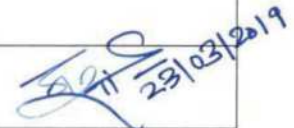
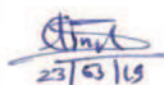
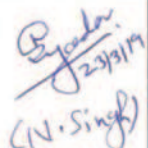
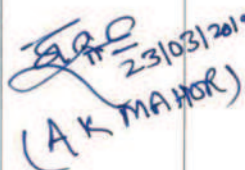


MAIN SUPPLIER'S NAME: BHARAT HEAVY ELECTRICALS LIMITED, BHOPAL (A GOVERNMENT OF INDIA UNDERTAKING) 					
NAME OF SUB-VENDOR: N/A					
NPCIL PO NO.: CMM/FTP/10-33-1-1149/e-PO/30599, DTD: 25.01.19					
QA REF. NO.: MAIN VENDOR: QAX-TH-1483, QAX-TH-1484, QAX-TH-1485, QAX-TH-1486 & QAX-TH-1487 SUB VENDOR: 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: D2O HEAT EXCHANGERS					
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	CONDENSER & HEAT EXCHANGER ENGG. DIVISION BHEL BHOPAL	Document No.
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REVISION CONTROL SHEET

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REV. No Date	Description of Revision	Prepared By	Checked By	Approved By
00, 08.03.2019	Original submission. No change in NPCIL specification no PC-M-1108.	-Sd- (ARUN KUMAR)	-Sd- (N.SINGH)	-Sd- (A.K.MAHOR)
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NUCLEAR POWER CORPORATION OF INDIA LTD.
(A Government of India Enterprise)

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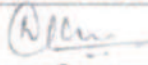
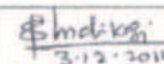
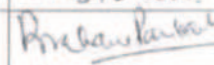
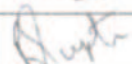
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TECHNICAL SPECIFICATION

FOR

CARBON STEEL FORGINGS FOR PHT SYSTEM HEAVY WATER HEAT EXCHANGERS

REF. USI NO. : 33000

	NAME	Designation	SIGNATURE	DATE
PREPARED BY	Lokesh Dwivedi	SEE		3.12.2014
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DOCUMENT TYPE : TECHNICAL SPECIFICATION

NO. : PC-M-1108

TITLE : **CARBON STEEL
FORGINGS FOR PHT SYSTEM HEAVY WATER
HEAT EXCHANGERS**

REV. NO. & DATE	DESCRIPTION OF REVISION	PREPARED BY	CHECKED BY	REVIEWED BY	APPROVED BY

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 एनपीसीआईएल NPCIL	NUCLEAR POWER CORPORATION OF INDIA LTD	
	ATOMIC POWER PROJECT	Page No. : 1 of 12
	TECHNICAL SPECIFICATION FOR CARBON STEEL FORGINGS FOR PHT SYSTEM HEAVY WATER HEAT EXCHANGERS	Rev. No. : 0

1.0 SCOPE

This specification covers the technical requirements for Carbon Steel Forgings for PHT System Heavy Water Heat Exchanger components such as tube sheet, channel head/primary head, shell, dished end, nozzles etc. The configuration of forgings, numbers required etc. are indicated in the relevant tendering documents. (The dimensions specified in the tender drawings are minimum requirement)

2.0 CONTENTS

The requirements of this specification are presented under the following headings:

Sr. No.	Description	Clause No.
1	Scope	1.0
2	Contents	2.0
3	Applicable Codes and Standards	3.0
4	Materials	4.0
5	Packing and Shipment	5.0
6.	Test Sample location for forgings.	Annexure-1

3.0 APPLICABLE CODES AND STANDARDS

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 case of any conflict between the following codes / standards and this specification, then generally this specification shall govern. The supplier must get confirmation from Purchaser (NPCIL) in case of any such conflict

- | | | |
|----|--------------------|--|
| 1) | ASME – Section II | – Part A – Ferrous Materials |
| 2) | ASME – Section III | - Division 1 – Sub – Section NB |
| 3) | ASME - Section V | – Non Destructive Examination |
| 4) | ASTM | - Relevant Standards for testing and examination |

