

International Standard



3183

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Oil and natural gas industries — Steel line pipe

Industrie du pétrole et du gaz naturel — Tubes en acier pour conduites

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FOREWORD

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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.

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It has been approved by the member bodies of the following countries :

Belgium	Italy	Romania
Czechoslovakia	Japan	Spain
Egypt, Arab Rep. of	Korea, Rep. of	Switzerland
France	Mexico	United Kingdom
Germany, F.R.	Netherlands	USA
Hungary	New Zealand	Yugoslavia
Iran	Poland	

The member bodies of the following countries expressed disapproval of the document on technical grounds :

Australia
Canada
USSR

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Oil and natural gas industries — Steel line pipe

1 SCOPE AND FIELD OF APPLICATION

1.1 This International Standard specifies the characteristics of plain-end steel line pipe used in the oil and natural gas industries.

1.2 This pipe shall be manufactured in the sizes, thicknesses and grades given in table 14.

1.3 High-strength steel line pipe is covered in ISO 3845.

1.4 Spiral-welded steel line pipe will be covered in a future International Standard.

1.5 Threaded-end steel line pipe is not covered in this International Standard.

2 REFERENCES

ISO/R 202, *Flattening test on steel tubes*.

ISO 375, *Steel — Tensile testing of tubes*.

ISO 404, *Steel and steel products — General technical delivery requirements*.¹⁾

ISO/R 1027, *Radiographic image quality indicators — Principles and identification*.

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

ISO 3845, *Oil and natural gas industries — High-test steel line pipe*.²⁾

3 DEFINITION AND SYMBOLS

3.1 Definition

For the purpose of this International Standard, the following definition applies.

line pipe : Pipe used as an element of a pipe-line by the oil

and natural gas industries principally for the transport of liquid or gaseous products.

3.2 Symbols

D : Nominal outside diameter of pipe, in millimetres.

a : Nominal wall thickness of pipe, in millimetres.

$R_{t0,5}$: Yield strength corresponding to a total elongation of 0,5 %, in newtons per square millimetre.

R_m : Tensile strength, in newtons per square millimetre.

A : Elongation after fracture on proportional test specimen, $L_0 = 5,65 \sqrt{S_0}$, in per cent.

p : Hydrostatic test pressure, in bars.

4 INFORMATION TO BE SPECIFIED BY THE PURCHASER

4.1 In placing the order, the purchaser must specify the following :

- a reference to ISO 3183;
- quantity (number of metres or number of lengths);
- steel grade and class (see tables 1 and 2);
- pipe type : Plain-end line pipe (see 7.4);
- process of manufacture of the pipe (see clause 5) : seamless, electric-welded, submerged-arc or butt-welded;
- size (outside diameter), in millimetres (see table 13);
- mass per unit length, in kilograms per metre, or thickness in millimetres (see table 14);
- range lengths (see table 6);
- delivery date and shipping instructions;
- mill inspection (when required).

1) At present at the stage of draft. (Revision of ISO/R 404.)

2) At present at the stage of draft.

4.2 In placing the order, the purchaser must also specify his requirements concerning the following stipulations which are optional :

- k) chemical ladle analyses (see 9.1);
- l) chemical check analyses on product (see 9.2);
- m) method of processing steel (see 6.1);
- n) acceptance of jointers (see 8.5.3);
- o) welding method for jointers (see C.1);
- p) possible cancelling of end bevel (see 7.4.1);
- q) repairing of defects (see 11.2.2);
- r) special coatings (see clause 16).

4.3 Attention is also called to the following stipulations which are subject to agreement when placing the order :

- s) average lengths (see 8.5);
- t) special marking instructions (see 15.4).

5 MANUFACTURING PROCESSES

This International Standard is applicable to seamless or welded pipe manufactured according to the following process.

5.1 Seamless

Seamless pipe is defined as a steel tubular product manufactured without a welded seam by hot working a solid billet of steel, if necessary followed by cold finishing to produce the desired shape, dimensions and properties.

5.2 Welded

5.2.1 Electric welding

Electric-welded pipe is pipe having one longitudinal seam formed by electric-flash welding, electric-resistance welding or electric-induction welding, without the addition of extraneous metal.

5.2.2 Submerged-arc welding

This process is applicable to grades E 21 and E 24 only.

Submerged-arc welded pipe is pipe having one longitudinal seam formed by automatic submerged-arc welding. At least one pass is made on the inside and at least one pass on the outside of the pipe.

If so agreed by the interested parties, submerged-arc welded pipe may have two longitudinal seams positioned approximately 180° apart. For this pipe, all weld tests provided for shall be performed after forming and welding. For each seam, at least one pass shall be made on the inside and at least one pass on the outside.

The end welding of longitudinal seams, if not carried out by an automatic process, is to be effected by a process and a welder qualified in accordance with annex B.

5.2.3 Butt welding

This process is applicable to grade E 17 only.

Butt-welded pipe is pipe having one longitudinal seam formed by mechanical pressure to make the welded junction, the edges being furnace-heated to the welding temperature prior to application of the pressure.

5.3 Heat treatment

5.3.1 Pipe is delivered as-rolled or heat-treated.

In the second case, it shall receive one of the following treatments :

- a) normalizing;
- b) normalizing and tempering;
- c) sub-critical stress relief;
- d) sub-critical age hardening.

5.3.2 After welding, the seam in electric-resistance or electric-induction welded grade E 24 pipe shall be treated at a minimum temperature of 538 °C or in such a way that no untempered martensite remains.

5.4 Pipe furnished to this International Standard, except butt-welded, is delivered with expansion or without expansion at the option of the manufacturer, unless otherwise stipulated when placing the order.

6 MATERIAL

6.1 Processing

The only processes approved by this International Standard are the following :

- Open hearth, electric furnace or converter using blown, industrially pure oxygen, or a combination of these processes.

6.2 Ladle analysis

The ladle analysis requirements for the various grades of steel are shown in table 1.

6.3 Mechanical characteristics

The specimen mechanical characteristics for the various grades of steel are shown in table 2.

TABLE 1 — Ladle analysis

Grade and class	Carbon %	Manganese %		Phosphorus %	Sulphur %
	max.	min.	max.	max.	max.
E 17	0,21	0,30	0,60	0,045	0,06
E 21	0,22		0,90	0,04	0,05
E 24 — 1	0,22		1,15	0,04	0,05
E 24 — 2	0,27		1,15	0,04	0,05

TABLE 2 — Mechanical characteristics

Grade	Yield strength $R_{t0,5}$ min.	Tensile strength R_m min.	Elongation ¹⁾ $L_o = 5,65 \sqrt{S_o}$ min.
	N/mm ²	N/mm ²	%
E 17	172	310	27
E 21	207	331	25
E 24	241	413	21

1) If other gauge lengths are used, the corresponding elongation shall be determined in accordance with ISO 2566. In cases of dispute, the gauge length of $5,65 \sqrt{S_o}$ shall be used.

7 DIMENSIONS, WORKMANSHIP

7.1 Diameters, thicknesses and masses

Pipe supplied to the diameters, thicknesses and masses specified when placing the order shall be chosen from tables 13 and 14.

7.2 Workmanship

Pipe shall be rejected if it shows signs of poor quality as defined in the following paragraphs. The manufacturer must take reasonable precautions to minimize the recurrence of such imperfections.

The following imperfections are considered defects if they exceed the given limits :

7.2.1 Dents

- more than 6,3 mm deep as measured between the lowest point and the prolongation of the original contour of the pipe, or
- length exceeding one-half the pipe's outside diameter.

However, cold-formed dents deeper than 3,2 mm with a sharp bottom gouge are considered injurious. The gouge may be removed by grinding.

7.2.2 Offset of plate edges

Submerged-arc welded pipe :

- For thicknesses $\leq 12,5$ mm : offset greater than 1,6 mm.
- For thicknesses $> 12,5$ mm and ≤ 25 mm : offset greater than 3,2 mm.
- For thicknesses > 25 mm : offset greater than 1/8 of the wall thickness.

Electric-resistance welded pipe :

- Offset of edges plus flash trim : 1,5 mm.

7.2.3 Misalignment of seam in submerged-arc welded pipe

Incomplete penetration or fusion shown by non-destructive examination.

Evidence of tack weld made by electric-resistance welding remaining after submerged-arc welding.

7.2.4 Height of outside seam

Seam extending above prolongation of original surface of the pipe :

- 3,2 mm for thicknesses $\leq 12,5$ mm;
- 4,8 mm for thicknesses $> 12,5$ mm.

However, seams may be ground to acceptable limits.

7.2.5 Height of inside seam in electric-welded pipe

Flash (inside seam) extending 1,5 mm above the prolongation of the original inside surface.

7.2.6 Trim of inside seam in electric-welded pipe

Groove resulting from the flash trim exceeding 10 % of the thickness for thicknesses $\leq 3,6$ mm, 0,4 mm for thicknesses between 3,6 mm and 8 mm, 5 % of the thickness for thicknesses ≥ 8 mm.

7.2.7 Surface conditioning by grinding carried out in an incorrect (unworkmanlike) manner

7.3 Hard spots

The surface of welded pipe in sizes over 508 mm outside diameter shall be examined visually to detect irregularities in the curvature of the pipe. When this examination fails to disclose mechanical damage as the cause of an irregular surface, but instead indicates that the irregular surface may be attributed to a hard spot, the hardness of the area in question shall be determined. If the hardness is 35 Rockwell C (327 Brinell) or harder, and the dimension of the hardened area is greater than 50 mm in any direction, the section of the pipe containing the hard spot shall be cut off.

7.4 Pipe ends

7.4.1 Unless otherwise ordered, the pipes are to be delivered with ends bevelled to an angle of $30^\circ + 5^\circ_0$, as measured from a line drawn perpendicular to the axis of the pipe and with a root face of $1,6 \pm 0,8$ mm.

For pipe of outside diameter D 273 mm or larger, the ends shall be square machined within 1,6 mm (measured no less than three times per 8-hour working shift).

7.4.2 When internal machining is required to maintain the root face tolerance or to remove an internal burr on seamless pipe, the angle made by the machined surface with a line perpendicular to the axis of the tube shall not be less than the values given below :

Specified thickness, mm	Angle, degrees
< 10	83
10 to 14	80
14 to 17	79
> 17	76

For the removal of an internal burr on welded pipe larger than 114,3 mm outside diameter, the angle value shall be 83° or larger.

7.4.3 Both ends of submerged-arc welded pipe shall have the inside seam reinforcement removed for a distance of approximately 100 mm.

If so agreed when placing the order, approximately 150 mm of this excess inside weld thickness shall be removed for pipe of diameter D greater than or equal to 1 016 mm.

7.4.4 If so specified on the order, pipes shall be furnished with ends suitable for use with certain special couplings. Such pipe shall be sufficiently free from indentations, projections or roll marks for a distance of 200 mm from the end of the pipe, to permit proper make-up of coupling.

8 DIMENSIONAL TOLERANCES

8.1 Outside diameter

8.1.1 Pipe body

The tolerances on the outside diameter D are given in table 3.

TABLE 3

Outside diameter mm	Tolerance %
$60,3 \leq D < 101,6$	± 1
$114,3 \leq D < 457$	$\pm 0,75$
$D \geq 508$	± 1

For pipe of outside diameter D greater than or equal to 114,3 mm, measurements are to be made with a diameter tape no less than three times per 8-hour working shift.

8.1.2 Pipe ends

For a distance of 100 mm from each end, the outside diameter D of the pipe shall comply with the tolerances given in table 4.

TABLE 4

Diameter mm	Tolerances mm
$D \leq 273,1$	$+1,6$ $-0,4$
$D \geq 323,9$	$+2,4$ $-0,8$

For pipes of outside diameter D less than or equal to 508 mm, the plus tolerance shall be verified by the passage over the ends for a distance of 100 mm of a ring-gauge which has a bore equal to the outside diameter of the pipe plus the corresponding tolerance. The minus tolerance may be measured with a diameter tape. If so agreed when the order is placed, the tolerance on outside diameter D at the ends may be applied instead to the inside diameter at the ends.

For pipe of outside diameter D greater than 508 mm, the plus and minus tolerances shall be verified with a diameter tape. On expanded pipe of outside diameter D greater than 508 mm, the diameter, measured with a diameter tape at one end of the pipe, shall not differ by more than 2,4 mm from that at the other end. These measurements may be made on the internal diameter, at the manufacturer's option.

8.2 Inside diameter

If so agreed when placing the order, the tolerance at the ends may be applied to the inside diameter instead of the outside diameter.

8.3 Out-of-roundness

For pipe of outside diameter D greater than or equal to 559 mm, and for a distance of 100 mm from each end, the maximum outside diameter shall not be more than 1 % larger than the nominal outside diameter, and the minimum outside diameter shall not be more than 1 % smaller than this nominal outside diameter.

8.4 Thickness

8.4.1 At any given point, the thickness of each pipe length shall comply with the tolerances given in table 5.

TABLE 5

Process of manufacture	Outside diameter mm	Tolerances %
Seamless and welded	$D \leq 73$	+ 20 - 12,5
Seamless and welded	$73 < D \leq 88,9$	+ 18 - 12,5
Seamless	$D \geq 101,6$	+ 15 - 12,5
Welded	$101,6 \leq D \leq 457$	+ 15 - 12,5
Welded	$D \geq 508$	+ 17,5 - 10

For welded pipe, the weld area is not limited by the plus tolerance.

8.4.2 Thickness measurements shall be made with a mechanical caliper or with a properly calibrated non-destructive testing device of appropriate accuracy. In case of dispute, the measurement determined by use of the micrometer governs.

The mechanical caliper shall be fitted with contact pins having circular cross-sections of 6,3 mm. The pin contacting the inside surface shall be rounded to a radius of 38,1 mm; the end of the pin contacting the outside surface shall be rounded to a radius of not less than 38,1 mm.

8.5 Mass

8.5.1 Each pipe shall be weighed separately. However, pipe of outside diameter less than or equal to 114,3 mm may be weighed in lots whose size shall be determined by the manufacturer.

8.5.2 The masses determined shall be in accordance with the masses given in table 14, within the limit of the tolerances indicated in 8.5.3.

The mass m , expressed in kilograms per metre, is given by the following formula :

$$m = 0,024\ 66 (D - a) a$$

where

D is the outside diameter, in millimetres, rounded to the nearest 0,1 mm;

a is the specified thickness, in millimetres, rounded to the nearest 0,1 mm.

The result shall be recorded to the nearest 0,01 kg/m.

8.5.3 Per pipe and per lot, the tolerance shall be $\begin{matrix} + 10 \\ - 3,5 \end{matrix}$ %.

However, this tolerance in the case of "special" tubes (marked with an asterisk in table 14) shall be $\begin{matrix} + 10 \\ - 5 \end{matrix}$ %.

In the case of welded pipe of outside diameter greater than or equal to 508 mm, this tolerance shall be $\begin{matrix} + 12,5 \\ - 3,5 \end{matrix}$ %.

For a full carload (a minimum of 18 t) the tolerance shall be - 1,75 %.

NOTE — Specifications for separate pipe, pipe in lots and pipe in carloads apply simultaneously, except for orders of less than 18 t, where only the tolerance per pipe or pipe in lots applies.

8.6 Length

8.6.1 Pipe shall be furnished as stipulated in the order, namely in single random lengths, in double random lengths, or as agreed.

8.6.2 The limits on pipe lengths are given in table 6.

TABLE 6

	Shortest length in 100 % of shipment	Shortest length in 90 % of shipment	Minimum average length in 100 % of shipment
Single random lengths	2,7 m		5,3 m
Double random lengths	4,3 m	8,0 m	10,7 m
Lengths as agreed (> 6,1 m)	40 % of agreed average length	75 % of agreed average length	

8.6.3 Unless otherwise indicated when the order is placed, jointers may be furnished to a maximum of 5 % of the delivered length.

However, no short lengths used in making these jointers shall measure less than 1,5 m.

The jointers shall comply with the requirements of annex C.

8.7 Straightness

8.7.1 Pipe of outside diameter less than 114,3 mm shall be reasonably straight.

Pipe of outside diameter greater than or equal to 114,3 mm shall be random checked; any deviation shall not exceed 0,2 % of the length.

