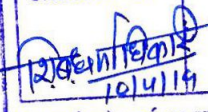
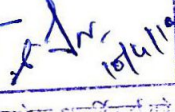
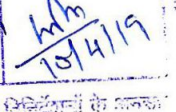
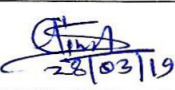
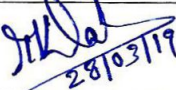
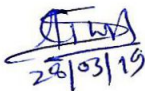


MAIN SUPPLIER'S NAME: BHARAT HEAVY ELECTRICALS LIMITED, BHOPAL (A GOVERNMENT OF INDIA UNDERTAKING) 					
NAME OF SUB-VENDOR: N/A					
NPCIL PO NO.: CMM/FTP/10-32-1-1152/e-PO/30447, DTD: 24.01.19					
QA REF. NO.: MAIN VENDOR: QAX-TH-1479 2190191 SUB VENDOR: N/A					
CUSTOMER: NUCLEAR POWER CORPORATION OF INDIA LIMITED (A GOVERNMENT OF INDIA ENTERPRISE) 					
PROJECT: 2x700MW GORAKHPUR HARYANA ANU VIDYUT PARIYOJANA (UNIT 1&2)					
EQUIPMENT: MODERATOR HEAT EXCHANGER					
DOCUMENT NO.: BHEL / NPCIL / 30447 / SS TUBES / CDE-19-3407					
TITLE: TUBES TECHNICAL SPECIFICATION FOR SOLUTION ANNEALED SEAMLESS STAINLESS STEEL TUBES.					
 न्यूक्लियर पावर कॉर्पोरेशन ऑफ इंडिया लिमिटेड NUCLEAR POWER CORPORATION OF INDIA LTD. ☒ अनुमोदित / APPROVED with minor comments. ☐ डिप्पणी के अनुसार अनुमोदित / APPROVED AS NOTED ☐ संशोधन को आगे बढ़ाएं / रोकें । PROCEED WITH / HOLD FABRICATION ☐ अंतिम ट्रान्स्पारेंसी एवं प्रिंटिंग भेजें । SEND FINAL TRANSPARENCIES & PRINTS ☐ संशोधन करें एवं अनुमोदन के लिए पुनः प्रस्तुत करें। REVISE AND RESUBMIT FOR APPROVAL जाँचकर्ता CHECKED BY  28/03/19 समीक्षकर्ता REVIEWED BY  28/03/19 अनुमोदन कर्ता APPROVED BY  28/03/19 किए जानेवाले कार्य का अनुमोदन आपूर्तिकर्ता को निर्दिष्टियों के अनुसार आपूर्ति के उत्तरदायित्व से मुक्त नहीं करता । The Approval of the work to be done does not relieve the supplier of responsibility of supply according to specifications.					
01	28.03.2019	2+10 = 12	 28/03/19	 28/03/19	 28/03/2019
00	08.03.2019	2+10 = 12	-Sd- (DK AUDH)	-Sd- (M WAHAB R)	-Sd- (ASNANI L)
REV NO.	DATE	PAGES	PREPARED BY	CHECKED BY	APPROVED BY

	CONDENSER & HEAT EXCHANGER ENGG. DIVISION BHEL BHOPAL	Document No.
		BHEL / NPCIL / 30447 / SS TUBES / CDE-19-3407
TECHNICAL SPECIFICATION FOR SOLUTION ANNEALED SEAMLESS STAINLESS STEEL TUBES		

REVISION CONTROL SHEET

BHEL					
REV. No Date	PAGES	Description of Revision	Prepared By	Checked By	Approved By
00, 08.03.2019	2+10=12	Original submission with correction in sr. nos. of clause no. 3 from cl no. 3.6 onwards.	-Sd- f (DK AUDH)	-Sd- (M WAHAB R)	-Sd- (ASNANI L)
01, 28.03.19	2+10=12	Cover sheet updated as per NPCIL comments dtd: 14.03.19	 28/03/19	 28/03/19	 28/03/2019 (AK MAHAR)

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ANNEXURE 1

SPECIFICATION FOR SOLUTION ANNEALED STAINLESS STEEL TUBING FOR HEAT EXCHANGERS

1.0 SCOPE

This specification covers the technical requirements for the supply of seamless solution annealed stainless steel tubing for heat exchangers. All the requirements in this specification represent minimum requirements.

