WELDED AUSTENITIC STAINLESS STEEL TUBES FOR CONDENSERS AND HEAT EXCHANGERS

1.0 GENERAL:

This specification governs the quality requirements of welded/welded and drawn, austentic stainless steel tubes from 10mm to 40mm outside diameter.

2.0 APPLICATION:

For use in Condensers and Heat Exchangers.

3.0 CONDITION OF DELIVERY:

The material shall be furnished in the heat treated condition as per clause 7.4 of this specification.

4.0 COMPLIANCE WITH NATIONAL STANDARDS:

There is no national standards for covering this material. However, this specification is based on ASTM A 249-2011, TP 304: " Welded Austenitic Steel , Boiler, Superheater, Heat exchanger and Condenser Tubes" and ASTM A 1016:"Specification for General requirements for Ferritic alloy steel, Austenitic alloy steel and stainless steel tubes".

5.0 DIMENSIONS AND TOLERANCES:

5.1 Sizes:

The tubes shall be supplied to the dimensions specified in BHEL order

5.2 Tolerances:

The tolerances on outside diameter, wall thickness and length shall comply with the following:

5.2.1 Tolerance on outside diameter:

Specified outside diameter, mm	Tolerance, mm
Upto 25.4	± 0.10
Over 25.4 to 40	± 0.15

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5.2.2 Tolerance on wall thickness:

Wall thickness tolerances shall be ± 10% of nominal wall thickness.

5.2.3 Tolerances on specified length of tubes:

Specified length of tube, metre	Tolerance, + mm
Upto 7	3.0
Over 7 upto 10	6.0
Over 10 upto 13	9.0
Over 13	12.0

5.2.4 Seam height:

The projection of weld seam inside the tube shall be ≤ 0.05 mm.

5.2.5 Straightness:

Straightness of finished tube shall not deviate by more than 0.75mm in any 900mm length.

6.0 PROCESS FOR RAW MATERIAL:

The steel shall be made by any process.

The primary melting is permitted to incorporate degassing or refining and is permitted to be followed by secondary melting, such as electroslag remelting or vacuum-arc remelting.

When steel of different grades is sequentially strand cast, the resultant transition material shall be removed using an established procedure that positively separates the grades.

7.0 MANUFACTURE:

7.1 Tubes shall be made from flat-rolled steel by an automatic welding process with no addition of filler metal.

7.2 Subsequent to welding and prior to final heat treatment, the tubes shall be cold worked either in both weld and base metal or in weld metal only. When cold drawn minimum reduction in cross-section area shall be 20%.

7.3 All lubricants used in the manufacture of tubes shall be removed from all surfaces prior to heat treatment. If any lubricant has been applied to the inside surface, tubes shall have the cleanliness of their inside surface confirmed by blowing close fitting acetone soaked felt plugs through at least 10% of the tubes. Dry (oil free) air or inert gas shall be used to blow the plugs through the tubes. If the plugs blown through the tubes show discolouration, all the tubes that have lubricant applied to the inside surface during manufacture shall be recleaned. After recleaning, check on 10% of the tubes shall be made as stated above, chloride content in the lubricant shall not exceed 50 ppm.

7.4 Material shall be heat treated by heating it to temperature range of 1040 to1065^0 C and quenching in water or rapidly cooling by other means to sufficiently low temperature to avoid carbide precipitation.

The tubes, after final heat treatment, shall be chemically descaled/pickled free form scale and passivated. When heat treatment is done in reducing atmosphere, pickling is not necessary.

7.5 The chlorine content in DM water during final ringing shall be limited to 10 ppm.

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8.0 FREEDOM FROM DEFECTS:

8.1 Finished tubes shall have smooth ends free from burrs. They shall be free from cracks, seams, scale, deleterious films in the bore and other harmful defects.

8.2 Surface roughness:

For the inner surface with the exception of weld seam, the roughness in longitudinal direction shall be allowable with in R_a = 2 microns or R_z = 10 microns.