 एनपीसीआईएल NPCIL	NUCLEAR POWER CORPORATION OF INDIA LTD	
	ATOMIC POWER PROJECT TECHNICAL SPECIFICATION FOR CARBON STEEL FORGINGS FOR PHT SYSTEM HEAVY WATER HEAT EXCHANGERS	Page No. : 2 of 12 Rev. No. : 0

4.0 MATERIALS

- 4.1.1 The carbon steel forgings shall be as per SA-350 "Carbon and Low Alloy Steel forgings requiring notch toughness testing for piping components". The steel shall be vacuum treated and forgings shall be supplied in the normalized condition to "Grade LF2 Class-1" (0.30% max. Carbon) for pressure vessels. In addition to the requirement of SA 350 Grade LF2, the forging shall also comply with all the minimum requirements of ASME Section III Sub-section NB with respect to material, testing, fracture toughness, and examination specified therein and additional requirements specified herein. The steel shall be "Fine grained" and the manufacturer shall indicate the grain size in the bid.
- 4.1.2 The steel shall be clean, homogeneous, intrinsically tough produced by any fine grain melting process and shall be fully killed. The steel shall be produced by vacuum treatment. Details of vacuum treatment, grain size and secondary metallurgical processes shall be indicated in the bid.
- 4.2 The forgings shall be forged as close as practicable to the finished forging shape. The tube sheet forgings shall be, in addition, forged in such a way that the face corresponding to tube side shall correspond to "bottom of the ingot". The manufacturer shall submit for approval to Purchaser, before start of work all the relevant details of the forging manufacture which shall also include the following :
- Ingot - Discard and forging orientation with respect to ingot bottom. Allocation for integral test coupons (for tests at manufacturer's works) and test plates (for purchaser's use) shall be from same melt/heat.
 - Rough forged shape (any hubs, protrusions such as for nozzles / flanges / weld edges etc.) on the forgings shall be obtained by forging operation.
 - Shape at normalizing or Pre-quench shape (when applicable), with various test specimen / chemical sample location and orientation.
 - Forging shape at various non-destructive examinations.

 एनपीसीआईएल NPCIL	NUCLEAR POWER CORPORATION OF INDIA LTD	
	ATOMIC POWER PROJECT	Page No. : 3 of 12
	TECHNICAL SPECIFICATION FOR CARBON STEEL FORGINGS FOR PHT SYSTEM HEAVY WATER HEAT EXCHANGERS	Rev. No. : 0

e) Finished shape of forgings.

4.3 All tube sheet forgings shall preferably be from the same melt / heat. If this is not possible due to ingot capacity limitation, atleast the tube sheet forgings under one item shall be from the same melt / heat along with its forged test plates. Forged test plates for Purchaser's use, shall be supplied from the same heat as that of the tube sheet forgings they represent, in sizes and quantities as indicated in tendering documents. The manufacturer shall clearly mention in his bid the number of melts / heats and the forging items made from each melt / heat. Adequate details relating to para 4.2 (a) through (e) above shall also be submitted along with the bid for proper technical evaluation of the forgings and their manufacture. Repair by welding shall not be permitted.

4.4 Hardness measurements shall be conducted on all forgings and forged test plates after heat treatment and before any further processing along the grid as defined in each product specification to demonstrate uniformity. The hardness value shall not exceed 187 HB. The HB values for tube sheet forgings and corresponding forged test plates shall be reasonably identical and bidder shall indicate the HB value range within which they will fall. The difference between minimum and maximum values shall not exceed 20 BHN. Test shall be carried out as per ASTM E-10.

4.5 In case of tube sheet forgings with integral hubs, an additional tensile test in hub direction from hub area in addition to the tests in para 4.7.3 shall be carried out. Similarly, any integral protrusions on the forgings normal to the main forging surfaces (i.e. protrusions in the thickness direction) shall also be tested by an additional tensile test, in addition to the tests in paragraph 4.7.3. The acceptance standard for these additional tests also are same as applicable SA material specification standards.

