Approval for Abridged version of Advertisement

Annexure-A for Tender approval note Ref: BHE ATP 629026E Dt.02.08.2010

	BHARAT HEAVY ELECTRICALS LIMITED (A Government of India Undertaking) **TIRUCHIRAPPALLI - 620 014.** **ADVANCED TECHNOLOGY PRODUCTS** **SUB-CONTRACTING.** PHONE: 0431 – 2575189, FAX: 0431– 2520565 E-MAIL : mtr@bheltry.co.in	**AN ISO 9000 COMPANY**

Sources Required for Testing, Machining & Aluminisation for Nut M120 x 6.

BHEL REQUIRES SOURCES FOR Testing, Machining & Diffusion Aluminisation by packed cementation process for Nut M120x6 for a quantity of 60 numbers. Full details are available in BHEL website **http://www.bhel.com** (Tender Notification page) or in Govt. Tenders website **http://tenders.gov.in** (Public sector units, Bharat Heavy Electricals Limited, page). Interested parties may contact the person in charge indicating the respective reference number given below:

Reference Number : 629026E	Contact Name	: M. Thiyagarajan Manager / Sub contracting / ATP
	Phone	: +91 431 2575189 / 2575180
	Fax	: +91 431 2520565
	E-Mail	: **mtr@bheltry.co.in**

BHARAT HEAVY ELECTRICALS LIMITED
TIRUCHIRAPPALLI - 620 014.

SUB CONTRACTING / ADVANCED TECHNOLOGY PRODUCTS

ANNEXURE TO TENDER 629 026 E

COMPONENT DETAILS: -

Sl. No	DESCRIPTION	RAW MATERIAL SUPPLY DETAILS	WORK ORDER No & DU - PART No.	Reqd. Qty. Nos.
1	NUT M120 X 6 3 -90 -628 -109 - 00826 / 04	Rod dia 200 x 1200 mm BLANK – 1B – **04 Nos.** **(01 no for Trial pieces)** specn: 25XIMΦ	D098 - 001 -1 - 90 -102 022 - 0104	30
2	NUT M120 X 6 3 -90 -628 -109 - 00826 / 04	Rod dia 200 x 1200 mm BLANK – 1B – **03 Nos.** specn: 25XIMΦ	D099 - 001 -1 - 90 -102 004 - 0104	30

SCOPE OF OPERATIONS:

1) Carryout confirmatory Test on all the Rods supplied by BHEL as per Specification.
2) Carryout Ultrasonic Test on all the Rods as per **Procedure and Acceptance Criteria for Ultrasonic examination of F321 BARS & FORGINGS.**
3) Manufacturing of NUT M120 X 6 Trial pieces – 02 nos. by machining as per drawing.
4) Prepare one Test coupon (size will be given)
5) Diffusion Aluminisation by packed cementation process of NUT M120 along with Test coupon.
6) Quenching and Tempering of NUT M120 along with Test coupon.
7) Testing of Mechanical properties, metallurgical evaluation and chemical composition as per approved procedure.
8) After getting clearance for Trial job, actual job 60 Nos. Shall be manufactured following the same sequence.
9) Stage and Final Inspection by QC / BHEL & QS / BARC.

NOTES:

1) The supplier should have supplied similar components in diffusion Aluminisation by packed cementation process for Nuclear applications (supplied to NPCIL / BARC etc.,)
2) End users certificate will not be given.
3) Delivery period requirement by January 2011.

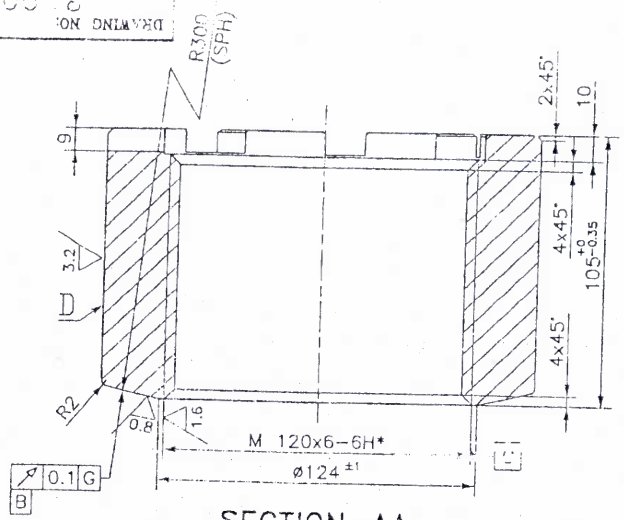
Interested Vendors can receive the procedures and specifications thro'post from the contact person mentioned.

Manager
SubContracting / ATP

DRAWING NO: 3-90-628-00826

ALL DIMENSIONS ARE IN MILLIMETERS

5.3 / 3.2 / 1.6 / 0.8



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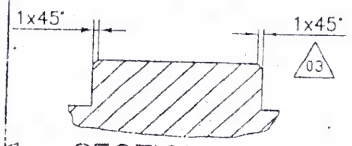

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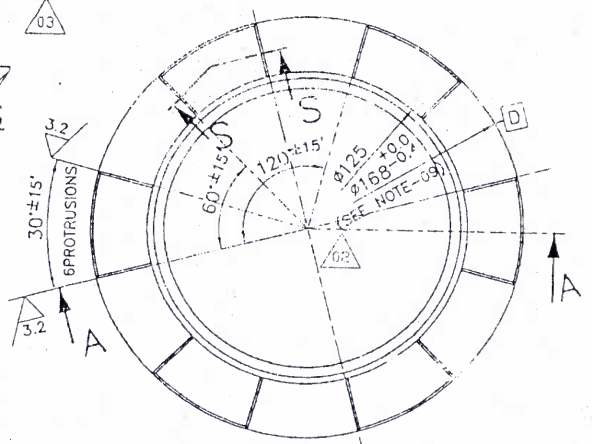

NOTES:

01. PRESERVE THE COMPONENT IN A PROPER PACKING.
02. DENTS ARE NOT PERMITTED ON THE SPHERICAL SURFACE.
03. * DIMENSIONS FOR REFERENCE.
04. THREADING 'G' SHALL BE FULL AND SHALL NOT HAVE BURRS AND SCRATCHES. BLUNTING OF ENTRY THREADS SHALL BE ENSURED.
05. CHECK THE SURFACE OF THREADING BY PT AS PER APPROVED PROCEDURE.
06. CHECK THE RADIUS OF SPHERE WITH A GAUGE PAIRED WITH GAUGE OF PART 3-90-628-00827. GAP BETWEEN GAUGE AND SPHERICAL SURFACE OF NUT SHALL NOT BE MORE THAN 0.1MM.THIS SURFACE SHALL NOT HAVE DENTS,LINES,MARKS ETC,.
07. (04) THE ITEM SHALL BE ALUMINIZATION COATED AS PER APPROVED PROCEDURE.
08. CHECK THE SURFACE BY CAPILLERY METHOD.
09. FOR DETERMINATION OF HARDNESS OF MATERIAL OF THE COMPONENT, IT IS PERMITTED TO MAKE FLAT SURFACE ON FACE 'D' OF LENGTH 50±3mm ALONG THE AXIS AND WIDTH 10±2mm. THE ROUNDING RADII SHALL NOT BE LESS THAN 3mm
10. CHECK THE BLANK OF PART BY UT AS PER APPROVED PROCEDURE
11. (04) THE COMPONENT SHALL BE HEAT TREATED AS PER APPROVED PROCEDURE AND HEAT TREATMENT PLAN AFTER ALUMINIZATION COATING.
12. MECHANICAL PROPERTIES OF MATERIAL OF COMPONENT AFTER HARDENING AND SUBSEQUENT HEAT TREATMENT SHALL BE:
    A) AT -20°C TEMPERATURE:
       IMPACT STRENGTH KCU≥ 29 J/cm² (3kgfm/cm²)
    B) AT 20°C TEMPERATURE:
       ULTIMATE TENSILE STRENGTH ≥ 784 MPA (80kgf/mm²)
       YIELD STRENGTH ≥ 685 MPA (70kgf/mm²)
       PERCENTAGE ELONGATION ≥ 14%
       IMPACT STRENGTH KCU ≥59 J/cm²(6kgfm/cm²)
       HARDENESS 262-311 HB WITH DIAMETER OF IMPRESSION 3.75-3.45 mm
    C) AT-350°C TEMPERATURE:
       YIELD POINT STRENGTH ≥ 587 MPA (60kgf/mm²)