8.7.2 Checking shall be carried out using a taut string or wire from end to end along the side of the pipe to measure the greatest deviation.

9 CHEMICAL ANALYSES

9.1 Ladle analysis

On request, for grades E 21 and E 24 pipe, the manufacturer shall supply the purchaser with a ladle analysis of each heat of steel used.

The analyses so obtained shall comply with the requirements of 6.2 and table 1.

For grade E 17 pipe, the manufacturer shall certify that the material has been analysed and meets the requirements of 6.2 and table 1.

9.2 Check analysis

9.2.1 If so agreed when the order is placed, the manufacturer shall perform analyses on two lengths of finished pipe from each lot of 400 ($60,3 \leq D \leq 141,3$ mm), 200 ($168,3 \leq D \leq 323,9$ mm) or 100 ($D \geq 355,6$ mm) of the same diameter.

For multiple-length seamless pipe, a length shall be considered as all of the sections cut from a particular multiple length.

9.2.2 The samples for check analysis shall be taken as follows :

a) Seamless pipe

At the manufacturer's option, cuttings or drillings for check analyses shall be taken either from the pipe at several points around the finished pipe or from the tensile test specimen.

If drillings are used, the minimum drill size shall be 12,5 mm. The drillings shall be taken by drilling all the way through the pipe wall.

b) Welded pipe

At the manufacturer's option, cuttings or drillings shall be taken from the finished pipe, plate, skelp, tensile test specimens or flattening test specimens.

Samples shall be taken at a minimum of 90° from the weld in such manner as to represent the total thickness.

For pipe having two longitudinal seams, samples shall be taken on the two plates.

If drillings are used, the minimum drill size shall be 12,5 mm.

9.2.3 The chemical composition of the product shall conform to the requirements specified in table 1, with the following permissible variations :

- Carbon : $\pm 0,03$ %
- Manganese : $\pm 0,10$ %
- Phosphorus : $\pm 0,005$ %
- Sulphur : $\pm 0,005$ %

When table 1 only specifies a maximum content, only the plus variation shall apply.

These tolerances are not applicable to rimmed steels.

9.2.4 If one of the lengths representing a lot fails to conform to the requirements of 9.2.3, at the manufacturer's option either the entire lot shall stand rejected or two additional lengths shall be tested for conformance to the specified requirements.

If both recheck analyses meet the specified requirements, the lot shall be accepted except for the initial defective length.

If both lengths representing a lot or one (or both) of the lengths used for the recheck analyses fail to give satisfactory results, at the manufacturer's option the entire lot shall be rejected or each of the remaining lengths shall be tested individually. These recheck analyses are only to be carried out on the unsatisfactory elements. The samples shall be taken in the manner specified in 9.2.2.

9.3 Mill-control check analysis

The manufacturer shall make a check analysis of each heat of steel used. A record of these analyses shall be available to the purchaser.

10 TECHNOLOGICAL TESTS

10.1 Nature of the tests

Depending on the manufacturing process, the pipe shall undergo the following tests as indicated.

- pipe body tensile tests;
- weld tensile tests;
- flattening tests;
- weld ductility tests;
- guided-bend tests of the weld;
- non-destructive inspection.

Every pipe shall withstand a hydrostatic test.

For each manufacturing process, table 7 indicates which tests are to be made.

10.2 Number of tests

The number of tests is indicated in table 7.

10.3 Tensile tests

10.3.1 Tests on the pipe body

10.3.1.1 The tests shall be carried out in accordance with ISO 375. The yield strength shall be the tensile stress required to produce an elongation of 0,5 % ($R_{t0,5}$).

TABLE 7 — Nature and number of tests

Type of test	Process of manufacture			
	Seamless	Electric-welded	Submerged-arc welded ⁴⁾	Butt-welded
Tensile test on specimen taken from pipe body	$D \leq 141,3$: 1 for every 400 lengths $141,3 < D \leq 323,9$: 1 for every 200 lengths $D \geq 355,6$: 1 for every 100 lengths			1 for every 400 lengths ¹⁾
Tensile test on weld specimen		$219,1 \leq D \leq 323,9$: 1 for every 200 lengths $D \geq 355,6$: 1 for every 100 lengths		
Mill-control tensile test (on pipe body)	1 for each E 21 or E 24 heat of steel			
Specimen flattening test		a) Grades E 21 and E 24 nonexpanded at each end of each length ³⁾ b) Grades E 21 and E 24 expanded 1 for every 100 lengths ¹⁾ c) Grade E 17, $D \geq 73$ mm 1 for every 400 lengths ¹⁾		$D \geq 73$ mm 1 for every 400 lengths ¹⁾
Special tests on the weld		Ductility test	Guided-bend test	
		$D \leq 141,3$: 1 per 400 lengths $141,3 < D \leq 323,9$: 1 per 200 lengths $D \geq 355,6$: 1 per 100 lengths	1 face-bend test and 1 root-bend test on 1 length for every 50 ¹⁾	
Hydrostatic test	On every pipe			
Non-destructive inspection	Optional	Each weld of E 21 and E 24 steel pipe		

1) Of the same size.

2) For seamless pipe in multiple lengths, one length is considered to be the sum of the sections obtained from this multiple length.

3) For multiple lengths cut into sections, additional tests on two intermediate rings.

4) For pipe having two longitudinal seams, samples shall be taken either on the two plates or on the two weld seams.

For electric-welded pipe of diameter D less than or equal to 168,3 mm and for seamless pipe, the specimens shall be taken longitudinally. For electric-welded and submerged-arc welded pipe of diameter D greater than or equal to 219,1 mm, they shall be taken transversely.

At the manufacturer's option, longitudinal specimens shall be either pipe sections or strip sections. Strip sections from seamless pipe may be taken from any location. Strip specimens from welded pipe shall be taken at approximately 90° from the weld or from the skelp parallel to the direction of rolling and approximately midway between the edge and the centre. Specimens shall represent the full thickness of the pipe from which they are cut and shall be tested without flattening.

Transverse specimens shall be taken from the side opposite the weld. They shall represent the full thickness of the pipe from which they are cut.

10.3.1.2 Strip specimens shall be approximately 38 mm wide in the gauge length if suitable curved-face testing grips are used or if the ends of the specimens are machined to reduce the curvature in the grip area; otherwise, they shall be approximately 19,0 mm wide for pipe 88,9 mm and smaller, 25,4 mm for pipe 101,6 to 193,7 mm (inclusive) and approximately 38 mm for pipe 219,1 mm and larger. In no case shall the width of the specimen in the gauge length be greater than four times the thickness of the specimen.

10.3.2 Weld tensile tests

Weld tensile tests shall be carried out in accordance with ISO 375. Determination of yield strength and elongation are not necessary.

The specimens shall be taken at 90° to the weld with the weld at the centre of the specimen.

The specimens shall represent the full thickness of the pipe from which they are cut.

The weld reinforcement shall not be removed.

10.3.3 If a tensile test specimen shows defective machining or flaws, it shall be discarded and another specimen substituted.

When the elongation of a tensile test specimen is less than that specified, a re-test shall be allowed if any part of the fracture is outside the middle third of the gauge length and indicated by scribe scratches marked on the specimen before testing.

10.4 Flattening test

10.4.1 The test shall be made in accordance with ISO/R 202. No opening in the weld shall take place as long as the distance between the plates is greater than the value of X indicated in table 8.

No cracks or breaks shall occur in the metal, elsewhere than in the weld, as long as the distance between plates is greater than the value of Y given in table 8.

For electric-welded pipe, evidence of laminations or burnt metal shall not develop during the entire test.

10.4.2 The specimens shall be tested as follows :

Grades E 21 and E 24 non-expanded steel pipe :

- single lengths :
 - one crop end, weld at 0°
 - one crop end, weld at 90°
(point of maximum bending)
- multiple lengths :
 - two crop ends, weld at 90°
 - two intermediate rings, weld at 0°

Grades E 21 and E 24 cold-expanded steel pipe :

101,6 mm ring cut from one end, weld at 90°

Grade E 17 steel pipe :

152,4 mm section, weld at 90°

10.4.3 For electric-welded pipe, the weld is considered to extend for a distance of 12,5 mm on either side of the fusion line.

10.5 Weld ductility test

10.5.1 For electric-welded pipe the weld ductility shall be determined by tests on full-section specimens of 51 mm minimum length. The specimens shall be flattened cold between parallel plates. The weld shall be placed 90° from the direction of applied force (point of maximum bending). No cracks or breaks exceeding 3 mm in any direction in the weld or the parent metal shall occur on the outside surface until the distance between plates is less than the value z calculated by the following formula :

$$z = \frac{3,07 a}{0,07 + 3 a/D}$$

where

z is the distance between flattening plates, in millimetres;

a is the specified wall thickness of the pipe, in millimetres;

D is the specified outside diameter of the pipe, in millimetres.

Cracks which originate at the edges of the specimen and which are less than 6 mm long shall not be cause for rejection. One test shall be made on a length of pipe from each lot of 400 lengths or less of each size 141,3 mm and smaller and from each lot of 200 lengths or less of each size 159 mm through 323,9 mm and from each lot of 100 lengths or less of each size 355,6 mm and larger. For multiple-length pipe, a length shall be considered as each section cut from a particular multiple length.

10.5.2 The weld ductility test may also serve as one of the flattening tests of 10.4.1, 10.4.2 and 10.4.3 by complying with the appropriate degree of flattening.

10.6 Guided-bend test

10.6.1 The test shall be performed in a jig in accordance with figure 2. A value for dimension *A* corresponds to any combination of diameter, thickness and grade. Table 9 gives the values of *A* for pipe sizes greater than or equal to 323,9 mm.

10.6.2 Specimens shall be taken at 90° to the weld with the weld at the centre as shown in figure 1.

10.6.3 For each lot, one face-bend and one root-bend specimen shall be bent approximately 180° in a jig.

These specimens shall not :

- fracture completely;
- reveal any cracks or ruptures in the weld metal greater than 3,2 mm in length, regardless of depth;
- reveal any cracks or ruptures in the parent metal, the heat-affected zone or the fusion line longer than 3,2 mm and deeper than 12,5 % of the specified thickness.

NOTE — Cracks which occur at the edges of the specimen and which are less than 6,3 mm long shall be neglected, regardless of depth.

10.6.4 If the rupture or crack in the specimen is caused by a defect or flaw, a new specimen shall be substituted for that specimen.

10.7 Retests

10.7.1 If a specimen representing a lot fails to conform to test requirements, the manufacturer may elect to make retests on specimens cut from two additional lengths from the same lot.

These specimens are to be taken in the same manner as the specimen which failed to meet the minimum requirements.

If these specimens conform to the specified requirements, all the lengths in the lot shall be accepted, except the length from which the initial defective specimen was taken.

If one of the retest specimens fails to conform to the specified requirements, the manufacturer may elect to individually test every length remaining in the lot. In this case, determinations shall be required only for the particular requirements with which the specimens failed to comply in the retests.

10.7.2 In case of unsatisfactory flattening tests on welded pipe in multiple lengths, the manufacturer may elect to make retests on each individual length, one end being tested with the weld at 0° and the other with the weld at 90°.

10.7.3 In case of unsatisfactory flattening tests on welded pipe in single lengths, the manufacturer may make retests on specimens cut from the same end of the length of pipe as the unsatisfactory specimen, until satisfactory results are obtained. However, the pipe shall not be shorter than 80 % of its length after the initial cropping.

Precautions shall be taken so that crop ends can be identified with respect to the length of pipe from which they were cut.

10.7.4 In case of unsatisfactory weld ductility tests, the manufacturer may elect to retest any length which has failed to conform to the test requirements, by cropping back and cutting two additional specimens from the same end. If the weld ductility test requirements are met by both of these additional tests, that length shall be acceptable. No further cropping and retesting is permitted.

10.8 Hydrostatic test

10.8.1 Each length shall withstand a hydrostatic test performed by the manufacturer.

The test pressure shall be held for not less than 5 s for seamless pipe and welded pipe in sizes 457,2 mm and smaller. It shall be held for not less than 10 s for welded pipe in sizes 508 mm and larger.

There shall be no leakage.

10.8.2 During the test, welded pipe shall be struck, with a hammer of mass approximately 1 kg, or its equivalent, near each weld at both ends of the pipe.

10.8.3 Except for butt-welded pipe, the testers shall be equipped with a recording gauge which records the test pressure and duration of time applied to each length of pipe or with some automatic interlocking device to prevent pipe from being classified as tested until the pressure and time requirements have been complied with. Such records or charts shall be available for examination at the mill by the purchaser's inspectors when the purchaser is so represented at the mill.

10.8.4 The pressure for each grade shall be as listed in table 14.

For grades E 21 and E 24 pipe, the hydrostatic test pressure *p* is computed using the following formula :

$$p = 2 \frac{Sa}{D}$$

where

p is the hydrostatic pressure, in megapascals;

a is the specified thickness, in millimetres;

D is the specified outside diameter, in millimetres;

S = 60 % of the minimum yield strength for the standard test, or = 75 % of the minimum yield strength for the alternative test.

TABLE 8 — Flattening test —
Distances between plates

	Distance between plates for grades	
	E 21 — E 24	E 17
X	$\frac{2}{3}D^*$	$\frac{3}{4}D$
Y	$\frac{1}{3}D$	60 % D

* D = outside diameter.

