Draft Indian Standard

Stainless Steel Welded Tubes for conveyance of aqueous liquids - Specification

1. SCOPE

This standard covers the requirements for Austenitic, Ferritic and duplex stainless steel welded tubes intended for conveyance of aqueous liquids including water for human consumption, suitable for use with compression fitting or press fitting. This standard is applicable to tubes of size from 6 mm to 267 mm outside diameter.

2 REFERENCES

The following standards contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below

3 TERMINOLOGY

3.1 The definitions as mentioned in IS 1956 (Part 8) shall apply.

4. SUPPLY OF MATERIAL

4.1 General requirements relating to the supply of the steel tubes shall conform to IS 1387.

5. MANUFACTURE

5.1 Unless otherwise agreed in order, the processes used in making the steel for production of pipes / tubes are left to the discretion of the manufacturer. When so desired, the purchaser shall be informed of the steel making process.

The steel shall be subject to refining treatments such as vacuum oxygen decarburization (VOD) / argon oxygen decarburization (AOD), followed by ladle refining to minimise dissolved gas contents, inclusions content and to meet the chemical composition with close tolerances.

5.2 The tubes shall be manufactured by automatic welding process without addition of filler metal.

5.3 The tubes may be supplied in
i) as welded condition or
ii) annealed (for ferritic SS) / solution annealed (for Austenitic and duplex SS) condition, if agreed between manufacturer and the purchaser

5.4 Weld seam:
External weld seem shall be removed. Internal weld seam, depending on the agreement between purchaser and the manufacturer, may or may not be removed.

6. Chemical Composition

6.1 The tubes shall be manufactured from the Stainless steel grades mentioned in Table 1. The chemical composition of the steel as determined on the ladle analysis shall conform to requirement as mentioned in Table 1.

The analysis of steel shall be carried out either by the method specified in IS228 and its relevant parts or any other established instrumental/chemical methods. In case of dispute the procedure given in IS 228 and its relevant parts shall be the referee method. However, where method is not given in IS 228 and its relevant parts, the referee method shall be as agreed to between the purchaser and the manufacturer.

6.2 Product Analysis

In case of product analysis Maximum permissible variations over the maximum limits specified in Table 1 shall be as per Table 2.

An analysis of each heat of steel shall be conducted by the steel manufacturer. The chemical composition thus determined, or that determined from a product analysis made by the tubular product manufacturer, shall confirm to the requirement.

Table 1 Chemical Composition, Percent
(*Clause 6.1 and 6.2*)

Sl No.	Grade Designation Letter Sumbol [see IS 1762 (Part 1)]	Numerical Symbol ISS	C Max	Si Max	Mn Max	Ni Max	Cr	Mo	S Max	P Max	N Max	Cu Max	Others
-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13	-14
i)	***Ferritic steels:***												
1	X02Cr17TiNb	430Ti	0.030	0.75	1.00	—	16.00-19.00	—	0.030	0.040	—	-¾	Ti or Nb 0.10-1.00
2	X02Cr18Mo2TiNb	444	0.025	1.00	1.00	1	17.5-19.5	1.75 - 2.50	0.030	0.040	0.035	—	(Ti+Nb)[0.20+4 (C+N)] Min, 0.80 Max
ii)	***Austenitic steels:***												–
1	X04Cr19Ni9	304	0.07	0.75	2.00	8.0-10.5	17.5-19.5	—	0.030	0.045	0.100	—	–
2	X 02Cr19Ni10	304 L	0.030	0.75	2.00	8.0. 12.0	17.5-19.5	—	0.030	0.045	0.100	—	–
3	X 04Cr17Ni12Mo2	316	0.08	0.75	2.00	10.0 - 14.0	16.0-18.0	2.0-3.0	0.030	0.045	0.100	—	—
4	X 02Cr17Ni12Mo2	316 L	0.030	0.75	2.00	10.0 - 14.0	16.0-18.0	2.0-3.0	0.030	0.045	0.100	—	—
5	X 04Cr17Ni12Mo2Ti	316 Ti	0.08	0.75	2.00	10.0 ·14. 0	16.0-18.0	2.0-3.0	0.030	0.045	0.100	—	Ti 5x (C + N) *Min — 0.70 Max*
6	X 04Cr19Ni13Mo3	317	0.08	0.75	2.00	11.0 - 15.0	18.0-20.0	3.0–4.0	0.030	0.045	0.100	—	—
7	X02Cr18Ni14Mo4N	317LMN	0.030	0.75	2.00	13.5 - 17.5	17.0-20.0	4.0-5.0	0.030	0.045	0.10 - 0.20	¾	—
8	X 04Cr18Ni10Ti	321	0.08	0.75	2.00	9.0-12.0	17.0-19.0	—	0.030	0.045	0.100		Ti 5 x(C + N) *Min* — 0.70 *Max*
9	X02Cr21Ni25Cu	904L	0.020	1.00	2.00	23.0 - 28.0	19.0-23.0	4.00 - 5.00	0.035	0.045	0.100	1.00 - 2.00	—

