



PRODUCT STANDARD
CDE DEPARTMENT, BHOPAL

HE - 54007

Rev. No.
06

Page No. **1** of **4**

TECHNICAL SPECIFICATION FOR
WELDED AUSTENITIC STAINLESS STEEL TUBES

1.0 MATERIAL

Straight/U-bend welded Austenitic Stainless Steel Tubes conforming to material specification **SA-688 TP 304 / 304N** of ASME section II part A; with **carbon limited to 0.05 % maximum**. The tube shall conform to the applicable requirements of SA-1016 of ASME sec. II part A. Tubes shall be supplied in **bright annealed condition**.

2.0 SIZE

As specified in Enquiry/Purchase order/Tube ordering drawing.

3.0 QUANTITY

As specified in our Enquiry/Purchase order.

4.0 MANUFACTURING

4.1 Tubes shall be made from flat steel by an automatic welding process with no addition of filler material.

4.2 Tube shall be longitudinally welded and shall be free from circumferential joint.

4.3 Subsequent to welding and prior to final heat treatment, the tube shall be cold worked either in both the weld metal & base metal (cold drawing) or, in the weld metal (Bead rolling/Bead hammering). For thicker tubes above 1.5 mm in thickness, cold drawing is preferred. Weld projection on inside and outside surface is not permissible.

4.4 Drawing and bending lubricants shall not contain Chloride of more than 50 ppm. Each cleaning operation shall be followed by rinse (s). Final rinsing shall be done using demineralized water with **chloride content limited to 10 ppm**.

4.5 **Hot bending to form U-Tubes is Not Acceptable.**

5.0 FINISH & TOLERANCES

5.1 The inside and outside surface of tubes shall be smooth and finish on both O.D. and I.D. shall be **1.6 microns** or, **better**



5.2 Permissible variation in dimensions shall be in accordance with SA-688 of ASME sec.II part-A, unless otherwise specified on drawing.

5.3 The wall thickness of the tube in the U-bend section shall not be less than the value determined by the equation :

$$T = \frac{T_o \times 4 \times R}{(4 \times R + D)}$$

where :

T = Wall thickness after bending, mm & **T_o** = Specified minimum tube wall thickness.
R = Centre line bend radius, mm & **D** = Nominal outside diameter of tube, mm.

Revision No.	Standard retyped & re-issued. Cl. 1.0, 4.3, 4.4, 6.2 & 7.1 modified. Cl.5.4, 6.1, 7.2 and 7.8 to 7.12 added.	Distribution	Approved By Product Standardisation Committee CDE - BHEL - Bhopal		
06		CDE	1		
Date of Rev.	 	HCM	1	Prepared By	Issued By
20.07.2013	(S. Saxena) (Taurani M L)	QHC	1	sd/- (B.N. Iyer)	sd/- (K.S. Pillai)
				Date of Issue	20.05.1987



PRODUCT STANDARD
CDE DEPARTMENT, BHOPAL

HE - 54007

Rev. no.
06

Page No. **2** of **4**

5.4 Tolerances on

- a. Outside diameter (St. leg portion) : ± 0.10 mm
- b. Outside diameter (U-bend portion) : Major & minor dia of tube shall be within 10% of nom. dia.
- c. Wall thickness on straight portion of tubes :
 - for minimum wall tubes : (+) **15** % / (-) 0%
 - for average wall tubes : ± 10 %
- d. Tube leg length; upto 6.0 m long: (+) 3.2 mm / (-) 0 ; from 6.0 m to 13.0 m : (+) 4.5 mm / (-) 0
Difference in length of tube legs of each tube shall be limited to 3.00 mm max.

