

INTERNATIONAL STANDARD



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Materials and equipment for petroleum and natural gas industries — Casing and tubing for oil or natural gas wells

Matériel d'équipement pour les industries du pétrole et du gaz naturel — Tubes de cuvelage et tubes de production pour puits de pétrole ou de gaz naturel

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FOREWORD

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

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

International Standard ISO 2645 was drawn up by Technical Committee ISO/TC 67, *Materials and equipment for petroleum and natural gas industries*, and circulated to the Member Bodies in December 1972.

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

Australia	Germany	Portugal
Austria	Hungary	Romania
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Canada	Israel	Turkey
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The Member Body of the following country expressed disapproval of the document on technical grounds :

U.S.A.

CONTENTS

	Page
1 Scope and field of application	1
2 References	1
3 Definitions	1
4 Manufacturing processes	1
5 Data to be given by the purchaser	1
6 Designation	2
7 Steels	2
8 Pipe condition	4
9 Permissible dimensional deviations	5
10 Chemical analyses	7
11 Mechanical and non-destructive tests	7
12 Inspection rights	11
13 Test reports	12
14 Couplings	12
15 Minimum mechanical characteristics	13
16 Thread protectors	13
17 Surface protection	13
18 Marking	13
Annexes	
A Bases for calculating the pipe body characteristics	15
B Basis for calculating the internal yield pressure of pipes and couplings	17

Materials and equipment for petroleum and natural gas industries — Casing and tubing for oil or natural gas wells

1 SCOPE AND FIELD OF APPLICATION

1.1 This International Standard specifies the characteristics of casing and tubing used in the operation of oil or natural gas wells.

1.2 It also specifies the characteristics of threaded casing and tubing couplings, and thread protectors.

1.3 It specifies the sizes, diameters, wall thicknesses and grades of steel.

1.4 Casing and tubing are divided into three classes :

- Class I : Steel pipes with standard mechanical properties;
- Class II : Steel pipes with high strength mechanical properties;
- Class III : Steel pipes with reduced proof stress range.

1.5 The requirements concerning pipe and coupling threads and inspection methods and instruments are given in ISO ...

1.6 This International Standard applies to both seamless and welded pipes.

2 REFERENCES

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

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

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

ISO ..., *Materials and equipment for petroleum and natural gas industries — Casing, tubing and line pipe threads — Threading, gauging and thread inspection*.¹⁾

3 DEFINITIONS

3.1 **casing** : A pipe run from the surface and intended to line the walls of a drilled well.

3.2 **tubing** : A pipe placed within a productive well to serve as an exhaust or delivery duct.

4 MANUFACTURING PROCESSES

4.1 Seamless process

Applicable to Classes I, II, III. A seamless pipe is a steel tubular product manufactured by hot working from a solid steel blank and, if necessary, by cold finishing to produce the desired shapes, dimensions and properties.

4.2 Welded process by resistance or flash

Applicable by resistance or flash to Class I pipes, and by flash to casing in C 66 steel.

4.3 Electrically welded process

Applicable to Class 1 pipes and to casing in C 66 steel.

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

5 DATA TO BE GIVEN BY THE PURCHASER

5.1 In placing orders the purchaser shall specify the following :

- a) the reference number of this International Standard;
- b) quantity (length or number of lengths);
- c) type of pipe :
 - casing**
 - threaded or plain-end,

1) In preparation.

- thread type,
- with or without couplings;

tubing

- upset or non-upset,
 - threaded or plain-end,
 - thread type,
 - with or without couplings;
- d) size (outside diameter) in millimetres (see tables 20, 22, 24, 26 and 28);
- e) mass per unit length in kilograms per metre, or wall thickness in millimetres (see tables 20, 22, 24, 26 and 28);
- f) class (I, II, III) and grade (see tables 1 and 2);
- g) length range (see 9.4);
- h) manufacturing process (seamless or welded);
- i) delivery date, shipping instructions and marking;
- j) mill inspection (if required).

5.2 The purchaser shall also state on the order his requirements concerning the following optional stipulations :

- normalizing of J 38 casing, and tubing, and of K 38 and N 56 casing;
- chemical, ladle and supplementary analyses;
- flattening test on grade H 28, seamless pipes;
- casing jointers;
- casing or tubing with couplings detached;
- coupling make-up (other than power-tight);
- pipe coating;
- non-destructive testing for class I and III pipes.