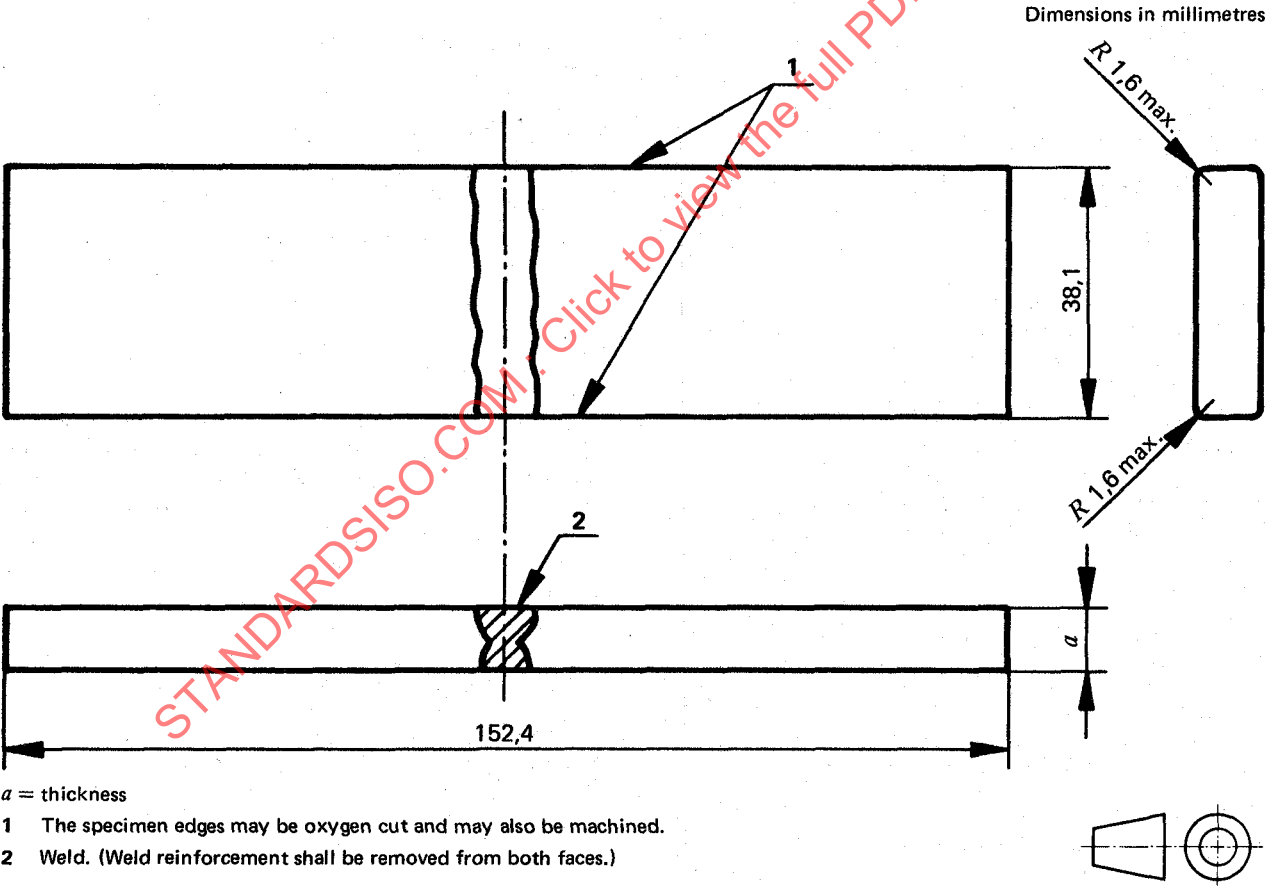
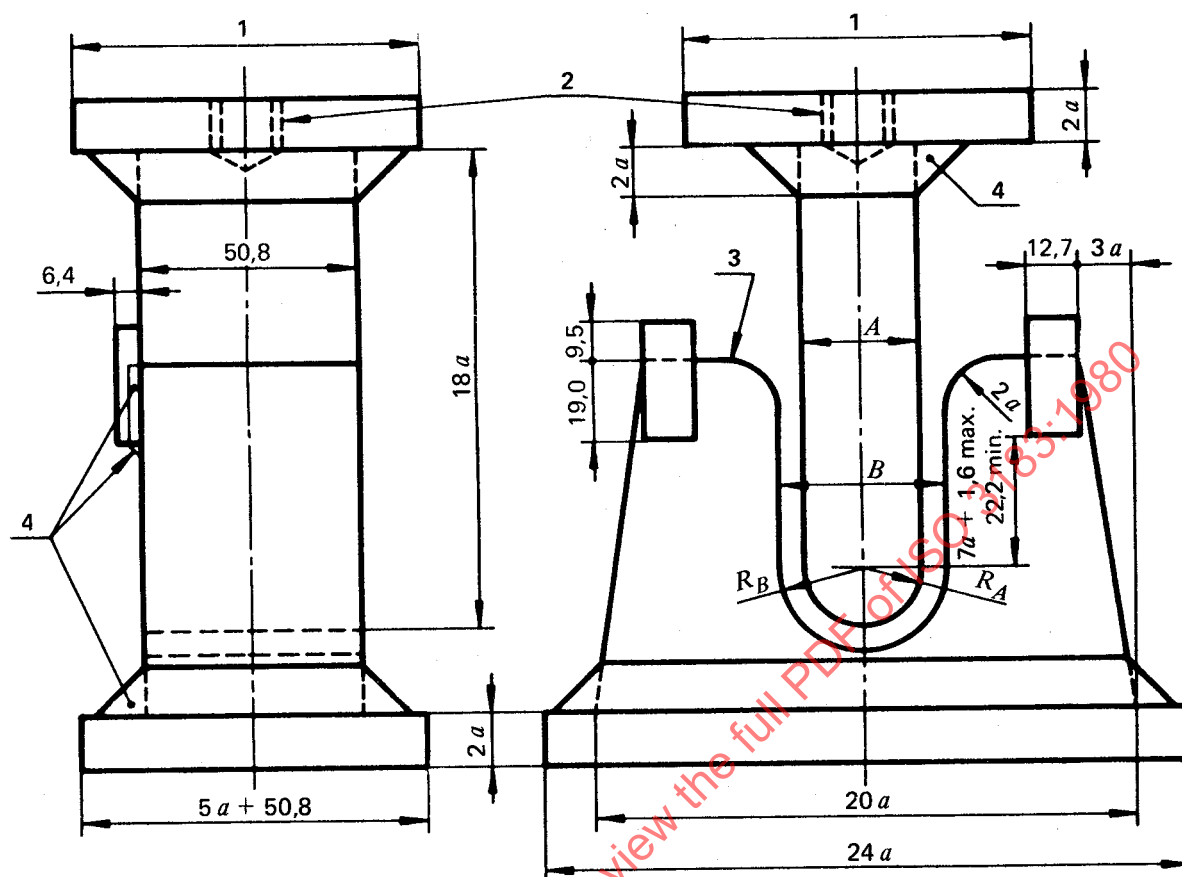
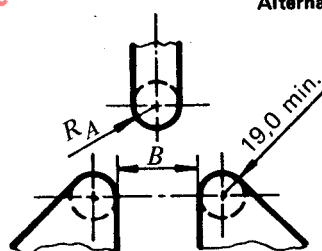


FIGURE 1 — Guided-bend test specimen (press-flattened curve specimen)

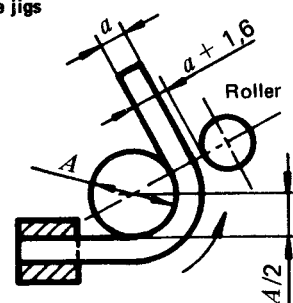
Dimensions in millimetres



Alternative jigs



Adjustable type



Wrap-around type

- 1 As required.
- 2 Tapped mounting hole.
- 3 Shoulders hardened and greased (hardened rollers may be substituted).
- 4 Weld.

$$A = \frac{1,15 \times 10^3 (D - 2a)}{e \frac{D}{a} - 2e - 1\,000} - a$$

where

- 1,15 = peaking factor;
 D = specified outside diameter, in millimetres;
 a = specified thickness, in millimetres;
 e = strain, in millimetres per metre;
 = 167,5 for grade E 21;
 = 137,5 for grade E 24;
 $R_A = A/2$;
 $B = A + 2a + 3,2 \text{ mm}$;
 $R_B = B/2$.

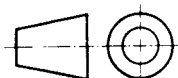


FIGURE 2 — Jig for guided-bend test

TABLE 9 — Jig dimensions for guided-bend test

Outside diameter <i>D</i>		Thickness <i>a</i>		Dimension <i>A</i>	
				Grade E 21	Grade E 24
mm	in	mm	in	mm	mm
323,9	12.75	4,0	0.160	25,7	32,8
		4,5	0.176	29,3	37,5
		4,8	0.192	31,5	40,4
		5,0	0.197	32,9	42,3
		5,6	0.219	37,5	48,3
		5,9	0.232	39,8	51,3
		6,3	0.250	42,9	55,5
		7,1	0.281	49,4	64,2
		8,0	0.312	57,0	74,5
		8,8	0.344	64,1	84,2
		9,5	0.375	70,6	93,2
		10,0	0.394	75,4	100,0
		11,0	0.438	85,5	114,2
		12,5	0.500	101,9	137,8
		14,2	0.562	122,5	168,4
		16,0	0.625	147,3	206,6
		17,5	0.688	170,8	244,2
		19,1	0.750	199,2	291,9
		20,0	0.787	217,0	323,1
		22,2	0.875	267,8	417,6
355,6	14	4,5	0.176	29,0	37,1
		4,8	0.192	31,1	39,9
		5,0	0.197	32,6	41,7
		5,6	0.219	37,0	47,5
		5,9	0.232	39,2	50,5
		6,3	0.250	42,3	54,5
		7,1	0.281	48,6	62,9
		8,0	0.312	55,9	72,7
		8,8	0.344	62,7	82,0
		9,5	0.375	68,9	90,5
		10,0	0.394	73,5	96,8
		11,0	0.438	83,0	110,0
		12,5	0.500	98,3	131,7
		14,2	0.562	117,4	159,3
		16,0	0.625	139,9	193,0
		17,5	0.688	159,3	222,9
		19,1	0.750	185,6	265,0
		20,0	0.787	200,9	290,3
		22,2	0.875	243,3	363,7
368	14.5	4,5	0.176	28,9	36,9
		4,8	0.192	31,0	39,7
		5,0	0.197	32,5	41,5
		5,6	0.219	36,8	47,3
		5,9	0.232	39,1	50,2
		6,3	0.250	42,1	54,2
		7,1	0.281	48,3	62,4
		8,0	0.312	55,5	72,2
		8,8	0.344	62,3	81,2
		9,5	0.375	68,4	89,6
		10,0	0.394	72,9	95,7
		11,0	0.438	82,2	108,7
		12,5	0.500	97,2	129,7
		14,2	0.562	115,7	156,5
		16,0	0.625	137,5	188,7
		17,5	0.688	157,6	219,4
		19,1	0.750	181,3	256,9
		20,0	0.787	195,9	280,6
		22,2	0.875	235,9	348,4

Outside diameter <i>D</i>		Thickness <i>a</i>		Dimension <i>A</i>	
				Grade E 21	Grade E 24
mm	in	mm	in	mm	mm
406,4	16	4,5	0.176	28,6	36,5
		4,8	0.192	30,7	39,2
		5,0	0.197	32,1	41,0
		5,6	0.219	36,4	46,6
		5,9	0.232	38,6	49,5
		6,3	0.250	41,5	53,3
		7,1	0.281	47,6	61,3
		8,0	0.312	54,6	70,6
		8,8	0.344	61,1	79,3
		9,5	0.375	66,9	87,2
		10,0	0.394	71,2	93,0
		11,0	0.438	80,1	105,2
		12,5	0.500	94,2	124,8
		14,2	0.562	111,5	149,2
		16,0	0.625	131,5	178,2
		17,5	0.688	149,7	205,2
		19,1	0.750	170,9	237,4
		20,0	0.787	183,7	257,4
		22,2	0.875	218,3	313,0
		25,0	1.000	270,3	401,8
419	16.5	4,8	0.192	30,6	39,1
		5,0	0.197	32,0	40,9
		5,6	0.219	36,3	46,4
		5,9	0.232	38,4	49,3
		6,3	0.250	41,4	53,1
		7,1	0.281	47,3	61,0
		8,0	0.312	54,3	70,2
		8,8	0.344	60,7	78,8
		9,5	0.375	66,5	86,5
		10,0	0.394	70,7	92,3
		11,0	0.438	79,5	104,2
		12,5	0.500	93,4	123,4
		14,2	0.562	110,3	147,3
		16,0	0.625	129,9	175,4
		17,5	0.688	147,6	201,4
		19,1	0.750	168,1	232,4
		20,0	0.787	180,5	251,5
		22,2	0.875	213,7	304,1
		25,0	1.000	263,2	387,2
457	18	4,8	0.192	30,4	38,7
		5,0	0.197	31,8	40,5
		5,6	0.219	36,0	45,9
		5,9	0.232	38,1	48,7
		6,3	0.250	41,0	52,4
		7,1	0.281	46,8	60,1
		8,0	0.312	53,6	69,1
		8,8	0.344	59,8	77,3
		9,5	0.375	65,4	84,8
		10,0	0.394	69,5	90,3
		11,0	0.438	78,0	101,7
		12,5	0.500	91,2	119,9
		14,2	0.562	107,3	142,3
		16,0	0.625	125,7	168,3
		17,5	0.688	142,2	192,1
		19,1	0.750	161,1	219,9
		20,0	0.787	172,4	236,9
		22,2	0.875	202,3	282,8
		25,0	1.000	246,0	352,9

TABLE 9 (continued)

Outside diameter <i>D</i>		Thickness <i>a</i>		Dimension <i>A</i>	
				Grade E 21	Grade E 24
mm	in	mm	in	mm	mm
508	20	5,6	0.219	35,6	45,4
		5,9	0.232	37,7	48,1
		6,3	0.250	40,5	51,8
		7,1	0.281	46,2	59,2
		8,0	0.312	52,8	67,9
		8,8	0.344	58,9	75,8
		9,5	0.375	64,3	83,0
		10,0	0.394	68,2	88,3
		11,0	0.438	76,3	99,1
		12,5	0.500	89,0	116,3
		14,2	0.562	104,2	137,2
		16,0	0.625	121,4	161,1
		17,5	0.688	136,7	182,7
		19,1	0.750	154,1	207,7
		20,0	0.787	164,3	222,7
		22,2	0.875	191,2	262,7
		25,0	1.000	229,6	321,7
559	22	5,6	0.219	35,3	45,0
		5,9	0.232	37,4	47,6
		6,3	0.250	40,2	51,2
		7,1	0.281	45,8	58,5
		8,0	0.312	52,2	66,9
		8,8	0.344	58,1	74,7
		9,5	0.375	63,4	81,6
		10,0	0.394	67,2	86,7
		11,0	0.438	75,0	97,1
		12,5	0.500	87,3	113,5
		14,2	0.562	101,8	133,3
		16,0	0.625	118,2	155,7
		17,5	0.688	132,6	175,8
		19,1	0.750	148,8	198,8
		20,0	0.787	158,3	212,4
		22,2	0.875	183,1	248,4
		25,0	1.000	217,9	300,3
610	24	5,9	0.232	37,1	47,3
		6,3	0.250	39,9	50,8
		7,1	0.281	45,4	57,9
		8,0	0.312	51,7	66,2
		8,8	0.344	57,5	73,7
		9,5	0.375	62,6	80,5
		10,0	0.394	66,4	85,4
		11,0	0.438	74,0	95,5
		12,5	0.500	85,9	111,3
		14,2	0.562	99,9	130,2
		16,0	0.625	115,6	151,5
		17,5	0.688	129,3	170,5
		19,1	0.750	144,7	191,9
		20,0	0.787	153,7	204,6
		22,2	0.875	176,9	237,6
		25,0	1.000	209,0	284,6
660	26	5,9	0.232	36,9	46,9
		6,3	0.250	39,6	50,4
		7,1	0.281	45,1	57,4
		8,0	0.312	51,3	65,6
		8,8	0.344	57,0	72,9
		9,5	0.375	62,1	79,6
		10,0	0.394	65,7	84,4
		11,0	0.438	73,2	94,2
		12,5	0.500	84,7	109,5
		14,2	0.562	98,4	127,8
		16,0	0.625	113,6	148,3
		17,5	0.688	126,8	166,3
		19,1	0.750	141,5	186,6
		20,0	0.787	150,1	198,5
		22,2	0.875	172,0	229,5
		25,0	1.000	202,2	272,9
711	28	6,3	0.250	39,4	50,1
		7,1	0.281	44,8	57,0
		8,0	0.312	51,0	65,0
		8,8	0.344	56,6	72,3
		9,5	0.375	61,5	78,8
		10,0	0.394	65,1	83,5
		11,0	0.438	72,5	93,1
		12,5	0.500	83,8	108,0
		14,2	0.562	97,1	125,7
		16,0	0.625	111,8	145,5
		17,5	0.688	124,6	162,8
		19,1	0.750	138,8	182,2
		20,0	0.787	147,0	193,6
		22,2	0.875	168,0	222,8
		25,0	1.000	196,7	263,4
762	30	6,3	0.250	39,2	49,8
		7,1	0.281	44,6	56,7
		8,0	0.312	50,7	64,6
		8,8	0.344	56,2	71,7
		9,5	0.375	61,1	78,1
		10,0	0.394	64,7	82,7
		11,0	0.438	71,9	92,2
		12,5	0.500	83,0	106,8
		14,2	0.562	96,0	124,0
		16,0	0.625	110,4	143,2
		17,5	0.688	122,8	159,9
		19,1	0.750	136,6	178,6
		20,0	0.787	144,5	189,5
		22,2	0.875	164,7	217,4
		25,0	1.000	192,2	255,8
813	32	6,3	0.250	39,1	49,6
		7,1	0.281	44,4	56,4
		8,0	0.312	50,4	64,2
		8,8	0.344	55,9	71,2
		9,5	0.375	60,7	77,5
		10,0	0.394	64,2	82,1
		11,0	0.438	71,4	91,4
		12,5	0.500	82,3	105,7
		14,2	0.562	95,1	122,6
		16,0	0.625	109,2	141,2
		17,5	0.688	121,3	157,5
		19,1	0.750	134,7	175,5
		20,0	0.787	142,4	186,0
		22,2	0.875	162,0	212,8
		25,0	1.000	188,4	249,5

TABLE 9 (concluded)

