	139*	124*	110*	97*	86*	76*	68*	60*	53*	47*	41*	36*	32*	28*	(25)*	(24)*	(21)*	–	–	–	–	–	–	–	–	–	–	–	–
		200 000	–	181*	165*	146*	133*	116*	103*	91*	80*	71*	63*	56*	49*	43*	38*	33*	29*	(26)*	(24)*	(22)*	(20)*	–	–	–	–	–	–	–	–	–	–	–	–
		250 000	–	176*	159*	140*	127*	110*	97*	86*	76*	67*	59*	52*	46*	40*	35*	31*	28*	(25)*	(23)*	(21)*	(19)*	–	–	–	–	–	–	–	–	–	–	–	–
P67	Q	10 000	–	–	–	–	–	–	220	203	186	171	157	143	131	120	109	99	90	82	75	68	61	55	50	45	40	–	–	–	–	–	–	–	–
		30 000	–	–	–	–	–	–	187	170	154	140	127	114	103	92	83	75	67	59	53	47*	41*	37*	32*	29*	(25)*	–	–	–	–	–	–	–	–
		50 000	–	–	–	–	–	–	173	154	138	125	112	101	90	81	73	65	57	50	44	39*	33*	29*	26*	(23)*	(20)*	–	–	–	–	–	–	–	–
		100 000	–	–	–	–	–	–	150	133	119	105	93	83	74	65	58	50	44	38	33	28*	(25)*	(22)*	–	–	–	–	–	–	–	–	–	–	–
		150 000	–	–	–	–	–	–	134*	118*	103*	90*	78*	69*	60*	52*	45	39	34	30	26	(23)*	(20)*	(17)*	–	–	–	–	–	–	–	–	–	–	–
		200 000	–	–	–	–	–	–	124*	108*	94*	81*	71*	61*	53*	46*	40*	34*	30*	(25)*	(23)*	(20)*	(17)*	–	–	–	–	–	–	–	–	–	–	–	–
		250 000	–	–	–	–	–	–	116*	100*	86*	75*	65*	56*	48*	41*	36*	31*	26*	(23)*	(20)*	(17)*	(15)*	–	–	–	–	–	–	–	–	–	–	–	–
P69	Q	10 000	–	223	207	192	177	164	152	141	130	121	112	103	95	87	80	74	68	62	57	53	48	44	40	37	34	32	30	27	25	23	21	19
		30 000	–	197*	182*	168*	155	143	132	122	113	104*	95*	88*	80*	74*	68	62	57	52	48	43	40	36	34	31	29	26	24	22	20	18*	16*	(14)*
		50 000	–	185*	171*	158*	146	135	124	114	105	97*	89*	81*	75*	68*	63	57	52	48	43	40*	36*	34*	31*	29*	26*	24*	22*	20*	18*	16*	(14)*	–
		100 000	–	171*	157*	145*	134*	123*	114*	104*	96*	88*	80*	73*	67*	61*	56*	51*	47*	42*	39*	36*	33*	30*	28*	25*	23*	21*	19*	17*	15*	–	–	–
		150 000	–	163*	150*	138*	127*	117*	108*	99*	90*	83*	76*	69*	63*	58*	53*	48*	43*	40*	36*	34*	31*	28*	26*	24*	21*	19*	17*	15*	(14)*	–	–	–
		200 000	–	158*	145*	134*	123*	113*	104*	95*	87*	79*	72*	66*	60*	55*	50*	46*	41*	38*	35*	32*	30*	27*	25*	22*	20*	18*	16*	(14)*	–	–	–	–
		250 000	–	154*	141*	130*	120*	110*	101*	92*	84*	77*	70*	64*	58*	53*	48*	44*	40*	37*	34*	31*	29*	26*	24*	21*	19*	17*	15*	–	–	–	–	–

NOTES TO TABLE 4

1) N = normalized, Q = quenched, T = tempered.

2) For temperatures and cooling conditions, see table 1.

3) Values given in parentheses were obtained by extrapolation beyond the stress range covered by the test data and are thus subject to greater uncertainty.

4) The stress rupture properties are valid only if the manganese content is $\geqslant$ 0,80 %.

5) Until values of stresses for rupture derived by ISO/TC 17/SC 10/ETP-Sub-Group are available, the values provided by national or similar standards, or by the quality control of the interested parties, shall, if necessary, be agreed at the time of enquiry and order.

