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TECHNICAL SPECIFICATION
FOR
SEAMLESS, COLD WORKED HEAT EXCHANGER TUBES TO SPECIFICATION ASME SB 163 NICKEL-IRON-CHROMIUM ALLOY UNS N08800 (MODIFIED)

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1.0 SCOPE

This Specification covers the technical requirements for the supply of Seamless cold worked Heat Exchanger Tubes to Specification ASME SB 163 Nickel-Iron-Chromium Alloy UNS N08800 modified as per this specification. All requirements of this specification represent minimum requirements

This specification is applicable for Steam Generators of 700 MWe projects beyond RAPP 7&8.

2.0 CONTENTS

The requirements of this specification are presented under following sections:

3.0 APPLICABLE SPECIFICATIONS

The following codes and standards of the issue in effect on the date of issuing tender document shall form part of this specification. In case of conflict between the Codes/ Standards listed below, with the requirements of this specification, the requirements which are more stringent shall govern.

3.1 Relevant ASTM Standards.

3.2 ASME – Section II Part B

3.3 ASME Section III NB

3.3 ASME – Section V, Non Destructive Examination.

4.0 MATERIAL, PROCESS OF MANUFACTURE, WORKMANSHIP AND REQUIREMENTS :

4.1 Material

The tubing shall comply with ASME-SB-163 Seamless Nickel and Nickel Alloy Condenser and Heat Exchanger Tubes, with particular requirements specified below. The alloy shall be that designated in ASME-SB-163 Nickel-Iron-Chromium alloy UNS N08800 with the following restricted chemical composition:

CHEMICAL COMPOSITION (Product & Ladle Analysis)

Element	Composition Present
C	0.03 max.
Si	0.3 to 0.7
Mn	0.40 – 1.0
P	0.015 max.
S	0.015 max.
Co	0.015 max. (To be aimed 0.01)
Al	0.15 to 0.45
Ti	0.6 max.
N	0.03 max.
Cu	0.075 max.
Cr	20 - 23
Ni	32 - 35
Fe	Remainder

Stabilisation

$$\frac{Ti}{C} = 12 \text{ minimum}$$

$$\frac{Ti}{C+N} = 8 \text{ minimum}$$

$$(N + P) = 0.045 \text{ maximum}$$

4.2 **Process of Manufacture and Workmanship**

The tubes shall be manufactured by cold working, heat treatment, final cold drawing to enhance yield strength, followed by straightening process. The tubes shall be supplied in U-bent form, in sizes and quantities indicated in the relavant Purchaser's drawing. The tubes shall be cold bent with subsequent glass bead peening to introduce uniform controlled residual compressive stresses at the outside tube surface. The shot peening procedure and the equipment used shall be qualified by demonstrating its effectiveness in producing consistent quality of tubes having compressive stresses extending to a depth of about 0.15 mm. The procedure shall be submitted to the Purchaser for his approval.

Materials, process and workmanship shall be of high quality and in accordance with good practice pertinent to the manufacture of Nickel-Iron-Chromium alloy heat exchanger tubes. Each rolled bar which will be used for tube manufacture shall be ultrasonically checked for internal soundness. Sufficient discard shall be made from the bar corresponding to the top of the ingot to ensure freedom from cavities and slag inclusions. The bars shall be further examined by taking macro specimens from each end and also subjected to chemical analysis, which shall be within the specified limits stated under clause 4.1.

Material shall be manufactured from ingots melted in electric furnace.

Mother hollows used for the manufacture of these tubes shall be produced from hot extrusion process.

4.3 **Grain Size**

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

4.4 **Halogen and Sulphur Content**

Chemicals, oils, lubricants, paint, etc. used during the manufacture, inspection/ examination etc. of tubes shall not contain halogen and sulfur in excess of 25 ppm each. These shall also be free from lead. However, if for technical reasons the lubricants used for tube drawing contain halogens in excess of the above stipulated limit, these may be

used provided the manufacturing procedure is such that excess of these element does not produce an harmful effect on quality of tubes on a long term trouble free service (40 years) basis. Subsequent cleaning shall, however, ensure cleanliness requirements stipulated in Section 12 of the specification.