Outside diameter <i>D</i>		Thickness <i>a</i>		Dimension <i>A</i>	
				Grade E 21	Grade E 24
mm	in	mm	in	mm	mm
864	34	6,3	0.250	39,0	49,4
		7,1	0.281	44,2	56,1
		8,0	0.312	50,2	63,8
		8,8	0.344	55,6	70,8
		9,5	0.375	60,4	77,0
		10,0	0.394	63,9	81,5
		11,0	0.438	70,9	90,7
		12,5	0.500	81,7	104,7
		14,2	0.562	94,3	121,3
		16,0	0.625	108,1	139,6
		17,5	0.688	120,0	155,4
		19,1	0.750	133,0	173,0
		20,0	0.787	140,6	183,1
		22,2	0.875	159,6	209,0
		25,0	1.000	185,2	244,2
914	36	6,3	0.250	38,8	49,2
		7,1	0.281	44,1	55,9
		8,0	0.312	50,0	63,5
		8,8	0.344	55,4	70,5
		9,5	0.375	60,1	76,6
		10,0	0.394	63,6	81,0
		11,0	0.438	70,5	90,1
		12,5	0.500	81,2	104,0
		14,2	0.562	93,6	120,2
		16,0	0.625	107,2	138,2
		17,5	0.688	118,9	153,6
		19,1	0.750	131,7	170,8
		20,0	0.787	139,0	180,7
		22,2	0.875	157,6	205,8
		25,0	1.000	182,5	239,8
1 016	40	8,0	0.312	49,7	63,0
		8,8	0.344	55,0	69,8
		9,5	0.375	59,7	75,9
		10,0	0.394	63,0	80,2
		11,0	0.438	69,9	89,1
		12,5	0.500	80,3	102,6
		14,2	0.562	92,4	118,4
		16,0	0.625	105,7	135,8
		17,5	0.688	117,0	150,7
		19,1	0.750	129,3	167,1
		20,0	0.787	136,5	176,6
		22,2	0.875	154,3	200,5
		25,0	1.000	170,8	232,6
1 067	42	8,8	0.344	54,8	69,6
		9,5	0.375	59,5	75,6
		10,0	0.394	62,8	79,9
		11,0	0.438	69,6	88,6
		12,5	0.500	79,9	102,0
		14,2	0.562	92,0	117,7
		16,0	0.625	105,0	134,8
		17,5	0.688	116,2	149,5
		19,1	0.750	128,4	165,6
		20,0	0.787	135,4	174,9
		22,2	0.875	152,9	198,3
		25,0	1.000	176,2	229,6

Outside diameter <i>D</i>		Thickness <i>a</i>		Dimension <i>A</i>	
				Grade E 21	Grade E 24
mm	in	mm	in	mm	mm
1 118	44	8,8	0.344	54,6	69,3
		9,5	0.375	59,3	75,3
		10,0	0.394	62,6	79,6
		11,0	0.438	69,3	88,2
		12,5	0.500	79,6	101,5
		14,2	0.562	91,5	117,0
		16,0	0.625	104,4	133,9
		17,5	0.688	115,8	148,8
		19,1	0.750	127,5	164,2
		20,0	0.787	134,4	173,4
		22,2	0.875	151,7	196,3
		25,0	1.000	174,5	227,0
1 168	46	8,8	0.344	54,5	69,1
		9,5	0.375	59,1	75,0
		10,0	0.394	62,4	79,3
		11,0	0.438	69,1	87,9
		12,5	0.500	79,3	101,1
		14,2	0.562	91,1	116,4
		16,0	0.625	103,9	133,1
		17,5	0.688	114,9	147,4
		19,1	0.750	126,8	163,1
		20,0	0.787	133,6	172,1
		22,2	0.875	150,6	194,7
		25,0	1.000	173,1	224,7
1 220	48	8,8	0.344	54,4	68,9
		9,5	0.375	59,0	74,8
		10,0	0.394	62,3	79,0
		11,0	0.438	68,9	87,6
		12,5	0.500	79,0	100,7
		14,2	0.562	90,8	115,8
		16,0	0.625	103,5	132,3
		17,5	0.688	114,3	146,5
		19,1	0.750	126,0	161,9
		20,0	0.787	132,8	170,8
		22,2	0.875	149,6	193,0
		25,0	1.000	171,7	222,6
1 420	56	8,8	0.344	54,0	68,3
		9,5	0.375	58,5	74,1
		10,0	0.394	61,7	78,2
		11,0	0.438	68,2	86,6
		12,5	0.500	78,2	99,3
		14,2	0.562	89,6	114,1
		16,0	0.625	102,0	130,1
		17,5	0.688	113,5	143,8
		19,1	0.750	123,8	158,5
		20,0	0.787	130,3	167,0
		22,2	0.875	146,7	188,4
		25,0	1.000	167,6	216,0

10.8.5 Higher pressures and longer time durations may be used if so agreed when the order is placed.

NOTE — The values of p are limited to

172 bar for $D \leq 88,9$ mm and

193 bar for $D > 88,9$ mm

For grade E 17, the values of p have been established arbitrarily.

10.9 Non-destructive inspection

10.9.1 The weld seam of grades E 21 and E 24 pipe shall be inspected full length (100 %) as indicated below :

— Submerged-arc welded pipe shall be inspected by radiological methods full length or for a distance of 200 mm from each end if also inspected full length by ultrasonic methods.

— Electric-welded pipe shall be inspected by ultrasonic or electromagnetic methods.

The location of the equipment in the mill shall be at the discretion of the manufacturer; but that control shall be performed after expansion in the case of cold expanded pipe.

10.9.2 Radiological inspection

10.9.2.1 EQUIPMENT

The homogeneity of a weld may be examined by means of X-rays which are directed through the weld material onto a suitable radiographic film or onto a fluorescent screen. The film, after development, shall show the shadowgraph of the weld and visible discontinuities. The shadowgraph may be observed directly on a fluorescent screen or it may be reproduced on a television screen. X-ray equipment using either film, a fluorescent screen, or a television screen shall be used, provided adequate sensitivity can be obtained.

Radiological equipment and techniques shall be used which have a sensitivity of at least 4 % of the thickness of the parent metal as measured by a penetrometer as described in 10.7.2.2. Fluoroscopic inspection shall not be performed at a speed greater than that at which the penetrometer can be read definitively.

10.9.2.2 REFERENCE STANDARDS

An image quality indicator (I.Q.I.), conforming to ISO/R 1027 shall be chosen to demonstrate the proper sensitivity of the radiographic process used. The proper sensitivity shall be better than 2 % for ISO wire I.Q.I. or 4 % for ISO hole I.Q.I.

The I.Q.I. shall be used to check the sensitivity of the equipment on one pipe in every lot of 50 pipes when the fluoroscopic method is used full length, and on each film when film is used. When film is used full length, one I.Q.I. shall be used for each length of pipe. The I.Q.I. shall also be used to check the radiographic equipment after any disconnecting or if a substantial change occurs during process.

10.9.2.3 ACCEPTANCE LIMITS

Radiological examination is applicable for detecting imperfections in the weld such as cracks, lack of penetration, lack of fusion, slag inclusions, and gas pockets or voids. The acceptance limits for minor imperfections are specified hereafter :

The maximum size and distribution of slag-inclusion and/or gas-pocket discontinuities shall not exceed those shown in tables 10 and 11 and figures 3 and 4.

NOTE — Unless the discontinuities are elongated, it cannot be determined with assurance whether the radiological indications represent slag inclusions or gas pockets. Therefore, the same limits apply to all circular-type discontinuities.

The important factors to be considered in determining rejection or acceptance limits are size and spacing of discontinuities and the sum of the diameters in an established distance. For simplicity, the distance is established as any 152,4 mm length. Discontinuities of this type usually occur in an aligned pattern, but no distinction is made between aligned or scattered patterns. The discontinuities may also be of assorted sizes.

10.9.2.4 INJURIOUS DEFECTS

Cracks, lack of complete penetration, or lack of complete fusion, as indicated by radiological examination, shall be considered as injurious defects.

10.9.2.5 WELD REPAIR

Any weld rejected as a result of radiological examination may be repaired at the option of the manufacturer; repair by welding shall be carried out in accordance with 11.3 and the weld shall be re-examined radiologically.

10.9.3 Ultrasonic and electromagnetic inspection

10.9.3.1 EQUIPMENT

Any equipment utilizing the ultrasonic or electromagnetic principles and capable of continuous and uninterrupted inspection of the weld seam shall be used. The equipment shall be checked with an applicable reference standard as described in 10.9.3.2, at least once every working shift to demonstrate its effectiveness and the inspection procedures. The equipment shall be adjusted to produce well-defined indications when the reference standard is scanned by the inspection unit in a manner simulating the inspection of the product.

10.9.3.2 REFERENCE STANDARDS

Reference standards shall have the same nominal diameter and the same thickness as the product being inspected, and may be of any convenient length as determined by the manufacturer. Reference standards shall contain machined notches, one on the inside surface and one on the outside surface, or a drilled hole, as shown in figure 5, at the option of the manufacturer. The notches shall be parallel to the weld seam and shall be separated by a distance sufficient to produce two separate and distinguishable signals. The 1,6 mm or 3,2 mm hole shall be drilled through the wall

perpendicular to the surface of the reference standard, as shown in figure 5.

NOTE — The reference standards defined above are convenient standards for the calibration of non-destructive testing equipment. The dimensions of these standards should not be construed as the minimum size imperfection detectable by such equipment.

10.9.3.3 ACCEPTANCE LIMITS

Table 12 gives the height of acceptance limit signals as a percentage of the height of signals produced by reference standards.

An imperfection that produces a signal greater than the acceptance limit signal given in table 12 shall be investigated for compliance with the requirements of 7.2.1 to 7.2.7 and 11.1. Alternatively, indicated imperfections in submerged-arc welded pipe may be reinspected by radiological methods in accordance with 10.9.2.

10.9.3.4 WELD REPAIR

Injurious defects in the weld, found by ultrasonic or electromagnetic methods of inspection, may be ground or repaired by welding in accordance with 11.3 and re-examined non-destructively.

10.9.4 Re-inspection of pipe ends

For expanded welded pipe non-destructively inspected prior to cold expansion, the weld at each end of each length shall be non-destructively re-inspected subsequent to cold expansion for a distance of at least 153 mm by any of the methods specified in 10.9.1, or by the magnetic particle method in accordance with 10.9.5.

10.9.5 Magnetic particle inspection

10.9.5.1 EQUIPMENT

The equipment used for magnetic particle inspection of pipe ends shall produce a circular magnetic field, transverse to the weld, and of sufficient intensity to indicate weld area defects in the external surface of the pipe of the following character : open welds, partial or incomplete welds, intermittent welds, cracks, seams, and slivers.

10.9.5.2 REFERENCE STANDARD

If requested by the purchaser, arrangements shall be made by the manufacturer to perform a demonstration for the purchaser or his representative during production of his order. Such demonstration shall be made on the basis of pipe in process or sample lengths of similar pipe retained

by the manufacturer for the purpose and which exhibit natural or artificially produced defects of the character stated in 10.9.5.1.

10.9.5.3 ACCEPTANCE LIMITS

The manufacturer shall mark each magnetic particle indication and subsequently explore each indication with respect to depth of the imperfection.

Imperfections which require grinding or chipping to determine their depth shall be completely removed by grinding or by cutting off, or may be repaired by welding in accordance with 11.3 and re-examined non-destructively.

10.9.6 Fluoroscopic operator qualification

10.9.6.1 Operators of fluoroscopic equipment shall be trained, tested and certified by the pipe manufacturer. Details of such training, testing and certification programs shall be available to the purchaser.

Included in this program shall be :

- a) classroom instructions in the fundamentals of radiological inspection techniques;
- b) on-the-job training designed to familiarize the operator with specific installations including the appearance and interpretation of weld defects. The length of time for such training shall be sufficient to ensure adequate assimilation of the knowledge required for conducting the inspection;
- c) knowledge of appropriate requirements of this International Standard.

10.9.6.2 Upon completion of the above, an examination shall be given by the manufacturer to determine if the operator is qualified to properly perform fluoroscopic examinations.

10.9.6.3 At least once per year, the operator shall sustain a physical examination to determine his optical capability to perform the required inspection.

10.9.6.4 Certified operators whose work has not included fluoroscopic examination for a period of one year or more shall sustain again the examination according to 10.9.6.2 and the optical examination according to 10.9.6.3.

10.9.6.5 Substantial changes in procedure or equipment shall require recertification of the operators according to 10.9.6.1 to 10.9.6.3.

TABLE 10 — Elongated slag-inclusion-type discontinuities¹⁾

Maximum dimensions		Minimum separation		Maximum number in any 152,4 mm (6 in)
mm	in	mm	in	
1,6 × 12,7	1/16 × 1/2	152,4	6	1
1,6 × 6,4	1/16 × 1/4	76,2	3	2
1,6 × 3,2	1/16 × 1/8	50,8	2	3

1) The maximum accumulated length of discontinuities in any 152,4 mm (6 in) length shall not exceed 12,7 mm (1/2 in).

TABLE 11 — Circular slag-inclusion- and gas-pocket-type discontinuities¹⁾
(see figure 4)

Size		Adjacent size		Minimum separation		Maximum number in any 152,4 mm (6 in)
mm	in	mm	in	mm	in	
3,2*	1/8*	3,2*	1/8*	50,8	2	2
3,2*	1/8*	1,6	1/16	25,4	1	varies
3,2*	1/8*	0,8	1/32	12,7	1/2	varies
3,2*	1/8*	0,4	1/64	9,5	3/8	varies
1,6	1/16	1,6	1/16	12,7	1/2	4
1,6	1/16	0,8	1/32	9,5	3/8	varies
1,6	1/16	0,4	1/64	6,4	1/4	varies
0,8	1/32	0,8	1/32	6,4**	1/4**	8
0,8	1/32	0,4	1/64	4,8	3/16	varies
0,4	1/64	0,4	1/64	3,2	1/8	16

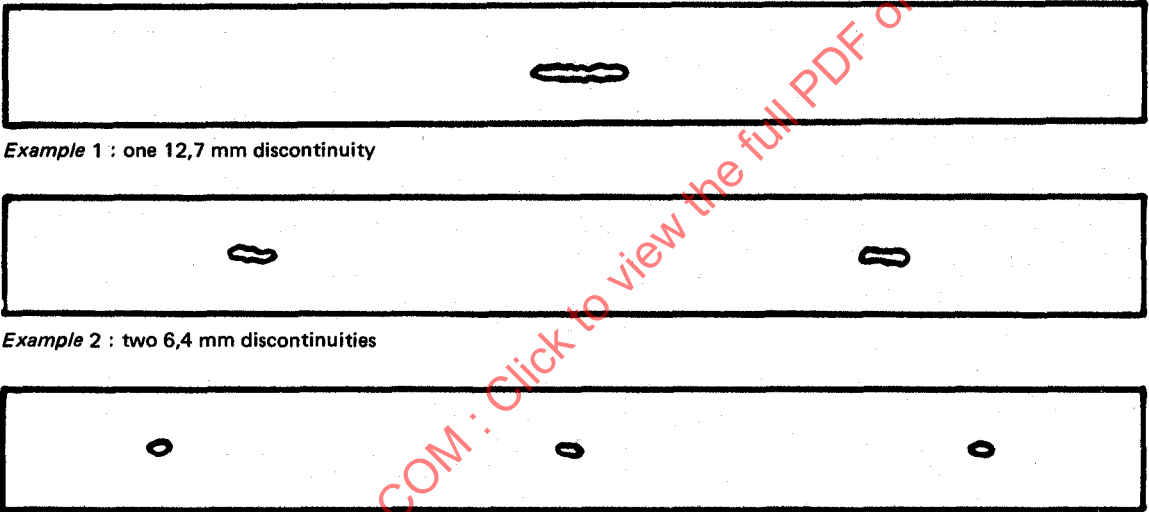
1) The sum of the diameters of all discontinuities in any 152,4 mm (6 in) shall not exceed 6,4 mm (1/4 in).

* The maximum size discontinuity for thicknesses of 6,4 mm (0.250 in) and less shall be 2,4 mm (3/32 in).

** Two discontinuities 0,8 mm (1/32 in) or smaller may be as close as one diameter apart, provided they are separated from any other discontinuity by at least 12,7 mm (1/2 in).