5.3 Attention is also called to the following stipulations which are subject to agreement at the time of ordering :

- test pressures for handling-tight make-up or higher alternatives;
- hydrostatic test at a value higher than the standard value;
- special threads or special finishes (see 8.2.1.2);
- thread compound;
- thread protectors;
- marking.

6 DESIGNATION

A pipe manufactured according to this International Standard shall be designated by :

- a) its type;
- b) the type of its ends and the threads of the latter;
- c) its size (outside diameter) in millimetres;
- d) its mass per unit length in kilograms per metre, or its wall thickness in millimetres;
- e) its grade;
- f) its length range;
- g) its manufacturing process;
- h) a reference to this International Standard.

Example :

Casing, Buttress, 114,3 X 5,7, K 38, range 2, seamless according to ISO 2645.

7 STEELS

7.1 Steelmaking

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

open-hearth, electric furnace or basic oxygen steelmaking processes.

7.2 Chemical composition

The limits of the permissible chemical composition are given in table 1 for each grade concerned.

7.3 Mechanical properties

The limits of the test piece mechanical properties (see 11.3.1) are given in table 2 for each steel concerned.

7.4 Heat treatment

The compulsory or optional heat treatments are given in table 3 for each grade concerned.

After final heat treatment C 52 steel pipes shall not be cold worked except for normal straightening operations. After final heat treatment C 66 steel casing shall not be submitted to tensile straining or cold expansion, nor shall they be cold reduced by more than 3 %.

Forged class II and III pipes and pipes of grade N 56 shall be heat treated over their full length after forging.

TABLE 1 — Chemical characteristics

Class	Grade of steel	C %	Si %	Mn %	P %	S %	Cr + Ni + Cu %	Cr %	Mo %
I	H 28 H 31 J 38 K 38 N 56				≤ 0,040	≤ 0,060			
II	P 72 P 76				≤ 0,040	≤ 0,060			
III	C 52 Type 1	≤ 0,50	≤ 0,35	≤ 1,90	≤ 0,040	≤ 0,060	≤ 0,50	0,80 to 1,10	0,15 to 0,30
	— Type 2	≤ 0,40	≤ 0,35	≤ 1,50	≤ 0,040	≤ 0,060			
	— Type 3	0,38 to 0,48		0,75 to 1,00	≤ 0,040	≤ 0,040			0,15 to 0,25
	C 66 ¹⁾	≤ 0,45	≤ 0,35	≤ 1,90	≤ 0,040	≤ 0,060			

1) In the case of quenching and tempering : C ≤ 0,40 with Mn ≤ 1,70
or C ≤ 0,45 with Mn ≤ 1,60

TABLE 2 — Mechanical characteristics

Class	Grade of steel	Proof stress, R_p	Minimum tensile strength R_m	Minimum elongation on $5,65 \sqrt{S_0}$ *
		N/mm ²	N/mm ²	%
I	H 28	$R_{p 0,5} \geq 276$	414	22,5
I	H 31	$R_{p 0,5} \geq 310$	483	19,3
I	J 38	$379 \leq R_{p 0,5} \leq 552$	517	18
I	K 38	$379 \leq R_{p 0,5} \leq 552$	655	14,3
III	C 52	$517 \leq R_{p 0,5} \leq 621$	655	14,3
I	N 56	$552 \leq R_{p 0,5} \leq 758$	689,5	13
III	C 66	$655 \leq R_{p 0,5} \leq 758$	724	12,8
II	P 72	$723 \leq R_{p 0,6} \leq 931$	827	11,3
II	P 76	$758 \leq R_{p 0,6} \leq 965$	862	10,8

* If other gauge lengths are used, the corresponding elongation values shall be obtained according to ISO 2566. In cases of dispute, the gauge length of $5,65 \sqrt{S_0}$ shall be used.

TABLE 3 — Heat treatments

Unless specified in the order, heat treatments shall be left to the discretion of the manufacturer.

Class	Casing	Heat treatment
I	K 38 J 38	Normalizing, if specified in the order
	N 56	Normalizing, or quenching and tempering
II	P 76	Quenching and tempering, or normalizing and tempering
III	C 52 types 1,3	Normalizing and tempering
	C 52 type 2	Quenching and tempering
III	C 66	Quenching and tempering (538 °C min.)
Class	Tubing	Heat treatment
I	J 38	Normalizing, if specified in the order
I	N 56	Normalizing, or quenching and tempering
II	P 72	Quenching and tempering, or normalizing and tempering
III	C 52 types 1,3	Normalizing and tempering
	C 52 type 2	Quenching and tempering
III	C 66	Normalizing and tempering, or quenching and tempering (538 °C min.)