Approved 03709

VARIANT NUMBERS	ITEM NUMBER	DESCRIPTION	STD	DRAWING NUMBER	ITEM NO	MATERIAL CODE	A/C	UNIT	UNIT WEIGHT	GS
		ROD ø200x105 LG		FREE ISSUE		25X1MO	A		8. 100	
					VAR NO	MATERIAL SPECN		D1	QUANTITY	

TOLERANCE IF NOT SPECIFIED SHALL BE AS BELOW (REFER IS:2102-m)

LINEAR				ANGULAR	
0.5 TO 3	±0.1	400 TO 1000	±0.8	0 TO 10	± 1°
3 TO 6	±0.1	1000 TO 2000	±1.2	10 TO 50	±30'
6 TO 30	±0.2	2000 TO 4000	±2.0	50 TO 120	±20'
30 TO 120	±0.3	——	——	120 TO 400	±10'
120 TO 400	±0.5	——	——	OVER 400	±5'

REV	DATE	ALTERED : CHD&APPD :
03	021107	CUSTOMER'S COMMENTS INCORPORATED.
02	210406	REFERENCE SURFACE-D MENTIONED NOTE-6&7 CORRECTED
01	070206	NOTE 9, 10&12 ADDED

DATE 01.12.070408 ALTERED : CHD&APPD : NOTE-7 &11 ALTERED.

TYPE OF PRODUCT OR NAME OF CUSTOMER/PROJECT: BARC

REF: A3/B1B2/3110/143/07-04/DD

PRODN DRG

Bharat Heavy Electricals Ltd
UNIT: HIGH PRESSURE BOILER PLANT
TIRUCHIRAPALLI - 620014

05-229/D

	NAME	SIGNATURE	DATE	NO. OF VAR
DRN	K.R.		210406	
CHD	BGK		210406	
APPD	A.S		210406	

DEPT	GRADE OF UNTOL DIM	SCALE	WEIGHT (Kg)	REF TO ASSY / OLD DWG	ITEM NO	NO OF ITEMS
NC	C/M/F	1:2, 1:1	8.1	0-90-628-00237	04	
CODE 150						

TITLE: NUT - M120x6

CARD CODE: U 01

DRAWING NO : 3-90-628-0082604

REV

Size A3

1 Scope of Work

- Carryout UT on supplied FIM
- Conduct confirmatory test on supplied FIM rods
- Machining of Nut M120-2 nos Trial pieces.
- Conduct diffusion aluminization as per approved procedure, quenching and tempering on Nut M120 -2 nos (trial pieces) and one Test Coupon & carryout Mechanical and Metallurgical Testing of Test piece to establish procedure.
- Machining of actual job.
- Aluminization of Nut M120 along with Test Coupon.
- Quenching and tempering of Nut M120 along with Test Coupon.
- Testing of Test Coupon and job for acceptance.
- Packing and delivery with final approved documents.

2 General Requirements

2.1 The FIM rods of size ϕ200 mm -1200 mm Length of material grade 25X1MΦ, shall undergo Ultrasonic Test by both normal and angle beam method as per procedures MDN/BHEL/321/UTP/0608 dt 03.06.2008 using reference blocks made from one of the batch.

2.2 Specimen location on test coupons of supplied material shall be done after accounting discard length as per approved material sampling and test plan (MSTP). The specimen orientation, position and numbers shall be as per approved MSTP.

2.3 Material from each batch of supply shall be tested for mechanical properties, metallurgical evaluation and chemical composition. Refer Annexure-1 for extent of testing and Annexure-2 for acceptance norms.

2.4 In the event of specimens not meeting the required property, retest shall be carried out with double the number of specimens under advice of BARC & BHEL (customer) representatives.

3 Confirmatory tests of raw material in the as supply condition:

3.1 The Vendor shall prepare NDE reference blocks to carryout UT of the supplied rods as per approved sketch/drawing by customer.

3.2 The supplied FIM rods shall undergo confirmatory tests prior to further processing for machining of Nut M120 as per para 2.3 above.

4 Machining of M120 Nuts

4.1 M120 Nuts -2 nos shall be machined to requirements of drawing. The machined pieces shall be subjected to inspection (dimension, surface condition, checking of thread profile etc.) by customer.

4.2 Easily removable rust preventive coating shall be applied on the finish machined pieces.

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4.3 The machined pieces shall be stored in soft packing to avoid damages.

4.4 Rust preventive coating shall be removed properly to the satisfaction of customer just prior to loading for aluminization.

5 Establishment of Aluminization Procedure using Trial Piece

2nos of M120 Nuts and Test Coupon of adequate size shall be subjected to aluminization and subsequent heat treatment as per annexed procedure and approved QAP. Witness stages shall be clearly identified in the QAP. Nut M120 will be checked for aluminization thickness on both Thread profile and other surfaces. Test coupon will be subjected to mechanical testing and metallurgical evaluation as per Annexure-1. After Successful completion of trial piece and establishing the procedure, actual job shall be manufactured following the same sequence.

6 Heat Treatment for Aluminization

6.1 Heat treatment for Aluminization, Quenching and Tempering of trial piece, test coupons and job shall be carried out in Vertical position with suitable fixture using **ELECTRIC FURNACE as per Heat treatment plan enclosed**. Supplier shall use calibrated furnace.

6.2 Furnace Loading scheme for Heat treatment & position of thermocouples on the job shall be submitted for approval along with QAP. At least four thermocouples shall be used for each container.

6.3 Heat treatment shall be performed to meet the requirements, generating heat treatment chart / graph. The graph shall be submitted along with final documentation.

7 Material Testing subsequent to Heat treatment

7.1 Material Testing subsequent to heat treatment shall be done as per Annexure-1 of this specification. Two samples per batch for parallel metallographic study shall be given to customer.

7.2 Liquid penetrant test and Ultrasonic Test by Normal beam shall be done as per approved procedure as referred in para 1 of this document.

7.3 The coated surfaces shall have a smooth, uniform appearance.

7.4 Visual inspection of the coating shall be performed prior to dimensional inspection.

7.5 The threads in final condition shall be checked by both GO & NO GO gauges.

8 Re-Test

8.1 Retesting shall be conducted with prior written approval of customer.

8.2 Retest shall be done using double the number of specimens for each failure.

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9 Stages for Witness / HOLD point

Job shall be carried out as per approved QAP. At the minimum following shall be Witness / HOLD point during the processing:

- Material Verification
- Dimension checking after initial machining of M 120 Nuts
- Verification and acceptance of purity of ferro-aluminium powder and aluminization mixture
- Verification of surface cleanliness of job and container prior to Aluminization
- Verification for spacing of job and test pieces of container during packing
- Sealing of container and its air tightness
- Verification of furnace parameters for aluminization, quenching and tempering
- NDE (PT & UT)
- Material testing (mechanical & metallurgical)

10 Documentation & certification

10.1 For certification of completion and acceptance of job, details of heat treatment carried out, HT chart, properties obtained, observations on chemical and metallurgical aspects, observations in UT etc. shall be furnished. These will also form part of final documentation.

10.2 Two copies each, of the Test Certificates shall be provided in ink signed form.

10.3 Scanned soft copies of all documents shall also be provided in CDs as final documentation.

11 Marking, Packing & Safe-delivery

11.1 In addition to original identification marks, clear marking of HT Batch number shall be provided on each nut.

11.2 Sea-worthy packing shall be carried out before dispatch.

11.3 Safe-delivery to BHEL, Tiruchirapalli shall be done for further manufacturing.

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Annexure-1

Extent of Testing for Aluminisation of M120 Nuts

(A) Chemical Composition

Material grade	C	Mn	Si	Cr	S	P (max)	Ni	Cu (max)	Mo	V	Ti	W
	%	%	%	%	%	%	%	%	%	%	%	%
25X1MΦ	0.22-0.29	0.4-0.7	0.17-0.37	1.5-1.8	0.025 max	0.03 max	0.3 max	0.2 max	0.25-0.35	0.15-0.3	0.03 max	0.3 max

Al, B, Ba, Nb, Ce and N to be reported for all grades wherever not specified

(B) Mechanical Testing Requirements

1. Confirmatory tests of raw material in supply condition

Chemistry	Tensile Test*		Imact Test (KCU)	Hardness	Grain Size	Macro	Micro	Inclusion Rating	IGCT
	RT	350 °C							
1	1	1	3	1	1	1	1	1	-

2. Acceptance tests on trial samples

Tensile Test*		Imact Test (KCU)		Micro Hardness (two perpendicular surfaces)	Macro	Micro & Grain size
RT	350 °C	-20 °C	RT			
1	1	3	3	1	1	1

3. Acceptance tests for actual rods.

Tensile Test for each direction (L +Tr)*		Imact Test (KCU)		T_{KO} determination	Hardness	Grain Size	Macro	Micro	Inclusion Rating
RT	350 °C	- 20 °C	R	with Cv-curve					
2	2	3	3	Determination for information	Survey on job as per attached sketch	1	1	1	1

* Sub-size Tensile transverse specimen shall be taken wherever possible.