2.0 APPLICABLE SPECIFICATIONS

The following codes and standards of the issue in effect at the date of issuing the tender document shall form part of this specification. In the event that certain provisions of the codes/standards listed below conflict with the provisions of this specification shall govern.

- Relevant ASTM Standards.
- ASME - Section II – Materials.
- ASME - Section V Non-destructive examination.

3.0 MATERIALS, PROCESS, WORKMANSHIP AND REQUIREMENTS

- 3.1 The tubes shall comply with ASME – SA-213 seamless austenitic alloy steel heat exchanger tubes. The chemical composition and grade shall be that designated in ASME-SA-213 TP-316L and as mentioned at Para 3.4 of this annexure.
- 3.2 The tubes shall be manufactured by cold drawing process. Material, process and workmanship shall be of high quality and in accordance with good practice pertinent to the manufacture of stainless steel heat exchanger tubes. The manufacturing practice shall ensure no pickup of harmful impurities either during alloy making or during fabrication. The cold working during final straightening process shall be kept to minimum and the residual stress value shall not exceed 7 kg/mm².
- 3.3 Chemicals, oils, lubricants, paints etc. used during the manufacture, inspection/examination etc. of tubes shall not contain halogen and sulphur exceeding 25 ppm each. These shall also be free from lead. However, if for technical reasons the lubricants used for tube drawing may contain halogen in excess of above stipulated limit, these may be used provided the manufacturer guarantees that tubes so manufactured shall give trouble free service for at least 40 years and subject to NPCIL approval. Subsequent cleaning shall, however, meet cleanliness requirements stipulated at 3.18 of this annexure.

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- 3.4 The chemical composition requirements for both product and ladle analysis shall be as per SA 213 TP 316L except that Carbon shall be restricted to 0.03% (max.). Additional requirement is that Cobalt shall not exceed 0.03 %.

3.5 Dimensions and Tolerance

The cross sectional dimensions and length shall be as specified in the drawings.

3.6 Heat Treatment

The tubes shall be Bright Annealed. The details of heat treatment (such as type of furnace, atmosphere in the furnace, rate of heating and cooling; soaking temp. and time, etc.) shall be reported in Test Certificates.

3.7 Grain Size

The grain size shall be determined according to ASTM-E-112 and shall be ASTM micro grain size number 8 or finer. Attempts shall be made to achieve a grain size of 10 or finer.

3.8 Surface Condition

The tubes shall be in bright finish condition. The inside and outside surface of tubes shall be very smooth and the finish shall be, both of OD and ID, 1.6 microns (CLA) or better.

3.9 Hardness Check

The hardness shall not be more than RB-85 and preferably be in the range of RB-80 to 85.

3.10 Intergranular corrosion resistance test

Intergranular corrosion resistance test shall be done in accordance with ASTM-A-262 practice A/E.

3.11 Stress Corrosion Cracking Test

Stress corrosion cracking test shall be done in accordance ASTM-G-36. The tube specimen shall be bent 180° to radius 35 mm and then subjected to stress relieve annealing as per the procedure to be adopted for production tubes. Then the bend tube shall be immersed in boiling $MgCl_2$ solution for 100 hours. The effect of 100 hours boiling shall show no crack when examined at 400 magnifications and also on liquid penetrant examination.

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The time required for initiation of crack shall be determined and reported in test certificate.

3.12 Test Coupon Numbers and Location

A 'lot' shall be as specified in ASME SA 213 and following test shall be carried out as specified in SA 213:

- 3.12.1 Product analysis.
- 3.12.2 Tension test.
- 3.12.3 Hardness test.
- 3.12.4 Flare test.
- 3.12.5 Flattening test.
- 3.12.6 Inter-granular corrosion test shall be done on one sample from each melt and heat treatment batch.
- 3.12.7 Microstructure and grain size shall be determined on one sample from each lot. Micrographs are to be attached to test reports.
- 3.12.8 One stress corrosion cracking test is to be done on one sample tube from each melt and heat treatment batch.
- 3.12.9 Surface roughness on OD and ID shall be measured on one tube in each lot.
- 3.12.10 Residual stresses on finished tube shall be determined on one sample per lot.
- 3.13 Non Destructive Examination
 - 3.13.1 Ultrasonic Examination of Tubes
 - 3.13.1.1 Each finished straight tube shall be examined over the entire volume of the material. Each tube shall be examined by ultrasonic examination method after finish heat treatment (Bright annealing). The procedure for ultrasonic examination shall be generally in accordance with Article 5 of ASME Section-V. The standard for testing and acceptance criterion shall be as follows:
 - 3.13.1.2 The tubes shall be examined by ultrasonic method in accordance with the examination procedure in two opposite circumferential directions and also in two opposite axial directions. Reference specimen for both circumferential and axial scanning shall be as per mentioned below in Clause 3.13.1.2.3.