8 PIPE CONDITION

8.1 Diameters, wall thicknesses and masses

The pipes supplied shall have the diameters, wall thicknesses and masses shown in tables 20, 22, 24, 25, 26 and 28.

8.2 Pipe ends

8.2.1 Casing

Ends may be finished to accommodate the various types of threads.

8.2.1.1 Casing shall in principle be furnished with both ends machined with a round thread (8 threads per inch) (see ISO . . .), one of the ends being fitted with a coupling.

NOTE — For grades H 28, H 31, J 38, K 38 where two thread types (long and short) are given in table 20, pipes with short thread will be delivered. In case the thread type is not stipulated on the purchase order, the manufacturer should be responsible for obtaining clarification from the purchaser. See clause 5.

Delivery may be made without couplings or with a (normal or special) coupling with special make-up as defined in 8.4.

8.2.1.2 If stated in the order, end finishes may be as follows :

- Buttress threads¹⁾ with or without couplings;
- Extreme-Line threads¹⁾ in the so-called "integral" form without couplings (table 25);

— special end finish, according to previous written agreement between supplier and purchaser.

8.2.1.3 In certain cases pipes may be furnished with square-cut plain ends.

8.2.2 Tubing

Ends may be finished to accommodate the various types of threads.

8.2.2.1 Pipes may have upset ends. In principle these shall be furnished with a round thread (8 threads per inch) (see ISO . . .).

One end shall normally be fitted with a (normal or special) coupling made up as defined in 8.4.

Delivery may also be made without couplings or with a special handling-tight make-up.

8.2.2.2 In certain cases pipes may be furnished either with non-upset, square-cut plain ends or with upset, non-finished ends but with all burrs removed.

If so stated in the order, ends may have a special finish.

8.3 Threading of pipes and couplings

Threads and thread inspection methods shall conform to ISO . . ., except for special cases.

Ends shall not be rounded out by hammering to secure compliance with threading requirements.

1) See ISO . . .

The inside and outside edges of all pipe types shall be free of burrs.

8.4 Coupling make-up and thread protection

8.4.1 Regular clearance couplings shall be screwed onto the pipe power-tight. However, if so specified on the order they may be screwed on handling-tight or shipped separately.

8.4.2 Special clearance tubing couplings shall be screwed on handling-tight. If so required on the order they may, however, be shipped separately.

8.4.3 A high-grade thread compound shall be applied to cover the full surface of the engaged thread of either the pipe or the coupling.

Compound type and grade shall conform to the relevant requirements in national standards and may be specified on the order.¹⁾

8.4.4 The pipe ends without couplings and the non-engaged end of couplings shall be provided with thread protectors conforming to clause 15.

All exposed thread parts shall be coated with a high-grade thread compound.

NOTE — Handling-tight is defined as sufficiently tight that the coupling cannot be removed except by the use of a wrench. The purpose of making-up couplings handling-tight is to facilitate removal of the couplings for cleaning and inspecting threads and applying fresh thread compound before using the pipe.

This procedure has been found to result in less chance of thread leakage, because mill-applied couplings made-up power-tight, although leak proof at the time of make-up, may not always remain so after transportation, handling and use.

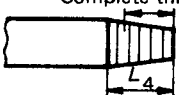
9 PERMISSIBLE DIMENSIONAL DEVIATIONS

9.1 Outside diameter

9.1.1 Pipe body

The tolerances on the outside diameter of the pipe are given in table 4.

TABLE 4 — Tolerances on diameter

Pipe body		Pipe ends
Outside diameter	Tolerances	Complete threads 
$D < 114,3 \text{ mm}$	$\pm 0,79 \text{ mm}$	Permissible deviations These shall be such that length L_4 and the number of complete threads within this length conform to the tolerances given in ISO ...
$D \geq 114,3 \text{ mm}$	$\pm 0,75 \%$	

9.1.2 Upset ends

Close to the upset end at the part of the pipe affected by heating and upsetting, the outside diameter may be within the tolerances given in table 5.