6) The stress rupture properties are valid only if the Al_{met} content is $\leqslant$ 0,010 %.

GENERAL NOTES – Values are subject to revision when more data become available.

Values for the longer times have been extrapolated by the method approved by TC 17/SC 10/ETP-Sub-Group, to a greater or lesser degree depending upon the duration of the tests from which the values have been derived.

In analysing the data on austenitic steels, no differentiation has been made between boron-containing and boron-free casts.

The derivation of the values marked with an asterisk may have involved extended extrapolation. The values are recommended values, but their use should take account of the extent and duration of the test data on which they were based (see ISO/DATA No. 1).

TABLE 5 — **Impact properties at low temperature**

Steel No.	Reference heat treatment 1,2)	Plate thickness mm	Provisional minimum impact test value, $KV^{3,4,5)}$ in joules, average of three tests									
			Temperature, °C									
			0	− 20	− 40	− 50	− 80	− 100	− 120	− 150	− 170	− 195
P5	N	⩽ 100	55	47	31	27						
P9	N											
P15	N											
P18	N											
P41	N, N + T, Q + T	⩽ 50	71	63	55	51	27					
P42	N											
P43	N		59	55	51	47	39	27				
P44	Q + T		63	59	55	55	47	39	27			
P45	N + Q + T, Q + T	⩽ 30	71	67	63	63	55	55	51	47	43	39
P49	Q	⩽ 16	86	86	82	82	78	78	74	74	71	71
P52	Q		78	78	74	74	71	71	67	67	63	63
P55	Q											

1) N = normalized, Q = quenched, T = tempered.

2) For temperatures and cooling conditions, see table 1.

3) V-notch test piece, longitudinal.

4) Single values not less than 70 % of the average value.

5) The values apply to standard 10 mm × 10 mm test pieces. Where it is necessary to use subsidiary standard test pieces the values shall be agreed between the interested parties.

