International Standard ISO 3306

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Plain end as-welded and sized precision steel tubes — Technical conditions for delivery

Tubes de précision en acier, soudés, calibrés extérieurement, à extrémités lisses — Conditions techniques de livraison

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established 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. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 3306 was prepared by Technical Committee ISO/TC 5, *Ferrous metal pipes and metallic fittings.*

This second edition cancels and replaces the first edition (ISO 3306-1975), of which it constitutes a technical revision.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Plain end as-welded and sized precision steel tubes — Technical conditions for delivery

1 Scope and field of application

This International Standard specifies the technical conditions for delivery of as-welded and sized tubes with plain ends, manufactured from the grades of steel shown in table 2, with precision dimensional tolerances and in those dimensions shown in table 8 which have been selected from ISO 4200.

Tubes in accordance with this International Standard are used mainly for purposes where importance attaches to dimensional accuracy and, if required, small thicknesses and surface finish.

If such tubes are intended for use in hydraulic piping equipment, they shall be used only in the annealed or normalized condition.

2 References

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

ISO 2604/3, *Steel products for pressure purposes — Quality requirements — Part 3: Electric resistance and induction-welded tubes.*

ISO 3545, *Steel tubes and tubular shaped accessories with circular cross-section — Symbols to be used in specifications.*

ISO 4200, *Plain end steel tubes, welded and seamless — General tables of dimensions and masses per unit length.*

ISO 6892, *Metallic materials — Tensile testing.*

ISO 8492, *Metallic materials — Tubes — Flattening test.* 1)

ISO 8493, *Metallic materials — Tubes — Drift expanding test.* 2)

3 Symbols

D = Outside diameter of the tube

T = Thickness of the tube wall

R_m = Tensile strength in newtons per square millimetre

R_{eH} = Upper yield strength in newtons per square millimetre

A = Elongation after fracture, as a percentage, of original gauge length (L_o), $L_o = 5{,}65\sqrt{S_o}$

S_o = Cross-sectional area of the gauge length

KM = As-welded and sized

GKM = Annealed in controlled atmosphere

GZF = Annealed in controlled atmosphere and descaled

NKM = Normalized in controlled atmosphere

NZF = Normalized in controlled atmosphere and descaled

4 Information to be supplied by the purchaser

4.1 Mandatory information

The purchaser shall state the following details in his enquiry and order:

a) quantity;

b) reference to this International Standard;

c) grade of steel;

d) required condition of tubes at delivery;

e) outside diameter and thickness;

f) length.

4.2 Optional conditions

Certain alternatives are permitted; other supplementary requirements may be specified and the purchaser shall state his requirements in his enquiry and order; if he does not do so, supply will be made at the option of the manufacturer.

4.3 Designation

The tubes shall be designated in the following sequence by

— the name of the product;

— reference to this International Standard;

— the grade of steel, the condition of tubes at delivery;

— the outside diameter and the thickness.

1) At present at the stage of draft. (Revision of ISO/R 202-1961 which remains in force until publication of ISO 8492.)

2) At present at the stage of draft. (Revision of ISO/R 166-1960 which remains in force until publication of ISO 8493.)

Example:

As-welded and sized precision steel tubes, in accordance with ISO 3306, in steel R37, annealed in a controlled atmosphere (GKM), of outside diameter 25 mm, thickness 2 mm, in random lengths, shall be designated as

Steel tubes ISO 3306-R37-GKM-25 × 2

5 Manufacturing processes

5.1 Steel-making processes and deoxidation

The tubes shall be manufactured from a steel produced by an open or electric hearth, or one of the basic oxygen steel-making processes.

The method of manufacture and deoxidation process is left to the option of the manufacturer.

At the purchaser's request, the supplier shall indicate the steel-making process and the deoxidation procedure used.

Rimmed steel is permitted for steel grades R28, R33 and R37.

5.2 Tube-making process

The tubes shall be manufactured from either hot- or cold-rolled steel strip longitudinally welded continuously by the passage of an electric current across the abutting edges without the addition of filler metal and sized. For certain applications, the tubes may be heat-treated. The condition of the tubes at delivery shall be chosen from table 1.

5.3 Heat treatment; delivery condition

The tubes are normally delivered in one of the conditions shown in table 1.

6 Chemical composition, mechanical properties and weldability

6.1 Chemical composition

6.1.1 Ladle analysis

On ladle analysis, the steel shall show the composition given in table 2, appropriate to the steel type specified.