10	X01Cr20Ni25Mo6Cu	904LN	0.020	0.50	2.00	24.0 - 26.0	19.0- 21.0	6.00 - 7.00	0.010	0.030	0.15 - 0.25	0.50 - 1.50	—
iii)	***Duplex:***												—
1	X 02Cr22Ni6Mo3N	2205	0.030	1.00	2.00	4.5- 6.5	22.0- 23.0	3.0- 3.5	0.020	0.030	0.14 - 0.20	—	—
2	X 02Cr23Ni4CuN	2304	0.030	1.00	2.50	3.0- 5.5	21.5- 24.5	0.05 - 0.60	0.030	0.040	0.05 - 0.20	0.05 - 0.60	—

Table 2 Permissible Variation Between Specified Analysis and Product Analysis

Sl No.	**Element**	**Limits of Ladle Analysis as Shown in Table 1,** *Percent*		**Permissible Deviation[1)]**
		Over	Upto and Including	± unless specified as +
i)	C	—	0.03	+0.005
		0.03	0.2	0.01
		0.2	0.6	0.02
		0.6	1.2	0.03
ii)	Si	—	1	0.05
		1	2.5	0.1
iii)	Mn	—	1	0.03
		1	3	0.04
		3	6	0.05
		6	10	0.06
		10	14	0.1
iv)	Al	—	0.3	0.05
v)	Cr	10	15	+0.15
		15	20	0.2
		20	30	0.25
vi)	Mo	—	0.6	+0.03
		0.6	1.75	0.05
		1.75	3	0.1
vii)	Ni	—	1	+0.03
		1	5	0.07
		5	10	0.1
		10	20	0.15
		20	30	0.2
viii)	N	—	0.02	0.005
		0.02	0.15	0.01
		0.15	0.35	0.02
ix)	Ti	—	1	+0.05
x)	Nb	—	1.2	+0.05
xi)	S	—	0.04	+0.005
		0.04	0.2	0.01
		0.2	0.5	0.02
xii)	P	—	0.04	+0.005
		0.04	0.1	0.01

xiii)	Ta	—	1.5	+0.05
xiv	Cu	—	0.5	+0.03
		0.5	1	0.05
		1	3	0.1
		3	4	0.15
xv)	V	—	0.5	+0.03
		0.5	1.5	0.05
xvi)	W	—	1	+0.03
		1	2	0.05

NOTE ¾ Tolerance shall be mutually as agreed to between the purchaser and the supplier for other alloying elements.

[1)] The use of '+'means that in one cast the deviation may occur over the upper value or under the lower value of the specified range in the table but not both at the same time.

7. Tolerances in Wall Thickness, Diameter, length

The recommended Nominal OD and wall thickness combinations can be selected as per different series given below along with the tolerance on the wall thickness, diameter and length shall be as given in table 3 and 4

Table 3: Size of tubes and Permitted Variations

Series – 1 (Applicable for Capillary, Compression & Press fitting type of tubes)

Tubes for Capillary application with OD of series 1 can have Thickness as per Series 2

Nominal OD	Tol. on OD	Thick
6	+0.04/-0.06	0.6
8	+0.04/-0.06	0.6
10	+0.04/-0.06	0.6
12	+0.04/-0.06	0.6
15	+0.04/-0.06	0.6
18	+0.04/-0.06	0.7
22	+0.05/-0.05	0.7
28	+0.05/-0.05	0.8
35	+0.07/-0.03	1
42	+0.07/-0.03	1.1
54	+0.07/-0.16	1.2
66.7	+0.05/-0.62	1.2
76.1	+0.2/-0.56	1.5
103	+0.8/-0.8	1.5
108	+0.3/-0.8	1.5

Tolerance on wall thickness shall be ±10% of the nominal thickness for series 1.