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3.13.1.2.1 Circumferential Direction

The procedure for ultrasonic examination of tubes shall be in accordance with ASTM-E-213 standard for longitudinal discontinuities and the requirements of this paragraph. The procedure shall provide a sensitivity which will consistently detect defects that produce indications equal to or greater than the indications produced by standard defects included in Clause 3.13.1.2.3 reference specimen. Products with defects that produce indications equal to or in excess of the reference standard are unacceptable.

3.13.1.2.2 Axial Direction

The ultrasonic examination of tubes shall include angle beam scanning in the axial direction. The procedure for axial scan shall be in accordance with ASTM-E-213 'Standard method for ultrasonic examination of pipe and tubing for longitudinal discontinuities' except that the propagation of sound in the tube wall shall be in axial direction instead of circumferential direction. Products with defects that produce indications equal to or in excess of the reference standard are unacceptable.

3.13.1.2.3 Reference Specimen

The reference specimen shall be of the same OD and thickness and of the same nominal composition and heat treated as the tubing. For circumferential scanning the standard defects shall be axial notches or grooves on the outside and inside surface of the reference specimen and shall have length approximately 25.4 mm (1") or less, a width not to exceed 1.5 mm (1/16") for a square notch or U notch, a width proportional to the depth for V notch and a depth not greater than 0.1016 mm (0.004") for all notches.

For axial scanning in accordance with ASTM-E-213, a transverse (circumferential) notch shall be introduced on the inner and outer surface of the standard. Dimensions of the transverse notch shall not exceed those of the longitudinal notch. The reference specimen shall be from the tubing being examined.

The reference specimen shall be long enough to simulate the handling of the tubing being examined through the examination equipment. When more than one standard defect is placed in a reference specimen, the defects shall be located so that indications from each defect are separate and distinct without mutual interference or amplification. All upset metal and burrs adjacent to the reference notches shall be removed.

3.13.1.2.4 Checking and Calibration of Equipment

The proper functioning of the examination equipment shall be checked and the equipment shall be calibrated by the use of the reference specimen as a minimum, at the following stages.

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- a) At the beginning of each production run of a given size and thickness of a given material.
- b) After every 4 hours or less during the production run.
- c) At the end of a production run.
- d) At any time a malfunctioning is suspected.

If during any check it is determined that the testing equipment is not functioning properly, the entire product that has been tested since the last valid equipment calibration shall be re-examined.

3.13.2 OD and Thickness Measurement

NPCIL requires a very high degree of reliability for uniformity/within required limits, of the thickness and OD all along the length of the tube using UT or other suitable method.

3.13.3 Dye Penetrant Examination.

After hydrostatic test, all U-bends shall be examined by liquid penetrant method over complete U-bend portion plus 150 mm at each end of the bend as per ASME Section-V. Similarly, a 150 mm length at end of the tubes also shall be LP checked.

3.14 Repairs

Superficial external surface defects may be eliminated by mechanical means only provided the minimum wall thickness requirement after repair is still complied with and the surface area is blended smoothly. The repaired area shall be re-examined by appropriate nondestructive examination to ascertain freedom from defects and subjected to wall thickness measurement. The repair procedure shall be prepared by the supplier and subject to NPCIL approval prior to its application on production tubes. Tubes repaired shall be clearly identified and reported to NPCIL.

3.15 Hydrostatic Testing

Each tube shall be hydrostatic tested using internal pressure of 200 kg/cm²(g) after bending. The water used shall be demineralised and shall have conductivity 10 µs/cm max. at inlet. An increase of 3 µs/cm (max.) at the outlet is permissible. The test pressure shall be maintained for a duration of 10 seconds minimum. The water used shall not have halogen and sulphur content in excess of 25 ppm each.