9.0 CHEMICAL COMPOSITION:

The analysis of material shall be as follows:

Element	Weight percent min.	Weight percent max.
Carbon	-	0.08
Manganese	-	2.00
Phosphorus	-	0.045
Sulphur	-	0.030
Silicon	-	1.00
Nickel	8.0	11.00
Chromium	18.0	20.00

10.0 MECHANICAL PROPERTIES:

10.1 Tensile test:

Material of tube, when tested in accordance with ASTM A 370, shall show the following properties:

Ultimate tensile strength : 515 MPa, min.

Yield strength : 205 MPa, min.

Elongation on 50 mm gauge length : 35 percent, min.

10.2 Hardness:

The tubes shall have a hardness number not exceeding Rockwell No. B 90.

11.0 TEST SAMPLES:

11.1 Heat analysis:

An analysis of each heat of steel shall be made by the steel manufacturer to determine the percentage of elements specified in clause 9.0.

If the secondary melting processes of clause 6.0 employed, the heat analysis shall be obtained from one remelted ingot or product of one remelted ingot of each primary melt. The chemical composition thus determined shall conform to the requirements specified in clause 9.0.

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11.2 Product analysis:

An analysis of one tube shall be made for each heat. The chemical composition thus determined shall conform to the requirements specified in clause 9.0.

11.2.1 If the original test for product analysis fails, retests of two additional tubes shall be made. Both the results for the element in question shall meet the requirements of this specification. Otherwise, all remaining material in the heat or lot shall be rejected or at the option of the manufacturer, each tube may be individually tested for acceptance. Tubes which do not meet there requirements of specification shall be rejected.

11.2.2 Lot Size:

For **flattening, flange and residual stress** requirements, the term lot applies to all tubes prior to cutting of the same nominal size and wall thickness which are produced from the same heat of steel. When final heat treatment in batch type furnace, a lot shall include only those tubes of same size and from the same heat which are heated in the same furnace charge. When the final heat treatment is in a continuous furnace, the number of the tubes of the same size and from the same heat in a lot shall be determined from the size of the tubes as prescribed in Table –I given below:

For **tension and hardness** requirements, the term lot applies to all tubes prior to cutting of the same nominal diameter and wall thickness which are produced from the same heat of steel. When final heat treatment is in batch type furnace, a lot shall include only those tubes of the same size and the same heats which are heat treated in the same furnace charge. When the final heat treatment is in a continuous furnace a lot shall include all tubes of the same size and heat, annealed in the same furnace at the same temperature, time of heat and furnace speed.

TABLE-I

Number of tubes in a lot heat treated by the continuous process shall be as below:

Size of tube	Size of lot
50.8 mm and below but over 25.4mm in outside diameter and under 5.1mm in wall thickness	Not more than 75 tubes
25.4 mm or less in outside diameter	Not more than 125 tubes

Note:
The lot shall be made from the finished tubes of ordered length with cutting margin for eddy current testing.

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12.0 MECHANICAL TESTS ON FINISHED TUBES:

12.1 Tension Test:

Tension test shall be made on two specimens from each lot as per ASTM A 370 and shall meet the requirements as given in clause 10.1.

12.2 Hardness Test:

Material of tube when tested shall not show hardness more than as specified in clause 10.2. Specimens shall be taken from two tubes from each lot.

12.3 Reverse Bend Test:

When tested in accordance with ASTM A 249, there shall be no evidence of cracks or of overlaps resulting from the reduction in thickness of weld areas by cold working. One test shall be made on specimen from each 450 m of finished tubing.

12.4 Flattening Test:

One flattening test shall be made on each end of one finished tube per lot, not the one used for flange test. The test shall be conducted as per ASTM A 1016.

12.5 Flange Test:

One flange test shall be made on each end of one finished tube per lot, not the one used for flattening test. The test shall be conducted as per ASTM A 1016.

13.0 INTERGRANULAR SUSCEPTIBILITY TEST:

One inter granular test shall be made on one specimen per heat of the finished tube covering the weldment and the parent metal as per ASTM A 262 practice E. The specimen bent according to practice E shall not show any sign of fissures either on the weldment or on the parent metal.