Table 1 — Delivery condition

Description	Explanation	Symbol	Mechanical properties
As-welded and sized	No heat treatment after the welding and sizing process. For this reason, the tubes are workable only within certain undefined limits.	**KM**	See table 3
Annealed	After the final sizing process, the tubes are annealed in a controlled atmosphere.	**GKM**	See table 4
	After the annealing treatment, the tubes are descaled mechanically or chemically (pickled).	**GZF**	
Normalized	The tubes are heated to a temperature above the upper transformation point and cooled. Both stages of heat treatment are carried out in a controlled atmosphere.	**NKM**	See table 5
	After the normalization treatment, the tubes are descaled mechanically or chemically (pickled).	**NZF**	

Table 2 — Chemical composition on ladle analysis

Grade[1]	C max.	Si max.	Mn max.	P max.	S max.
	%	%	%	%	%
R28	0,13[2]	—	0,60	0,050	0,050
R33	0,16[2]	—	0,70	0,050	0,050
R37	0,17[2]	0,35	0,8	0,050	0,050
R44	0,21	0,35	1,2	0,050	0,050
R50	0,23	0,55	1,6	0,050	0,050

1) The designations used are provisional.

2) Rimmed steel may be used for steel grades R28, R33 and R37. If used for R33 and R37, the carbon content may be increased to 0,19 % max.

6.1.2 Product analysis

If a check analysis is required on tubes made from killed steel, the permissible deviations given in ISO 2604/3 apply.

6.2 Mechanical properties

6.2.1 The mechanical properties depend on the delivery condition. They are specified in tables 3, 4 and 5.

For tubes delivered in the annealed condition, the yield stress may be taken as 50 % of the minimum tensile strength given in table 4, for the purpose of calculating the test pressure.

Table 3 — Mechanical properties in the as-welded and sized condition — KM

Grade	R_m min.	A min. on 5,65 $\sqrt{S_o}$
	N/mm²	%
R28	300	10
R33	330	8
R37	400	7
R44	430	6
R50	520	5

Table 4 — Mechanical properties in the annealed condition — GKM and GZF

Grade	R_m min.	A min. on 5,65 $\sqrt{S_o}$
	N/mm²	%
R28	270	30
R33	320	27
R37	340	26
R44	400	24
R50	480	23

Table 5 — Mechanical properties in the normalized condition — NKM and NZF

Grade	R_{eH} min.	R_m min.	A min. on 5,65 $\sqrt{S_o}$
	N/mm²	N/mm²	%
R28	155	280	28
R33	195	320	25
R37	215	360	24
R44	255	430	22
R50	285	490	21

6.2.2 The tubes shall meet the appropriate requirements of the tests given in clause 9 (see tables 6 and 7).

6.3 Weldability

Tubes in the annealed or normalized condition are suitable for welding without special precautions. For as-welded and sized tubes which are welded or brazed, the mechanical properties in the heat-affected zone may be affected by the welding or brazing temperature.

7 Dimensions, masses and tolerances

7.1 Dimensions and masses

7.1.1 Diameters and thickness

The dimensions for outside diameter and thickness are given in table 8.

7.1.2 Masses

The mass per unit length of the tubes is given in table 8, the values being taken from ISO 4200.

7.1.3 Lengths

Concerning lengths, a distinction is drawn between:

a) random lengths between 2 and 7 m: these are supplied if, when ordering, no special agreement is reached concerning tube length;

b) exact length.

7.2 Tolerances

7.2.1 Diameter

The permissible variations on outside diameter given in table 8 apply to tubes in the as-welded and sized condition. As a result of distortion during annealing, with annealed and normalized tubes, the variations in diameter are greater; the permissible values are as follows:

Thickness, T (mm) Outside diameter, D (mm)	**Tolerance**
$T/D \geqslant 1/20$	the values given in table 8
$T/D < 1/20$ and $T/D \geqslant 1/40$	1,5 times the values given in table 8
$T/D < 1/40$ and $T/D \geqslant 1/60$	twice the values given in table 8
$T/D < 1/60$	2,5 times the values given in table 8

7.2.2 Thickness

Tolerances on thickness are given in table 8.

7.2.3 Ovality

The permissible variations in the tube outside diameter include ovality.

7.2.4 Lengths

Exact lengths: the following variations are permissible:

Length	Tolerance
⩽ 500 mm	$^{+2}_{0}$ mm
> 500 mm but ⩽ 2 000 mm	$^{+3}_{0}$ mm
> 2 000 mm but ⩽ 5 000 mm	$^{+5}_{0}$ mm
> 5 000 mm but ⩽ 7 000 mm	$^{+10}_{0}$ mm
> 7 000 mm	by agreement

If, in individual cases, lengths are required with a greater degree of accuracy, the permissible variations shall be agreed upon when ordering.

7.2.5 Straightness

The tubes shall be straight. For diameters greater than or equal to 16 mm, the total bend shall not exceed 0,2 % of the overall length of the tube. The bend measured on any length of 1 m shall not exceed 1,5 mm.