4.5 Surface Condition

The tubes shall be in bright finish condition. The inside and outside surfaces of the tubes shall be very smooth and the finish after shot peening shall be better than 1.6 microns (CLA) on internal surfaces and 3.3 microns on external surface.

4.6 Heat Treatment

Tubes shall be supplied in cold worked condition, with glass bead, shot peening on the tube outer surface. The details of annealing temperature, soaking time, etc. must be indicated in the test certificate. Detailed procedure of heat treatment shall be submitted for approval before start of manufacture. The details of heat treatment including furnace type, furnace atmosphere, rate of heating, soaking time, rate of cooling, thermocouple location, etc. shall be submitted for approval before start of manufacture.

5.0 Mechanical Tests

The following requirements shall be met with after final annealing and cold drawing. Unless otherwise stated testing shall be done in accordance with ASTM B 163.

5.1 Tensile Test

Properties	At Room Temp	At 350^0 C	Unit
Tensile strength	569-697	495 min	N/ mm^2
	58-71	50.5 min	Kp/mm^2
0.2% Yield strength	334-471	295 min	N/ mm^2
	34-48	30.0 min	Kp/mm^2
% Elongation on 5d or 50mm whichever is higher (See Note Below)	30	To be reported	%

Note: Where 'd' is the Equivalent Diameter

5.2 **Hardness**

The hardness shall be measured on sample tubes and shall be about 170 vickers. The maximum hardness however can be upto 270 vickers in the cold worked part of the smallest bend. Hardness shall be checked on sample bent tubes before shot peening.

All measurements shall be done on the Vickers Scale.

5.3 **Flare Test**

Flare test shall be made on both ends of each tube with expanding tool having an included angle of 60^0 until the specified outside diameter has been increased by 20%. The pieces cut from the tube ends for flare test shall be checked for freedom from temper discoloration on inside before subjecting them to flare test.

5.4 **Intergranular Corrosion resistance Test**

Intergranular corrosion resistance rest shall be done accordance with ASTM-G-28 on one sample from each melt heat treatment batch. The specimen shall be sensitized by heating it up to 650^0 C, soaking for 15 minutes and then water quenching. The heating shall be rapid and shall not take more than 1.5 min. The corrosion rate as calculated per G 28 shall not exceed 0.6 mm/year. The guaranteed maximum value of the corrosion rate shall be indicated in the bid.

5.5 **Stress Corrosion Cracking Test**

Stress corrosion cracking test shall be done in accordance with ASTM-G-36 on samples from each melt and heat treatment batch. The tube specimens (with and without shot peening) shall be bent 180^0 to the shortest radius on order. The bends shall be immersed in boiling $MgCL_2$ solution for 100 hours. The effect of 100 hours boiling shall show no crack by examining at 400 magnification and also by liquid penetrant examination.

In addition to above SCC test, one sample per heat shall be boiled to determine the time required for initiation of crack or maximum of 500 hours.
The residual stress developed on the tube shall be measured and reported.

5.6 **Test Coupon Numbers and Location**

A 'Lot' shall consist of 100 tubes max. from the same melt and heat treatment batch. Test coupons shall be taken from the finished tubes.

5.6.1 A ladle analysis for each heat shall be performed. One product analysis chemical shall be made on each 'lot of tubes'.

5.6.2 One tension test each at Room Temperature and at 350^0 C shall be made on each lot of tubes. The mechanical properties like Tensile Strength, Yield Strength and % Elongation, etc. shall be recorded.

5.6.3 Hardness shall be measured on 3% of tubes in each lot.

5.6.4 One flare test shall be made on each end of every tube prior to cutting to length.

5.6.5 Intergranular corrosion test shall be done on one sample from each melt and heat treatment batch.

5.6.6 Microstructure and grain size shall be determined on one sample from each 'Lot'. Micrographs are to be attached to test reports.