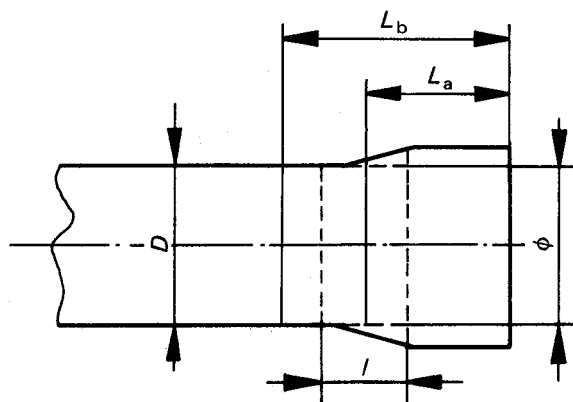


FIGURE 1 — Upset end

TABLE 5 — Tolerances on upset ends

Casing			
Outside diameter D mm	Tolerances	On length /	
$D \leq 127,0$	+ 2,8 mm – 0,75 % D	127 mm	
$139,7 \leq D \leq 219,1$	+ 3,2 mm – 0,75 % D	# D	
$D \geq 244,5$	+ 4,0 mm – 0,75 % D		
Tubing			
Outside diameter mm	Length L_a^* mm	Tolerance on diameter at distance L_a mm	Length L_b^* mm
60,3	152,4	$D + 2,4 - 0,8$	254
73	159	$D + 2,4 - 0,8$	260
88,9	165	$D + 2,4 - 0,8$	267
101,6	165	$D + 2,8 - 0,8$	267
114,3	171,5	$D + 2,8 - 0,75 \% D$	273

* Lengths L_a and L_b are measured from the pipe end. L_b is the distance from which the tolerances given in 9.1 for the pipe body apply.

The alterations in the diameter between the points of measurement at distances L_a and L_b shall be smooth and progressive, not abrupt.

9.2 Wall thickness

9.2.1 Each length of pipe shall conform to the following specifications :

At any place the minimum thickness shall not be less than 87,5 % of the tabulated thickness, the maximum thickness being limited by the mass tolerance (see 9.3.3).

1) An International Standard on compounds is in preparation; meanwhile reference may be made to API Spec 5A2, latest edition.

Thickness measurements shall be made with a gauge fitted with contact pins having a diameter of 6,35 mm. The end of the pin contacting the inside surface of the pipe shall be rounded to a radius of 38 mm; the end of the pin contacting the outside surface shall be flat or rounded to a radius of 38 mm.

Thickness measurements can also be made using appropriately calibrated non-destructive equipment of adequate accuracy. In case of dispute the mechanical gauge measurement will, however, be relied upon.

9.3 Mass

9.3.1 Each casing and tubing shall be weighed separately. However, tubing of diameters less than or equal to 33,4 mm may be weighed in convenient lots. Threaded and coupled pipes may be weighed with their couplings attached.

Threaded pipes with or without couplings shall be weighed without thread protectors except for wagon load weighings where proper allowances must be made for the mass of the thread protectors in the total mass.

9.3.2 The masses determined shall conform to the specified (or adjusted calculated) masses for the end finishes provided for in the order within the tolerances stipulated in 9.3.3. Calculated masses shall be determined in accordance with the following formula :

W_L = (W_{pe}L) + e_w

where

W_L is the calculated mass of a pipe of length L, in kilograms;

W_{pe} is the plain end theoretical mass per unit length in kilograms per metre;

L is the length of pipe, as defined in 9.4, in metres;

e_w is the mass gain or loss due to end finishing, in kilograms.

9.3.3 On one pipe or on one lot of pipes for lot-weighed pipes (D ≤ 33,4 mm) the tolerance shall be ^{+6,5}/_{-3,5} %.

On a complete wagon load (i.e. 18 t minimum) the tolerance shall be ⁰/_{-1,75} %.

NOTE — Tolerances per pipe lot or pipe wagon load are applicable simultaneously, except for loads less than 18 t where the tolerance ^{+6,5}/_{-3,5} % only is obligatory.

9.4 Length

9.4.1 Pipes shall be furnished in the length range specified in the order. The length ranges shall comply with table 6. When the pipe is furnished with threads and couplings, the length is measured from the outer face of the coupling to the opposite plain spigot end. For Extreme-Line casing, the length shall be measured from the box end to the opposite threaded spigot end.

9.4.2 If so specified in the order, for round thread casing only, jointers (i.e. two pieces coupled to make a standard length) may be furnished to a maximum of 5 % of the order. No length used in making a jointer shall be less than 1,52 m and the jointer total length shall conform to the standard length of the one-piece pipe.