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3.16 Straightness

The tube shall be free from kinks, local distortions etc. and shall be straight within 1 in 1000. This shall be checked by rolling the tubes on inspection bench as well as by comparing with certified straight edge placed side by side

3.17 Requirement for U-Bent tubes

Each tubes shall be U-bent to various radii (the exact bend radius and number of tubes in each bend radius shall be specified in relevant purchase drawing) with following additional requirements.

3.17.1 Procedure for Bending Qualification.

Before bending, the procedure of bending shall be qualified as under:

2 numbers (minimum) of smallest bend radius shall be bent in each process of bending for qualification. Bending qualification shall be done on each bending machine used for bending. These 2 sample bends shall be made in the presence of NPCIL or their Authorized Inspection Agency and subjected to following examinations:

Entire surface of bent tubes shall be visually examined for ripples, scratches and other surface defects. The cross sections at 2 positions minimum (to be agreed upon) for each bend shall be plotted by a suitable device to ascertain non-circularity and ovality.

Bending procedure qualification tubes shall be hydrostatic tested and after hydrostatic test entire bend surfaces shall be liquid penetrant tested. Radius of bend shall be checked by layout.

One of the two bends shall be cut transversely into eleven equally spaced sections starting at the start of the bend and finishing at the end of the bend (resulting in 10 rings) for further examination. The other bend is sectioned in longitudinal plane (Plane of flexure) into two halves for further examination.

Each of the above sections shall be examined for following :

Visually examine internal surface for ripples , scratches and other surface defects. check the surface finish on internals as well as external surface on each bend sections.

Measure the wall thickness at internal and external apex as well as at neutral bending axis for each section and compare with the wall thickness before bending, at minimum of 3 places.

- Measure the ovality and non-circularity at each section.
- Measure hardness on each cut piece, at minimum of 3 places.

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- c) Optical illustration of the outline of the cross sections obtained by the two above said sectional planes (viz. Transverse and Longitudinal) for each of the test bends. Choice of the transverse sections for such illustration shall be exercised by NPCIL or his authorized inspection agency.

Non-circularity and ovality, thinning and other dimensions shall meet the requirements as below. In U-bent portion, acceptable ovality shall be 6% maximum.

The above tube bending procedure is valid until the settings in the qualified machine is not disturbed or this machine is not used for other job.

- 3.17.2 Ovality shall be defined as

$$\text{Ovality} = \frac{\text{OD max} - \text{OD min}}{\text{Min OD before bending}}$$

OD = Outsider Diameter

- 3.17.3 For out of roundness of tube other than ovality shall not be more than 6%, supplier may prepare the measurement procedure & submit for NPCIL approval.

- 3.17.4 In U-bent portion, wall thinning shall not exceed 10% of the minimum wall thickness.

- 3.17.5 After U-bending, the bend shall be stress relieved on bent portions plus with at least 150 mm straight length portion on either side of the bends. During annealing, an inert gas atmosphere shall be maintained inside the tubes.

After heat treatment, the outside surface of the bend portions plus 150 mm straight portion on either side of the bends shall be pickled free from any scales discoloration etc. and passivated.

- 3.17.6 After hydro test, all the U-bent tubes shall be examined by liquid penetrant inspection as per Clause 3.13.3.

- 3.17.7 Each bent tube shall be checked for passage by Ball Passing (Teflon) Test using a ball size as $9.2^{+0/-0.1}$ mm

- 3.17.8 The straightness requirements for the bent tubes shall be as follows:-

- 3.17.8.1 The straight portion of the tubes shall be free from kinks, bends, local distortions etc. and shall be straight within 1 in 1000.

- 3.17.8.2 The U-bent portion shall be free from kinks, local distortions.

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3.17.8.3 The leg spacing measured between the points of tangency of the bend to the legs shall have tolerance of ± 1 mm for bend radius (R) < 220 mm, ± 1.6 mm for R > 220 mm and < 450 mm, ± 2 mm for R > 450 mm. The tangency point shall be marked on both legs by electro etching.

3.17.9 The tolerance on length of U-bend tube legs and 'squareness of ends' shall be as follows:

3.17.9.1 Length of U-bend tube legs – The length of tube legs as measured from the point of tangency of the bend and the tube leg to the end of tube leg shall not be less than that specified (as specified in relevant purchase drawing) but may not exceed the specified values by 4 mm. However difference in leg lengths shall not exceed 3 mm.