5.6.7 One stress corrosion cracking test is to be done on one sample from each lot.

5.6.8 Surface roughness on OD and ID shall be measured on 1% tubes completed in each shift.

5.6.9 Compressive stress measurement on 3 sample tubes per heat treatment batch.

6.0 **NON DESTRUCTIVE EXAMINATION**

6.1 **Liquid Penetrant Examination (LPE)**

The bent tubes shall be subjected to Liquid Penetrant Examination (LPE) on the entire bent portion and 150 mm straight length beyond the bent portion. Apart from this LPE shall also be conducted for a length of 450 mm at each end of the bent tube.. LPE shall be conducted in accordance with NB-2556 of ASME Section III NB, ASTM E165 and

relevant Article of ASME Section V. The extent of tubes subjected to Liquid Penetrant examination is set out in para 8.9. Liquid Penetrant Examination shall be done prior to shot peening but after the hydrostatic test. No indications are permitted.

6.2 Ultrasonic Examination

Each tube shall be subjected to Ultrasonic Examination after heat treatment. The ultrasonic examination shall be carried out generally in accordance with NB 2552 of ASME Section III NB, ASTM E 213 and relevant Article of ASME Section V.

The standards for testing and acceptance criteria over and above ASME requirements shall be as follows:-

The reference specimen shall be of the nominal diameter, thickness, nominal composition and heat treated condition as the product being examined. The standard defect shall be internal and external notches both in transverse and longitudinal direction. The notches shall be saw tooth wedge shaped groove having 60^0 angle opening, with sides at right angle and max. depth of 0.1 mm. The external notches shall be 1.5 mm long and internal notches 2.0 mm long.

The ultrasonic examination shall be done in two opposite circumferential and two opposite axial directions. Defect indications equal to or greater than those from the reference standard shall be unacceptable.

6.3 Eddy Current Examination

Each tube shall be subjected to eddy current examination as per NB 2554 of ASME Section III NB, ASTM E571 and relevant Article of ASME Section V except that in the reference standard a through wall hole not exceeding 0.8mm in diameter shall be used in lieu of 1.5 mm diameter hole stated therein .

Defect indication equal to or greater than those from the reference standard shall be unacceptable.

In the event of an order, bidder shall supply at least 10 straight tube pieces of at least 0.5 m length each containing various types of eddy current subsurface indications in mid half length, from the rejected (color marked) tube stock during production job eddy current examination. This would enable Purchaser to conduct any investigation using eddy current ID probes at a later date.

6.4 Non-destructive examination indications found to be within the acceptable standards shall be investigated to establish that they are harmless (eg. not cracks or pores) for the intended use of the tubes. Adequate number of such acceptable defects, categorized into various types, shall be metallographically investigated. The results of investigation shall be documented to form a detailed illustrated catalogue of defects.

The categorized defect indications chosen for metallographic investigation shall be examined prior to sectioning by suitable eddy current ID probes to obtain eddy current signals of the individual defect location and recorded along with corresponding production UT / ET examination signal results to form part of defect catalogue. This is required in connection with signal interpretation during inservice inspection of tubes.

6.5 **O.D and Thickness Measurement**

Purchaser requires very high degree of reliability on uniformity, within the required limits, of the thickness and OD all along the length of the tube. OD and wall thickness over the entire length of each tube shall be measured ultrasonically and reported.

7.0 BENDING PROCEDURE QUALIFICATION

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

7.1 For each 100 number or less of tubes of smallest bend radius, 2 numbers (minimum) of bends of smallest radius shall be bent in each process of bending for qualification. These 2 sample bends shall be made in the presence of Purchaser or his Authorised Inspection Agency and subjected to following examinations:

7.1.1 Entire surface 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.

7.1.2 Bending procedure qualification tubes shall be hydrostatic tested and after hydrostatic test, entire bend surface and 150mm straight length beyond bend portion shall be subjected to liquid penetrant examination . Radius of bend shall be checked by layout.

7.1.3 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.

7.1.4 Each of the above sections shall be examined for following:

a) Visually examine internal surface for ripples, scratches and other surface defects.

b) Check the surface finish on internals as well as external surface on each bend sections.

c) 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.

d) Measure the ovality and non-circularity at each section.

e) Measure hardness on each cut piece, at minimum of 3 places.

f) 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 illustrations shall be exercised by the Purchaser or his authorized inspection agency.

g) Non-circularity and ovality, thinning and other dimensions shall meet the requirements as specified in purchase drawing.