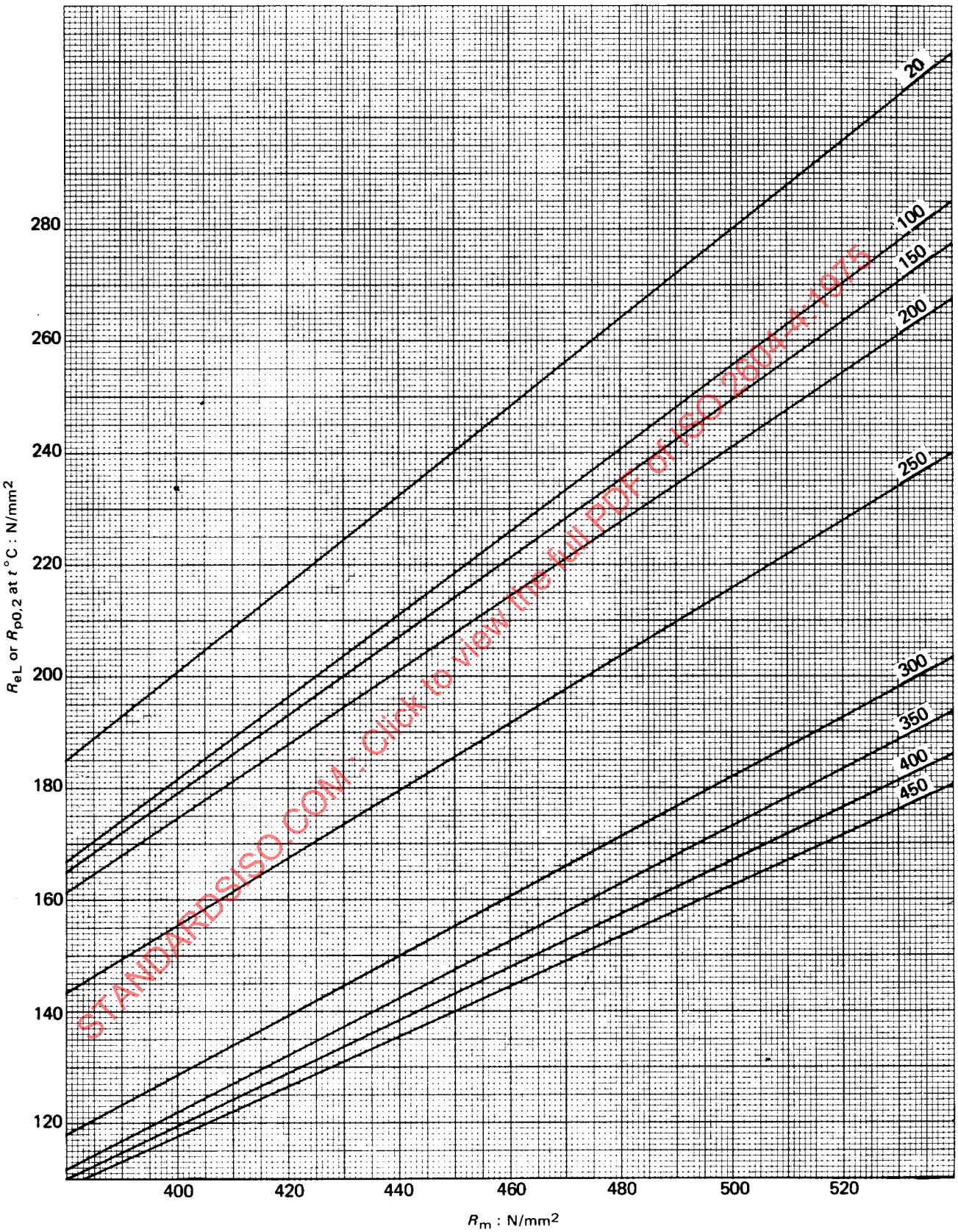

FIGURE 1 – **95 % LCL lines for :**

Steels :	P3, P7, P11, P16 (C and CMn; coarse grained)
Heat treatment :	Normalized
Thickness :	⩽ 16 mm