Cv-curve shall be generated with six temperature points. -12 °C, 0 °C and RT shall be

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Annexure 2

Acceptance values for Mechanical testing

%age shear fracture shall be reported for each impact test

Tensile Test								Impact Test (KCU) J/cm^2		Hardness	
RT				-50 °C				-20 °C	RT	dia of indentor (mm)	Value (max)
YS (MPa)	UTS (MPa)	% elongation	%RA	YS (Mpa)	UTS (MPa)	% elongation	%RA				
685	784	16	50	587	To be reported	To be reported	To be reported	29	59	3.75 - 3.45 min	262-311 BHN

Acceptance values for Metallurgical examination

1. Metallographic examination shall reveal smooth, uniform and continuous coating.
2. Coating thickness shall be determined on testers (representative parts) by microscope at 100X magnification. Coating thickness shall be 100 microns to 120 microns. Coating thickness shall be measured both before and after Q & T heat-treatment.
3. Coating shall be adherent to the base metal, free of cracks, chips, spalling, staining, residual process material (internally and externally) or other imperfections pertaining to the coating and handling process.
4. Coating shall be free from defects such as cracks, pits, lack of diffusion, burned or rough areas, pinholes, nodules etc.

Grain Size not coarser than	Macro		Micro	Inclusion Rating
	To be reported	Not permitted		
5	Central porosity Dotted discontinuity Liquation square General spotty liquation	Shrink holes, shrinkage liquation, shrinkage porosity, blow holes, cracks, flakes, occuled gas, reppled surface	Micro-structure to be reported	To be reported

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PROCEDURE FOR DIFFUSION ALUMINIZATION

1.0 This document describes the procedure, quality control, acceptance norms and inspection stages for diffusion aluminization of components followed by quenching and tempering for fasteners manufactured from material grade 25X1MΦ. The method of diffusion aluminization is by pack cementation process.

2.0 Definitions

2.1. **Container** – Vessel for carrying out the aluminizing process.

2.2. **Batch** – Specific quantity of jobs, test coupons and dummy jobs determined for undergoing combined specific stages of diffusion aluminisation in a single container.

2.3. **Job** – Number of finished machined jobs undergoing aluminisation as per approved drawing.

2.4. **Test coupons** – Steel blanks to manufacture specimens for mechanical tests.

2.5. **Dummy jobs** – Aluminized simulated fasteners to determine the thickness of aluminized layer on surfaces and threaded portions.

2.6. **Charge** – One or several batches with each batch consisting of jobs with the corresponding no. of test coupons and dummy jobs of the same heat treatment cycle.

2.7. **Powder Batch** – All Ferro-Aluminium powder batch from same certified lot.

3.0 Requirements for manufacturing and preparation of jobs, test coupons and dummy jobs

3.1. The blank shall be machined to requirements as per drawing.

3.2. Surface finish of fully machined surfaces of the job and test coupons shall be better than Ra 1.6 μm.

3.3. Protective temporary rust preventive coatings shall be applied immediately after machining to prevent corrosion of surfaces. Proper cleaning of surfaces shall be ensured prior to use for aluminisation.

3.4. Both test coupons and dummy jobs shall be of same heat and melt as the actual job. They shall undergo combined specific stages of diffusion aluminisation and heat treatment with the actual jobs. Proper identification shall be provided by punching at approved location on each job, test coupons and dummy jobs.

3.5. One container may contain many jobs as per approved scheme.

3.6. Size of the charge is determined based on power and capacity of the furnace and load lifting capacity of the heat treatment fixture by the manufacturer performing the job.

3.7. Adequate no. of dummy jobs shall be planned for each batch of jobs and be located as per approved sketch. Figure-1 may be used as reference.

3.8. Size of the dummy jobs shall be such that it simulates the actual thread profile on job. This shall not be smaller than diameter 20 mm and length 60 mm.

3.9. Test coupons shall be in the form of hollow cylinders with OD 170 mm, wall thickness 25 mm and height 100 mm.

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4.0 Preparation

4.1. Cleaning of parts, test coupons and dummy jobs

4.1.1. Prior to processing of parts, all surfaces (internal and external) shall be cleaned to be free of oil, grease, mill scale, and other foreign materials.

4.1.2. Cleaning procedure involves acid pickling to remove mill scale, removal of oil, and grease by vapor degreasing and abrasive/grit blasting. Jobs, test coupons and dummy jobs shall be washed with acetone/isopropyle alchohol or electrochemically degreased prior to aluminisation.

4.1.3. Presence of scales and rust on the inside surfaces of container, surface of jobs, test coupons and dummy jobs is not permissible.

4.1.4. From this point on until packing, parts should be handled with clean cotton gloves to prevent contamination.

4.2. Containers

4.2.1. Material of construction – 5 mm thick sheets of approved grade of Austenite SS.

4.2.2. The inner surfaces of the containers, before aluminizing, should be free of rust, oil, water and other liquids. This shall be witnessed by customer prior to filling with aluminizing powder.

4.2.3. Welded hermetically sealed containers with fused stopper to prevent entry of oxygen shall be used as per figure 1. Use of unsealed containers is not permitted.

5.0 Preparation of ferroaluminum powder

Refer Annexure-I for the method of ferro-aluminum powder preparation. Re-use of ferro-aluminium powder shall not be done and for each batch fresh ferro-aluminum powder shall be used.

6.0 Preparation of aluminizing mixture

6.1. Prior to mixing, all the aluminizing constituents shall be dried for each at least one hour till the water vapors are removed as under: -

6.1.1. Drying of ferroaluminum powder at a temperature of 150-300 °C for at least one hour.

6.1.2. Calcination of Alumina at a temperature of 800 °C for at least one hour.

6.1.3. Drying of Ammonium iodide in clean trays at a temperature of 50-100 °C for at least one hour.

6.2. The sequence of preparation of aluminizing mixture is as under: -

6.2.1. Aluminizing mixture shall be prepared by mixing the following in specified proportions: -

a) 89 % by weight of ferro aluminum powder of particle size from 0.2 to 1.0 mm.

b) 10 % by weight of Alumina powder.

c) 1 % by weight of Ammonium iodide powder.

6.2.2. Weigh the aluminizing mixture constituents (ferroaluminium, alumina and ammonium iodide).

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6.2.3. Fill the constituents in a barrel and stir them till mixture is uniform. Mixing is permissible by other means, but without additional grinding.

6.2.4. After aluminizing, the mixture is sieved through a sieve with mesh of 2-3 mm.

6.2.5. The freshly prepared mixture before use should be subject to sensitized heating in the container with fused stopper. Charging in the furnace at not more than temperature of 500 °C, heating up to 850-870 °C, holding time of at least one hour and after heating the container, air cool it. Charging temperature and rate of heating are selected to avoid spilling of mixture and is specified depending on the size of the container, in which sensitized heating is carried out.

7.0 Check for chemical composition of the aluminizing mixture (charge)

Details of the measurement means, auxiliary apparatus, materials, calculations and processing of the results are described in the Annexure-II.

8.0 Packing for aluminizing

8.1. Packing of part like fasteners in the container should be done in the vertical position keeping some in one row. Nuts may be kept in several rows along the height keeping the hole vertical.

8.2. Dummy jobs should be placed in the hottest and coldest sections of the furnace loads. Determine such locations prior to actual processing of parts through furnace surveys. This shall be done with approval of customer.