TABLE 12 — Acceptance limits

Type of weld	Type of notch (see figure 5)	Size of hole mm	Acceptance limit signal %
Submerged-arc	N 5	1,6	100
	All other	3,2	33 1/3
Electric-resistance, electric-flash and elec- tric induction	N 10, V 10	3,2	100
	B, P	—	80



Example 1 : one 12,7 mm discontinuity

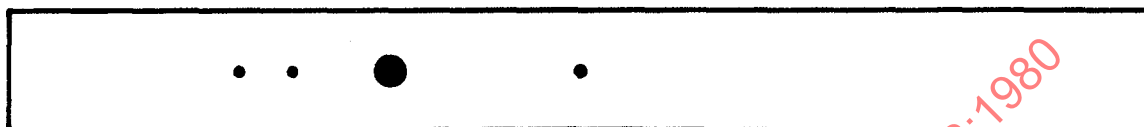
Example 2 : two 6,4 mm discontinuities

Example 3 : three 3,2 mm discontinuities

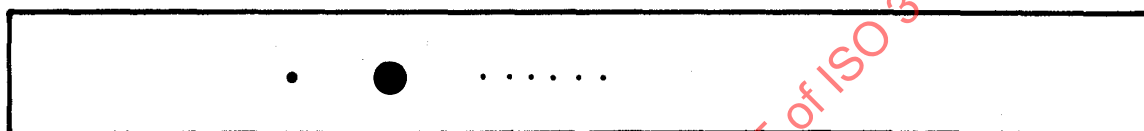
FIGURE 3 — Examples of maximum distribution patterns of indicated elongated slag-inclusion-type discontinuities



Example 1 : two 3,2 mm discontinuities



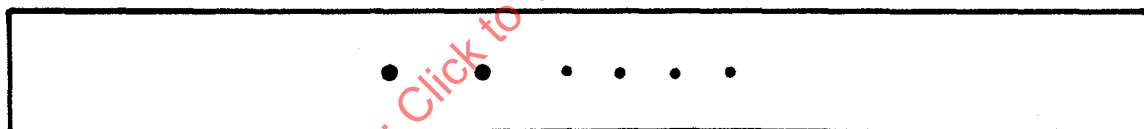
Example 2 : one 3,2 mm, one 1,6 mm, two 0,8 mm discontinuities



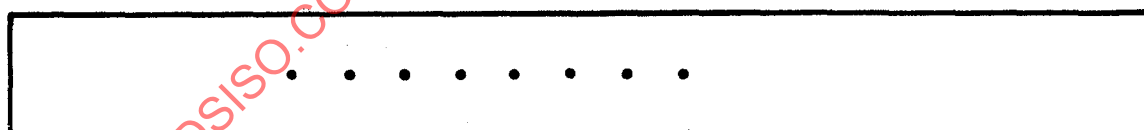
Example 3 : one 3,2 mm, one 0,8 mm, six 0,4 mm discontinuities



Example 4 : four 1,6 mm discontinuities



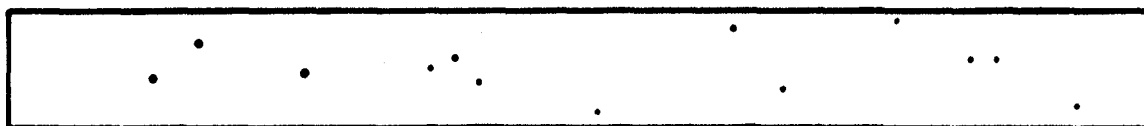
Example 5 : two 1,6 mm, four 0,8 mm discontinuities



Example 6 : eight 0,8 mm discontinuities



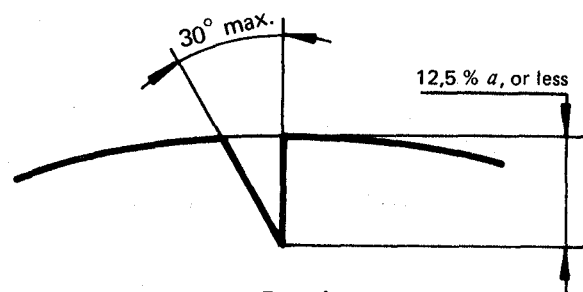
Example 7 : sixteen 0,4 mm discontinuities



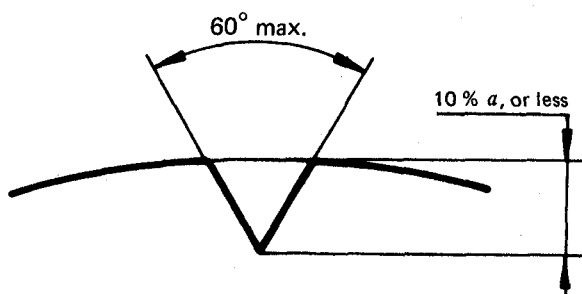
Example 8 : scattered, three 0,8 mm, ten 0,4 mm discontinuities

FIGURE 4 — Examples of maximum distribution patterns of indicated circular slag-inclusion- and gas-pocket-type discontinuities

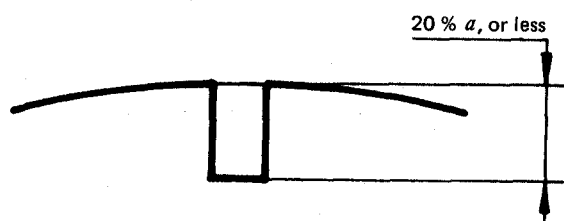
Dimensions in millimetres



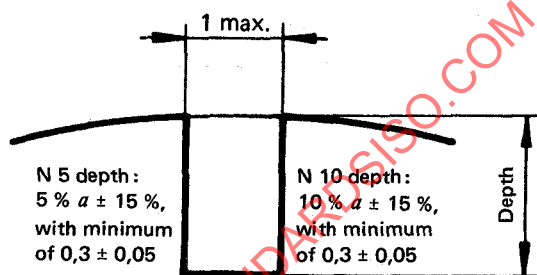
B notch



V 10 notch

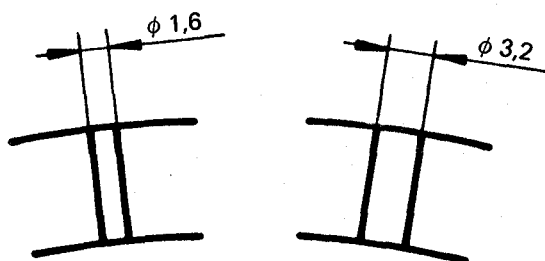
Area of each side : 3,87 mm² max.

P (parallel-sided) notch



Length :
for Eddy currents : 38 max.
for diverted flux and ultrasonic : 50 min,
at full depth

N 5 and N 10 notches



Drilled hole

FIGURE 5 — Reference standards (see 10.9.3.2)

11 VISUAL INSPECTION AND REPAIR OF DEFECTS

All finished pipe shall be visually examined. It shall be free of injurious defects as defined in 11.1.

Pipe containing such defects shall be rejected. However, in certain cases covered in 11.2, these injurious defects may be repaired by welding in accordance with the procedure defined in 11.3.

11.1 Injurious defects

11.1.1 Cracks, sweats and leaks

11.1.2 Laminations

Laminations extending into the face or bevel of the pipe and having a transverse dimension exceeding 6,3 mm shall be considered injurious defects. Pipe containing such defects shall be cut back until all such lamination is removed.

11.1.3 Arc burns

Arc burns, defined as localized points of surface melting caused by arcing between electrode or ground and pipe surface, shall be considered as injurious defects.

NOTE — Contact marks, defined as intermittent marks adjacent to the weld line, resulting from the electrical contact between the electrodes supplying the welding current and the pipe surface, are not injurious defects.

11.1.4 Other defects

Any imperfection having a depth greater than 12,5 % of the specified thickness, measured from the surface of the pipe.

Such defects may :

- be removed by grinding, provided the remaining wall thickness is within specified limits;
- be repaired in accordance with 11.2 and 11.3;
- be cut off within the limits of requirements on length.

11.1.5 Undercuts

Undercutting on submerged-arc welded pipe is the reduction in thickness of the pipe wall adjacent to the weld where it is fused to the surface of the pipe.

Undercuts more than 0,8 mm in depth are considered to be injurious.

Undercuts longer than one-half the specified thickness of the pipe and 0,4 to 0,8 mm in depth but not exceeding 12,5 % of the specified thickness shall be removed by grinding.

11.2 Repair of injurious defects

11.2.1 Seamless pipe and parent metal of welded pipe

Repair is permissible, except in the following cases :

- a) depth of defect exceeds 33,3 % of the specified thickness of the pipe;
- b) depth exceeds 12,5 % of the specified thickness :
 - on a length greater than 25 % of the specified outside diameter of the pipe;
 - more than one repair required in any length equivalent to 10 times the specified outside diameter.

11.2.2 Weld seam

The weld seam of electric resistance welded and induction welded pipe shall only be repaired with the agreement of the purchaser.

Welds by other procedures shall be repaired at the option of the manufacturer.

11.3 Procedure for repairs of injurious defects

11.3.1 Repair of the weld seam of electric-resistance-welded and induction-welded pipe

The repair procedure shall conform to the following requirements and shall meet the approval of the purchaser's representative.

It shall include the entire weld zone defined as extending up to 12,7 mm on either side of the fusion line.

- a) complete removal of the defect by chipping or grinding and thorough cleaning of the cavity;
- b) minimum length of the repair weld : 50,8 mm;
- c) minimum distance between individual repairs : 3 m;
- d) manual or semi-automatic submerged-arc welding, inert-gas metal-arc welding, or manual metal-arc welding using low hydrogen electrodes;
- e) minimum metal temperature in the area to be repaired : 10 °C;
- f) welding procedure and performance qualified in accordance with annex B;
- g) when a repair weld is made through the full thickness, it shall include weld passes made from both the outside diameter and the internal diameter of the pipe;
- h) the starts and stops of outside diameter and internal diameter repair welds shall not coincide;
- i) repair weld ground to merge smoothly into the original contour of the pipe; maximum crown : 1,5 mm;
- j) repair welds inspected either by ultrasonic methods in accordance with 10.9.3 or by radiological methods in accordance with 10.9.2, at the manufacturer's option;

- k) each repaired pipe shall be hydrostatically tested, after repair, in accordance with 10.8.

11.3.2 Other repairs

The repair procedure for defects not covered by 11.3.1 shall conform to the following requirements and shall meet the approval of the purchaser's representative.

- l) complete removal of the defect and thorough cleaning of the cavity;
- m) manual, semi-automatic or automatic submerged-arc welding, inert-gas welding, or manual or semi-automatic metallic-arc welding using coated electrodes;
- n) repair procedure and performance qualified in accordance with annex B, except in the case of automatic submerged-arc welding;
- o) each length hydrostatically tested after repair in accordance with 10.9.

12 RIGHTS TO INSPECTION

When the inspector representing the purchaser inspects the pipe, this procedure is governed by the provisions of clause 5 of ISO/R 404.

Pipe which shows injurious defects on inspection or which proves defective in use shall be rejected and the manufacturer so notified. He shall be able to verify the merits of the claim.

If destructive tests are made other than at the place of manufacture, the purchaser shall pay for that material which conforms to this International Standard but shall not pay for any material which fails to meet the specification.

13 DESIGNATION

Pipe manufactured to this International Standard shall be designated by :

- a) its type;
- b) its size (outside diameter), in millimetres;
- c) its thickness, in millimetres, or its mass per unit length, in kilograms per metre;
- d) its grade and class;
- e) its range length;
- f) its process of manufacture;
- g) its reference to ISO 3183.

Example :

Line pipe 406,4 × 9,5, E 24, single random lengths, seamless, to ISO 3183.

14 REPORTS

Test reports may be requested by the purchaser. They shall conform to clause 4 of ISO/R 404.

15 MARKING

15.1 Pipe manufactured in accordance with this International Standard shall be marked in the sequence indicated in 15.3.

15.2 The marking shall be paint stencilled on the outside surface starting at a point approximately 300 mm from one end. However, if so agreed when the order is placed, all or part of the sequence may be placed on the inside surface of the pipe. Additional paint markings as desired by the manufacturer or as requested by the purchaser are not prohibited.

15.3 Marking sequence

- a) Manufacturer's name or mark.
- b) ISO monogram, or reference to this International Standard.
- c) Size (outside diameter) in millimetres.
- d) Mass, in kilograms per metre (for sizes 114,3 mm and larger).
- e) Grade (E 17, E 21, E 24).
- f) Process of manufacture :
 - 1) Seamless : S
 - 2) Electric-welded : E
 - 3) Submerged-arc-welded : I
 - 4) Butt-welded : F
- g) Type of steel :
 - 1) Electric-furnace steel : E
 - 2) Rephosphorized steel E 17-2 : R

NOTE — No marking is provided for open-hearth or basic-oxygen steel.

- h) Heat treatment (where applicable) :
 - 1) Normalized or normalized and tempered : HN

2) Subcritical stress-relieved : HS

3) Subcritical age-hardened : HA

i) Hydrostatic test pressure (shall be indicated if it is higher than that given in table 14).

j) Supplementary requirements :

Seamless pipe non-destructively inspected : CND

15.4 Optional marking

If so agreed when placing the order, the length in metres and centimetres shall be paint stencilled on the outside surface at least 60 cm from the end or, if so agreed between the purchaser and the manufacturer, at a suitable place on the inside surface.

15.5 Die stamping

If he so elects, the manufacturer may die stamp the pipe or plate.

Hot die stamping is permissible in every case. Unless otherwise agreed when placing the order, cold die stamping is prohibited for grades E 21 and E 24 pipe or plate not subsequently heat treated and all pipe with thickness of 4 mm and less. When permitted, cold die stamping shall be done with rounded or blunt dies.

For welded pipe, with the exception of butt-welded pipe, the die stamping shall be at least 25 mm from the weld.

16 SURFACE PROTECTION

Unless otherwise ordered, pipe shall be given a mill coating to protect it from rusting in transit.

If bare pipe or specially coated pipe is desired by the purchaser, he shall indicate this on the purchase order.

For special coatings, the purchase order shall indicate whether the coating is to be applied to the full length or whether a certain specified distance from the ends is to be left uncoated.

Unless otherwise specified, such bare ends shall be given a coating of oil for protection in transit.

TABLE 13 — Choice of thicknesses

Dimensions in millimetres

Diameter	Thickness																		
	1,6	1,8	2,0	2,3	2,6	2,9	3,2	3,6	4,0	4,5	4,8	5,0	5,6	5,9	6,3	7,1	8,0	8,8	9,5
60,3						x													
73																			
76,1						x													
88,9							x												
101,6								x											
114,3									x										
141,3																			
159										x									
168,3										x									
193,7																			
219,1																			
273,0																			
323,9																			
355,6																			
368																			
406,4																			
419																			
457																			
508																			
559																			
610																			
660																			
711																			
762																			
813																			
864																			
914																			
1 016																			
1 067																			
1 118																			
1 168																			
1 220																			
1 420																			

NOTE — If so agreed when placing the order, pipe may be furnished with thicknesses between those appearing in the table.