14.0 RESIDUAL STRESSES:

The residual circumferential stresses after tube straightening shall be kept as low as possible. In any case these shall be limited to 4 kg/mm^2 (compressive or tensile). One specimen shall be tested per lot. Procedure for residual stress measurement shall be approved by BHEL.

15.0 EDDY CURRENT TSET:

Each tube shall be subjected to eddy current tested as per ASTM E 426 and any tube failing to pass the standard shall be rejected.

16.0 PRESSURE TEST:

Unless otherwise specified, any one of the following tests shall be conducted on each tube:

a) Hydraulic test or Air under water pressure test as per ASTM A 1016. Demineralised water shall be used for testing having chloride content not exceeding 10 ppm.

b) Helium leak test or Air-air differential pressure test, after getting approval for test method by BHEL.

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17.0 QUALITY REQUIREMENT:

Manufacturer shall furnish quality plan on BHEL format along with their quotation. Quality plan shall be approved by BHEL, identifying the check points for witnessing the inter stage / final inspection testing by BHEL/its customer/third party, for compliance before start of manufacture.

18.0 RETESTS:

Should any one of the test specimens first selected by BHEL representative fails to pass the mechanical tests, the tube from which the specimen was taken shall be rejected and further tubes from the same batch shall be selected for testing. Should any of the test specimen from this additional samples fail, the batch represented by them shall be liable for rejection.

19.0 INSPECTION AT SUPPLIER'S WORKS:

BHEL's representative shall have a free access at all times until work on contract of BHEL is being performed shall offer BHEL'S representatives all reasonable facilities without charge to satisfy the latter that the material is being furnished in accordance with this specification.

20.0 TEST CERTIFICATES:

Three copies of the test certificate shall be supplied, unless otherwise stated on the order. The test certificate shall bear the following information:

In addition, supplier shall ensure to enclose one copy of each test certificate along with the despatch documents to facilitate quick clearance of material.

AA 107 53, Rev.09 : Welded Austenitic Stainless Steel Tubes for Condensers and Heat Exchangers

BHEL Order No.

Suppliers' s Name.

Test certificate No.

Size, and quantity

Identification marks

Process of manufacture

Heat treatment batch No.

Percentage reduction in cross section area if applicable (for welded & drawn tubes).

21.0 TEST RESULTS:

Results of chemical analysis, mechanical properties and all other tests shall be given as mentioned at clause numbers 12.0, 13.0, 14.0, 15.0, 16.0, 17.0 & 18.0 for each lot and heat, whichever is applicable.

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22.0 DOCUMENTS TO BE FURNISHED:

Following documents shall be furnished along with the offer:

1. A process chart clearly indicating the sequence of manufacturing.
2. Purchase specification for strips.
3. Heat treatment details.
4. Welding procedure and weld details.
5. Packing box drawing
6. Quality plan.

23.0 CHECKLIST:

Each supplier shall fill the enclosed check list as per **Annexure-A** and submit the same along with each batch.

24.0 PACKING AND MARKING:

Shall be as per BHEL standard AA 049 00 02: Preservation packing and marking of heat exchanger tubes.

25.0 REFERRED STANDARDS (Latest Publications Including Amendments):

1) AA 0490002	2) ASTM A 249	3) ASTM A 262
4) ASTM A 370	5) ASTM E 426	6) ASTM A 1016

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CORPORATE PURCHASING SPECIFICATION

ANNEXURE - A (Clause 23.0)

CHECK LIST FOR AA 107 53: WELDED AUSTENITIC STAINLESS STEEL TUBES FOR CONDENSERS AND HEAT EXCHANGERS

(To be filled by Supplier)