TABLE 6 — Length ranges

	Range 1		Range 2		Range 3	
	m	ft	m	ft	m	ft
Casing (jointers included)	4,9 to 7,6	16 to 25	7,6 to 10,4	25 to 34	10,4 and over ¹⁾	34 and over
On 95 % min. of a shipment (see table 8)						
— maximum variation	1,8	6	1,5	5	1,8	6
— minimum length	5,5	18	8,5	28	11,0	36
Tubing	6,10 to 7,3	20 to 24	8,5 to 9,7	28 to 32		
On 100 % min. of a shipment (see table 8)						
— maximum variation	0,6	2	0,6	2		
— minimum length	6,1	20	8,5	28		

1) By agreement at the time of ordering the upper limit may be stated by the purchaser.

9.5 Inside diameter

Each pipe shall be checked over its whole length with a cylindrical mandrel in conformity with table 7.

The front end of the mandrel shall be rounded to allow an easy fit in the pipe. The mandrel shall enter the pipe freely over its whole length with a reasonable effort. The pipe shall not be rejected as long as it is not tested free of foreign materials and supported to avoid collapse.

TABLE 7 — Dimensions of check mandrel
Values in millimetres

Nominal outside diameter <i>D</i>	Mandrel length	Minimum mandrel diameter ²⁾
Casing ¹⁾		
$D \leq 219,1$	152	$d - 3,2$
$244,5 \leq D \leq 339,7$	305	$d - 4$
$D \geq 406,4$	305	$d - 4,8$
Tubing		
$D \leq 73$	1 067	$d - 2,4$
$D \geq 88,9$	1 067	$d - 3,2$

1) For Extreme-Line casing the mandrel minimum diameter is specified in column 5 of table 24.
2) d = theoretical internal diameter.

9.6 Curvature

All pipes shall be delivered with a reasonable straightness.

9.7 Loads

Wagon loads shall comply with table 8.

TABLE 8 — Wagon loads (see ranges — table 6)

Order smaller than one wagon load	Order larger than one wagon load	
	Railway shipment direct from mill to final consignee	Railway shipment interrupted from mill to final consignee
Total tolerances of ranges	Total variation on 5 % maximum of shipment, required per wagon load in the corresponding range	Total variation on 5 % maximum of shipment, required for total load in the corresponding range

10 CHEMICAL ANALYSES

10.1 Ladle analysis

When requested by the purchaser, the manufacturer shall furnish a ladle analysis of each steel heat used. In addition,

the purchaser, upon request, shall be furnished with the results of such other chemical analyses as may be obtained. The analyses, so determined, shall conform to the requirements specified in 7.2.

10.2 Check analysis

10.2.1 Two finished pipe lengths shall be analysed by the manufacturer from each lot of 400 ($\phi \leq 139,7$ mm) or 200 ($\phi \geq 168,3$ mm) pipes of the same diameter. For multiple-length seamless pipes, a length is considered as all of the sections cut from a particular multiple length.

10.2.2 The samples shall be composed of cuttings or drillings representing the full wall thickness of the pipe. If drillings are used the minimum drill size shall be 12,7 mm.

10.2.3 If the check analysis on one length representing the lot fails to conform to the requirements of 7.2, the manufacturer will be allowed to re-test two supplementary lengths. If the re-check is satisfactory, the lot shall be accepted except for the defective length. If both lengths representing the lot, or one (or both) length(s) of the re-check analysis fail, at the manufacturer's option the entire lot shall be rejected or individual re-check analyses carried out. These re-check analyses shall be made on defective elements only. Samples shall be taken as specified in 10.2.2.

10.3 Mill-control check analyses

A ladle analysis of each steel heat used shall be made by the manufacturer. A record of such analyses shall be available to the purchaser.

11 MECHANICAL AND NON-DESTRUCTIVE TESTS

11.1 Nature of tests

Class I, II and III pipes shall be tested for tensile strength and flattening strength. They shall also be submitted to hydrostatic tests. Class II pipes shall be submitted to non-destructive inspection. This inspection is optional for class I and III pipes.

11.2 Number of tests

The number of tests shall conform to the requirements of table 9.

11.3 Tensile tests

11.3.1 Tensile tests shall be carried out in accordance with ISO 375. Proof stress values shall be determined for an elongation under load of 0,5 % or 0,6 % (see table 2).

Test pieces, at the manufacturer's option, shall be either full sections or strips with the same heat treatment as the pipe (see figure 2). A test piece shall represent the full thickness of the pipe from which it is taken; it must not be flattened before testing. In the case of welded pipes the test piece shall be taken approximately 90° from the weld.