TABLE 14 — Dimensions, masses and test pressures

Outside diameter	Thickness	Mass per unit length	Inside diameter	Test pressure				
				Grade				
				E 21		E 24		E 17
				Standard test	Alternative test	Standard test	Alternative test	
mm	mm	kg/m	mm	MPa				
60,3	2,3	3,29	55,7	9,5	11,8	11,0	13,8	4,1
	2,6	3,70	55,1	10,7	13,4	12,5	15,6	4,1
	2,9	4,10	54,5	11,9	14,9	13,9	17,2	5,5
	3,2	4,51	53,9	13,2	16,5	15,3	17,2	6,9
	3,6	5,03	53,1	14,8	17,2	17,2	17,2	6,9
	4,0	5,55	52,3	16,5	17,2	17,2	17,2	6,9
	4,5	6,19	51,3	17,2	17,2	17,2	17,2	7,6
	4,8	6,57	50,7	17,2	17,2	17,2	17,2	8,3
	5,0	6,82	50,3	17,2	17,2	17,2	17,2	8,3
	5,6	7,55	49,1	17,2	17,2	17,2	17,2	9,0
	5,9	7,91	48,5	17,2	17,2	17,2	17,2	9,0
	6,3	8,39	47,7	17,2	17,2	17,2	17,2	9,6
	7,1	9,31	46,1	17,2	17,2	17,2	17,2	9,6
	8,0	10,3	44,3	17,2	17,2	17,2	17,2	9,6
	8,8	11,2	42,7	17,2	17,2	17,2	17,2	9,6
	9,5	11,9	41,3	17,2	17,2	17,2	17,2	9,6
	10,0	12,4	40,3	17,2	17,2	17,2	17,2	9,6
73	2,3	4,01	68,4	7,8	9,8	9,1	11,4	4,1
	2,6	4,51	67,8	8,8	11,1	10,3	12,9	5,0
	2,9	5,01	67,2	9,9	12,3	11,5	14,4	5,5
	3,2	5,51	66,6	10,9	13,6	12,7	15,8	6,9
	3,6	6,16	65,8	12,2	15,3	14,3	17,2	6,9
	4,0	6,81	65,0	13,6	17,0	15,8	17,2	6,9
	4,5	7,60	64,0	15,3	17,2	17,2	17,2	6,9
	4,8	8,07	63,4	16,3	17,2	17,2	17,2	6,9
	5,0	8,38	63,0	17,0	17,2	17,2	17,2	6,9
	5,6	9,31	61,8	17,2	17,2	17,2	17,2	7,6
	5,9	9,76	61,2	17,2	17,2	17,2	17,2	7,6
	6,3	10,4	60,4	17,2	17,2	17,2	17,2	8,3
	7,1	11,5	58,8	17,2	17,2	17,2	17,2	9,0
	8,0	12,8	57,0	17,2	17,2	17,2	17,2	9,0
	8,8	13,9	55,4	17,2	17,2	17,2	17,2	9,0
	9,5	14,9	54,0	17,2	17,2	17,2	17,2	9,0
	10,0	15,5	53,0	17,2	17,2	17,2	17,2	9,0
	11,0	16,8	51,0	17,2	17,2	17,2	17,2	9,0
	12,5	18,6	48,0	17,2	17,2	17,2	17,2	9,0
	14,2	20,6	44,6	17,2	17,2	17,2	17,2	9,6
76,1	2,3	4,19	71,5	7,5	9,4	8,7	10,9	4,8
	2,6	4,71	70,9	8,5	10,6	9,9	12,4	5,6
	2,9	5,23	70,3	9,5	11,8	11,0	13,8	6,4
76,1	3,2	5,75	69,7	10,4	13,1	12,2	15,2	8,0
	3,6	6,44	68,9	11,8	14,7	13,7	17,1	8,0
	4,0	7,11	68,1	13,1	16,3	15,2	17,2	8,0
	4,5	7,95	67,1	14,7	17,2	17,1	17,2	8,0
	4,8	8,44	66,5	15,7	17,2	17,2	17,2	8,0
	5,0	8,77	66,1	16,3	17,2	17,2	17,2	8,0
	5,6	9,74	64,9	17,2	17,2	17,2	17,2	8,0
	5,9	10,2	64,3	17,2	17,2	17,2	17,2	
	6,3	10,8	63,5	17,2	17,2	17,2	17,2	
	7,1	12,1	61,9	17,2	17,2	17,2	17,2	
	8,0	13,4	60,1	17,2	17,2	17,2	17,2	10,5
	8,8	14,6	58,5	17,2	17,2	17,2	17,2	
	9,5	15,6	57,1	17,2	17,2	17,2	17,2	
	10,0	16,3	56,1	17,2	17,2	17,2	17,2	
	11,0	17,7	54,1	17,2	17,2	17,2	17,2	
	12,5	19,6	51,1	17,2	17,2	17,2	17,2	
	14,2	21,7	47,7	17,2	17,2	17,2	17,2	
88,9	2,3*	4,91	84,3	6,4	8,0	7,5	9,4	4,1
	2,6*	5,53	83,7	7,3	9,1	8,5	10,6	4,1
	2,9*	6,15	83,1	8,1	10,1	9,4	11,8	5,5
	3,2*	6,76	82,5	8,9	11,2	10,4	13,0	6,9
	3,6*	7,57	81,7	10,1	12,6	11,7	14,6	6,9
	4,0*	8,37	80,9	11,2	14,0	13,0	16,3	6,9
	4,5	9,37	79,9	12,6	15,7	14,6	17,2	6,9
	4,8	9,95	79,3	13,4	16,8	15,6	17,2	6,9
	5,0	10,3	78,9	14,0	17,2	16,3	17,2	6,9
	5,6	11,5	77,7	15,6	17,2	17,2	17,2	6,9
	5,9	12,1	77,1	16,5	17,2	17,2	17,2	
	6,3	12,8	76,3	17,2	17,2	17,2	17,2	
	7,1	14,3	74,7	17,2	17,2	17,2	17,2	
	8,0	16,0	72,9	17,2	17,2	17,2	17,2	9,0
	8,8	17,4	71,3	17,2	17,2	17,2	17,2	
	9,5	18,6	69,9	17,2	17,2	17,2	17,2	
	10,0	19,5	68,9	17,2	17,2	17,2	17,2	
	11,0	21,1	66,9	17,2	17,2	17,2	17,2	
	12,5	23,6	63,9	17,2	17,2	17,2	17,2	
	14,2	26,2	60,5	17,2	17,2	17,2	17,2	
101,6	2,3*	5,63	97,0	5,6	7,0	6,5	8,2	3,1
	2,6*	6,35	96,4	6,4	7,9	7,4	9,3	3,6
	2,9*	7,06	95,8	7,1	8,9	8,3	10,3	4,1

* See 8.5.3.

TABLE 14. (continued)

Outside diameter	Thickness	Mass per unit length	Inside diameter	Test pressure				
				Grade				
				E 21		E 24		E 17
				Standard test	Alternative test	Standard test	Alternative test	
mm	mm	kg/m	mm	MPa				
101,6	3,2*	7,76	95,2	7,8	9,8	9,1	11,4	4,8
	3,6*	8,70	94,4	8,8	11,0	10,2	12,8	5,5
	4,0*	9,63	93,6	9,8	12,2	11,4	14,2	6,1
	4,5*	10,8	92,6	11,0	13,8	12,8	16,0	6,9
	4,8*	11,5	92,0	11,7	14,7	13,7	17,1	8,3
	5,0*	11,9	91,6	12,2	15,3	14,2	17,8	8,3
	5,6*	13,3	90,4	13,7	17,1	15,9	19,3	8,3
	5,9*	13,9	89,8	14,4	18,0	16,8	19,3	8,3
	6,3*	14,8	89,0	15,4	19,3	17,9	19,3	8,3
	7,1*	16,5	87,4	17,4	19,3	19,3	19,3	8,3
	8,0	18,5	85,6	19,3	19,3	19,3	19,3	11,7
	8,8	20,1	84,0	19,3	19,3	19,3	19,3	
	9,5	21,6	82,6	19,3	19,3	19,3	19,3	
	10,0	22,6	81,6	19,3	19,3	19,3	19,3	
	11,0	24,6	79,6	19,3	19,3	19,3	19,3	
	12,5	27,5	76,6	19,3	19,3	19,3	19,3	
	14,2	30,6	73,2	19,3	19,3	19,3	19,3	
114,3	2,3*	6,35	109,7	5,0	6,2	5,8	7,3	4,1
	2,6*	7,16	109,1	5,7	7,1	6,6	8,2	4,5
	2,9*	7,97	108,5	6,3	7,9	7,3	9,2	5,0
	3,2*	8,77	107,9	7,0	8,7	8,1	10,1	5,5
	3,6*	9,83	107,1	7,8	9,8	9,1	11,4	6,2
	4,0*	10,9	106,3	8,7	10,9	10,1	12,7	6,9
	4,5	12,2	105,3	9,8	12,2	11,4	14,2	7,8
	4,8	13,0	104,7	10,4	13,0	12,1	15,2	8,3
	5,0	13,5	104,3	10,9	13,6	12,7	15,8	8,3
	5,6	15,0	103,1	12,2	15,2	14,2	17,7	8,3
	5,9	15,8	102,5	12,8	16,0	14,9	18,7	8,3
	6,3	16,8	101,7	13,7	17,1	15,9	19,3	8,3
	7,1	18,8	100,1	15,4	19,3	18,0	19,3	9,3
	8,0	21,0	98,3	17,4	19,3	19,3	19,3	
	8,8	22,9	96,7	19,1	19,3	19,3	19,3	11,7
	9,5	24,6	95,3	19,3	19,3	19,3	19,3	
	10,0	25,7	94,3	19,3	19,3	19,3	19,3	
	11,0	28,0	92,3	19,3	19,3	19,3	19,3	
	12,5	31,4	89,3	19,3	19,3	19,3	19,3	
	14,2	35,1	85,9	19,3	19,3	19,3	19,3	
	16,0	38,8	82,3	19,3	19,3	19,3	19,3	
	17,5	41,8	79,3	19,3	19,3	19,3	19,3	
141,3	2,3*	7,88	136,7	4,0	5,1	4,7	5,9	
	2,6*	8,89	136,1	4,6	5,7	5,3	6,7	
	2,9*	9,90	135,5	5,1	6,4	5,9	7,4	
	3,2*	10,9	134,9	5,6	7,0	6,5	8,2	
	3,6*	12,2	134,1	6,3	7,9	7,4	9,2	
	4,0*	13,5	133,3	7,0	8,8	8,2	10,2	
	4,5*	15,2	132,3	7,9	9,9	9,2	11,5	
	4,8*	16,2	131,7	8,4	10,5	9,8	12,3	
	5,0*	16,8	131,3	8,8	11,0	10,2	12,8	
	5,6*	18,7	130,1	9,8	12,3	11,5	14,3	
	5,9*	19,7	129,5	10,4	13,0	12,1	15,1	
	6,3*	21,0	128,7	11,1	13,8	12,9	16,1	
	7,1*	23,5	127,1	12,5	15,6	14,5	18,2	
	8,0*	26,3	125,3	14,1	17,6	16,4	19,3	
	8,8*	28,8	123,7	15,5	19,3	18,0	19,3	
	9,5	30,9	122,3	16,7	19,3	19,3	19,3	
	10,0	32,4	121,3	17,6	19,3	19,3	19,3	
159	11,0	35,3	119,3	19,3	19,3	19,3	19,3	
	12,5*	39,7	116,3	19,3	19,3	19,3	19,3	
	14,2	44,5	112,9	19,3	19,3	19,3	19,3	
	16,0*	49,4	109,3	19,3	19,3	19,3	19,3	
	17,5	53,4	106,3	19,3	19,3	19,3	19,3	
	19,1	57,6	103,1	19,3	19,3	19,3	19,3	
	2,9*	11,2	153,2	4,5	5,7	5,3	6,6	
	3,2*	12,3	152,6	5,0	6,2	5,8	7,3	
	3,6*	13,8	151,8	5,6	7,0	6,5	8,2	
	4,0*	15,3	151,0	6,2	7,8	7,3	9,1	
	4,5	17,1	150,0	7,0	8,8	8,2	10,2	
	4,8	18,3	149,4	7,5	9,4	8,7	10,9	
	5,0	19,0	149,0	7,8	9,8	9,1	11,4	
	5,6	21,2	147,8	8,7	10,9	10,2	12,7	
	5,9	22,3	147,2	9,2	11,5	10,7	13,4	
	6,3	23,7	146,4	9,8	12,3	11,5	14,3	
	7,1	26,6	144,8	11,1	13,9	12,9	16,1	
	8,0	29,8	143,0	12,5	15,6	14,6	18,2	
	8,8	32,6	141,4	13,7	17,2	16,0	19,3	
	9,5	35,0	140,0	14,8	18,6	17,3	19,3	
	10,0	36,7	139,0	15,6	19,3	18,2	19,3	
	11,0	40,1	137,0	17,2	19,3	19,3	19,3	
	12,5	45,2	134,0	19,3	19,3	19,3	19,3	
	14,2	50,7	130,6	19,3	19,3	19,3	19,3	

* See 8.5.3.

TABLE 14 (continued)

Outside diameter	Thickness	Mass per unit length	Inside diameter	Test pressure					
				Grade					
				E 21		E 24		E 17	
				Standard test	Alternative test	Standard test	Alternative test		
mm	mm	kg/m	mm	MPa					
159	16,0	56,4	127,0	19,3	19,3	19,3	19,3		
	17,5	61,1	124,0	19,3	19,3	19,3	19,3		
	19,1	65,9	120,8	19,3	19,3	19,3	19,3		
168,3	2,9*	11,8	162,5	4,3	5,4	5,0	6,2		
	3,2*	13,0	161,9	4,7	5,9	5,5	6,9		
	3,6*	14,6	161,1	5,3	6,6	6,2	7,7		
	4,0*	16,2	160,3	5,9	7,4	6,9	8,6		
	4,5	18,2	159,3	6,6	8,3	7,7	9,7		
	4,8	19,4	158,7	7,1	8,9	8,2	10,3		
	5,0	20,1	158,3	7,4	9,2	8,6	10,7		
	5,6	22,5	157,1	8,3	10,3	9,6	12,0		
	5,9	23,6	156,5	8,7	10,9	10,1	12,7		
	6,3	25,2	155,7	9,3	11,6	10,8	13,5		
	7,1	28,2	154,1	10,5	13,1	12,2	15,3		
	8,0	31,6	152,3	11,8	14,8	13,7	17,2		
	8,8	34,6	150,7	13,0	16,2	15,1	18,9		
	9,5	37,2	149,3	14,0	17,5	16,3	19,3		
	10,0	39,0	148,3	14,8	18,4	17,2	19,3		
	11,0	42,7	146,3	16,2	19,3	18,9	19,3		
	12,5	48,0	143,3	18,4	19,3	19,3	19,3		
	14,2	54,0	139,9	19,3	19,3	19,3	19,3		
	16,0	60,1	136,3	19,3	19,3	19,3	19,3		
	17,5	65,1	133,3	19,3	19,3	19,3	19,3		
	19,1	70,3	130,1	19,3	19,3	19,3	19,3		
	20,0	73,1	128,3	19,3	19,3	19,3	19,3		
	22,2	80,0	124,9	19,3	19,3	19,3	19,3		
193,7	2,9*	13,6	187,9	3,7	4,6	4,3	5,4		
	3,2*	15,0	187,3	4,1	5,1	4,8	6,0		
	3,6*	16,9	186,5	4,6	5,8	5,4	6,7		
	4,0*	18,7	185,7	5,1	6,4	6,0	7,5		
	4,5	21,0	184,7	5,8	7,2	6,7	8,4		
	4,8	22,3	184,1	6,2	7,7	7,2	9,0		
	5,0	23,2	183,7	6,4	8,0	7,5	9,3		
	5,6	26,0	182,5	7,2	9,0	8,4	10,5		
	5,9	27,3	181,9	7,6	9,5	8,8	11,0		
	6,3	29,1	181,1	8,1	10,1	9,4	11,8		
	7,1	32,6	179,5	9,1	11,4	10,6	13,3		
	8,0	36,6	177,7	10,3	12,8	11,9	14,9		
	8,8	40,1	176,1	11,3	14,1	13,1	16,4		
	9,5	43,1	174,7	12,2	15,2	14,2	17,7		

Outside diameter	Thickness	Mass per unit length	Inside diameter	Test pressure					
				Grade					
				E 21		E 24		E 17	
				Standard test	Alternative test	Standard test	Alternative test		
mm	mm	kg/m	mm	MPa					
193,7	10,0	45,3	173,7	12,8	16,0	14,9	18,7		
	11,0	49,5	171,7	14,1	17,6	16,4	19,3		
	12,5	55,8	168,7	16,0	19,3	18,7	19,3		
	14,2	62,8	165,3	18,2	19,3	19,3	19,3		
	16,0	70,0	161,7	19,3	19,3	19,3	19,3		
	17,5	75,9	158,7	19,3	19,3	19,3	19,3		
	19,1	81,9	155,5	19,3	19,3	19,3	19,3		
	20,0	85,7	153,7	19,3	19,3	19,3	19,3		
	22,2	93,9	149,3	19,3	19,3	19,3	19,3		
219,1	3,2*	17,0	212,7	3,6	4,5	4,2	5,3		
	3,6*	19,1	211,9	4,1	5,1	4,8	5,9		
	4,0*	21,2	211,1	4,5	5,7	5,3	6,6		
	4,5	23,8	210,1	5,1	6,4	5,9	7,4		
	4,8	25,4	209,5	5,4	6,8	6,3	7,9		
	5,0	26,4	209,1	5,7	7,1	6,6	8,2		
	5,6	29,5	207,9	6,3	7,9	7,4	9,2		
	5,9	31,0	207,3	6,7	8,4	7,8	9,7		
	6,3	33,1	206,5	7,1	8,9	8,3	10,4		
	7,1	37,1	204,9	8,0	10,1	9,4	11,7		
	8,0	41,6	203,1	9,1	11,3	10,6	13,2		
	8,8	45,6	201,5	10,0	12,5	11,6	14,5		
	9,5	49,1	200,1	10,8	13,5	12,5	15,7		
	10,0	51,6	199,1	11,3	14,2	13,2	16,5		
	11,0	56,4	197,1	12,5	15,6	14,5	18,1		
	12,5	63,7	194,1	14,2	17,7	16,5	19,3		
	14,2	71,8	190,7	16,1	19,3	18,7	19,3		
	16,0	80,1	187,1	18,1	19,3	19,3	19,3		
	17,5	87,0	184,1	19,3	19,3	19,3	19,3		
	19,1	94,2	180,9	19,3	19,3	19,3	19,3		
	20,0	98,2	179,1	19,3	19,3	19,3	19,3		
	22,2	107,8	174,7	19,3	19,3	19,3	19,3		
273	3,6*	23,9	265,8	3,3	4,1	3,8	4,8		
	4,0*	26,5	265,0	3,6	4,5	4,2	5,3		
	4,5*	29,8	264,0	4,1	5,1	4,8	6,0		
	4,8*	31,7	263,4	4,4	5,5	5,1	6,4		
	5,0	33,0	263,0	4,5	5,7	5,3	6,6		
	5,6	36,9	261,8	5,1	6,4	5,9	7,4		
	5,9	38,9	261,2	5,4	6,7	6,3	7,8		
	6,3	41,4	260,4	5,7	7,2	6,7	8,3		
	7,1	46,6	258,8	6,5	8,1	7,5	9,4		

* See 8.5.3.