Special tolerances may be agreed between the manufacturer and the purchaser.

7.2.6 End preparation

The tube ends shall be cut nominally square to the axis of the tube. By agreement between the interested parties, special end-finishing may be applied.

When random lengths are supplied, they shall be mill-cut only and not subjected to end-finishing except that the ends shall be free from excessive external burrs.

8 Appearance and soundness

8.1 Appearance

The tubes shall have a smooth external surface, the degree of smoothness depending on the method of manufacture. The tubes shall have a workmanlike finish but small imperfections are permissible provided that the thickness remains within the lower tolerance limit.

The external fin shall be removed but may still be visible. Where the internal fin is removed, the residual fin height shall not exceed 0,30 mm if removed by cutting and 0,50 mm if removed by rolling. Where the internal fin is not removed, the internal fin height shall not exceed 60 % of the thickness with a minimum of 0,80 mm.

Tubes annealed or normalized in a controlled atmosphere may have a discoloration but shall be free from loose scale.

8.2 Rectification

Surface imperfections may be dressed provided that the thickness after dressing remains within the lower tolerance limit. Peening of surface defects is not permitted.

9 Inspection and testing

9.1 General requirements

Tests are normally applied only as a quality control by the supplier. If required for tubes supplied against a particular order, this shall be specifically stated in the order.

According to the provisions of the order, the tubes may be subjected to a final inspection prior to delivery, following the indications given in 9.1.1, 9.1.2 and 9.2.

Acceptance testing may be carried out by an agent appointed by the purchaser. This agent may be an outside inspector or may be selected from the staff of the manufacturer. The details of the acceptance testing shall be agreed upon at the time of ordering.

9.1.1 Summary of tests

The tubes shall be subjected to the following tests:

a) visual inspection;

b) tensile test;

c) drift expanding test; or

d) flattening test.

Drift expanding tests shall be made only in the case of tubes made from R28, R33, R37 and R44 in an annealed or normalized condition where thickness is between 1 and 6 mm; in the case of all other dimensions and grades of steel, the flattening test shall be made where annealed or normalized tubes are concerned.

A leaktightness test is not normally provided for these tubes. If these tubes are to be used for carrying fluids, and are in the normalized or annealed condition, they shall be tested. The leaktightness test shall be specified on the order.

9.1.2 Definition of a lot; selection and preparation of test pieces

The tubes subjected to acceptance tests shall be tested in lots. A lot comprises 200 tubes of the same steel grade, delivery condition and dimension.

All fractions of a lot comprising less than 200 tubes shall be considered as a complete lot. All fractions of a lot comprising less than 20 tubes shall be distributed among the other lots.

The tensile test and the drift expanding or flattening tests shall be carried out on one tube selected at random from each lot.

9.2 Test methods and results

All tests shall be carried out at ambient temperature.

9.2.1 Tensile test

In this test, carried out in accordance with ISO 6892, the tensile strength and percentage elongation shall be measured and the values obtained shall correspond to those in tables 3, 4 and 5. In the normalized condition, the upper yield strength shall also be measured and the values obtained shall correspond to those given in table 5.

9.2.2 Flattening test

The flattening test shall be carried out in accordance with ISO 8492. The test piece shall show neither crack nor fissure when the distance between the platens is not greater than the values given in table 6.

9.2.3 Drift expanding test

The drift expanding test shall be carried out in accordance with ISO 8493. The test piece shall show neither crack nor fissure before expansion reaches the values given in table 7.

9.2.4 Leaktightness test

Tubes shall pass a hydraulic pressure test at a pressure of 5 MPa (50 bar). A different pressure may be used, by agreement between the purchaser and the manufacturer.

The manufacturer may substitute for this test another type of test which guarantees an equivalent quality.

9.2.5 Visual inspection

With all tubes a visual inspection shall be made, as far as possible, of the external and internal surfaces.

Table 6 — Flattening test (in circumstances where the diameter and thickness allow deformation of the test sample)

Grade	Delivery condition	Distance between platens
	Normalized or annealed	After the test carried out according to ISO 8492[1], the distance H, in millimetres, between the platens shall not be greater than the value given by the formula: $H = \frac{(1 + c)\,T}{c + (T/D)}$ where T[2] is the thickness, in millimetres; D[2] is the outside diameter, in millimetres; c is the steel constant, varying with the grade:
R28		0,09
R33		0,09
R37		0,09
R44		0,07
R50		0,06

1) The weld shall be at 90° to the direction of the force induced.

2) Symbols from ISO 3545.

Table 7 — Drift expanding test
(The internal fin may be removed before testing)

Grade	Delivery condition	Expansion[1]	
		$1 < T \leqslant 4$	$4 < T \leqslant 6$
		%	%
R28	Normalized or annealed	12	8
R33		12	8
R37		10	6
R44		8	5

1) T is the thickness in millimetres.