4.6 Additional Requirements

a) Simulated post weld heat treatment of mechanical test samples. For simulated heat treatment details refer the tender documents. In addition to testing on simulated post weld heat treated test coupons, one set of tensile and notch



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ATOMIC POWER PROJECT

TECHNICAL SPECIFICATION FOR

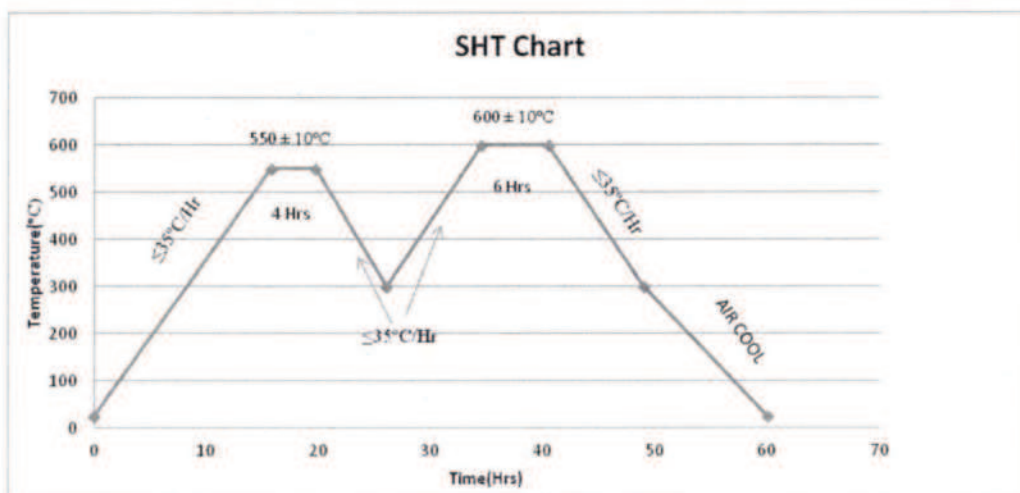
CARBON STEEL FORGINGS FOR PHT SYSTEM HEAVY WATER HEAT EXCHANGERS

Page No. : 4 of 12

Rev. No. : 0

toughness (drop weight) tests shall be carried out for each melt / heat per one type of forging in normalized condition or quenched and tempered condition, as applicable.

The Simulated heat treatment (SHT) to be done on test coupons as per the following cycle.



b) Ultrasonic Testing :

Ultrasonic examination shall be performed in accordance with the requirements of NB-5000 of Section III of ASME Code using procedures and standards such as to ensure consistent detection and discrimination of transverse and longitudinal defects. The reference standards shall be made from material of the same composition, diameter, thickness and surface condition and heat treatment conditions as of the material which is to be examined. All forgings shall be ultrasonically examined using normal and angle beam examination

Reference block calibration shall be performed using at least three holes, spaced to approximate minimum, mean, and maximum thickness as tested,

 एनपीसीआईएल NPCIL	NUCLEAR POWER CORPORATION OF INDIA LTD ATOMIC POWER PROJECT TECHNICAL SPECIFICATION FOR CARBON STEEL FORGINGS FOR PHT SYSTEM HEAVY WATER HEAT EXCHANGERS	Page No. : 5 of 12
		Rev. No. : 0

and shall be used to generate a distance amplitude correction (DAC) curve.
The following hole sizes apply:

1. 1/16 in. [1.5 mm] flat bottom holes (FBH) for thicknesses less than 1.5 in. [40 mm]
2. 1/8 in. [3 mm] FBH for thicknesses of 1.5-6 in. [40-150 mm] inclusive
3. 1/4 in. [6 mm] FBH for thicknesses over 6 in. [150 mm]

All recordable indication (above 20% of reference level) apparently within acceptance limits shall be investigated to confirm that they are parallel to the forging faces and not in transverse direction i.e. not in thickness direction.

Defect indications exceeding 20% of reference level in thickness direction and exceeding the reference level parallel to the forging faces are not acceptable. In case of tube sheet with integral hubs, the hub for depth at least one hub (big end) thickness, shall be free from defect indications equal to or above 3% hub thickness. Similarly, in case of forgings with integral protrusions the protrusion and the portion in the forging underneath the protrusion for depth at least equal to the thickness of such protrusion, shall be free from defect indications equal to or above 3% of protrusion thickness. The protrusion meant for nozzles and forged solid, shall be UT examined after the nozzle openings are machined.

c) ASME Section III fracture toughness requirements :

The RTNDT shall not be higher than minus 15°C. This implies that CV tests as per Section III-NB shall be carried out at a temperature not exceeding +18 degree C (RTNDT + 33 degree C) and meet the requirements specified in NB 2300.