TABLE 14 (continued)

Outside diameter	Thickness	Mass per unit length	Inside diameter	Test pressure					
				Grade					
				E 21		E 24		E 17	
				Standard test	Alternative test	Standard test	Alternative test	Standard test	Alternative test
mm	mm	kg/m	mm	MPa					
273	8,0	52,3	257,0	7,3	9,1	8,5	10,6		
	8,8	57,3	255,4	8,0	10,0	9,3	11,7		
	9,5	61,7	254,0	8,6	10,8	10,1	12,6		
	10,0	64,9	253,0	9,1	11,4	10,6	13,2		
	11,0	71,1	251,0	10,0	12,5	11,7	14,6		
	12,5	80,3	248,0	11,4	14,2	13,2	16,6		
	14,2	90,6	244,6	12,9	16,2	15,0	18,8		
	16,0	101,4	241,0	14,6	18,2	16,9	19,3		
	17,5	110,3	238,0	15,9	19,3	18,5	19,3		
	19,1	119,6	234,8	17,4	19,3	19,3	19,3		
	20,0	124,8	233,0	18,2	19,3	19,3	19,3		
	22,2	137,3	228,6	19,3	19,3	19,3	19,3		
323,9	4,0*	31,6	315,9	3,1	3,8	3,6	4,5		
	4,5*	35,4	314,9	3,5	4,3	4,0	5,0		
	4,8*	37,8	314,3	3,7	4,6	4,3	5,4		
	5,0*	39,3	313,9	3,8	4,8	4,5	5,6		
	5,6*	44,0	312,7	4,3	5,4	5,0	6,3		
	5,9	46,3	312,1	4,5	5,7	5,3	6,6		
	6,3	49,3	311,3	4,8	6,0	5,6	7,0		
	7,1	55,5	309,7	5,4	6,8	6,3	7,9		
	8,0	62,3	307,9	6,1	7,7	7,1	8,9		
	8,8	68,4	306,3	6,7	8,4	7,9	9,8		
	9,5	73,7	304,9	7,3	9,1	8,5	10,6		
	10,0	77,4	303,9	7,7	9,6	8,9	11,2		
	11,0	84,9	301,9	8,4	10,5	9,8	12,3		
	12,5	96,0	298,9	9,6	12,0	11,2	14,0		
	14,2	108,4	295,5	10,9	13,6	12,7	15,8		
	16,0	121,5	291,9	12,3	15,3	14,3	17,9		
	17,5	132,2	288,9	13,4	16,8	15,6	19,3		
	19,1	143,6	285,7	14,6	18,3	17,1	19,3		
	20,0	149,9	283,9	15,3	19,2	17,9	19,3		
	22,2	165,2	279,5	17,0	19,3	19,3	19,3		
355,6	4,5*	39,0	346,6	3,1	3,9	3,7	4,6		
	4,8*	41,5	346,0	3,4	4,2	3,9	4,9		
	5,0*	43,2	345,6	3,5	4,4	4,1	5,1		
	5,6*	48,3	344,4	3,9	4,9	4,6	5,7		
	5,9*	50,9	343,8	4,1	5,2	4,8	6,0		
	6,3*	54,3	343,0	4,4	5,5	5,1	6,4		
	7,1*	61,0	341,4	5,0	6,2	5,8	7,2		
	8,0	68,6	339,6	5,6	7,0	6,5	8,1		
355,6	8,8	57,3	336,6	6,1	7,7	7,2	8,9		
	9,5	61,7	335,6	6,6	8,3	7,7	9,7		
	10,0	64,9	335,6	7,0	8,7	8,1	10,2		
	11,0	71,1	333,6	7,7	9,6	8,9	11,2		
	12,5	80,3	330,6	8,7	10,9	10,2	12,7		
	14,2	90,6	327,2	9,9	12,4	11,5	14,4		
	16,0	101,4	323,6	11,2	14,0	13,0	16,3		
	17,5	110,3	320,6	12,2	15,3	14,2	17,8		
	19,1	119,6	317,4	13,3	16,7	15,5	19,3		
	20,0	124,8	315,6	14,0	17,5	16,3	19,3		
	22,2	137,3	311,2	15,5	19,3	18,1	19,3		
368	4,5*	40,3	359,0	3,0	3,8	3,5	4,4		
	4,8*	43,0	358,4	3,2	4,0	3,8	4,7		
	5,0*	44,8	358,0	3,4	4,2	3,9	4,9		
	5,6*	50,0	356,8	3,8	4,7	4,4	5,5		
	5,9*	52,7	356,2	4,0	5,0	4,6	5,8		
	6,3*	56,2	355,4	4,3	5,3	5,0	6,2		
	7,1*	63,2	353,8	4,8	6,0	5,6	7,0		
	8,0	71,0	352,0	5,4	6,8	6,3	7,9		
	8,8	77,9	350,4	5,9	7,4	6,9	8,6		
	9,5	84,0	349,0	6,4	8,0	7,5	9,3		
	10,0	88,3	348,0	6,8	8,4	7,9	9,8		
	11,0	96,8	346,0	7,4	9,3	8,6	10,8		
	12,5	109,6	343,0	8,4	10,5	9,8	12,3		
	14,2	123,9	339,6	9,6	12,0	11,2	13,9		
	16,0	138,9	336,0	10,8	13,5	12,6	15,7		
	17,5	151,3	333,0	11,8	14,8	13,8	17,2		
	19,1	164,3	329,8	12,9	16,1	15,0	18,8		
	20,0	171,6	328,0	13,5	16,9	15,7	19,3		
	22,2	189,3	323,6	15,0	18,7	17,4	19,3		
406,4	4,5*	44,6	397,4	2,8	3,4	3,2	4,0		
	4,8*	47,5	396,8	2,9	3,7	3,4	4,3		
	5,0*	49,5	396,4	3,1	3,8	3,6	4,4		
	5,6*	55,3	395,2	3,4	4,3	4,0	5,0		
	5,9*	58,3	394,6	3,6	4,5	4,2	5,2		
	6,3*	62,2	393,8	3,9	4,8	4,5	5,6		
	7,1*	69,9	392,2	4,3	5,4	5,1	6,3		
	8,0	78,6	390,4	4,9	6,1	5,7	7,1		
	8,8	86,3	388,8	5,4	6,7	6,3	7,8		
	9,5	93,0	387,4	5,8	7,3	6,8	8,5		

* See 8.5.3.

TABLE 14 (continued)

Outside diameter	Thickness	Mass per unit length	Inside diameter	Test pressure								
				Grade								
				E 21		E 24		E 17				
Standard test	Alternative test	Standard test	Alternative test									
mm	mm	kg/m	mm	MPa								
406,4	10,0	97,8	386,4	6,1	7,6	7,1	8,9					
	11,0	107,3	384,4	6,7	8,4	7,8	9,8					
	12,5	121,4	381,4	7,6	9,6	8,9	11,1					
	14,2	137,3	378,0	8,7	10,8	10,1	12,6					
	16,0	154,0	374,4	9,8	12,2	11,4	14,2					
	17,5	167,8	371,4	10,7	13,4	12,5	15,6					
	19,1	182,4	368,2	11,7	14,6	13,6	17,0					
	20,0	190,6	366,4	12,2	15,3	14,2	17,8					
	22,2	210,3	362,0	13,6	17,0	15,8	19,3					
	25,0	235,1	356,4	15,3	19,1	17,8	19,3					
	419	4,8*	49,0	409,4	2,8	3,6	3,3	4,1				
5,0*		51,0	409,0	3,0	3,7	3,5	4,3					
5,6*		57,1	407,8	3,3	4,1	3,9	4,8					
5,9*		60,1	407,2	3,5	4,4	4,1	5,1					
6,3*		64,1	406,4	3,7	4,7	4,3	5,4					
7,1*		72,1	404,8	4,2	5,3	4,9	6,1					
8,0		81,1	403,0	4,7	5,9	5,5	6,9					
8,8		89,0	401,4	5,2	6,5	6,1	7,6					
9,5		95,9	400,0	5,6	7,0	6,6	8,2					
10,0		100,9	399,0	5,9	7,4	6,9	8,6					
11,0		110,7	397,0	6,5	8,2	7,6	9,5					
12,5		125,3	394,0	7,4	9,3	8,6	10,8					
14,2		141,7	390,6	8,4	10,5	9,8	12,3					
16,0		159,0	387,0	9,5	11,9	11,0	13,8					
17,5		173,3	384,0	10,4	13,0	12,1	15,1					
19,1		188,4	380,8	11,3	14,2	13,2	16,5					
20,0		196,8	379,0	11,9	14,8	13,8	17,3					
22,2		217,2	374,6	13,2	16,5	15,3	19,2					
25,0		242,9	369,0	14,8	18,5	17,3	19,3					
457		4,8*	53,5	447,4	2,6	3,3	3,0	3,8				
		5,0*	55,7	447,0	2,7	3,4	3,2	4,0				
	5,6*	62,3	445,8	3,0	3,8	3,5	4,4					
	5,9*	65,6	445,2	3,2	4,0	3,7	4,7					
	6,3*	70,0	444,4	3,4	4,3	4,0	5,0					
	7,1*	78,8	442,8	3,9	4,8	4,5	5,6					
	8,0	88,6	441,0	4,3	5,4	5,1	6,3					
	8,8	97,3	439,4	4,8	6,0	5,6	7,0					
	9,5	104,8	438,0	5,2	6,5	6,0	7,5					
	10,0	110,2	437,0	5,4	6,8	6,3	7,9					
	11,0	121,0	435,0	6,0	7,5	7,0	8,7					

Outside diameter	Thickness	Mass per unit length	Inside diameter	Test pressure								
				Grade								
				E 21		E 24		E 17				
Standard test	Alternative test	Standard test	Alternative test									
mm	mm	kg/m	mm	MPa								
457	12,5	137,0	432,0	6,8	8,5	7,9	9,9					
	14,2	155,1	428,6	7,7	9,6	9,0	11,2					
	16,0	174,0	425,0	8,7	10,9	10,1	12,7					
	17,5	189,7	422,0	9,5	11,9	11,1	13,8					
	19,1	206,3	418,8	10,4	13,0	12,1	15,1					
	20,0	215,5	417,0	10,9	13,6	12,7	15,8					
	22,2	238,0	412,6	12,1	15,1	14,0	17,6					
	25,0	266,3	407,0	13,6	17,0	15,8	19,3					
	508	5,6*	69,4	496,8	2,7	3,4	3,2	4,0				
		5,9*	73,1	496,2	2,9	3,6	3,4	4,2				
		6,3*	77,9	495,4	3,1	3,9	3,6	4,5				
7,1*		87,7	493,8	3,5	4,3	4,0	5,1					
8,0		98,6	492,0	3,9	4,9	4,6	5,7					
8,8		108,3	490,4	4,3	5,4	5,0	6,3					
9,5		116,8	489,0	4,6	5,8	5,4	6,8					
10,0		122,8	488,0	4,9	6,1	5,7	7,1					
11,0		134,8	486,0	5,4	6,7	6,3	7,8					
12,5		152,7	483,0	6,1	7,6	7,1	8,9					
14,2		172,9	479,6	6,9	8,7	8,1	10,1					
16,0		194,1	476,0	7,8	9,8	9,1	11,4					
17,5		211,7	473,0	8,6	10,7	10,0	12,5					
19,1		230,3	469,8	9,3	11,7	10,9	13,6					
20,0		240,7	468,0	9,8	12,2	11,4	14,2					
22,2		266,0	463,6	10,9	13,6	12,6	15,8					
25,0		297,8	458,0	12,2	15,3	14,2	17,8					
559	5,6*	76,4	547,8	2,5	3,1	2,9	3,6					
	5,9*	80,5	547,2	2,6	3,3	3,1	3,8					
	6,3*	85,9	546,4	2,8	3,5	3,3	4,1					
	7,1*	96,6	544,8	3,2	3,9	3,7	4,6					
	8,0	108,7	543,0	3,6	4,4	4,1	5,2					
	8,8	119,4	541,4	3,9	4,9	4,6	5,7					
	9,5	128,7	540,0	4,2	5,3	4,9	6,1					
	10,0	135,4	539,0	4,4	5,6	5,2	6,5					
	11,0	148,7	537,0	4,9	6,1	5,7	7,1					
	12,5	168,5	534,0	5,6	6,9	6,5	8,1					
	14,2	190,8	530,6	6,3	7,9	7,3	9,2					
	16,0	214,2	527,0	7,1	8,9	8,3	10,3					
	17,5	233,7	524,0	7,8	9,7	9,1	11,3					
	19,1	254,3	520,8	8,5	10,6	9,9	12,4					
	20,0	265,8	519,0	8,9	11,1	10,3	12,9					

* See 8.5.3.