9.2.6 Control of dimensions

The tubes shall be checked for compliance with diameter and thickness.

9.3 Invalidation of tests

The specifications of ISO 404 apply.

9.4 Retest

The specifications of ISO 404 apply.

10 Marking

The tubes shall be marked by labels which are fixed securely to the bundle or crate containing the tubes, and which shall contain the following information:

a) the manufacturer's mark;

b) the grade of steel (see table 2);

c) the delivery condition.

11 Protection

The tubes shall be delivered with surface protection. Unless otherwise agreed, the manufacturer's standard mill protection may be used.

12 Documents

If acceptance tests are agreed in the order, a works certificate shall be supplied, relating to the tests provided for in clause 9. The type of document supplied shall be in accordance with ISO 404.

13 Complaints after delivery

In the event of a complaint, the manufacturer shall have an opportunity to check the merit of the claim within a reasonable time. The contested items shall remain available for this purpose.

In particular, if imperfections appear after subsequent use by the purchaser, it is necessary to submit the product to a check.

Table 8 — Dimensions and masses per unit length

Values in millimetres

Outside diameter			Thickness[2], ± 10 % with ± 0,2 mm min.[3]															
			(0,8)	1	(1,2)	1,5	(1,8)	2	(2,2)	2,5	(2,8)	3	(3,5)	4	(4,5)	5	(5,5)	6
Series[1] 2	Series[1] 3	Tolerance	Masses per unit length, kg/m															
6		± 0,12	0,103	0,123														
8			0,142	0,173	0,201	0,240												
10			0,182	0,222	0,260	0,314												
12			0,221	0,271	0,320	0,398	0,453	0,493										
	14		0,260	0,321	0,379	0,462	0,542	0,592										
16			0,300	0,370	0,438	0,536	0,630	0,691	0,749									
	18		0,339	0,419	0,497	0,610	0,719	0,789	0,857	0,956								
20		± 0,15	0,379	0,469	0,556	0,684	0,808	0,888	0,966	1,08	1,19	1,26						
	22		0,418	0,518	0,616	0,758	0,897	0,986	1,07	1,20	1,33	1,41						
25			0,477	0,592	0,704	0,869	1,03	1,13	1,24	1,39	1,53	1,63						
	28		0,537	0,666	0,793	0,980	1,16	1,28	1,40	1,57	1,74	1,85						
	30		0,576	0,715	0,852	1,05	1,25	1,38	1,51	1,70	1,88	2,00	2,29					
32		± 0,20	0,616	0,765	0,911	1,13	1,34	1,48	1,62	1,82	2,02	2,15	2,46					
	35			0,838	1,00	1,24	1,47	1,63	1,78	2,00	2,22	2,37	2,72					
38				0,912	1,09	1,35	1,61	1,78	1,94	2,19	2,43	2,59	2,98	3,35				
40				0,962	1,15	1,42	1,70	1,87	2,05	2,31	2,57	2,74	3,15	3,55				
	45	± 0,30		1,09	1,30	1,61	1,92	2,12	2,32	2,62	2,91	3,11	3,58	4,04				
50				1,21	1,44	1,79	2,14	2,37	2,59	2,93	3,26	3,48	4,01	4,54	5,05			
	55				1,59	1,98	2,36	2,61	2,86	3,24	3,60	3,85	4,45	5,03	5,60			
60		± 0,40			1,74	2,16	2,58	2,86	3,14	3,55	3,95	4,22	4,88	5,52	6,16	6,78		
70					2,04	2,53	3,03	3,35	3,68	4,16	4,64	4,96	5,74	6,51	7,27	8,01	8,75	
80					2,33	2,90	3,47	3,85	4,22	4,78	5,33	5,70	6,60	7,50	8,38	9,25	10,1	
	90	± 0,50				3,27	3,92	4,34	4,76	5,39	6,02	6,44	7,47	8,48	9,49	10,5	11,5	12,4
100						3,64	4,36	4,83	5,31	6,01	6,71	7,18	8,33	9,47	10,6	11,7	12,8	13,9
	110	± 0,60						5,33	5,85	6,63	7,40	7,92	9,19	10,5	11,7	12,9	14,2	15,4
120								5,82	6,39	7,24	8,09	8,66	10,1	11,4	12,8	14,2	15,5	16,9
	140	± 0,70										10,1	11,8	13,4	15,0	16,6	18,2	19,8
160		± 0,80												15,4	17,3	19,1	21,0	22,8

1) See ISO 4200 for definition of series. The classification of the outside diameter is the same.

2) Thicknesses in parentheses shall be avoided wherever possible.

3) Tolerance on thickness for tubes of outside diameters 6 and 8 mm: ± 15 %.