A. Name of Principal Supplier :

B. Name of Indian Agent :

1.0	Grade of material as per specification	:	Yes/No
2.0	Mechanical properties as per specification	:	Yes/No
3.0	Bright annealing	:	Yes/No
4.0	Maximum residual stress (< 4 kg/mm^2)	:	Yes/No
5.0	Method of measurement of residual stress-X-ray diffraction (if any other method, specify the same)	:	Yes/No
6.0	Seam height	:	Yes/No
7.0	**Pressure test offered:**		
	i) Hydraulic test	:	Yes/No
	ii) Pneumatic test	:	Yes/No
	iii) Helium leak test	:	Yes/No
	iv) Air-air differential pressure test	:	Yes/No
8.0	**NDT tests offered:**		
	Eddy current test	:	Yes/No
9.0	**Other tests:**		
	i) Inter angular	:	Yes/No
	ii) Residual stress test	:	Yes/No
	iii) Reverse bend test	:	Yes/No
	iv) Flattening test	:	Yes/No
	v) Flange test	:	Yes/No
10.0	Chloride content in water during final rinsing, 10 ppm, max	:	Yes/No

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11.0 Chloride content in water during Hydro / Air under water testing, 10 ppm, max. : Yes/No

12.0 Finish of tubes:

i) Outside surface : R_a = 2 micron : Yes/No
ii) Inside surface : R_z = 10 micron : Yes/No

13.0 Brief write-up on manufacturing process enclosed : Yes/No

14.0 Quality plan on BHEL format enclosed ; Yes/No

15.0 Details of previous experience enclosed (For new suppliers only) : Yes/No

16.0 Lifting beam offered : Yes/No

17.0 Packing box drawing enclosed : Yes/No

18.0 End guides included (Both ends) ; Yes/No

19.0 Percentage reduction in cross-section area as per specification (For welded and drawn tubes only) : Yes/No

C. Deviations taken (Please specify clearly, if any) : Yes/No.

1
2
3

Date: **Signature &**

Place: **Seal of manufacturer**

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PRESERVATION, PACKING AND MARKING OF HEAT EXCHANGER TUBES

1.0 SCOPE:

This standard stipulates the requirements of preservation, packing and marking of ferrous and non ferrous heat exchanger tubes.

2.0 PRESERVATION:

2.1 End Caps/Guides:

All the tubes shall be provided with plastic end caps of conical shape on both sides, in order to avoid ingress of water and other foreign matter and to serve as a guide for tube insertion through the support plates during assembly of the Heat exchangers.

A typical figure of the plastic guide is shown in the fig 2 for guidance.

2.2 Rust prevention:

All carbon steel tubes shall be applied with suitable temporary rust preventive on the outer surface of the tubes and required quantity of rust inhibitive powder shall be inserted inside the tubes before end capping.

3.0 PACKING:

3.1 The tubes shall be wrapped with polythene sheet in order to avoid movements and rubbing and packed in wooden cases (as an alternate bubble sheet and thermocol also acceptable) with suitable cushioning materials. The bottom of the case shall be rigid to enable the tubes to maintain straightness. Special lifting tackles, including beams, wherever necessary shall be provided with each case to avoid damage during transit. The case shall be fastened with corner metal plates and nailed at all cleats. The reinforcing bolts shall be bound with band steel.
A suitable amount of desiccant such as silica gel shall be placed in each packing box.

3.2 Each package shall be of convenient weight for ease in handling. The weights shall not exceed 2000 kg (Gross) when tubes longer than 7000 mm are ordered.

3.3 The recommended packing case design and the method of packing is illustrated in Fig. No.1 Any alternate method of packing shall be submitted to BHEL for approval.

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4.0 MARKING:

4.1 Each tube shall be stenciled with the following information:

a) BHEL order number:
b) BHEL Specification No.
c) Melt/Heat No:
d) Size of tube:
e) Supplier 's mark

4.2 A metal label shall be securely attached to each packing case, punched with the following details :

a) BHEL order number:
b) BHEL Specification No.
c) Consignment or Identification No.
d) Size of the tubes and Total weight
e) Supplier's Name

4.3 The packing case shall be marked with the following symbols in order to avoid damage during transit:

a) A mark indicating UP-DOWN position of the case.
b) A mark indicating that the case shall not be given any impact.
c) A mark indicating that the case shall be kept free from contact with moisture.
d) A mark showing the slinging position.