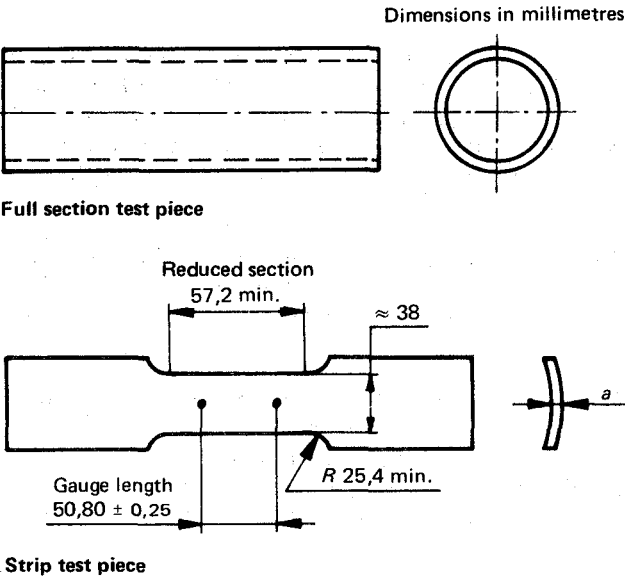


FIGURE 2 – Tensile test pieces

In the case of heat treated pipes, the test piece shall be submitted to the same treatment as the finished pipe.

The mechanical properties of upset ends shall meet the requirements for the pipe body. In case of dispute the minimum tensile strength and the proof stress shall be determined on a test piece taken from an upset end.

11.3.2 The width of the test piece gauge length shall be about 38 mm if suitable face testing grips are used or if the ends of the test piece are machined to reduce the curvature in the grip area; otherwise it shall be approximately 19 mm for pipes 88,9 mm and smaller, 25,4 mm for pipes from 101,6 to 193,7 mm, and approximately 38 mm for pipes 219,1 mm and larger. In no case shall the width of the test piece gauge length be greater than four times the thickness of the test piece.

11.3.3 If any tensile test piece shows defective machining or develops flaws, it may be discarded and another test piece substituted. When the elongation of any tensile test piece is less than that specified, a re-test is allowed if any part of the fracture is outside the middle third of the gauge length as indicated by scribe scratches marked on the test piece before testing.

TABLE 9 – Number of tests

Test	Number of tests		
	Class I	Class II	Class III
Tensile test on test piece	$D \leq 139,7$ mm : 1 per 400 lengths $D \geq 168,3$ mm : 1 per 200 lengths 1) 2)	Casing : 1 per 100 lengths Tubing : 1 per 200 lengths 1) 2)	
Mill-control tensile test	1 per heat		
Flattening test on test piece	On non-upset or untreated pipes : on each end of each pipe ^{3) 4)} On upset and treated pipes : test pieces shall be taken at each end of each pipe before upsetting and treatment or on pipes at the rate of 1 per 20 lengths (casing) and 1 per 100 lengths (tubing). In this case test pieces shall be treated in a similar way to that specified for the grade concerned.		
Hydrostatic test	On each pipe		
Non-destructive inspection	Optional	On the whole length of each pipe	Optional

1) In the case of treated pipes, all pipes in a lot shall have been submitted to the same treatment.

2) In the case of seamless pipes in multiple lengths, a length is classed as the sum of the sections obtained from this multiple length.

3) The test shall not be carried out for seamless pipes of grade H 28 and H 31.

4) In the case of seamless pipes in multiple lengths cut in sections, tests shall be made at each end of the multiple length.

TABLE 10 — Distance z between plates

Grade of steel	Distance z with		
	$D/a < 3,93$	$3,93 \leq D/a < 16$	$D/a \geq 16$
H 28	$(0,83 - 0,020\ 6\ D/a)\ D$	$(0,83 - 0,020\ 6\ D/a)\ D$	$0,5\ D$
H 31	$(0,88 - 0,020\ 6\ D/a)\ D$	$(0,88 - 0,020\ 6\ D/a)\ D$	$0,55\ D$
J 38, K 38	$(1,104 - 0,051\ 8\ D/a)\ D$	$(0,98 - 0,020\ 6\ D/a)\ D$	$0,65\ D$
	$9 \leq D/a \leq 25$		
C 52, N 56	$(1,074 - 0,019\ 4\ D/a)\ D$		
C 66	$(1,080 - 0,017\ 8\ D/a)\ D$		
P 72, P 76	$(1,086 - 0,016\ 3\ D/a)\ D$		

D = outside diameter in millimetres
 a = wall thickness in millimetres

11.4 Flattening test

This test is applicable for all grades except H 28 and H 31 in the case of seamless pipes.