8.3. The sequence of packing the jobs, test coupons and dummy jobs along with the aluminizing mixture in the containers is as under: -

8.3.1. At the bottom ammonium iodide with mass fraction of 0.05-0.1% of the mixture mass of the container is put, then a layer of aluminizing mixture at least 50 mm thickness is put and further jobs, test coupons and dummy jobs should be kept at a distance of at least 10 mm and the distance from the wall of the container – at least 20 mm.

8.3.2. While filling the mixture in the container it is necessary to pack it by lightly knocking the container with a hammer. The top of the part should be covered with at least 10 mm thick aluminizing mixture.

8.4. Hermetic sealing of the container: -

8.4.1. It is necessary to seal a cover for which fill the chute with dry calcinated river sand to half of its height and fill the cover of the container after burying it with sand.

8.4.2. Fill sodium silicate crushed to pieces up to 3 mm till the edge of the slot formed between the cover and the chute.

8.4.3. It is preferred to use easily fusible soda-sulphate block.

9.0 Aluminisation process

9.1. During the aluminisation process, aluminium diffuses into the substrates and the surface becomes rich in aluminium.

9.2. Temperature mode of aluminizing is checked by thermocouple of furnace and control thermocouples fitted in the container.

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9.3. Furnaces during aluminisation should have uniform temperature pattern of ±10 °C in charging and ensure maintenance of given temperature mode within an error band of ±10 °C.

9.4. Observe the following regimes of heating and cooling of the container (capacity up to 0.25 m^3) during aluminisation: -

9.4.1. Placing of the container in the furnace to a maximum of 500 °C and holding it for 3 hrs (depending on the volume of container) by the control thermocouple.

9.4.2. Heating the furnace to 750 °C by the control thermocouple and holding it for 3 hrs.

9.4.3. Further heating the furnace to 860 °C by the control thermocouple and holding for 10-12 hrs.

9.4.4. Cooling in air or in water without wetting the smooth shutter.

9.5. The duration of holding and temperature regime given above is confirmed for specific equipment and container, depending on the thickness of aluminized layer being obtained.

10.0 Dismantling of containers after aluminizing

10.1. The containers cooled to normal temperature are unpacked.

10.2. The parts and dummy jobs should be cleaned by using metallic and ordinary brushes. The place of significant sticking may be cleaned by an abrasive paper of graininess 25-10. The finally cleaned parts should be thoroughly washed in hot water, dried or wiped with a cleaning cloth.

11.0 Quality Control of parts after Aluminizing

11.1. Dummy jobs are to be examined according to ASTM C 664-87, "Standard Test Methods for Thickness of Diffusion Coating".

11.2. The quality control of jobs after aluminizing includes visual inspection of parts, determination of thickness of aluminized layer and checking using thread gauges.

11.3. Visual inspection of the state of aluminized parts surface is carried out for the expected features enlisted below.

11.3.1. Compact surface of solidified silicate block in the cover of the container is smooth or blistered due to gas release.

11.3.2. Free flow of the mixture and its grey colour.

11.3.3. Absence of significant scouring and flaking on aluminized surface of parts

11.3.4. Color of parts: - matty silver, bright, grey and dark grey. Spots in the form of dark points and of different color are permissible.

Final conclusion about the aluminizing quality may be done after heat treatment.

11.4. Thickness of the aluminized layer should be checked on one dummy job from each container.

11.5. The thickness of aluminized layer is determined by the microstructure at a resolution of 100X on metallographic specimens manufactured from dummy jobs.

11.6. Unetched zone separating the frontal boundary from the structure of the base metal is taken as the thickness of the aluminized layer.

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11.7. Electrolytic etching should be carried out in aqueous solution of oxalic acid with mass fraction of 10% or alcohol solution of nitric acid with mass fraction of 4%.

11.8. A brittle zone of aluminized layer which gets partially flaked during manufacturing of the metallographic specimen is not considered.

11.9. The thickness of the layer should be within 0.10-0.12 mm. Quality control reporting should include the maximum, minimum and average coating thickness of the individual measurements made on the dummy job.

11.10. In case the thickness of aluminized layer is not sufficient, repeat aluminizing is carried out at temperature in the recommended regime and with the holding time calculated w.r.t. the increasing of the aluminized layer thickness by 0.01 mm in 10 minutes. The recommended calculation for holding time is decided with approval of customer.

11.11. In isolated cases, the thickness of the aluminized layer may be kept within 0.12-0.20 mm provided remaining requirements of design document are observed. Decision regarding tolerance in the production of parts with aluminized layer thickness of up to 0.2 mm is taken by the manufacturer s department.

11.12. Test coupons have to undergone mechanical testing as per the approved MSTP to determine any mechanical property changes due to the aluminisation cycle. This testing also includes hardness/micro hardness measurements.

12.0 Heat treatment of aluminized parts and post-HT QC

12.1. Heat treatment of aluminized parts shall be carried out as per approved heat treatment plan.

12.2. In view of the presence of various impurities in cooling mediums, the colour of the aluminized surface after heat treatment may change from light grey and from bright to yellowish- grey with spots of various shades and temper colours. Main rejection sign (while analyzing the quality of aluminized surface) is testing the aluminized layer.

12.3. Scouring of the surface - aluminized layer to a thickness not more than 0.02 mm, when total thickness of the layer is at least 0.08 mm is permissible. Brittle zone is included in the total thickness of the aluminized layer.

12.4. Checking of mechanical properties of parts after heat treatments should be carried out on test coupons which have undergone heat treatment in one batch.

12.5. Hardness must be tested at place envisaged in the drawing. Before measuring the hardness scuffing of surfaces with abrasive paper is permissible.

12.6. After heat treatment, dimensions of thread are checked by using gauges (GO/NO GO).

12.7. In case of flaking of surface layer after hardening with tempering, it is necessary to carry out hydro abrasive or sand blasting by using quartz or corundum sand and ground grain or ground powder with graininess not more than 32. Cleaning is carried out till flaking particles of the surface layer are removed. Parts like inner threads and faces are subjected to sand blasting.

12.8. Cleaning of flaked layer with a metallic brush or abrasive paper till readings releasing flaking particles are removed is permissible.

13.0 **Transportation and storage of parts:** The parts should be transported and stored in a tare preventing contamination and formation of dents.

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Annexure-I

Preparation of Ferro-Aluminum powder

1.0 Aluminum mass fraction 45-50%

2.0 Iron mass fraction 55-50%

3.0 Chemical composition of the molten ferro-aluminium shall be checked prior to use.

4.0 The powder mix shall be free from rust, oil and other contaminations.

5.0 Handling of the powder shall be with use of gloves.

6.0 Sieving shall be carried out for a period of 30 minutes. For preparing aluminizing mix, a fraction of 0.2 to 1.0 mm only shall be taken.

7.0 Powder of size less than 0.2 mm goes waste. Powder of size more than 1.0 mm may be used after grinding and subsequent acceptance as per para 1.3 and 1.4 above.

8.0 The aluminizing mixture shall be dried at a temperature of 120 °C - 150 °C for at least 2 hours. The thickness of the mixture layer in trays or in boxes should not exceed 200 mm during drying.

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Annexure-II

Checking of chemical composition of Aluminizing mixture

1. **Required apparatus and material:-**

- Laboratory balance with a weighing error of ±0.0003 gm.
- Laboratory funnels.
- Demineralised paper filters: red strip, blue strip,
- beaker
- Measuring flask
- Pipette
- Burette
- crucible
- Desiccators
- Draying cabinet with maximum heating temperature of 150°c.
- Muffle furnace with maximum heating temperature of 900°c

(A) Determination of mass fraction of ammonium iodide in aluminizing mixture by volumetric method

1 –Reagent solution –

- Analytically pure carbamide, in the solution with mass fraction of 20 %.
- Chemically pure sodium nitrite, in the solution with mass fraction of 3 %.
- Chemically pure sulphuric acid, in the solution with mass fraction of 20 %.
- Potassium iodide, 1st, in the solution with mass fraction of 20 %.
- Crystalline sodium thiosulphste, in the solution with mass fraction of 0.1 mole/gm.
- Pure soluble starch, in the solution with mass fraction of 0.5%
- Distilled water

2 –Analysis preparation –

Charge sample of 70 gm is put in a beaker, 50 cm^3 of distilled water poured and stirred. The solution with a precipitate is allowed to settle and then liquid with a precipitate is drained through a filter (red strip) into a measuring flask with a capacity of 250 cm^3. The operation for washing the charge is repeated five times, after which the solution in flask is brought to the marking by adding distilled water. The obtained solution is used for measuring ammonium iodide on the basis of iodine content.