Series – 2 (Applicable for Compression & Press fitting type of tubes)

Specified Outside Diameter OD	Tolerance on OD	Specified Wall thickness T	Tolerance on T
12	±0.10	1.0	±0.10

15	±0.10	1.0	±0.10
18	±0.10	1.0	±0.10
22	±0.11	1.2	±0.10
28	±0.14	1.2	±0.10
35	±0.18	1.5	±0.10
42	±0.21	1.5	±0.15
54	±0.27	1.5	±0.15
64	±0.32	2.0	±0.15
76.1	±0.38	2.0	±0.15
88.9	±0.44	2.0	±0.15
108	±0.54	2.0	±0.15
133	±1.00	3.0	±0.30
159	±1.00	3.0	±0.30
219	±1.50	3.0	±0.30
267	±1.50	3.0	±0.30

The Outside Diameter tolerances given in table 2 include Ovality.

The customer must specify the requirement is from which series.

Table 4: Tolerance on Length

Specified Length	**Permissible variation in cut length mm**
Up to & including 6 M	+6/-0
Above 6 M to ≤12 M	+12/-0
Above 12 M	To be agreed between the purchaser and the manufacturer

8. Drift Expanding Test – One end of one tubes of Austenitic and Duplex steel shall be expanded using a conical tool having an included angle of 60 degree until the maximum outside diameter is increased by 25%. For Ferritic steel, the criteria shall be agreed upon to before ordering. One specimen shall be drawn from a lot of up to 400 tubes.

9. *Flattening Test*— *F*lattening tests shall be carried out in accordance with IS:2328-2018 on a sample drawn from a lot of up to 400 tubes.
A section of tube not less than 100mm in length shall be flattened cold between parallel plates. The weld shall be placed 90 degree from the direction of the applied force. No cracks or breaks on the inside or outside surfaces shall occur before the distance between the plates is 5 times the thickness.

10. Leak Tightness Test

10.1 Each tube shall be subjected to the hydrostatic test or non-destructive eddy current test or air under water test in accordance with requirement mentioned thereof. The type of test to be used shall be at the option of the manufacturer, unless otherwise specified in the purchase order.

10.2 Hydrostatic Test

10.2.1 Each length of tube shall be tested by the manufacturer to a minimum hydrostatic pressure of 5 MPa for tubes up to and including 76.1 mm outside diameter, and 3 MPa for tubes greater than 76.1 mm outside diameter.

10.2.2 The test pressure shall be held for a minimum of 5 s. The test pressure shall be held for a time sufficient to permit the entire length of the tube to be inspected.

10.2.3 The hydrostatic test may not be capable of testing the end portion of the tube. The length of tube that cannot be tested shall be determined by the manufacturer and, if specified in the purchase order, reported to the purchaser.

10.2.4 The hydrostatic test may be performed prior to the final length, or prior to upsetting, swaging, expanding, bending, or other forming operations.

10.3 Eddy-Current Testing

Eddy-Current test shall be carried out in accordance with IS: 6398-2:2020. The reference standard shall contain, following reference discontinuities:

10.3.1 Drilled Hole—The reference standard shall contain three or more holes, equally spaced circumferentially around the tube and longitudinally separated by a sufficient distance to allow distinct identification of the signal from each hole. The holes shall be drilled radially and completely through the tube wall, with care being taken to avoid distortion of the tube while drilling. Run the calibration standard through the test coils three times, with the weld turned at 120° on each pass. The hole diameter shall not exceed the following Table 4:

NPS Designator, (inch)	Hole Diameter (mm)
½	1.0
Above ½ to 1 ¼	1.4
Above 1 ¼ to 2	1.8
Above 2 to 5	2.2
Above 5	2.7

10.4. Air under water test

The tubes shall be tested at a minimum pressure of 0.6 MPa . No air bubbling shall occur.

11. Non-destructive Test of weld seam

Non-destructive testing of the weld seam shall be carried out in accordance with IS: 6398-2:2020 for the detection of imperfections to acceptance level E4H.