4.7 Requirements for Forgings to Specification – 350 Gr. LF2 Class-1

4.7.1 Grain Size

The grain size shall be 6 or finer. The grain size and micro/macro-structure shall be examined and reported.

 नएनपीसीएल NPCIL	NUCLEAR POWER CORPORATION OF INDIA LTD ATOMIC POWER PROJECT TECHNICAL SPECIFICATION FOR CARBON STEEL FORGINGS FOR PHT SYSTEM HEAVY WATER HEAT EXCHANGERS	Page No. : 6 of 12
		Rev. No. : 0

4.7.2 Chemical Composition

The chemical composition of product and ladle analysis shall be as per Table 1 of SA-350 for Grade LF2 with additional restrictions on impurity elements as below

Sulphur	0.025% max.
Phosphorous	0.025% max.
Aluminium	0.04% max.
Vanadium	0.01% max.
Chromium	0.25% max.
Copper	0.30% max.
Cobalt	0.02% max.
Nickel	0.40% max.
Moloybdenum	0.10% max.
Tin	0.011% max.
Nitrogen	0.013% max.
Arsenic	0.025% max.
Antimony	0.007% max.

4.7.3 Mechanical Requirements

a) Tension Test

The material shall conform to requirements for tensile properties as per SA 350 LF2 Class-1 material specification. For the number of tests, test

 ननपीसीआईएन NPCIL	NUCLEAR POWER CORPORATION OF INDIA LTD	
	ATOMIC POWER PROJECT	Page 7 of 12
	TECHNICAL SPECIFICATION FOR CARBON STEEL FORGINGS FOR PHT SYSTEM HEAVY WATER HEAT EXCHANGERS	No. : Rev. No. : 0

location and orientation, refer corresponding clause of SA-350 LF2 material specification.

b) Impact Test

For requirement of number of tests, test location and orientation, refer Clause 7.2 of SA-350 LF2 Class-1 material specification.

c) Nil Ductility Transition Temperature as per ASME Section III

Drop weight tests and additional CV impact tests to determine the nil ductility transition temperature RTNDT shall be in accordance with NB-2300.

4.8 Non-Destructive Examination and Acceptance Standards

4.8.1 Ultrasonic Examination and Acceptance Standards

The ultrasonic examination shall be in accordance with ASME Section III para NB-2542. The extent of examination shall be 100%. Refer para 4.6 (b) for additional requirements on UT.

4.8.2 Magnetic Particle Examination and Acceptance Standards

The magnetic particle examination shall be in accordance with Section III, para NB-2545. The extent of examination shall be 100%. Demagnetization after the test is required.

4.8.3 Time of Examination

The acceptance examination shall be performed at the time of manufacture as given in NB-2547 of ASME Code Section III.

 एनपीसीआईएल NPCIL	NUCLEAR POWER CORPORATION OF INDIA LTD	
	ATOMIC POWER PROJECT	Page No. : 8 of 12
	TECHNICAL SPECIFICATION FOR CARBON STEEL FORGINGS FOR PHT SYSTEM HEAVY WATER HEAT EXCHANGERS	Rev. No. : 0

4.9 Test Specimen Requirements

The location of test specimens required in addition to NB requirements is shown in annexure 1. The tests specified below are for one test location in a forging not exceeding 4500 kg. For forgings exceeding 4500 kg, two sets one each from two test locations are required from two diametrically opposite locations. The requirements given below are for one test location.