8.0 PRODUCTION CONTROL

8.1 The production of U bends shall be taken up after qualification of the bending procedure as stated above. Ovality and out of roundness shall be measured on each tube for the smallest bend radius. Beyond that, for each radius, the first two production bends shall

be measured for ovality, non-circularity (outline of cross section), bend radius at 5 locations and surface defects and then every 10^{th} bend shall be measured for these dimensions. Wall thickness at the bends shall be measured by UT on each tube in first and second row. For balance tubes, this shall be measured on first 2 tubes and then every 10^{th} tube for each row. If wall thickness does not conform to the requirements for any bend, all the previous bends shall be checked.

8.2 The ovality in the U-bend portion as measured by micrometer screw gauge shall not exceed 5%. Ovality for this purpose is defined as

$$\text{Ovality} = \frac{\text{O.D. max. - O.D. min.}}{\text{O.D. nominal}}$$

Where O.D = outside diameter.

8.3 Out of roundness of tube other than ovality shall be determined using the formula:

$$\frac{\text{maximum radius - minimum radius}}{\text{maximum radius}} \times 100\%$$

Where maxi radius = outside radius of smallest possible surrounding circle.

Minimum radius = smallest distance of contour from centre of smallest possible surrounding circle.

The out of roundness shall not exceed 6%.

8.4 Each bent tube shall be checked after shot peening by a ball go-through test with a specified ball diameter of 15.77 mm.

8.5 The internal and external surface finish shall be measured on 1% of the tubes completed in each shift. The tubes shall be very smooth and surface condition shall meet requirements stated in section 4.5.

8.6 The tubes shall be free from kinks/local distortions. The straight portion of bent tubes shall be straight within 0.5 mm in one meter. The tolerance on leg spacing shall be as per relevant Purchaser's drawing.

8.7 The tolerance on other parameters are as follows :-

Outside diameter	:	19.0 + 0.12 mm - 0.03
Thickness	:	1.1 ± 10%
Eccentricity ($\frac{t\,max - t\,min}{2 \times t\,avg}$)	:	≤ 5%
Minimum wall thickness in the bend region	:	0.91 mm
Leg length deviation	:	+3 -0.0
Leg length difference	:	2 mm (maximum)
End squareness deviation	:	0.2 mm (maximum)
Bend radius tolerance < 300 mm > 300 mm	:	± 0.75 mm ± 1.50 mm

8.8 Each tube shall be hydrostatically tested as per requirements of para 9 of this specification. Hydrostatic test shall be done after bending. For such tubes hydrostatic test on straight length tubes prior to bending is not required.

8.9 After hydrostatic test, U-Bends shall be subjected to liquid penetrant examination (LPE) over the complete U bend portion and 150 mm of the straight length beyond the bend. Apart from this 450 mm length of the tube at each end shall also be subjected to LPE. The scope of LPE shall be as follows:

8.9.1 All the tube bends of the smallest bend radius shall be L.P. examined. In case of any unacceptable indication found in this examination, all the bends in next higher radius shall also be subjected to LP examination. This process will continue till all the bends in a particular radius are defect free. The charges for this examination are considered to be included in the cost of the product.

8.9.2 For remaining tube bends not covered under 8.9.1 shall be subjected to random LP examination upto a maximum of 2% of the remaining tube bends at purchaser's option. If any unacceptable defect is found in the examination all the tube bends in that radius and all the bends in lower radii shall be subjected to LP examination free of cost. The charges for this examination shall be on "unit rate" (LP charge / bend) indicated by the bidder for this random 2% LP check.

8.9.3 With above limited LP examination scope, the manufacturer shall be obliged to replace (free of cost) all the tubes having unacceptable defect revealed during LP examination conducted by the purchaser.

8.9.4 Alternatively, manufacturer may indicate LPE charges for all bent tubes on unit rate basis.

8.10 Glass bead peening procedure shall be qualified on sample tubes before taking up the production tubes. For sample tubes, 3 tubes must be taken out and kept for acceptance purposes with respect to uniformity and adequacy of peening operation as follows:

a) with maximum acceptance level.

b) with normal acceptance level.

c) with minimum acceptance level.