11.4.1 The flattening test shall be carried out in accordance with ISO/R 202.

No cracks or breaks shall occur anywhere in the test piece until the distance between plates z is less than that specified in table 10.

If a test piece representing class II or III pipes or grade N 56 pipes is shown defective at a point of maximum bending (12 h and 6 h), the test shall be pursued until the remaining part of the test piece breaks at 90° from the point of maximum bending (3 h or 9 h).

Premature fracture at the point of maximum bending shall not be taken into account for the possible rejection of the pipes.

11.4.2 In the case of welded pipes, the weld shall be placed at the point of maximum bending. At the discretion of the inspector, separate tests shall be made with the weld 90° from the point of maximum bending.

Evidence must not appear of poor texture, incomplete fusion in the weld, laminations, burnt metal or extruded metal.

11.5 Hydrostatic test

11.5.1 Test pressure

Each length shall be hydrostatically tested at the manufacturer's works, unless otherwise specified in the order.

The test shall be carried out at the pressures given in table 11.

TABLE 11 — Test pressures

Grade of steel	Diameter of pipe D	Pressure p
H 28, H 31, J 38, K 38	$D \leq 244,5\text{ mm}$	$p = 0,914 \times p_E$ with 207 bar max.
—	$D \geq 273\text{ mm}$	$p = 0,685 \times p_E$ with 207 bar max.
Other grades		$p = 0,914 \times p_E$ with 689,5 bar max.

p = test pressure

p_E = internal yield pressure specified in table 20, 22, 24, 26 or 28 for the adopted end type.

If so specified in the order, class I and II pipes may, however, be tested at the pressure given by the formula, no account being taken of the maximum limit.

The test pressure shall be held for at least 5 s. No leakage shall then occur.

11.5.2 Welded pipes

While under pressure, welded pipes shall be struck at both ends near the weld with a 1 kg hammer or its equivalent.

Pressure shall then be reduced to not less than one-half and maintained for a sufficient period to permit thorough inspection of the weld for leakage or sweats.

11.5.3 Threaded pipes with couplings

a) Couplings made-up power-tight

For diameters less than 406 mm the test shall be carried out with the coupling

For diameters 406 mm and greater, hydrostatic testing before threading is permitted.

b) Couplings made-up handling-tight

The test shall be carried out as agreed in the order on plain end or threaded and coupled pipes. Minor leakage at the joint shall be disregarded in this case.

11.5.4 Special test

A higher pressure may be used if agreed between supplier and purchaser. In any case, the pressure shall never exceed the values given in annex B.

11.6 Non-destructive testing

11.6.1 Applications and options

In a case where such testing is specified (see table 12) in addition to visual inspection, casing and tubing shall be tested over their full length to detect longitudinal defects, by magnetic particle inspection, or by an ultrasonic method, or by an electromagnetic method. Furthermore the ends of upset pipes shall be inspected for transverse defects by the magnetic particle method. The location of the equipment in the mill will be at the discretion of the manufacturer. However, the non-destructive testing shall take place after all heat-treating operations, but may take place before cropping or threading.

11.6.2 Magnetic particle inspection

When magnetic particle inspection is employed for longitudinal defect detection, the entire outside surface of the pipe and the inside surface for a distance of 305 mm from the end of casing or of 152 mm from the end of tubing should be inspected. The inside and outside surfaces of the ends of upset pipes shall be inspected for transverse defects by the magnetic particle method. Magnetic particle

inspection of casing and tubing may be employed on inside surfaces after heat treatment and before end cropping.

If defects are found, further cropping is permissible provided that the inside surface is again inspected by the magnetic particle method as stipulated above. The depth of all defects revealed by this inspection shall be determined.

11.6.3 Electromagnetic or ultrasonic inspection

a) Equipment

For pipe inspection, any equipment utilizing the electromagnetic or ultrasonic principles may be used provided that it is capable of continuous and uninterrupted inspection of the outer surface of the pipe.

The equipment shall have sufficient sensitivity to indicate injurious defects and it shall be checked as prescribed in 11.6.3.b).

b) Reference standard

A reference standard taken from the pipes as supplied and having the same nominal diameter and wall thickness as the product being tested shall be used at least once every working turn to demonstrate the effectiveness of the inspection equipment.

The reference standard shall have 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.

c) Notch (see table 12)

Standard notches (types 12,5 % and 5 %) shall be made in the reference standards.