5.0 HANDLING AT PORT, SITE, SHOP, ETC., 9INCLUDING TRANSPORTATION):

5.1 Procedure:

If the tube length is more than 7000 mm invariably beams are ordered by BHEL, two in numbers which are supplied with first consignment by the vendor.

On receipt of consignment at port, boxes and lifting beams shall be inspected. If boxes are found broken, inspection of tubes shall be carried out. Broken box shall be suitably repaired before sending to site. Boxes shall be inspected before loading on the truck/trailer at supplier's works. Repair shall be carried out if required.

Invariably lifting beam shall be used for handling of boxes.

Boxes shall be placed on the floor on supports (at least 300 mm above the floor). Distance between supports shall not be more than 500 mm. While handling /stacking, vertical direction as marked on the box shall be followed.

Boxes shall be stacked on each other in such a way that are upright, straight and not projecting outside the lower box. Normally not more than 3 boxes shall be kept on each other.

5.2 Loading of boxes on trailers/trucks:

Preferably trailer shall be of flat floor and its length shall not less than the box. However, in case it is not feasible, following is recommended:

Box length max. in metres	Floor length not less than in metres
20	18.5
15	14
10	9.5
8	7.6

In case, the floor of trailer/truck is not flat, following procedure shall be adopted:

a) Packers of suitable strength shall be placed on the floor such that when boxes are placed, the packer's bottom of the boxes is horizontal.

b) Packers shall be placed such that at the driver end, the box projects maximum 300 mm from the support and on the opposite end, it is 300 mm less than end of the floor such that total projection from last support shall not be more than as specified above.

c) Boxes shall be placed on each other as specified in clause 5.1. The each vertical row shall the secured tight using ropes /wires and tightened with each other and secured with the trailer floor suitably. The gap between the tightening rope/wire shall not be more than 2 metres.

d) Out of two lifting beams, one number shall be sent with first consignment and the second lifting beam with the last consignment.

e) Boxes shall be covered with tarpaulin and tightened suitably so as to prevent seepage of water.

5.3 Receipt at site:

The boxes shall be again inspected at the site for any breakage, if found shall be reported back to concerned unit.

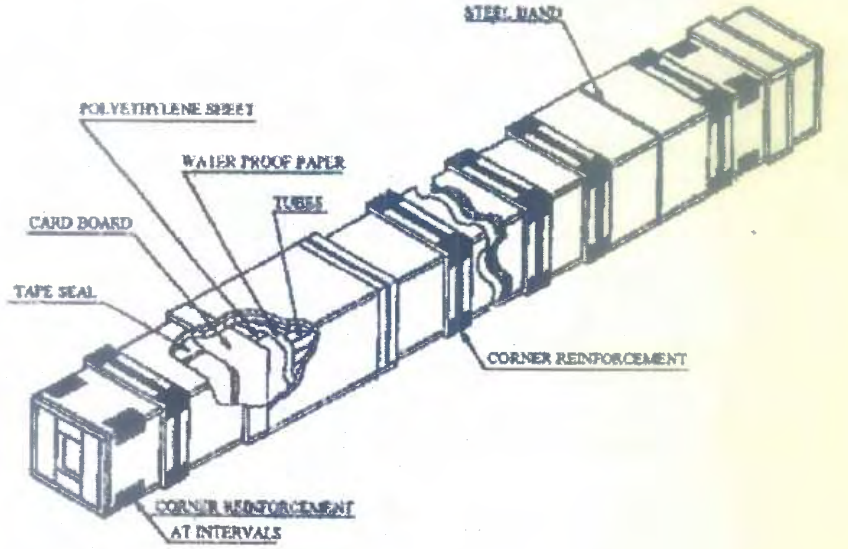
The boxes from trailer/truck shall be lifted using lifting beam only supplied with the first and last consignment and stacked in the store in line with clause 5.1.

The boxes shall be covered with tarpaulin to prevent water seeping in the boxes.