These samples shall be used as comparators for checking the peening operation. Separate sets of samples shall be made for comparison with straight and bent portion of U-tubes. The compressive stress values verses depth from the O.D. and I.D. tube surfaces shall be determined for the above three acceptance levels by an accurate method (such as x-ray diffraction). The procedure and stress values/profile shall be subjected to Purchaser's approval. The bidder shall indicate the method and the guaranteed stress values/profile in his bid. The compressive stresses shall exist upto a minimum of 0.12 mm depth from the tube outside surface both in the straight and bent portions of the tube.

8.11 During production, internal and external surfaces of all tubes shall be visually inspected using optical aids such as boroscope for ascertaining freedom from surface defects and temper colors. If necessary, test pieces from tubes shall be taken and investigated. The complete external surface of the tubes shall be inspected for adequate and uniform peening effect and compared with reference standards for acceptance. U-tubes shall be in a free condition while their dimensions, straightness, etc. are being checked with respect to the specified values.

O.D. of each tube shall be checked either automatically by UT or manually by limit gauges at both ends and also over the entire length at random intervals. However, actual dimensions are to be recorded at those locations for a minimum of 1% of tubes, distributed over the whole production quantity.

8.12 **REPAIRS**

Repairs are generally not allowed. However, superficial external surface defects may be removed by mechanical means prior to the shot peening operation provided the minimum wall thickness requirement after repair are still complied with and the surface area is blended smoothly. The repaired area shall be re-examined by appropriate non-destructive examination to ascertain freedom from defects and subjected to wall thickness measurement. The repair procedure shall be prepared by the supplier and subject to purchaser's approval prior to its application on production tubes. Tubes repaired shall be clearly identified and reported to purchaser.

9.0 HYDROSTATIC TESTING

Each tube shall be hydrostatic tested at an internal pressure of 25 plus one minus zero MPa. The water used shall be demineralised water 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 sulfur in excess of 25 ppm each.

10. DOCUMENTATION

10.1 Procedure and Plans

The following procedures and plans shall be submitted to the Purchaser for review and approval in six copies each before start of manufacture. No manufacturing activity shall start unless written approval of related documents is obtained.

a) Manufacturing procedure giving sequence of operations right from melting, ingot pouring, and tube manufacturing and testing.

b) Heat treatment plan.

c) Mechanical testing procedures.

d) Non-destructive Examination procedures.

e) Wall thickness measurement procedure.

f) Glass bead peening procedure.

g) Quality Assurance Manual / plan.

h) Cleaning procedure adopted during various stages of manufacture.

i) Repair procedure.

j) Tube bending qualification and production bending/control procedures (to include measurement / plotting of ovality, non-circularity / cross section).

k) Material samples and testing plan.

l) Metallurgical examination procedures (macro etch, microstructure and grain size).

m) Dimensional control procedures (for ID, OD and bend radius, etc.)

n) Surface finish measurement and inspection procedures.

o) Hydro test procedure.

p) Ball-pass through test procedure.

q) Compressive stress measurement procedure.

r) Quantitative measurement of contaminants such as chloride, SiO_2, halogens, sulfur and lead.

s) Corrosion resistance test procedure.

t) Any other procedure having bearing on tube quality.

10.2 REPORTS

The following reports shall be submitted to the Purchaser in Nine copies each:

a) Chemical analysis – ladle and product.

b) Mechanical test report.

c) Non-destructive examination report (along with properly identified recording strips for ultrasonic and Eddy current examinations showing defects accepted).

d) Heat treatment charts.

e) Visual and dimensional inspection report.

f) Hardness survey report.

g) Metallurgical examination reports, with photographs (such as Macro-etch, Micro-structure / grain size).

h) Illustrated catalogue of defects.

i) Corrosion resistance test reports, with photographs.

j) Compressive stress measurement report.

k) Tube bending qualification and production bend / reports.

l) Surface finish reports.

m) Hydro test reports.

n) Liquid penetrant examination reports.

o) Ball-pass through test reports.

p) Cleanliness/quantitative measurement of contaminants reports.

q) Material mix up test reports.

r) Any other reports on examinations/inspections/tests conducted on tubes for ensuring tube quality.