3 - Measurements –

An aliquot part (50 cm^3) of solution is put in flask, 50 cm^3 of carbamide solution and 8 cm^3 of sodium nitrite solution poured. The solution is stirred 10 cm^3 of sulphuric acid added, closed with a stopper and then stirred again after every 1-2 minutes for a period of 15 minutes. By slightly opening the stopper, 10 cm^3 of potassium iodide solution is added into the flask,

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stirred and iodine is titrated by using sodium thiosulphate solution and by adding starch solution at the end of titration. The titration is completed when full decolouring of the solution is obtained (disappearance of blue colour of the solution).

4 - **Processing of result –**

Mass fraction of ammonium iodide in percentage by weight in the charge is calculated by –

$$NH_4 = N.V.M.V_k / A.V_N.10$$

N - Molar concentration of thosulphate solution, mole / dm^3

V- Volume of sodium thosulphate solution consumed during titration of liquid part of the solution consumed during titration of liquid part of the solution being analyses, cm^3

M- Relative molar mass of ammonium iodide

V_k - capacity of measuring flask, cm^3

A- Mass of the charge taken for analysis, gm;

V_N - capacity of pipette (aliquot part of ammonium iodide solution being analyzed), cm^3

Relative error of given method is ± 2.8 %

(B) Determination of mass fraction of ammonium oxides in aluminizing solution by gravimetric method:

1-Regent and solution –

- Chemically pure hydrochloric acid, in 1:1solution.
- Chemically pure nitric acid
- Distilled water

2- preparation for carrying out analysis -

A charge sample weighing 0.5 gm is put in the beaker, 20 cm^3 of hydrochloric acid added and is put in the sand bath for heating till the sample ism fully dissolved . Then some drops of nitric acid added to the solution and the solution is boiled for some minuets for complete removal of nitrogen oxides

The solution is cooled and filtered into a measuring flask with a capacity of 250 cm3 through a filter "blue" strip. The charge residue on the filter is first washed several portion of 1% mass fraction of hot hydrochloric acid till there is negative reaction on iron ion and then many times with water ,after which the solution in the flask is brought up to the marking by adding distilled water. The precipitate is used for measuring aluminum oxide and the solution for measuring ions of iron and aluminum

3- Carrying out the analysis:

The washed precipitate on the filter is dried and calcined in muffle furnace at a temperature of 100 °C and then reduced ash and calcined in muffle furnace at a temperature of 800 °C till the mass is constant . After cooling in the desiccators the crucible with a precipitate with a weighed.

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4-Processing of result:

Fraction of aluminum oxide in % by weight in the charge is calculated by following formula

$$Al_2O_3 = A. B / 100$$

A- Calcined residue mass of the charge, gm.

B- Sample weight of charge, gm.

Relative error in the given method for determining insoluble residue of the charge is ± 8.3% as there is:-

a) Non uniformity in distribution of job of the charge.

b) Difference in sizes of charge grains that were included in the sample for analysis.

(C) Determination of mass fraction of iron and aluminum in aluminizing mixture by chelatometric method.

The methodology is meant for measuring concentration of aluminum and iron contents in the aluminizing mixture.

1-Reagents and solution –

- Sulphosalicyclic acid $2H_2O$, analytically pure in solution of with mass fraction of 20 % ;
- Analytically pure trilon in solution of 0.1mole/gm^3,
- Analytically pure zinc sulphate $7H_2O$ in solution of with mass fraction of 10 % (buffer solution pH -5)
- Chemically pure ammonium hydroxide
- Sample of 5.5 gm of chemically pure ammonium acetate, is dissolved in 35 cm^3 of ammonia and the solution is brought to the level of 100 cm^3 with distilled water (buffer solution pH-10);
- Chemically sodium chloride
- Xylenon orange indicator, indicator sample of 0.2 gm and 20 gm of sodium chloride is thoroughly dissolved in mortar till a uniform coloured powder isn formed.

2-Preparation for carrying out analysis:

Ratio between the treated solution of trilon Б and zinc sulphate is set by tritating trilon and zinc sulphate.

10 cm^3 of trilon (from burette) is put in the conical flask with a capacity of 250 cm^3, 100 cm^3 of distilled water and 5 cm^3, of buffer solution pH-10 added and treated with zinc sulphate solution till the colour of the indicator change from blue to rose. The ratio between the solution of trilon and zinc sulphate are calculated as per the following formula-

$$\acute{a} = V_1/V_2$$

V_1- volume of trilon solution taken for titration, cm^3 ;

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V_2- Volume of zinc sulphate solution consumed for titration, cm^3.

* Dark blue chromium serves as indicator.

3-Carrying out analysis

An aliquot part (25 cm^3) of solution obtained as per above is put in the conical flask with a capacity of 500 cm^3 and 50 cm^3 of hot distilled water is added so that the temperature of the solution is within 50-60 °C, 5 cm^3 of sulphosalicyclic acid is added, the solution gets a violet colour and pH of solution is checked on a universal indicator paper

pH-2 and titrated by vigorously stirring with trilon solution till the colour changes to lemon-yellow;

Then 25 cm^3 of trilon is added to the solution, heated to temperature of 80 °C, paper "Congo" is inserted and buffer solution pH-5 added till the indicator colour changes from blue to rose and 10 cm^3 of buffer solution pH -5 is added. This solution is titrated with zinc sulphate solution till the colour changes from orange to bright red; xylinon orange is the indicator.

4-Calculation of measurement result:

Fraction in weight percentage in the charge sample, being analysed is calculated as per the following formula

$$Fe = 0.002792.* V*K*V_K*100 / V_n* a$$

Where 0.002792- iron titrate of trilon, gm/cm^3;

V- Volume of trilon used for titration of iron, cm^3.

K- Correction factor of molar concentration of trilon;

V_K- capacity of measuring flask, cm^3.

V_n- capacity of pipette (aliquot part of the solution being analyzed), cm^3;

a- mass of charge sample, gm.

Relative error for determining iron content is ±2.9 %.

Mass fraction of aluminum in % is calculated as per the following formula-

$$Al = 0.001349.(V_{TP}- V_{3n}\acute{\alpha}) * V_K*100 / V_K * A$$

Where 0.001349 – aluminum titrate of trilon, gm/ cm^3;

V_{TP} - Volume of trilon added to the solution in excess, cm^3;

V_{Zn} - Volume of zinc sulphate used for titration of trilon, $cm,^3$;

$\acute{\alpha}$ - Ratio between the titrated solutions of trilon and zinc sulphate;

V_K- Capacity of measuring flask, cm^3;

V_n – Capacity of pipette (aliquot part of the solution being analyzed) cm^3

A- Mass of the charge sample, gm.

Relative error for determining aluminum is ± 2.75

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PROCEDURE AND ACCEPTANCE CRITERIA FOR ULTRASONIC EXAMINATION OF F321 BARS & FORGINGS

Proc no. MDN/BHEL/321/UTP/608

1 SCOPE:

This document describes the test procedures and acceptance criteria for Ultrasonic examination of F321 Forgings by contact method.

2 ULTRASONIC TEST INSTRUMENT:

Make	:	Kraut Kramer / Panametrics
Type	:	USN52, USM25, USD 15X, EPOCH 4+
Frequency	:	0.5 MHZ – 25 MHZ
Calibrated gain	:	upto 110 dB
Operating node	:	Pulse echo contact method

3 APPLICABLE DOCUMENT:

3.1 ASTM A388 M
3.2 ASTM A 745 M
3.3 As per Tender document specification No: TDC: 6: 371 / 03

4 INSTRUMENT CALIBRATION:

4.1 Ultrasonic Testing Machine shall be calibrated as per T-530 of ASME B&PV Code Sec V article 5 for screen height Linearity & Amplitude Control Linearity.

4.2 Screen height Linearity: The UT instruments shall provide Linear Vertical presentation within ± 10% for 20% to 80% of the Calibrated Screen Height. This will be performed at the beginning and end of the shift

4.3 Amplitude Control Linearity: The UT Instruments shall utilize and amplitude control accurate over its useful range to ± 20% of the nominal amplitude ratio. This will also be performed at the beginning and end of the shift.