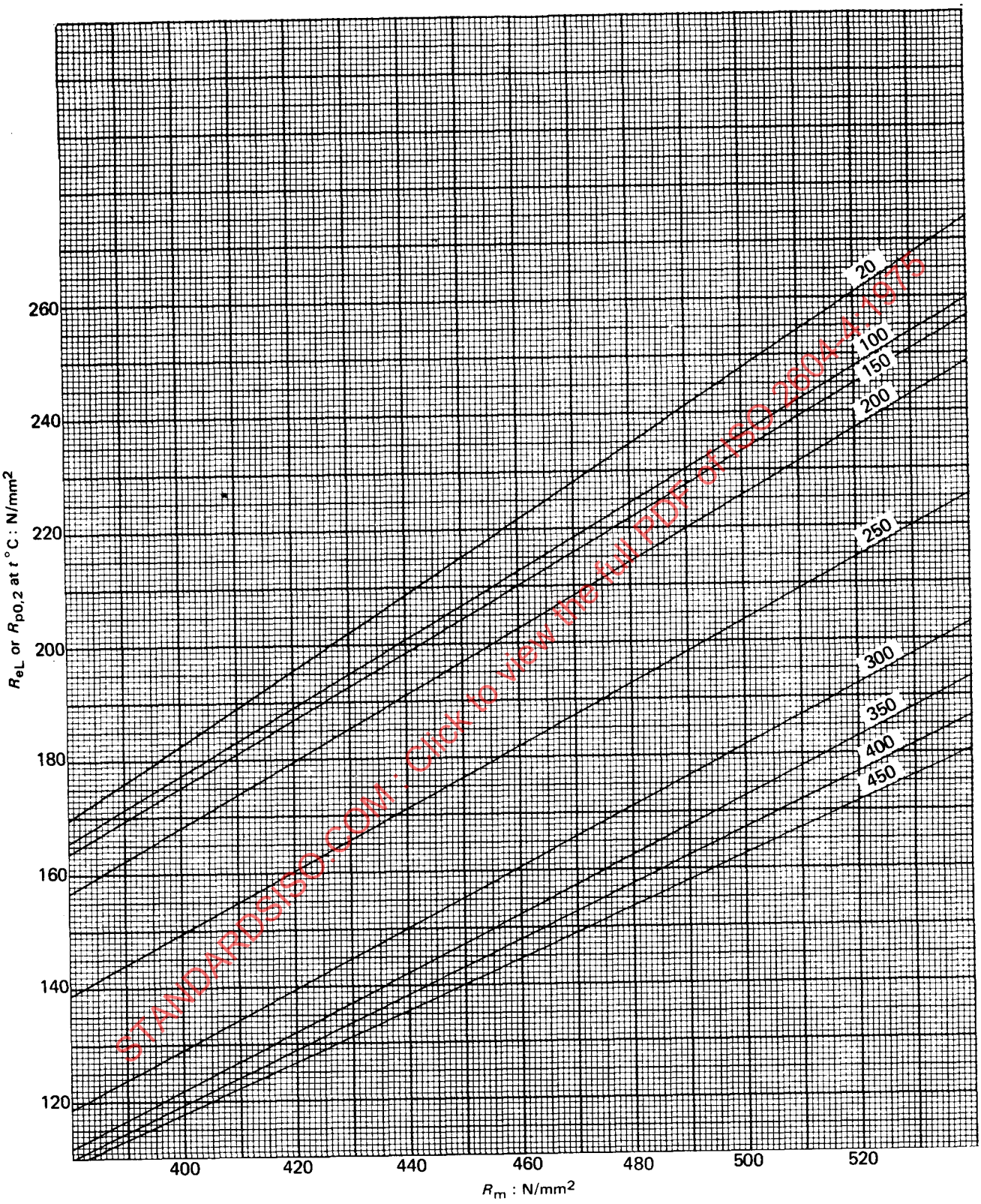

FIGURE 2 – **95 % LCL lines for :**

Steels :	P3, P7, P11, P16 (C and CMn; coarse grained)
Heat treatment :	Normalized
Thickness :	> 16 mm but ⩽ 40 mm