4.9.1 Tube Sheet/Test Plate

a) Tension Test

Two specimens, one tangential (to the maximum working i.e. deformation direction) and another axial (thickness) direction shall be tested at room temperature. One additional specimen in hub direction / protrusion direction shall be taken for tube sheets with hubs / nozzle protrusions.

b) Drop Weight Test

The specimens (P2) in accordance with ASTM E-208 shall be oriented in tangential direction. The RTNDT shall not be higher than minus 15 degree C.

c) Impact Test

- i) One set of three specimens in tangential direction at minus 46.6 deg.C
- ii) One set of three specimens oriented in tangential direction shall be tested at RTNDT + 33 deg.C. The values shall meet the requirements of Section III, para NB 2331. The notch of the Cv specimen for (i) & (ii) above shall be normal to the surface of material.

 एनपीसीएल NPCIL	NUCLEAR POWER CORPORATION OF INDIA LTD ATOMIC POWER PROJECT TECHNICAL SPECIFICATION FOR CARBON STEEL FORGINGS FOR PHT SYSTEM HEAVY WATER HEAT EXCHANGERS	
	Page No. : 9 of 12	Rev. No. : 0

4.9.2 Top Flange (Primary Head with Integral Nozzle)

a) Tension Test

Three specimens, oriented in radial, tangential and axial directions (with respect to the maximum working i.e. deformation direction) shall be tested at room temperature.

b) Drop Weight Test : Similar to that indicated in 4.9.1 (b) above.

c) Impact Test : Similar to that indicated in 4.9.1 (c) above.

4.9.3 Dished Heads - Forged

a) Tension Test

One number with its longitudinal axis oriented parallel to the major working i.e. deformation and another normal (thickness) to the major working direction shall be tested at room temperature.

b) Drop Weight Test : Similar to that indicated in 4.9.1 (b) above.

c) Impact Test : Similar to that indicated in 4.9.1 (c) above.

4.9.4 Shell/Nozzle - Forged

d) Tension Test

One number with its longitudinal axis oriented parallel to the major working i.e. deformation and another normal (thickness) to the major working direction shall be tested at room temperature.

e) Drop Weight Test : Similar to that indicated in 4.9.1 (b) above.

f) Impact Test : Similar to that indicated in 4.9.1 (c) above.

 ननपीसील NPCIL	NUCLEAR POWER CORPORATION OF INDIA LTD	
	ATOMIC POWER PROJECT TECHNICAL SPECIFICATION FOR CARBON STEEL FORGINGS FOR PHT SYSTEM HEAVY WATER HEAT EXCHANGERS	Page No. : 10 of 12 Rev. No. : 0

4.10 Quality Surveillance

The forgings shall be subjected to quality surveillance by the Purchaser or his authorized agency during manufacture. Forgings shall not be shipped until the shipping release is given by the Purchaser / his authorized agency.

4.11 Repairs

Minor surface defects should be smoothly ground and blended without impairing the thickness shown on the drawing. No other repairs shall be carried out without the prior approval of the Purchaser. All repairs shall be recorded. All non-conformities shall be reported to the Purchaser to determine their disposal.

4.12 Dimensional Check

Each forging shall be checked for dimensional compliance with approved drawing. The actual dimensions shall be recorded in a sketch / chart and submitted for final acceptance.

4.13 Procedures, plans, Reports and Documentation

The Forging Manufacturer shall prepare manufacturing, testing, examination procedures / plans and obtain Purchaser's approval before manufacture. The manufacturer shall prepare separate QAP and Manufacturing Sequence and Testing Plan (MSTP) for each type of forging and same shall be submitted to Purchaser for approval. The manufacturer shall be responsible for preparation and issue of all reports, certificates and documentation which shall be certified by Purchaser / his authorized agency. Such certified final documents shall be supplied in bound volumes with proper identification. Final documentation containing all the above shall also be submitted in soft form (pdf format) with proper indexing.

 एनपीसीआईएल NPCIL	NUCLEAR POWER CORPORATION OF INDIA LTD	
	ATOMIC POWER PROJECT	Page No. : 11 of 12
	TECHNICAL SPECIFICATION FOR CARBON STEEL FORGINGS FOR PHT SYSTEM HEAVY WATER HEAT EXCHANGERS	Rev. No. : 0

4.14 Marking

Each forging shall be marked as per SA-350 material specification. It shall also include the heat number, in case of tube sheet forgings the reference of corresponding forged test plate identification, marking on tube sheet forging indicating correspondence with top / bottom of original ingot.