Approved as noted

4.4 Checking & Calibration of Equipment: The proper functioning of the examination equipment shall be checked and the equipment shall be calibrated by the use of the Calibration standard at the beginning and end of each examination, when examination personnel are changed and at any time that malfunctioning is suspected, as a minimum. If during any check it is determined that the testing equipment is not functioning properly all of the products that has been tested since the last valid equipment calibration shall be reexamined.

4.5 Recalibration (if required) as per Para 7.2.3 of SA – 388.

5 All testing personnel shall be qualified as per requirement of SNT-TC-1A. Testing shall be done by Level I or II but interpretation shall be done by Level II Personnel.

6 REFERENCE BLOCK :

Material under test/material having similar ultrasonic characteristics shall be taken as reference blocks wherever applicable or IIW V_1 or V_2 blocks.

7 SEARCH UNITS :

The following probes will be used for Ultrasonic testing as per ASTM A 388M & ASTM A 745 M

Type	Make	Size	Frequency
Normal beam	Kraut Kramer or Panametrics	10-24 mm dia Crystal	0.5 MHZ to 5 MHZ depending upon the response
Angle beam	-do-	8mm X 9mm to 20mm X 22mm	-do-

8 TESTING STAGE:

Solution Annealed & Machined.

9 SURFACE CONDITION:

Machined to surface roughness suitable for Ultrasonic Testing as per ASTM A 388 M and will not exceed 6 Microns. Preparation of forging for Ultrasonic examination shall be as per Para 6 of SA-388

10 COUPLANT:

Oil or any other suitable couplant shall be used for proper contract of the search unit with the material. Oil + Grease will be used specially for scanning on vertical surfaces. Couplants may not be comparable to one another and hence the same couplants shall be used for calibration and examination

11 REFERENCE REFLECTORS:

Normal Beam Testing : 2mm/3 mm / 5 mm CRR with attenuation, transfer and curvature correction.

Angel Beam Testing : 2 mm / 3 mm CRR

12 SCANNING:

with at least 15% overlap.

Each product shall be 100% ultrasonically examined. For circumferential scanning 35° probe and for axial scanning 45° probe shall be used. The rate of probe movement for testing shall not exceed 150 mm/Sec. The extent of scanning and the directions are given in Table 1.

13 ACCEPTANCE CRITERIA:

As mentioned in Table 1 for single defect and as per Table T-1 of TDC reproduced below.

Table T-1

Acceptance levels for UT of forged shells, dished heads, hollows, bars and plates						
Beam	Scanning direction	Local Indication CRR Max (mm)		Indications with linear extent		Accumulated indications Total/m^2
		A	B	Orientation	Length	
Normal	Radial	3	5	Any	No extended flaw indication is acceptable	2 Numbers
Normal	Axial	2	3			
Angle	Axial	2	3			
Angle	Circumferential	2	3			

A – For thickness up to 40 mm ; B – for thickness above 40 mm.

1. Indications suspected to be planar in nature shall be investigated. Cracks are not acceptable.
2. Extended defects are not acceptable.

14 RECORDABLE INDICATIONS:

All indications equivalent to 50% or above of a reflection from CRR as given in table 1 shall be recorded and reported. The length of the recordable indication shall be measured by echo drop method and the drop shall be up to the recording level. If the measured length is found to be more than the size of the beam at the specific beam path, the indication shall be considered extended.

15 POST EXAMINATION CLEANING:

All forgings will be properly cleaned with cloth soaked with Acetone.

See Annexure-1

Approved as noted

Approved as noted.

Reviewed By

A. K. Tamarchem.

Approved By 30.7.08

BARC.

(P. K. Mishra)

Table 1.

Size (mm)	Normal Beam Examination		Angle beam Examination	
	Scanning	Reference	Scanning Direction	Reference
Round Bars: i) Dia ≤ 40 mm ii) 40 < Dia < 320 mm **Figure 1**	Radial	i) 3 mm CRR ii) 5 mm CRR	Axial	i) 2 mm CRR ii) 3 mm CRR
			Circumferential*	i) 2 mm CRR ii) 3 mm CRR
1400 Dia X 80 mm **Figure 5**	Top & Bottom Flat faces Radial from OD to extent possible.	5 mm CRR BWE to 5 Div-0.5 MHz probe	Top & Bottom Flat faces to the extent possible.	3 mm CRR
Squares & Forged Slabs **Figure 2**	All 4 Sides & and from both end faces to the extent possible.	5 mm CRR	Two perpendicular directions on one major face	3 mm CRR
Hot Rolled slabs < 40 mm Thk **Figure 4a**	One major face	3 mm CRR	Two perpendicular directions on one major face	2 mm CRR
Hot Rolled Slabs > 40 mm Thk **Figure 4b**	i. One Major Face ii Across width from both sides to the extent possible only for width≤200 (250) mm	5 mm CRR	Two perpendicular directions on one major face	3 mm CRR
Rings **Figure 3**	Radial from OD & ID	5 mm CRR	Axial on OD	3 mm CRR
	End Faces	5 mm CRR	Circumferential on OD ID to the extent.	3 mm CRR

Note: 1. 45° probes for angle beam scanning except for circumferential scanning of round bars (marked *-where 35° probe shall be used)

2. During Normal beam scanning Total Loss of back echo (BWE <5%) not attributable to geometric configurations / metallurgical structure of material shall be cause for rejection.

Approved as noted
A. K. Tamadhane

Approved
(BARC)