One set of test reports / certificates including packing list shall be sent along with the material in a suitable fashion to facilitate inventory control identification and release of material to fabricators of heat exchangers from Purchaser's stores. Final documentation containing all the above shall also be submitted in soft form (pdf format) with proper indexing.

11.0 QUALITY SURVEILLANCE

The material covered in this specification shall be subjected to quality surveillance by the Purchaser or his Authorised inspection agency. The Purchaser and/or his Authorised Inspection Agency shall have access to the msupplier's works at all reasonable times to carry out quality surveillance on the item ordered. The Supplier shall render all necessary help and extend inspection and testing facilities to the Purchaser/Authorised Inspection Agency to satisfy him that the material is being furnished in accordance with this specification.

The Purchaser or his `Authorised Inspection Agency' will witness the tests at various stages as indicated below. The stages shall be clearly identified in the manufacturing plan to be submitted by the supplier in the required format. The supplier shall notify the inspection agency and the Purchaser at least a fortnight before the commencement of each stage of testing.

a) Heat treatment.

b) Ultrasonic Tests.

c) Eddy Current Tests.

d) Mechanical Tests.

e) Corrosion Resistance Test.

f) Bending Procedure Qualification.

g) Hydrostatic Test.

h) Liquid Penetrant Examination.

i) Preparation of reference samples for tube bends and for glass bead peering.

j) Glass bead peering qualification.

k) Ball-test on first three small radii U-bends.

l) Final Visual Examination and Marketing.

m) Cleanliness before packing.

n) Packaging for shipment.

12.0 CLEANING, IDENTIFICATION MATERIAL MIX-UP TEST, PACKING & SHIPMENT

12.1 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 exist shows no discoloration during its passage through the tube. The cleanliness shall be checked by wiping test as follows:

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

b) Quantitative evaluation of chlorides, silica, lead, halogens and sulfur. These contaminants shall be as low as possible. The bidder shall give in their bid the guaranteed maximum values which shall be less than the following:

Chlorides	20 μ g /dm^2
Silica	30 μ g /dm^2
Halogens & Sulfur (total)	25 p.p.m.
Lead, Fluorides and suphate	to be indicated

Cleanliness check shall be carried out on one tube per 500 tubes.

c) Chemicals, lubricants, cleaning agents and any other materials used in the manufacture, inspection testing and packaging shall be free from contaminants such as halogens and sulfur. In any case sulfur and halogens shall not exceed 25 ppm each.

12.2 **Identification**

The tube number shall be marked on each tube by electro etching or by any other suitable permanent marking method, at approximately 200 mm from each end. Complete history of each tube shall be placed in box containing the tube. As a minimum, following information shall be provided in the Check List: Material Specification, Melt Heat No. & Lot No., Supply Condition, Tube Identification number and Radius of Bend.

In addition each box containing tubes shall bear the Purchase Order number, destination, size and number of tubes, manufacturer's symbol and authorized inspection agency's seal.

12.3 **Testing For Material Mix-up**

Spectroscopic, semi qualitative, non-destructive (sigma test) check shall be carried out to ascertain the tube of the same type of alloy from different quality manufacture are not mixed up during production and testing.

12.4 **Packing and Shipment**

After cleaning, both ends of each tube shall be plugged with special plug. At each end two plugs and one plastic cap (halogen free) shall be put.

Each tube shall be packed in halogen free polythene sleeve and heat sealed on both ends. The polythene sleeve shall be of soft grade (transparent) and at least 0.1 mm thick. The U bends shall be packed in a proper sequence and other packing requirements as per Purchaser's drawing for packing details-U-tubes indicated in the tender document.

The tubes shall be packed full length in suitable padded water 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 object such as nails, etc. project

into the container to possibly damage the tubing. Each package shall also contain corresponding packing list. The container is likely to be subjected to multiple handling at docks in an event of trans-shipment. The containers should be designed sturdily to withstand such multiple handling and would require the approval of Purchaser. The packing boxes shall be reinforced by welded cross steel beams. The packing cases may be inspected on arrival as a precautionary measure by the Purchaser.