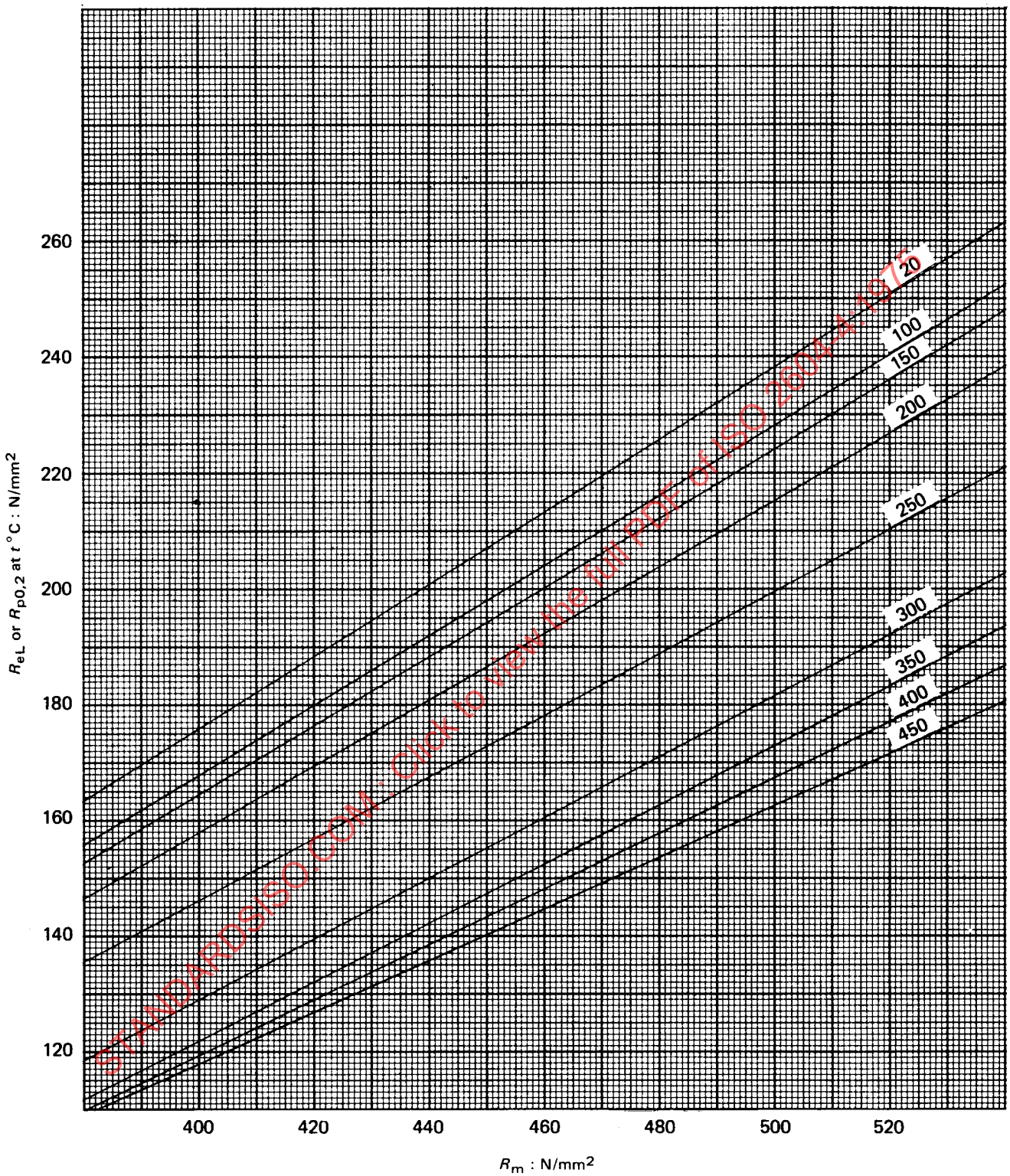

FIGURE 3 — **95 % LCL lines for :**

Steels : P3, P7, P11, P16 (C and CMn; coarse grained)