6.0 HEAT TREATMENT

- 6.1 All lubricants or any type of coating on both outside & inside surface on tubes, used in the manufacturing process for straight tube or in the U-bending process, shall be removed fully before the heat treatment of tubes. Cleaning of tube inside surface may be ensured by blowing closely fitted acetone soaked felt plugs.
- 6.2 Straight tubes shall be cleaned and **bright annealed** at a minimum temperature of **1040 Deg. Cent.** Followed by fast quenching to below **370 Deg.Cent.** to prevent chromium carbide precipitation. Intermediate annealing as required to be done by vendor to meet the final requirements.
- 6.3 All bend of U-bend tubes shall be annealed at a temperature of 1040 Deg. Cent. minimum followed by rapid cooling below 370 Deg. Cent.. Annealing shall include bend portion plus a minimum of 150 mm of straight length of each leg beyond the point of tangency to the bend. The solution annealing procedure shall be such that it does not leave any sensitized area/zone in any portion of entire tube (bend as well as straight portion). This shall be demonstrated by testing adequate number of sample tubes representing all sections and portions i.e. bend as well as complete straight portion. The tubes shall be cleaned thoroughly prior to annealing.
- 6.4 If annealing of U- bend is accomplished by electric resistance method, no arc burn or, copper deposits from clamps shall be allowed.

7.0 TESTINGS

- 7.1 Tubes shall be tested for **chemical composition & mechanical properties** i.e. tensile strength, yield strength, elongation, hardness, flattening, flaring, reverse bend etc. in finished condition with quantum of check as per SA-688 of Sec. II Part A: Latest.
- 7.2 **Hardness testing of finished tubes:** Finished tube samples shall be subjected to hardness test. Hardness in the finished tubes shall be limited to **85 HRB**. Quantum of check shall be two(2) tubes per lot as per SA-688.
- 7.3 All straight tubes or, U-tubes before bending operation, shall be examined by **Eddy Current Examination** covering the entire length, as per supplementary requirement S-2 of SA-688; ASME Sec. II Part A: Latest. Untested ends & defective tubes shall be discarded with permanent mark on the same.
- 7.4 Sample tubes shall be examined for resistance to **Inter Granular Corrosion** by conducting **IGC Test** as per ASTM-A 262 practice-E with sample tubes drawn from each lot. This testing shall be carried out on samples of straight tubes in finished condition and also on the center of bend tube sample i.e. tube of the smallest radius bend which is heat treated.
- 7.5 If specified on tube ordering drawing, bends portion of all U-tubes shall be examined by **Liquid Penetration Examination** method to ensure that bends are free from any kind of surface defects like cracks etc.