4.15 Deviations

Any deviation from the above requirements shall be clearly brought out and informed to the Purchaser/NPCIL for review. Only after NPCIL approval/acceptance to the deviation the manufacturer shall proceed further. Otherwise, it will be deemed that the bidder agrees with all the above requirements.

5.0 PACKING AND SHIPMENT

The forgings shall be subjected to quality surveillance by the Purchaser or his authorized agency during manufacture. The forgings shall not be shipped until the shipping release is given by the Purchaser/his authorized agency.

The forgings shall be protected against corrosion and damage in transit and shall be properly preserved and packed for sea-worthiness. The Supplier shall submit a preservation and packing plan for Purchaser's review and approval.

Before shipment suitable rust preventive coating shall also be applied on the forgings to ensure sea-worthiness and storage in tropical climate for at least two years.



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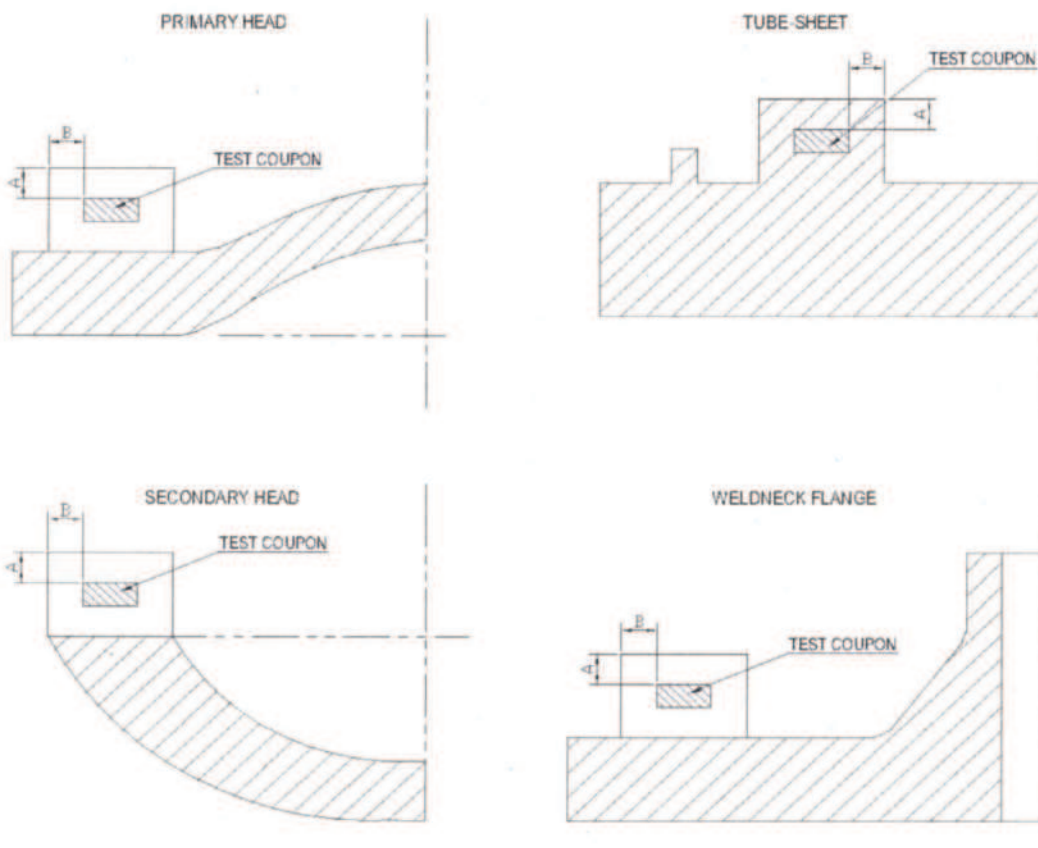
CARBON STEEL FORGINGS FOR PHT SYSTEM HEAVY WATER HEAT EXCHANGERS

Page 12 of 12
No. :

Rev. : 0
No. :

Annexure-1

SKETCH-1



DIMENSIONS 'A' AND 'B' SHALL BE AS PER ASME NB-2223

TEST SAMPLE LOCATION FOR FORGINGS