Heat treatment : Normalized

Thickness : > 40 mm but ⩽ 63 mm

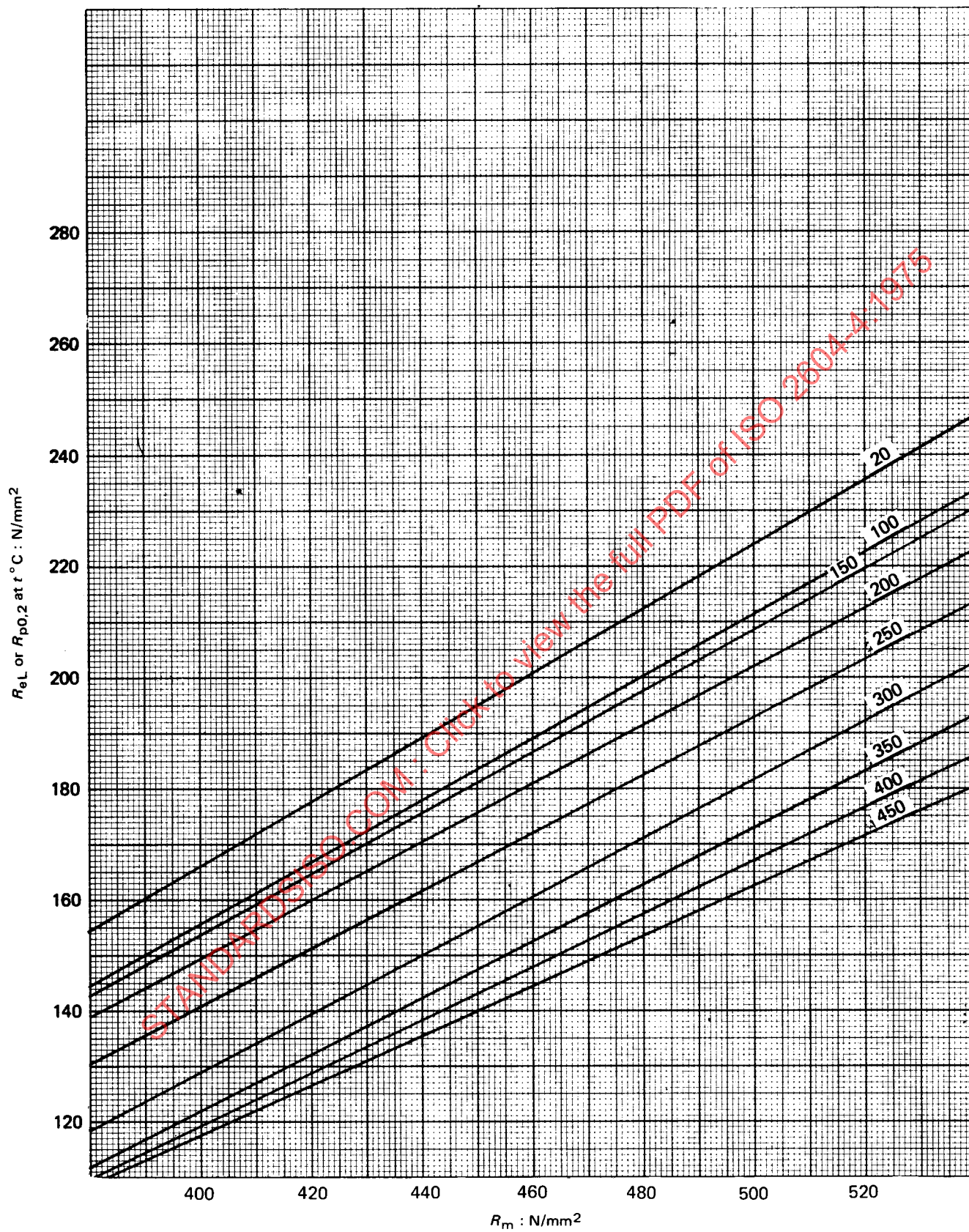

FIGURE 4 — **95 % LCL lines for :**

Steels :	P3, P7, P11, P16 (C and CMn; coarse grained)
Heat treatment :	Normalized
Thickness :	> 63 mm but ⩽ 100 mm

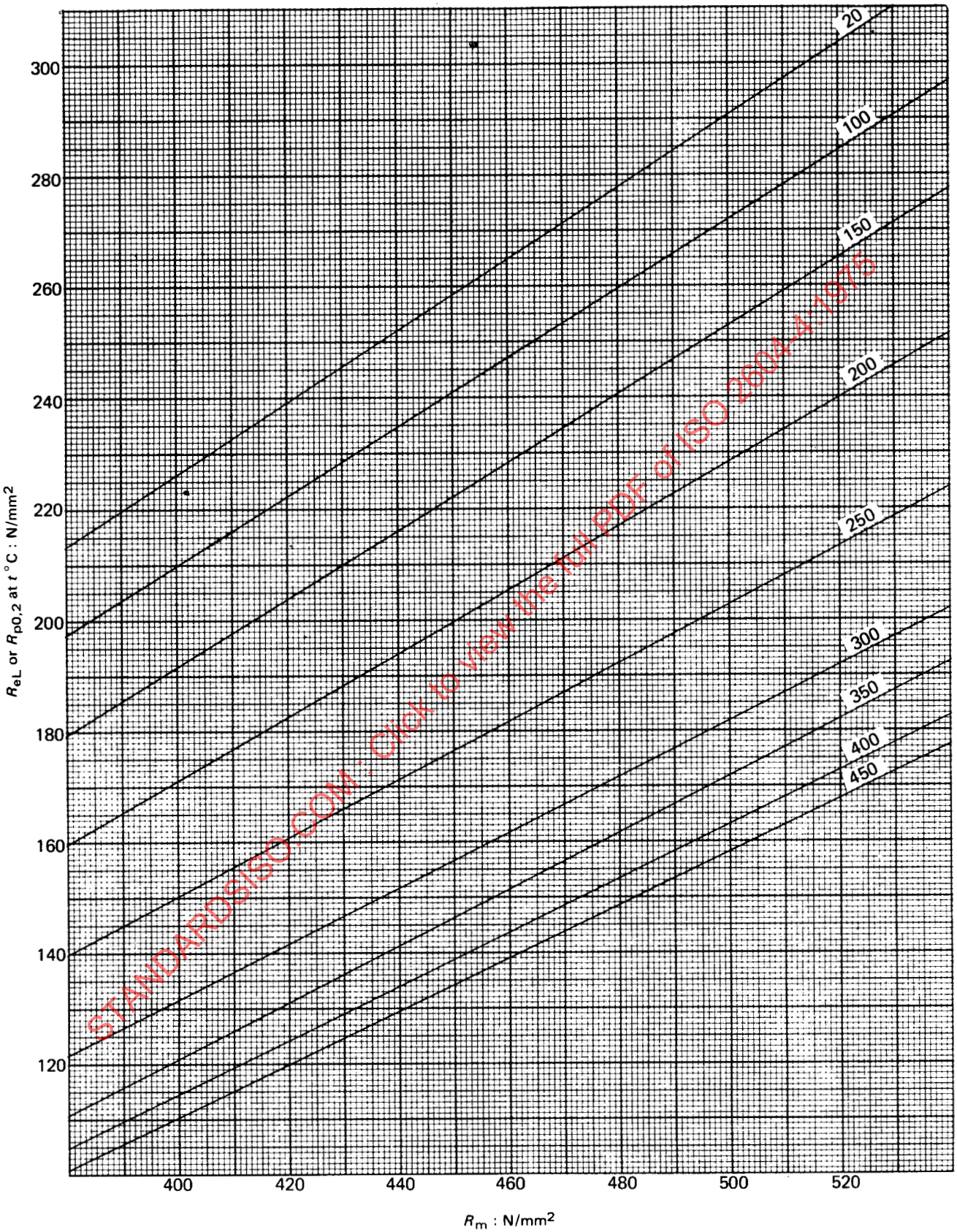

FIGURE 5 — **95 % LCL lines for :**

Steels :	P5, P9, P13, P18 (C and CMn; fine grained)
Heat treatment :	Normalized
Thickness :	⩽ 16 mm