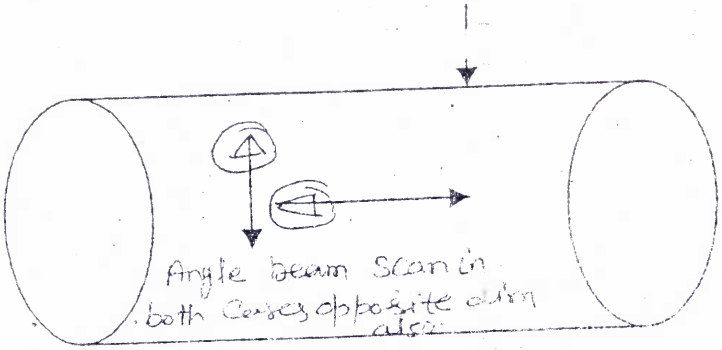


Figure 1

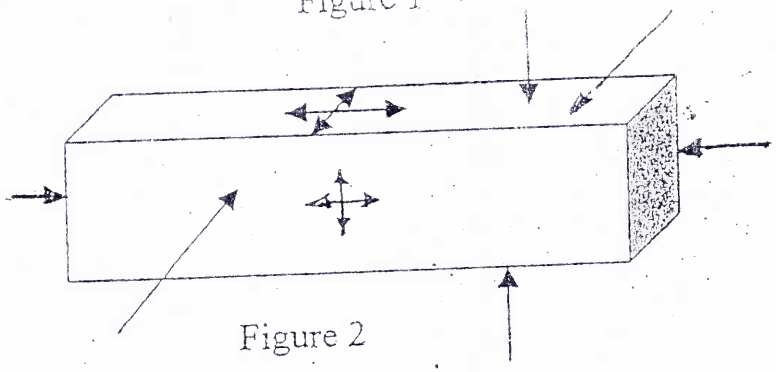


Figure 2

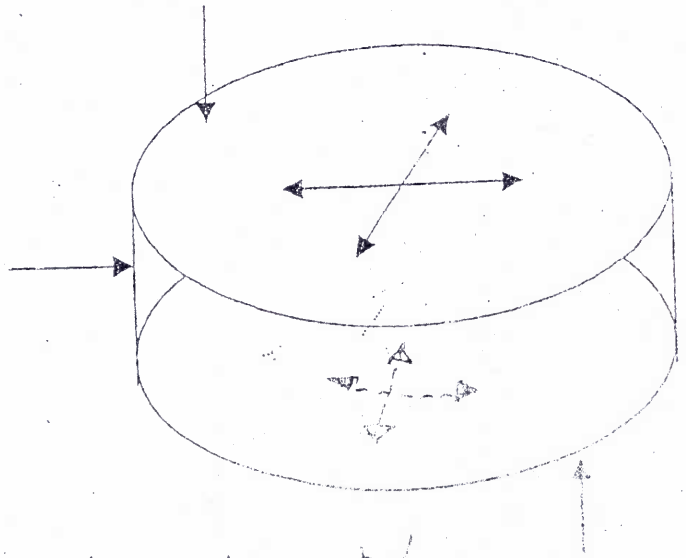


Figure 5

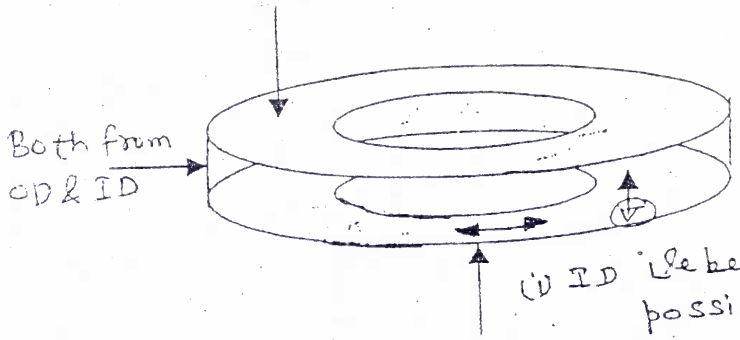


Figure 3

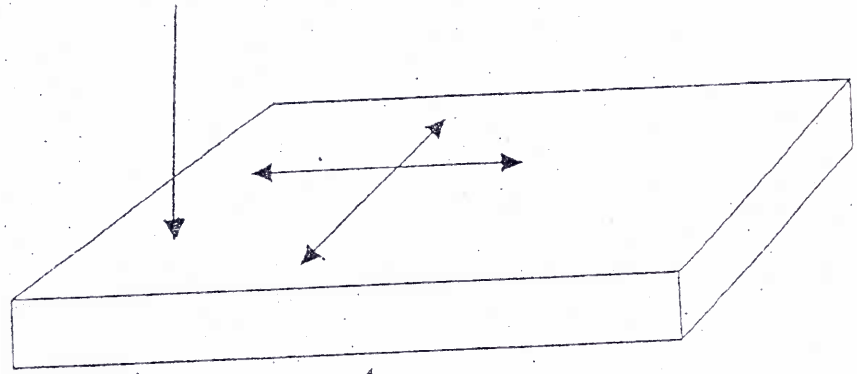


Figure 4a

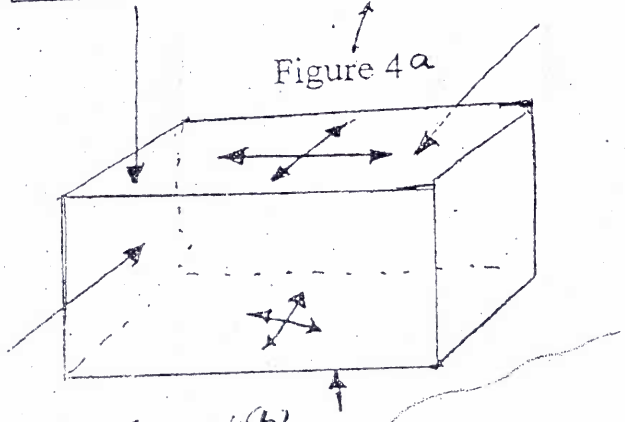
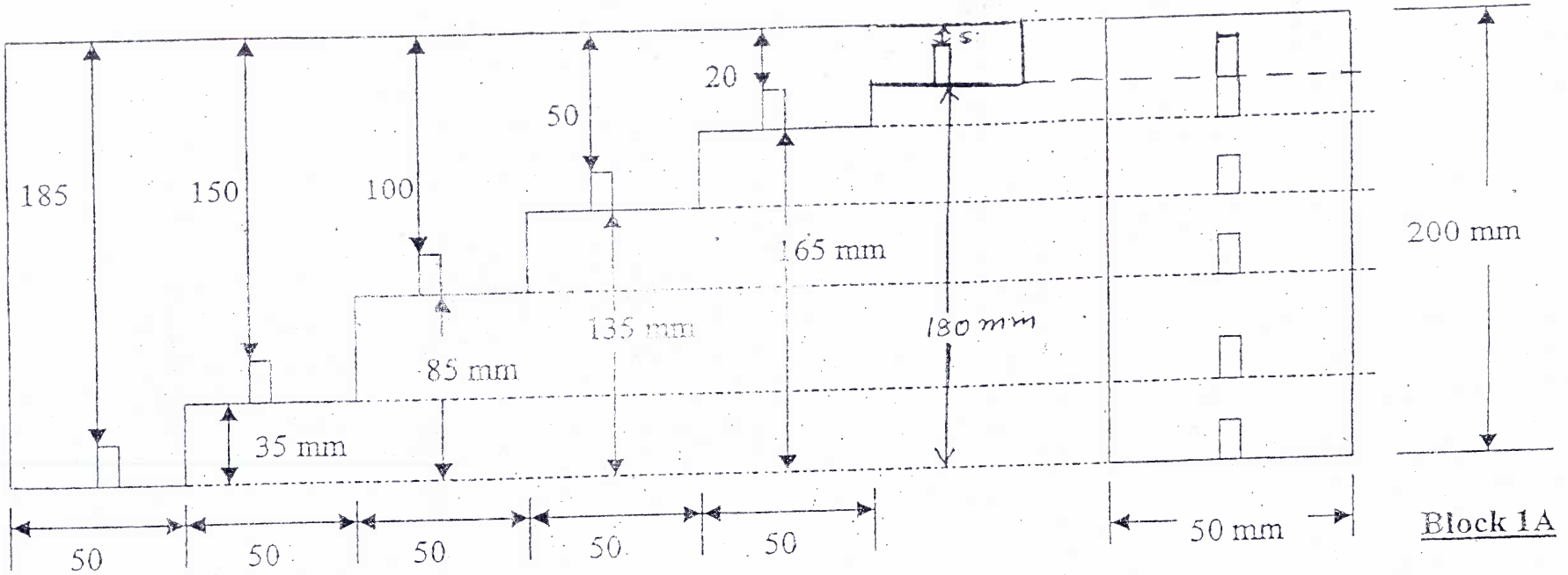


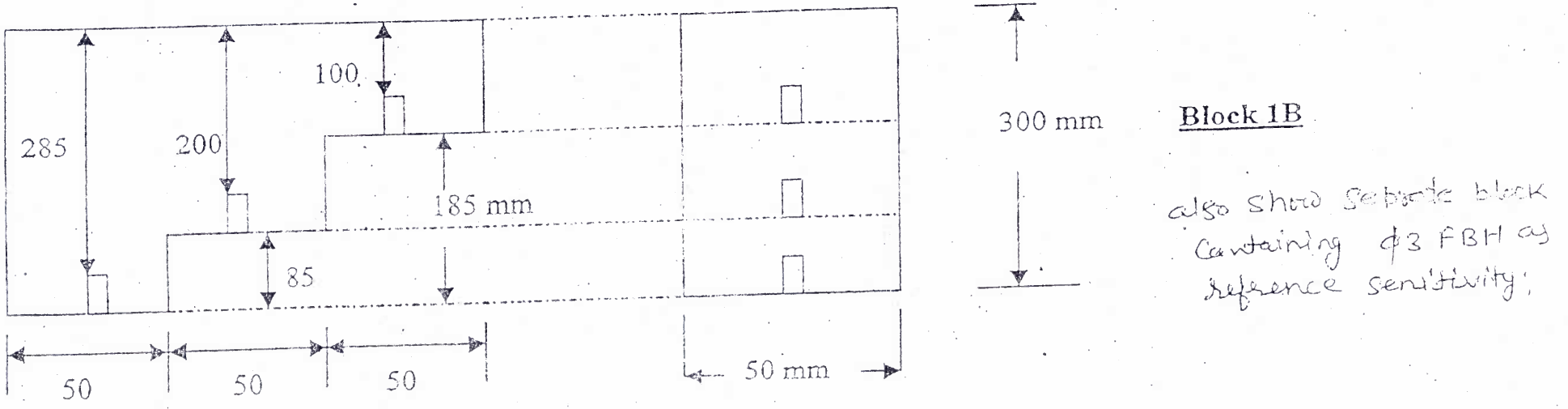
Figure 4(b)