6.0 REFERRED STANDARDS (LATEST PUBLICATIONS INCLUDING AMENDMENTS):

NIL

CORPORATE STANDARD



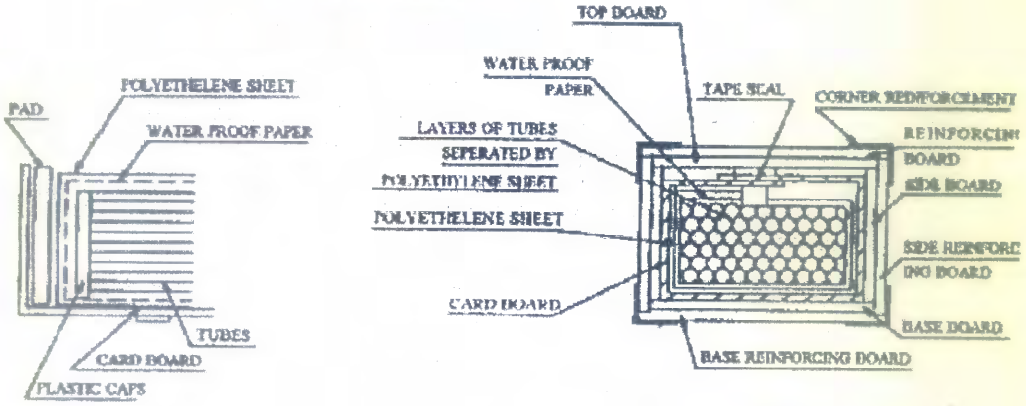


FIG. 1 TYPICAL PACKING OF HEAT EXCHANGER TUBES

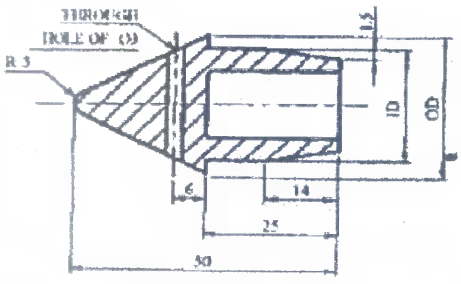


FIG. 2 TYPICAL DRAWING OF CAP FOR TUBE END

(All dimensions are in mm)

MANUFACTURER'S NAME AND ADDRESS		STANDARD QUALITY PLAN			TO BE FILLED BY BHEL	TO BE FILLED BY BHEL
BHEL	VENDOR'S NAME	ITEM	WELDED AUSTENITIC SS TUBES	QP NO.	QA/BI/QP/306	
				REV.	01	
		DRG. NO.	AS PER PO			
		SPEC.	AA10753			
		REV	AS PER PO	Page 1 of 2		

SL. NO.	COMPONENT & OPERATIONS	CHARACTERISTICS	CLASS	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORMS	FORMAT OF RECORDS	D	AGENCY M	AGENCY B	AGENCY N	REMARKS
1	2	3	4	5	6	7	8	9		10			11
1	RECEIVING COIL INSPECTION	IDENTIFICATION & VERIFICATION OF SUPPLIER'S CERTIFICATE VISUAL & DIMENSIONS CHEMICAL / MECHANICAL PROPERTIES	MAJOR	VERIFICATION OF MILL TC & VISUAL INSPECTION	100%	VENDOR'S STD.	BHEL SPEC	MILL TC IR		P	V	-	
2	FORMING & WELDING	WELDING PARAMETERS	MAJOR	VISUAL	100%	-DO-	VENDOR'S STD	IR		P	V	-	
3	ID BEAD ROLLING	ID BEAD HEIGHT	MAJOR	MEASURE	100%	-DO-	BHEL SPEC	IR		P	V	-	
4	TUBE CLEANING	SURFACE CLEANLINESS	MAJOR	VISUAL	100%	-DO-	VENDOR'S STD	IR		P	V	-	
5	BRIGHT ANNEALING	TIME & TEMP	MAJOR	MEASURE	100%	BHEL APPROVED VENDOR'S STANDARD	BHEL SPEC	IR		P	V	-	
6	STRAIGHTNESS	STRAIGHTNESS	MAJOR	MEASURE	100%	BHEL SPEC	BHEL SPEC	IR		P	V	-	
7	ECT	EDDY CURRENT TEST	CRITICAL	VISUAL	100%	BHEL SPEC/ ASTM E 426	BHEL SPEC	TC		P	W*	-	* 10% RANDOM
8	HYDRO OR AIR UNDER WATER TEST	LEAKAGE, PRESSURE & DURATION	CRITICAL	MEASURE	100%	BHEL SPEC	NO LEAKAGE	TC		P	W*	-	Air differential pressure test is acceptable in place of hydro / air under water test as per BHEL approved procedure
		WATER QUALITY IN CASE OF HT / AIR UNDER WATER	MAJOR	MEASURE	100%	BHEL SPEC	BHEL SPEC				V	-	