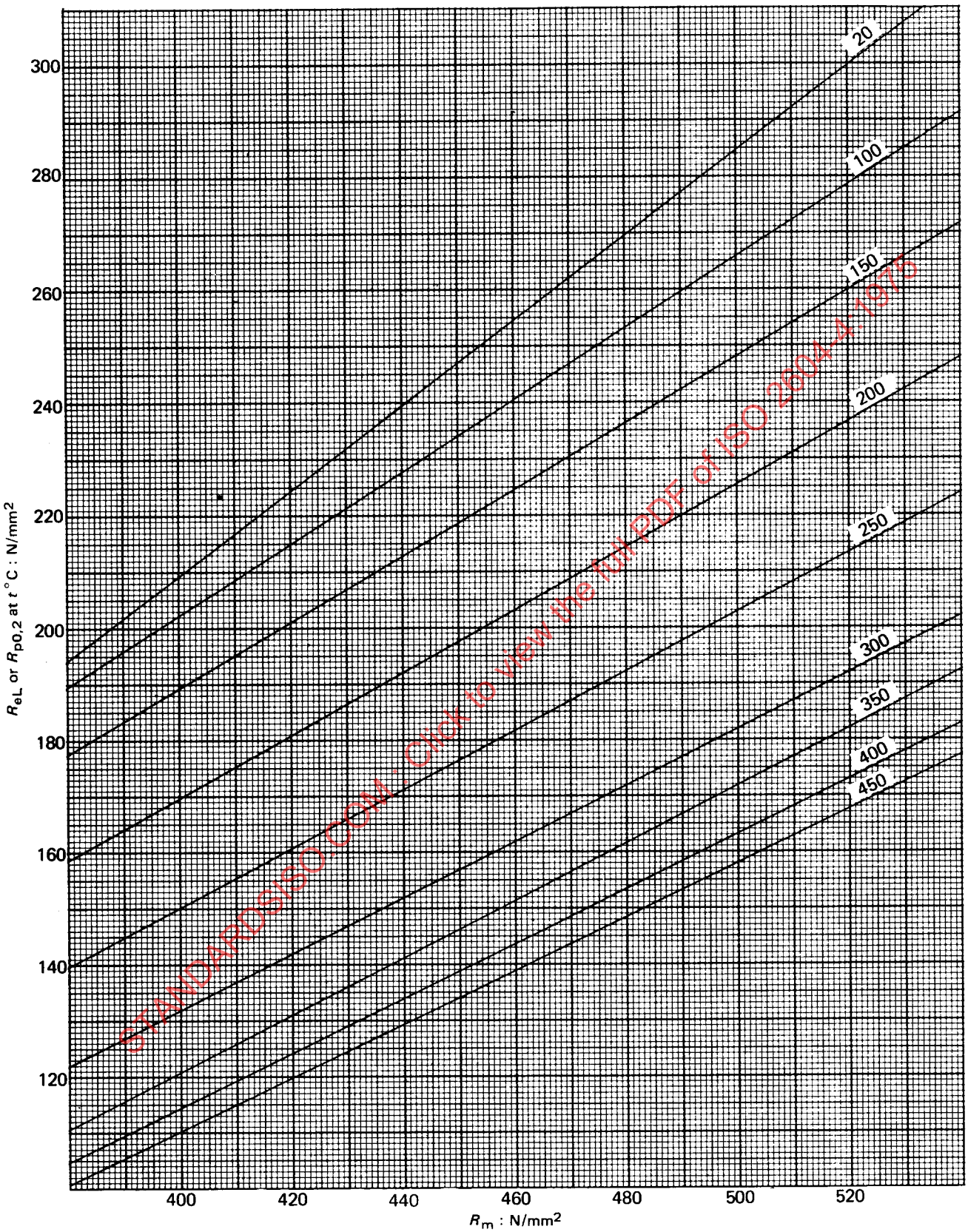

FIGURE 6 – **95 % LCL lines for :**

Steels : P5, P9, P13, P18 (C and CMn; fine grained)