3.17.9.2 Squareness of ends – The end of the tube may depart from square by not more than 0.25 mm.

3.17.10 The tolerance on bend radius shall be as follows :

For Radius less than 300 mm : ± 0.75 mm

For Radius more than 300 mm : ± 1.5 mm

3.17.11 The operations/activities listed in Clauses 3.18 to 3.21 shall be carried out after bending.

3.18 Marking and Identification

The tube number shall be marked on each tube by electro etching at approximately at 400 mm from each end. Tube marking shall be done before UT and it is to be ensured that the marking is available on each finish tube. Marking paint or ink shall not contain harmful metal or metal salts such as zinc, lead or copper which cause corrosive attack on heating. Complete history of each tube shall be available in check list/test certificate which shall be placed in the box containing the tube.

3.19 Cleaning

Each tube shall be thoroughly cleaned inside and outside prior to packing. Outside may be cleaned by wiping with cloth soaked in acetone. Inside cleaning shall be done by passing a clean felt sponge ball with the help of oil free dry air or Nitrogen until the ball at the exit shows no discolouration after its passage through the tube. On OD side also it shall be similarly checked. The cleanliness shall be checked by wiping test as follows:

- a) Qualitative evaluation of unacceptable dust, oil etc.

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- b) Quantitative evaluation of chlorides, sulphur and silicon impurities shall be done one tube in each lot and they shall not exceed.

Cl - 20 microgram/decimeter square
SiO₂ - 30 microgram/decimeter square
F&S - 50 microgram/decimeter square

3.20 Testing for material mix-up

To avoid inadvertent mix-up of tubes of different quality/manufacture, suitable checks such as spectroscopic analysis, sigma test etc. shall be carried out.

3.21 Packing and Shipment

- 3.21.1 After cleaning, both ends of each tube shall be capped with halogen free plastic caps.

Each tube shall be packed in halogen free polythene sleeve and heat sealed on both ends.

The tubes shall be packed row by row in vertical direction as per the packing arrangement. The packing arrangement (sequence) shall be provided by purchaser as per tube insertion procedure. The tubes shall be packed full length in suitable padded weather proof containers suitable not only for transportation but also for long storage in tropical conditions; special precautions shall be taken to ensure that no hard or sharp objects such as nails etc., project into the container as they may cause damage to the tubing.

- 3.21.2 Identification during shipment

Each package shall be clearly and legibly marked in suitable permanent manner with following information;

- 3.21.2.1 Purchase Order number

- 3.21.2.2 Destination

- 3.21.2.3 Number of tubes in the box.

4.0 PROCEDURES, TEST REPORTS AND DOCUMENTATION

- 4.1 Following procedure from shall be prepared and submit to NPCIL for approval..

- 4.1.1 Manufacturing procedure giving sequence of operations right from melting, ingot pouring, tube manufacture and testing.

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- 4.1.2. Q.A. plan containing all testing/inspection procedures including various tests of ASME-SA-213, chemical and mechanical testing, heat treatment, LPI, ultrasonic examination, OD and wall thickness measurement, inter-granular corrosion test, stress corrosion cracking procedure during various stages of manufacture, residual stress measurement, procedure for bending, stress relieve annealing, liquid penetrant inspection and various quality controls for U-bent tubes.
- 4.1.3 Non-destructive examination procedure (ultrasonic, liquid penetrant, OD and thickness measurement).
- 4.1.4 Cleaning procedure indicating different stages of cleaning during production and evaluation of items mentioned in 3.19 above.
- 4.1.5 Procedure for measuring residual stress on finished tubes.
- 4.1.6 For bent tubes, procedures covering, bending arrangement and procedure for stress relieve annealing, details of solution annealing, liquid penetrant inspection, checking of ovality, wall thinning and bend radius etc.
- 4.1.7 Packing procedure and suggested packing arrangement for long storage.
- 4.2 Documents to be submitted along with U bend tubes/straight tubes.
- 4.2.1 Test Reports/Certificates

The reports/certificates shall include chemical analysis, heat treatment details, mechanical properties and results of each test/inspection done on tube(s), non-destructive examination report along with properly identified recording strips for NDEs clearly showing defects accepted and micrographs. After completion of order, heat treatment chart shall be sent to NPCIL. UT record in hard form as well as soft form with suitable software to be submitted to NPCIL.