PRODUCT STANDARD
CDE DEPARTMENT, BHOPAL

HE - 54007

Rev. no.
06

Page No. **3** of **4**

- 7.6 Each straight tube or U-tube, upon completion of bending and annealing operations, shall be subjected to **hydrostatic pressure test**, at the pressure specified on the tube ordering drawing, using dematerialized water or using water chloride content limited to 10 ppm max.
- 7.7 One sample tube of each wall thickness at the minimum bend radius, for each respective wall thickness shall be sectioned and checked for **ovality & thickness variation** at bend, before commencing bending operation on tube being supplied against order.
- 7.8 **Microstructure Examination:** Microstructure check shall be carried out on at least one specimen per heat/heat treatment lot of finished tube to examine presence of harmful & undesirable metallurgical phase & structure. Photographs of microstructure examination on both base metal & weld metal shall be furnished with complete set of test certificates.
- 7.9 **Delta-Ferrite Examination:** Presence of delta-Ferrite content shall be examined in at least one specimen per heat/heat treatment lot of finished tube in each thickness. Delta-ferrite content shall be limited to 1.0% max in weld metal and 0.80% max. in base metal.
- 7.10 **Residual Chloride Check:** The residual chloride salt contamination on the inside and outside surface of the finished tube before packing shall not exceed a concentration level of **10.7 mg/sq.m.** of the tube surface. At least one specimen tube per lot of 500 finished tubes shall be checked for chloride salt contamination.
- 7.11 **Residual Hoop Stress Examination:** Tubes shall be manufactured in such a way that in the process of rolling, drawing, straightening, U-bending etc. the stresses induced in the tubes is bare minimum. In any case the residual stresses shall be limited **2.0 kg/sq.mm** (compressive or tensile) in the tubes with wall thickness above **18 BWG** (1.244 mm) and 4.0 kg/sq.mm (compressive or tensile) in the tubes with wall thickness below 18 BWG (1.244 mm). Residual stress shall be checked in one tube per lot of tube.
- 7.12 **NDE-Ultrasonic Examination:** Thick walled Tubes (**16 BWG** i.e. 1.651 mm & above) shall be subjected to ultrasonic examination. Vendor to furnish Ultrasonic examination procedure for review and approval by BHEL.
- 8.0 INSPECTION & QUALITY ACCEPTANCE**
- 8.1 Inspection shall be carried out by BHEL/ BHEL appointed inspection agency/ IBR/ IBR approved inspection agency/Customer as per the requirements indicated in the BHEL/Customer approved QA Plan and BHELs enquiry/purchase order. All the facilities shall be provided by the vendor for stage and final inspection by the inspection agency.
- 8.2 Vendor shall institute and enforce suitable quality assurance, details of which shall be furnished to BHEL along with the offer.
- 8.3 To enable BHEL inspector/Inspection agency to fix up stages of inspection, vendor shall furnish process Flow Chart & Quality assurance Plan indicating stages of inspection, along with the offer.
- 8.4 No shipment shall be made without prior specific clearance/ approval by BHEL/Inspection Agency, unless otherwise it is waived-off in writing by BHEL.
- 8.5 As specified in the purchase order, tubes shall be inspected by third party and in case of HP Heater tubes, test certificates duly signed by inspection agency in **IBR Form III B1** shall be furnished along with other test certificates of the tubes..

9.0 TEST CERTIFICATES

9.1 Four(4) sets of all test certificates covering atleast the following tests, duly signed by the inspection Agency are required.

- a. Heat Treatment Charts.
- b. Chemical Analysis (Ladle / Strip & Product).
- c. Mechanical Properties.
- d. Delta-Ferrite Examination
- e. Inter Granular Corrosion, IGC Test Report
- f. Residual Hoop Stress Test Report.
- g. Hardness Test Report.
- h. Micro-Structure examination report with photographs.
- i. Eddy Current Examination report.
- j. Liquid Penetration Examination (if specified).
- k. Ultrasonic Examination of tubes
- l. Hydro-static Test.
- m. Dimension verification Record including bead height measurement record.
- n. IBR Form III B1 (Original) – if specified.

All test certificates duly complied, shall be set with index in a plastic cover file for ease in handling & maintaining record.

10.0 PACKING & MARKING

10.1 All tubes shall be shipped in containers made up of fully seasoned wood & shall be free from the protruding nails and other objectionable projections. Tube shall be packed with bags of silica gel distributed along the length of the tube and all around inside the packing case. Tubes shall be held in position with adequate no. of separators/partitions to avoid movement and rubbing during handling & shipment. Each layer shall be separated from other layers throughout the length. The case shall be suitable constructed so as to prevent excessive bending during lifting/handling.

The lid of packing case shall be bolted type & tubes properly covered with polythene sheet to prevent flow of water inside the case thus rendering the case completely water proof. Each package shall be convenient weight for ease in handling. This shall **not** normally exceed **3500 kgs.(gross)**.

Package detail shall generally comply with BHEL Corporate Spec. **AA-0490003**.

10.2 Each tube shall be marked with following information along the tube length at regular intervals.

"Heat No., Material Specification, Tube size, Drawing Number and Item Number".

10.3 Each shipping unit shall be marked with the following.

"Purchase Order No., Material Specification, Overall Dimensions, Gross & Net Weight, Vendor's name & Heat No.. In case of box containing tubes of more than one heat, tubes of each heat shall be separately bundled and identified with the heat Number.

11.0 SUPPLEMENTARY REQUIREMENTS

For supplementary requirements, refer notes on Tube Drawing(s).