Heat treatment : Normalized

Thickness : > 16 mm but ⩽ 40 mm

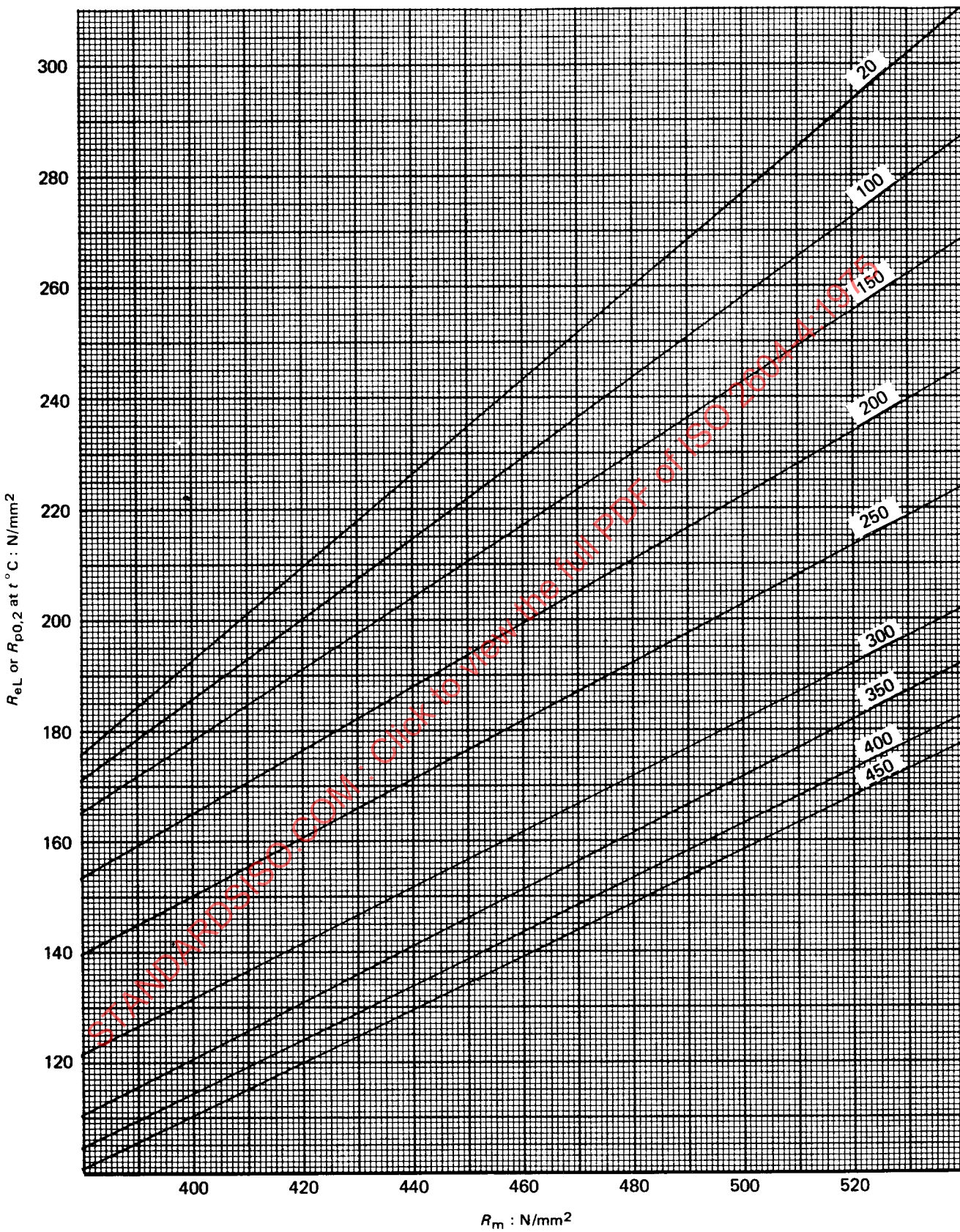

FIGURE 7 – **95 % LCL lines for :**

Steels : P5, P9, P13, P18 (C and CMn; fine grained)

Heat treatment : Normalized

Thickness : > 40 mm but ⩽ 63 mm