MANUFACTURER/SUBCONTRACTOR	LEGEND: ! RECORDS IDENTIFIED WITH 'TICK' SHALL BE ESSENTIALLY INCLUDED BY CONTRACTOR IN QA DOCUMENTATION. M: MANUFACTURER / SUBCONTRACTOR B: BHEL / NOM. INSPECTION AGENCY N: CUSTOMER INDICATE 'P' PERFORM 'W' WITNESS AND 'V' VERIFICATION ALL 'W' INDICATED IN COLUMN 'N' SHALL BE 'CHP' OF CUSTOMER	FOR CUSTOMER USE	APPROVED BY

18/01/14
QA

MANUFACTURER'S NAME AND ADDRESS		STANDARD QUALITY PLAN			TO BE FILLED BY BHEL	TO BE FILLED BY BHEL
BHEL	VENDOR'S NAME	ITEM	WELDED AUSTENITIC SS TUBES	QP NO.	QA/BI/QP/306	
				REV.	01	
		DRG. NO.	AS PER PO			
		SPEC.	AA10753			
		REV	AS PER PO	Page 2 of 2		

SL. NO.	COMPONENT & OPERATIONS	CHARACTERISTICS	CLASS	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORMS	FORMAT OF RECORDS		AGENCY			REMARKS
										M	B	N	
1	2	3	4	5	6	7	8	9	D	10			11
8	TEST ON TUBES	PRODUCT ANALYSIS	CRITICAL	CHEMICAL	1/HEAT	BHEL SPEC	BHEL SPEC	TC		P	V	-	** RANDOM
		TENSILE TEST HARDNESS		MECH.	2/LOT						W W		
		FLATTENING FLANGE			1/LOT						W** W**		
		REVERSE BEND			1/450 MT						W**		
		INTERGRANULAR TEST		CORROSION	1/HEAT						W		
		SURFACE ROUGHNESS		MEASURE	1/HEAT						W		
		RERSIDUAL STRESS		MEASURE	1/LOT	BHEL APPROVED VENDOR'S STD					W**		
9	FINAL INSPECTION	OD / WT / SEAM HEIGHT / STRAIGHTNESS / VISUAL/LENGTH	MAJOR	MEASURE	100%	BHEL SPEC & PO	BHEL SPEC & PO	IR		P	W*	-	* 10% RANDOM
10	IDENTIFICATION / PACKING		MAJOR	VISUAL	100%	BHEL APPROVED PACKING BOX DRAWING	BHEL SPEC	IR		P	V	-	

Agarwal 18/01/14
Sugandh QA, BHEL.

		LEGEND:	FOR CUSTOMER USE	
MANUFACTURER/SUBCONTRACTOR		! RECORDS IDENTIFIED WITH 'TICK' SHALL BE ESSENTIALLY INCLUDED BY CONTRACTOR IN QA DOCUMENTATION. M: MANUFACTURER / SUBCONTRACTOR B: BHEL / NOM. INSPECTION AGENCY N: CUSTOMER INDICATE 'P' PERFORM 'W' WITNESS AND 'V' VERIFICATION ALL 'W' INDICATED IN COLUMN 'N' SHALL BE 'CHP' OF CUSTOMER		APPROVED BY