12.5 The supplier shall be responsible for the shipment and safe delivery of tubes to the destination, specified in the pertinent tender document or purchase order. The tubes shall be shipped 'UNDER DECK' only in the ship to avoid sea water entry into the boxes during the shipment. The tubes shall be protected and covered to prevent damages, corrosion and ingress of foreign material.

12.6 **Identification during Shipment**

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

a) Purchase Order Number.

b) Destination.

c) Size and Number of Tubes.

d) Manufacturer's Emblem.

e) Seal of the Authorised Inspection Agency.

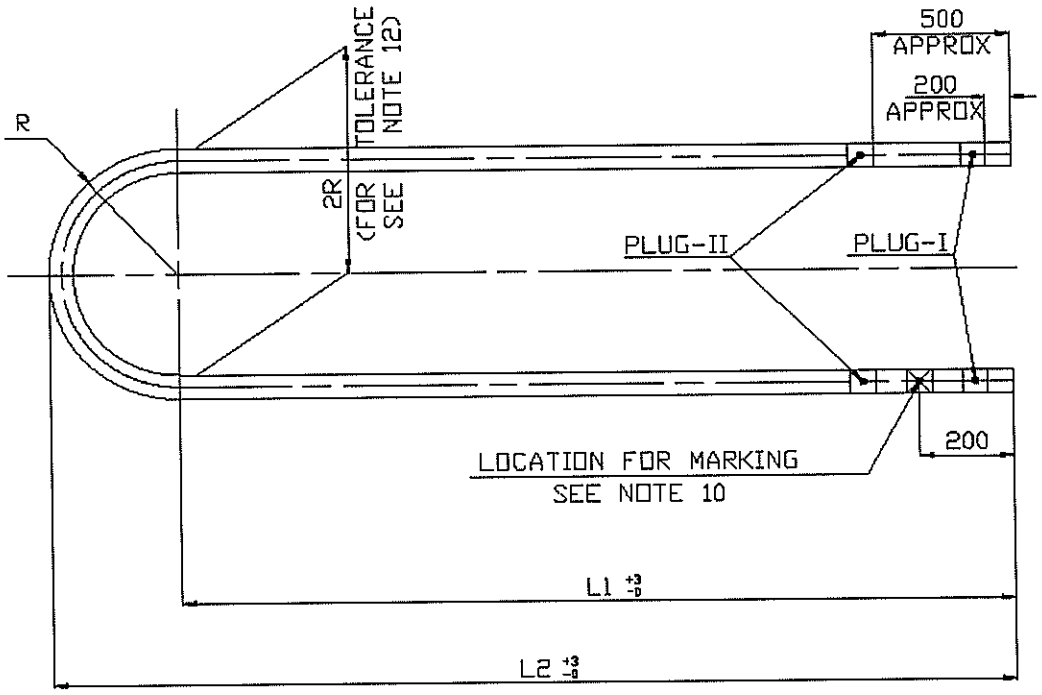

Figure:1

Notes :

1) For ordering dimensions refer purchase order.

2) Outside Diameter, mm (tolerance) : 19.0 (+0.12, -0.03)

3) Wall Thickness, mm (tmax - tmin.) / (2 x tavg.) : 1.1 ± 10%

4) Eccentricity : ≤ 5%

5) Minimum wall thickness in the bend region : 0.91 mm

6) Leg length difference : 2 mm (maximum)

7) End squareness deviation : 0.2 mm (maximum)

8) Bend radius tolerance, R <300 mm : ± 0.75 mm

>300 mm : ± 1.50 mm

9) Two felt plugs on either end of the tube shall be provided at location as shown in the figure.

10) Marking on tube shall be done at location shown; electric etching method shall be adopted for the above.

11) All quantities shall be covered in as few numbers of melts as practicable.

12) Tolerances on leg spacing shall be as given below :

Sl. No.	Bend Radius (R), mm	Tolerance on Dimension 2R, mm
1.	Less than 220	± 1
2.	220 < R < 450	± 1.8
3.	450 < R < 760	± 2.0
4.	More than 760	± 2.5