When using internal and external notches it is not necessary that they be farther apart than the distance required for signal differentiation.

TABLE 12 — Non-destructive testing

Class	Conditions	Standards						
		Ultrasonic inspection			Electromagnetic methods			
		Depth	Notch		Depth	Notch		Hole (diameter)
I and III	100 % by agreement	0,05 a	1 mm	50 mm	0,05 a	1 mm	38 mm	1,6 mm (0.062 5 in)
		0,125 a	1 mm	2 widths of probe	0,125 a	1 mm	38 mm	3,2 mm (0.125 in)
II	100 %	0,05 a	1 mm	50 mm	0,05 a	1 mm	38 mm	1,6 mm (0.062 5 in)

NOTE — The widths given for the notch are meant at full depth.
a : wall thickness in millimetres.

The notch sides shall be theoretically parallel and the bottom shall be theoretically perpendicular to the sides. The notch shall be cut on the external surface of the reference standard and shall be parallel to the pipe longitudinal axis except for seamless pipes, and at the option of the manufacturer it will possibly be oriented at an angle to allow maximum defect detection.

Lengths

- ultrasonic or diverted flux testing
 - α) 5 % *a* notch : 50 mm (2 in) min.
 - β) 12,5 % *a* notch : twice the probe length (total length).
- eddy current testing
 - total maximum length : 38 mm (1.5 in).

Width

1 mm (0.04 in) maximum.

Depth

Two types are used :

- α_1) 5 % *a* notch : 5 % of the specified wall thickness with a minimum of 0,3 mm (≈ 0.012 in).
- β_1) 12,5 % *a* notch : 12,5 % of the specified wall thickness with a minimum of 0,6 mm (≈ 0.024 in), with a depth tolerance ± 15 % and a minimum of $\pm 0,05$ mm (0.002 in).

11.6.4 Permissible depth of defects

For class II pipes and for class I and III pipes checked with 5 % *a* reference notch, all detected defects the depth of which is greater than 5 % but smaller than 12,5 % of the nominal wall thickness shall be removed by grinding or machining.

The maximum depth of grinding or machining is limited by the observance of the thickness tolerance, i.e. the remaining thickness at the bottom of the ground or machined part shall not be less than 87,5 % of the nominal thickness.

Where grinding or machining is done, use generous radii to prevent abrupt changes in wall thickness. After reducing these imperfections such areas shall be reinspected by one of the non-destructive testing methods specified above to verify complete removal of the defect.

11.6.5 Surface inspection of "Extreme-Line" casing

The upset portions of Extreme-Line casing shall be examined visually for defects.

The maximum permissible depth of defects from the inside or outside surface is 12,5 % of the theoretical pipe body wall thickness, except in the following two cases :

- a) pin end : on the inside surface, from the end of the pipe to the plane of the external shoulder (bored) : 0,38 mm.
- b) box end : on the outside surface :
 - for 121 mm from the end ($\phi < 193,7$ mm) : 0,25 mm.
 - for 165 mm from the end ($\phi < 219,1$ mm) : 0,25 mm.

All machined surfaces of the box end shall be free from seams and cracks; the threads shall be free from any imperfections which break the continuity.

11.7 Re-tests

In a case where a test on a pipe sample representative of the lot is not satisfactory the manufacturer may decide to re-test the product using test pieces taken on two additional pipes in the same lot.

These test pieces shall be cut as indicated in 11.3 and 11.4. If these test pieces meet the requirements, then all pipes in the lot shall be accepted except the one initially selected and from which the first defective test piece was cut.

If one of the test pieces fails to meet the requirements of the re-test, the manufacturer may choose to test individually all remaining pipes in the lot. In this case the test shall be carried out only for those properties which were not satisfactory at the re-test.

In case of unsatisfactory flattening re-tests per lot, the manufacturer may decide to re-treat and then re-test the lot. In case of individual testing the manufacturer may re-test test pieces cut on the same pipe end until satisfactory results are obtained. However, the pipe length shall not then be less than 80 % of that before the first cropping.

12 INSPECTION RIGHTS

When pipes are accepted by an inspector representing the purchaser, acceptance shall be in accordance with the requirements of clause 5 of ISO/R 404.

Pipes which show injurious defects on mill inspection or subsequently when applied in service may be rejected, and the manufacturer notified so that he will have the possibility to check the justice of the claim.

If destructive inspection is made other than at the place of manufacture, the purchaser shall only pay for those products which meet the requirements of this International Standard and not for those which result from rejection of non-conforming parts.