12. Retests

Should any one of the test pieces first selected fail to pass any of the tests specified, two further samples shall be selected for testing in respect of each failure from the same lot. Should the test pieces from both these additional samples pass, the material represented by the test samples shall be deemed to comply with the requirement of that particular test. Should the test pieces from either of these additional samples fail, the material represented by the test samples shall be deemed as not complying with the standard.

13. Workmanship, Finish, and Appearance

The tubes shall be clean and free from such defects as can be established by visual inspection. The tubes shall have a finish and surface condition which permits surface imperfections or marks requiring dressing to be identified.

Removal of imperfections by grinding is permitted, provided the wall thicknesses are not decreased to less than that permitted in the Permissible Variations in Wall Thickness

The ends shall be square cut and free from burrs.

The finished tubes shall be reasonably straight and shall be free from burr. For tubes over 50 mm in diameter, deviation from straightness over the entire length L shall not be more than 0.2% of the length. Deviation from straightness over any length of 1 M shall not exceed 3 mm.

14. Marking

14.1 Each tube / pipe shall be marked with the following details:
a) Name / trade-mark of the Manufacturer.
b) Grade.

14.2 Bundle / Lot marking: Each Bundle of all sizes should have following identifications:
a) Name / trade-mark of the Manufacturer.
b) Grade.
c) Lot / Batch No.
d) Outer Diameter & Thickness

Any other marking pattern can be used for internal traceability as per buyer's confirmation.

14.3 BIS CERTIFICATION MARKING

The product(s) conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed thereunder, and the products may be marked with the Standard Mark.

Optional Requirement

O1. Delivery Condition – Austenitic and duplex stainless steel tubes may be supplied in the solution annealed condition and ferritic Stainless steel tubes may be supplied in annealed condition.

If agreed, the pipes shall be supplied in the heat treatment condition as mentioned in table 5.

Table 5 Recommended Heat Treatment

Type	Grades	Heat treatment temp	Cooling
Ferritic	430Ti, 444	650	As appropriate for the grade
Duplex	2205, 2304,	1020-1100 925-1050	Rapid cooling in air or water
Austenitic	304,304L, 316,316L,316Ti,317, 317LMN, 321	1040	Quenched in water or rapidly cooled by other means
Austenitic	904L, 904LN	1100	

Temperature is minimum otherwise stated

Tensile Test

In such cases, Tubes (applicable for tubes of size as per series 2 of Table 3) shall confirm to the tensile properties prescribed in table 6. One tension test shall be carried out in accordance with IS:1608 (part 1) on a specimen for lots of not more than 50 tubes. Tension tests shall be made on specimens from two tubes for lots of more than 50 tubes.

Table 6. Tensile Requirements

Grade	Tensile Strength, Min MPa	Yield Strength, Min MPa	% Elongation (Min) on a Gauge length of 50 mm
430Ti	415	240	20
444	415	275	20
304	515	205	35
304L	485	170	35
316	515	205	35
316L	485	170	35
316Ti	515	205	35
317	515	205	35
317LMN	550	240	35
321	515	205	35
904L	490	215	35
906LN	650	295	35
2205	655	485	25
2304 OD<=25 mm	690	450	25
2304 OD>25 mm	600	400	25

O2. Stress Relieved Annealed Tubes – Grade 304L, 316L and 321 may be specified in Stress Relieved Annealed condition if these are to be used in corrosive atmosphere of particular type.

Stress Relieved Annealing is done at 845 to 900 degree C and air cooled or cooled slowly. This is done after straightening. After this annealing, no further straightening shall be done.

O3. Stabilizing Heat treatment – Subsequent to the solution annealing grade 321 require stabilizing heat treatment at a temperature below the solution annealing temperature, to be agreed upon between the producer and the purchaser.

O4. Intergranular Corrosion test – When agreed between producer and the purchaser, the test may be conducted as per IS IS 10461 Part 1 & 2 for austenitic stainless steel. For duplex stainless steel and ferritic stainless steel the test method shall be as agreed between purchaser and manufacturer ~~or in accordance with ISO 3651 – 2.~~ For austenitic grades containing Titanium or Columbium may require stabilizing heat treatment.