TABLE 14 (continued)

Outside diameter	Thickness	Mass per unit length	Inside diameter	Test pressure							
				Grade							
				E 21		E 24		E 17			
Standard test	Alternative test	Standard test	Alternative test								
mm	mm	kg/m	mm	MPa							
559	22,2	293,9	514,6	9,9	12,3	11,5	14,4				
	25,0	329,2	509,0	11,1	13,9	12,9	16,2				
610	5,9*	87,9	598,2	2,4	3,0	2,8	3,5				
	6,3*	93,8	597,4	2,6	3,2	3,0	3,7				
	7,1*	105,6	595,8	2,9	3,6	3,4	4,2				
	8,0	118,8	594,0	3,3	4,1	3,8	4,7				
	8,8	130,5	592,4	3,6	4,5	4,2	5,2				
	9,5	140,7	591,0	3,9	4,8	4,5	5,6				
	10,0	148,0	590,0	4,1	5,1	4,7	5,9				
	11,0	162,5	588,0	4,5	5,6	5,2	6,5				
	12,5	184,2	585,0	5,1	6,4	5,9	7,4				
	14,2	208,6	581,6	5,8	7,2	6,7	8,4				
	16,0	234,4	578,0	6,5	8,1	7,6	9,5				
	17,5	255,7	575,0	7,1	8,9	8,3	10,4				
	19,1	278,3	571,8	7,8	9,7	9,1	11,3				
	20,0	291,0	570,0	8,1	10,2	9,5	11,9				
	22,2	321,8	565,6	9,0	11,3	10,5	13,2				
	25,0	360,7	560,0	10,2	12,7	11,9	14,8				
660	5,9*	95,2	648,2	2,2	2,8	2,6	3,2				
	6,3*	101,6	647,4	2,4	3,0	2,8	3,5				
	7,1*	114,3	645,8	2,7	3,3	3,1	3,9				
	8,0	128,6	644,0	3,0	3,8	3,5	4,4				
	8,8	141,3	642,4	3,3	4,1	3,9	4,8				
	9,5	152,4	641,0	3,6	4,5	4,2	5,2				
	10,0	160,3	640,0	3,8	4,7	4,4	5,5				
	11,0	176,0	638,0	4,1	5,2	4,8	6,0				
	12,5	199,6	635,0	4,7	5,9	5,5	6,8				
	14,2	226,1	631,6	5,3	6,7	6,2	7,8				
	16,0	254,1	628,0	6,0	7,5	7,0	8,8				
	17,5	277,3	625,0	6,6	8,2	7,7	9,6				
	19,1	301,9	621,8	7,2	9,0	8,4	10,5				
	20,0	315,6	620,0	7,5	9,4	8,8	11,0				
	22,2	349,2	615,6	8,4	10,4	9,7	12,2				
	25,0	391,5	610,0	9,4	11,8	11,0	13,7				
711	6,3	109,5	698,4	2,2	2,8	2,6	3,2				
	7,1	123,2	696,8	2,5	3,1	2,9	3,6				
	8,0	138,7	695,0	2,8	3,5	3,3	4,1				
	8,8	152,4	693,4	3,1	3,8	3,6	4,5				
	9,5	164,3	692,0	3,3	4,1	3,9	4,8				
711	10,0	172,9	691,0	3,5	4,4	4,1	5,1				
	11,0	189,9	689,0	3,8	4,8	4,5	5,6				
	12,5	215,3	686,0	4,4	5,5	5,1	6,4				
	14,2	244,0	682,6	5,0	6,2	5,8	7,2				
	16,0	274,2	679,0	5,6	7,0	6,5	8,1				
	17,5	299,3	676,0	6,1	7,6	7,1	8,9				
	19,1	325,9	672,8	6,7	8,3	7,8	9,7				
	20,0	340,8	671,0	7,0	8,7	8,1	10,2				
	22,2	377,1	666,6	7,8	9,7	9,0	11,3				
	25,0	422,9	661,0	8,7	10,9	10,2	12,7				
762	6,3	117,4	749,4	2,1	2,6	2,4	3,0				
	7,1	132,2	747,8	2,3	2,9	2,7	3,4				
	8,0	148,7	746,0	2,6	3,3	3,0	3,8				
	8,8	163,5	744,4	2,9	3,6	3,3	4,2				
	9,5	176,3	743,0	3,1	3,9	3,6	4,5				
	10,0	185,4	742,0	3,3	4,1	3,8	4,7				
	11,0	203,7	740,0	3,6	4,5	4,2	5,2				
	12,5	231,0	737,0	4,1	5,1	4,7	5,9				
	14,2	261,9	733,6	4,6	5,8	5,4	6,7				
	16,0	294,3	730,0	5,2	6,5	6,1	7,6				
	17,5	321,3	727,0	5,7	7,1	6,6	8,3				
	19,1	349,9	723,8	6,2	7,8	7,2	9,1				
	20,0	366,0	722,0	6,5	8,1	7,6	9,5				
	22,2	405,0	717,6	7,2	9,0	8,4	10,5				
	25,0	454,4	712,0	8,1	10,2	9,5	11,9				
	813	6,3	125,3	800,4	1,9	2,4	2,2	2,8			
7,1		141,1	798,8	2,2	2,7	2,5	3,2				
8,0		158,8	797,0	2,4	3,1	2,8	3,6				
8,8		174,5	795,4	2,7	3,4	3,1	3,9				
9,5		188,2	794,0	2,9	3,6	3,4	4,2				
10,0		198,0	793,0	3,1	3,8	3,6	4,4				
11,0		217,6	791,0	3,4	4,2	3,9	4,9				
12,5		246,8	788,0	3,8	4,8	4,4	5,6				
14,2		279,7	784,8	4,3	5,4	5,1	6,3				
16,0		314,5	781,0	4,9	6,1	5,7	7,1				
17,5		343,3	778,0	5,3	6,7	6,2	7,8				
19,1		373,9	774,8	5,8	7,3	6,8	8,5				
20,0		391,1	773,0	6,1	7,6	7,1	8,9				
22,2		432,9	768,6	6,8	8,5	7,9	9,9				
25,0		485,8	763,0	7,6	9,5	8,9	11,1				

* See 8.5.3.

TABLE 14 (continued)

Outside diameter	Thickness	Mass per unit length	Inside diameter	Test pressure							
				Grade							
				E 21		E 24		E 17			
				Standard test	Alternative test	Standard test	Alternative test				
mm	mm	kg/m	mm	MPa							
864	6,3	133,3	851,4	1,8	2,3	2,1	2,6				
	7,1	150,0	849,8	2,0	2,6	2,4	3,0				
	8,0	168,9	848,0	2,3	2,9	2,7	3,3				
	8,8	185,6	846,4	2,5	3,2	2,9	3,7				
	9,5	200,2	845,0	2,7	3,4	3,2	4,0				
	10,0	210,6	844,0	2,9	3,6	3,3	4,2				
	11,0	231,4	842,0	3,2	4,0	3,7	4,6				
	12,5	262,5	839,0	3,6	4,5	4,2	5,2				
	14,2	297,6	835,6	4,1	5,1	4,8	5,9				
	16,0	334,6	832,0	4,6	5,8	5,4	6,7				
	17,5	365,3	829,0	5,0	6,3	5,9	7,3				
	19,1	398,0	825,8	5,5	6,9	6,4	8,0				
	20,0	416,3	824,0	5,8	7,2	6,7	8,4				
	22,2	460,8	819,6	6,4	8,0	7,4	9,3				
	25,0	517,2	814,0	7,2	9,0	8,4	10,5				
914	6,3	141,0	901,4	1,7	2,1	2,0	2,5				
	7,1	158,8	899,8	1,9	2,4	2,2	2,8				
	8,0	178,7	898,0	2,2	2,7	2,5	3,2				
	8,8	196,4	896,4	2,4	3,0	2,8	3,5				
	9,5	211,9	895,0	2,6	3,2	3,0	3,8				
	10,0	222,9	894,0	2,7	3,4	3,2	4,0				
	11,0	244,9	892,0	3,0	3,7	3,5	4,4				
	12,5	277,9	889,0	3,4	4,2	4,0	4,9				
	14,2	315,1	885,6	3,9	4,8	4,5	5,6				
	16,0	354,3	882,0	4,3	5,4	5,1	6,3				
	17,5	386,9	879,0	4,8	5,9	5,5	6,9				
	19,1	421,5	875,8	5,2	6,5	6,0	7,6				
	20,0	440,9	874,0	5,4	6,8	6,3	7,9				
	22,2	488,2	869,6	6,0	7,5	7,0	8,8				
	25,0	548,1	864,0	6,8	8,5	7,9	9,9				
1 016	8,0	198,9	1 000,0	2,0	2,4	2,3	2,8				
	8,8	218,6	998,4	2,2	2,7	2,5	3,1				
	9,5	235,8	997,0	2,3	2,9	2,7	3,4				
	10,0	248,1	996,0	2,4	3,1	2,8	3,6				
	11,0	272,6	994,0	2,7	3,4	3,1	3,9				
	12,5	309,3	991,0	3,1	3,8	3,6	4,4				
	14,2	350,8	987,6	3,5	4,3	4,0	5,1				
	16,0	394,6	984,0	3,9	4,9	4,6	5,7				
	17,5	430,9	981,0	4,3	5,3	5,0	6,2				
19,1	469,5	977,8	4,7	5,8	5,4	6,8					

Outside diameter	Thickness	Mass per unit length	Inside diameter	Test pressure								
				Grade								
				E 21		E 24		E 17				
				Standard test	Alternative test	Standard test	Alternative test					
mm	mm	kg/m	mm	MPa								
1 016	20,0	491,2	976,0	4,9	6,1	5,7	7,1					
	22,2	544,1	971,6	5,4	6,8	6,3	7,9					
	25,0	611,0	966,0	6,1	7,6	7,1	8,9					
1 067	8,8	229,6	1 049,4	2,0	2,6	2,4	3,0					
	9,5	247,7	1 048,0	2,2	2,8	2,6	3,2					
	10,0	260,7	1 047,0	2,3	2,9	2,7	3,4					
	11,0	286,5	1 045,0	2,6	3,2	3,0	3,7					
	12,5	325,0	1 042,0	2,9	3,6	3,4	4,2					
	14,2	368,7	1 038,6	3,3	4,1	3,8	4,8					
	16,0	414,7	1 035,0	3,7	4,7	4,3	5,4					
	17,5	452,9	1 032,0	4,1	5,1	4,7	5,9					
	19,1	493,6	1 028,8	4,4	5,6	5,2	6,5					
	20,0	516,4	1 027,0	4,7	5,8	5,4	6,8					
	22,2	572,0	1 022,6	5,2	6,5	6,0	7,5					
	25,0	642,4	1 017,0	5,8	7,3	6,8	8,5					
	1 118	8,8	240,7	1 100,4	2,0	2,4	2,3	2,8				
		9,5	259,7	1 099,0	2,1	2,6	2,5	3,1				
		10,0	273,2	1 098,0	2,2	2,8	2,6	3,2				
11,0		300,3	1 096,0	2,4	3,1	2,8	3,6					
12,5		340,8	1 093,0	2,8	3,5	3,2	4,0					
14,2		386,5	1 089,6	3,2	3,9	3,7	4,6					
16,0		434,8	1 086,0	3,6	4,4	4,1	5,2					
17,5		474,9	1 083,0	3,9	4,9	4,5	5,7					
19,1		517,6	1 079,8	4,2	5,3	4,9	6,2					
20,0		541,5	1 078,0	4,4	5,6	5,2	6,5					
22,2		599,9	1 073,6	4,9	6,2	5,7	7,2					
25,0		673,8	1 068,0	5,6	6,9	6,5	8,1					
1 168		8,8	251,6	1 150,4	1,9	2,3	2,2	2,7				
		9,5	271,4	1 149,0	2,0	2,5	2,4	2,9				
		10,0	285,6	1 148,0	2,1	2,7	2,5	3,1				
	11,0	313,8	1 146,0	2,3	2,9	2,7	3,4					
	12,5	356,2	1 143,0	2,7	3,3	3,1	3,9					
	14,2	404,0	1 139,6	3,0	3,8	3,5	4,4					
	16,0	454,5	1 136,0	3,4	4,3	4,0	5,0					
	17,5	496,5	1 133,0	3,7	4,7	4,3	5,4					
	19,1	541,1	1 129,8	4,1	5,1	4,7	5,9					
	20,0	566,2	1 128,0	4,3	5,3	5,0	6,2					
	22,2	627,3	1 123,6	4,7	5,9	5,5	6,9					
	25,0	704,7	1 118,0	5,3	6,6	6,2	7,7					

TABLE 14 (concluded)

Outside diameter	Thickness	Mass per unit length	Inside diameter	Test pressure							
				Grade							
				E 21		E 24		E 17			
Standard test	Alternative test	Standard test	Alternative test								
mm	mm	kg/m	mm	MPa							
1 220	8,8	262,8	1 202,4	1,8	2,2	2,1	2,6				
	9,5	283,6	1 201,0	1,9	2,4	2,3	2,8				
	10,0	298,4	1 200,0	2,0	2,5	2,4	3,0				
	11,0	328,0	1 198,0	2,2	2,8	2,6	3,3				
	12,5	372,2	1 195,0	2,5	3,2	3,0	3,7				
	14,2	422,2	1 191,6	2,9	3,6	3,4	4,2				
	16,0	475,1	1 188,0	3,3	4,1	3,8	4,7				
	17,5	518,9	1 185,0	3,6	4,5	4,1	5,2				
	19,1	565,6	1 181,8	3,9	4,9	4,5	5,7				
	20,0	591,8	1 180,0	4,1	5,1	4,7	5,9				
	22,2	655,7	1 175,6	4,5	5,7	5,3	6,6				
	25,0	736,7	1 170,0	5,1	6,4	5,9	7,4				
1 420	8,8	306,2	1 402,4	1,5	1,9	1,8	2,2				
	9,5	330,4	1 401,0	1,7	2,1	1,9	2,4				
	10,0	347,7	1 400,0	1,7	2,2	2,0	2,5				
	11,0	382,2	1 398,0	1,9	2,4	2,2	2,8				
	12,5	433,9	1 395,0	2,2	2,7	2,5	3,2				
	14,2	492,3	1 391,6	2,5	3,1	2,9	3,6				
	16,0	554,0	1 388,0	2,8	3,5	3,3	4,1				
	17,5	605,2	1 385,0	3,1	3,8	3,6	4,5				
	19,1	659,8	1 381,8	3,3	4,2	3,9	4,9				
	20,0	690,5	1 380,0	3,5	4,4	4,1	5,1				
	22,2	765,2	1 375,6	3,9	4,9	4,5	5,7				
	25,0	860,0	1 370,0	4,4	5,5	5,1	6,4				

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ANNEX A

SUPPLEMENTARY REQUIREMENTS : NON-DESTRUCTIVE INSPECTION OF SEAMLESS PIPE

A.1 INTRODUCTION

If specified on the purchase order, seamless pipe shall be inspected full length for longitudinal defects by either magnetic particle inspection or by ultrasonic or electromagnetic methods.

The location of the equipment in the mill shall be at the discretion of the manufacturer; however, the non-destructive inspection must take place after all heat-treating and expansion operations, if performed, but may take place before cropping, bevelling and end sizing.

A.2 MAGNETIC PARTICLE INSPECTION

When magnetic particle inspection is employed to detect longitudinal defects, the entire outside surface shall be inspected. The depth of all defects revealed by magnetic particle inspection shall be determined. Defects which are revealed by magnetic particle inspection and determined to be greater in depth than 12,5 % of the specified thickness shall be classified as injurious defects and be dealt with in accordance with the dispositions specified in 11.1.

A.3 ULTRASONIC OR ELECTROMAGNETIC INSPECTION OF SEAMLESS PIPE

A.3.1 Equipment

Any equipment utilizing the ultrasonic or electromagnetic principles and capable of continuous and uninterrupted inspection of the entire outer surface of the pipe or tube may be used.

The equipment shall be of sufficient sensitivity to indicate injurious defects and shall be checked as prescribed in A.3.2.

A.3.2 Reference standards

A reference standard having the same nominal standard diameter and thickness as the product being inspected shall be used to demonstrate the effectiveness of the inspection equipment and procedures at least once every working shift. The reference standard may be of any convenient length as determined by the manufacturer. It shall be scanned by the inspection unit in a manner simulating the inspection of the product. For ultrasonic inspection, the reference standard shall contain a machined notch as specified in figure 5. For electromagnetic inspection, the reference standard shall contain either a machined notch as specified in figure 5 or a 3,2 mm (1/8 in) drilled hole. The notch shall be in the outer surface of the reference standard and parallel to the longitudinal axis of the pipe or, at the option of the manufacturer, may be oriented at such an angle as to optimize the detection of anticipated defects. The 3,2 mm (1/8 in) hole shall be drilled radially through the wall of the reference standard. The inspection equipment shall be adjusted to produce a well-defined indication when the reference standard is scanned by the inspection unit.

A.3.3 Rejection limits

Any imperfection that produces an indication as great as the indication received from the reference standard shall be classified as an injurious defect. Injurious defects shall be dealt with in accordance with one of the dispositions specified in 11.1.

NOTES

1 The reference standards defined above are convenient standards for calibration of non-destructive testing equipment. The dimensions of these standards should not be construed as the minimum size imperfection detectable by such equipment.

2 Reference standards other than the specific notch described above may be used by agreement between the purchaser and manufacturer.