Approved as noted

Dr. Janardhanan

Dr. Baba





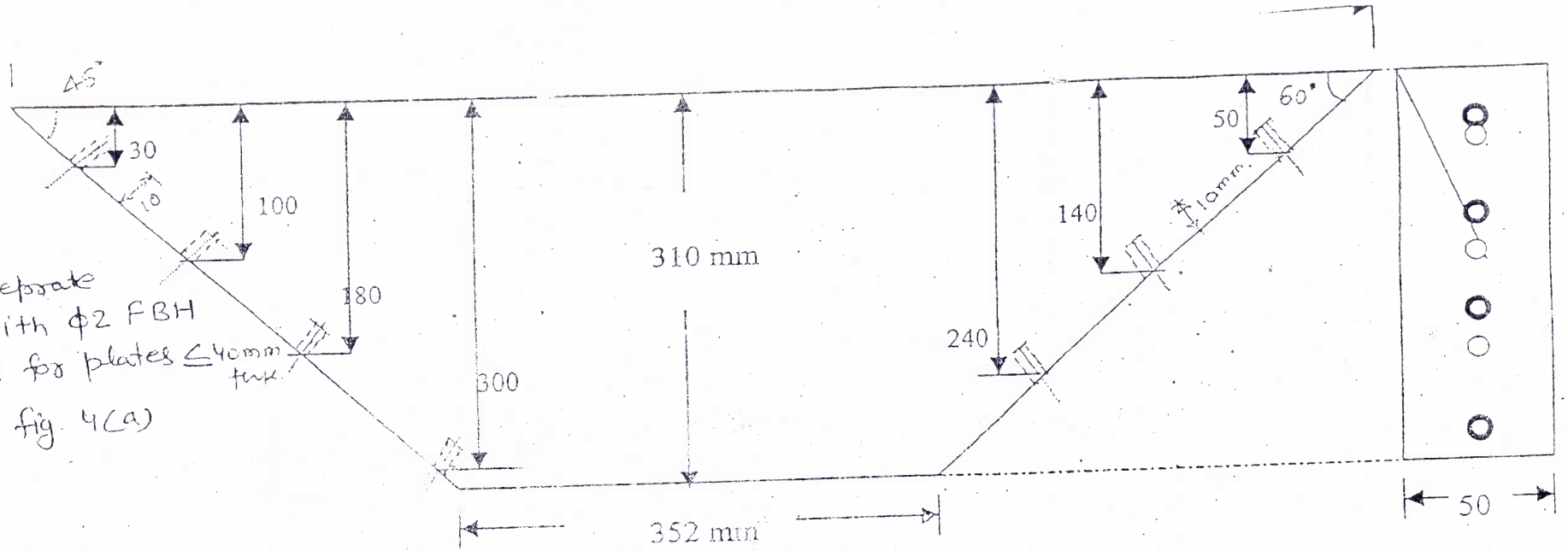
also show Separate block containing ϕ3 FBH as reference sensitivity.

Figure 1: Reference Block Numbers 1A & 1B For normal beam scanning. Reference reflectors 5 mm CRR X 15 mm- At center of steps

To be discussed and finalised

approved by Board

ϕ5 less



Show separate block with ϕ2 FBH needed for plates ≤ 40mm thick as per fig 4(a)

Figure 2: Reference block for Angle beam scanning (45°); Reference reflectors-3 mm CRR X 20 mm deep

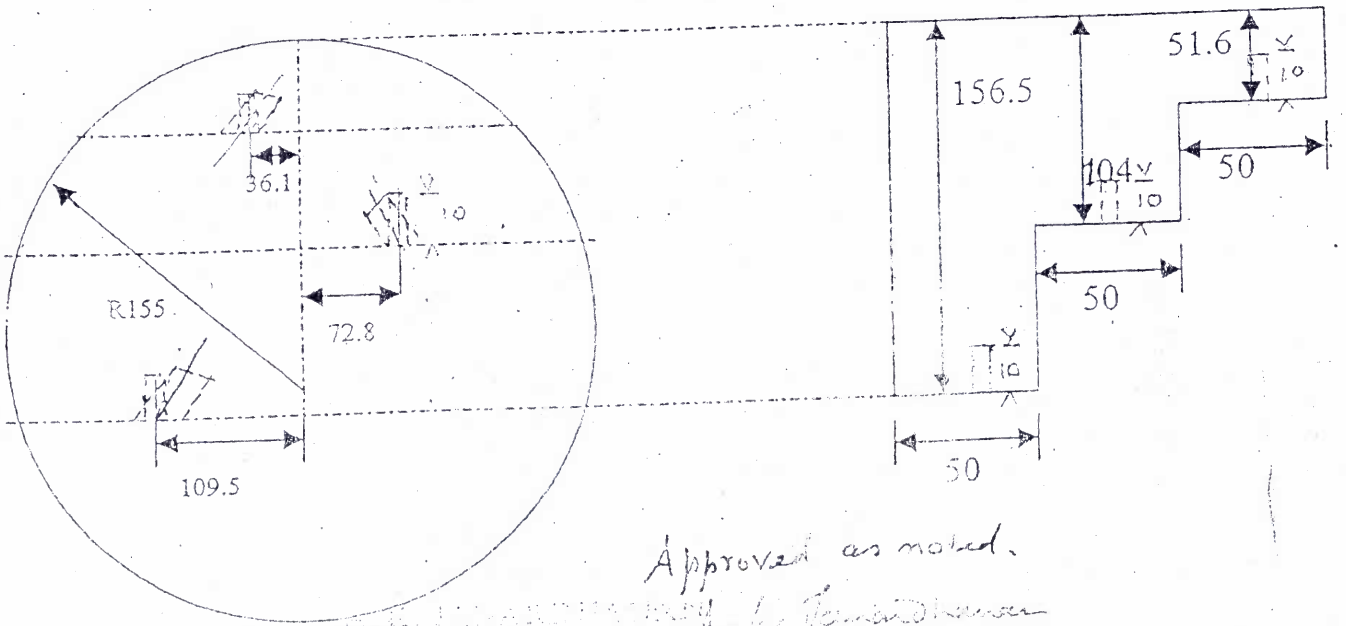


Fig 3: Reference block for angle beam scanning (35°) – Reference reflectors- 3 mm CRR X 20 mm deep.

Approved as noted.

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BARC/QS

PROCEDURE FOR IMMERSION ULTRASONIC TESTING OF BARS OF DIA ≤ 50:

1.0 SCOPE

This procedure is applicable for immersion ultrasonic testing of bars of dia ≤50.

2.0 APPLICABLE DOCUMENTS

2.1 ASTM E-317 for Linearity check for the instrument.

2.2 ASME Section III-NB 2542

3.0 CALIBRATION

3.1 Calibration of the flaw detector :

The ultrasonic system shall be calibrated for horizontal linearity and gain control using standard reference blocks as per ASTM E 317.

3.2 Search Unit

Line focused probe of 5MHZ frequency - ½ " dia and 3" focal length is used for calibration and scanning.

4.0 REFERENCE STANDARD

Reference standard shall be prepared from a bar which is subjected to same thermo-mechanical processing as the lot material.

Three holes of dia 2mm shall be made with varying depth for making DAC curve.

4.1 NORMALISATION :

The echo from the front surface is maximized by adjusting the search unit

WATER PATH ADJUSTMENT :

After normalizing the water path is adjusted to avoid reference echoes before back echo. The echoes from reference FBH/defect standard are maximized by manual adjustment of search units, water path and rotation of standard.

4.3 GATE SETTINGS :

Interface gate is introduced within the band width of the surface to avoid defect indications due to surface echo amplitudes. Gate is introduced by placing the start of the gate after the Interface gate and up to the beginning of back wall echo.

5.0 INSPECTION

5.1 The bar to be tested shall be normalized for maximum surface echo with line focused probe.

5.2 The gain is increased such that the amplitude of 2 dia FBH from the 3 FBH holes shall be brought to 80% of FSH. The DAC curve shall be stored in the program and used while testing. The gain is corrected whenever the reference standard being used and the inspection requirement differ (if 3 mm equivalent flaw is the acceptance criteria- 7 db will be subtracted from the gain used for drawing the DAC) an additional 6 dB is added for scanning.

5.3 The axial pitch is based on the effective beam width of the probe.

Linear speed = RPM X Effective beam width

$$\text{Axial index} = \frac{\text{Linear speed (mm/Min)}}{60}$$

5.4 The operator shall monitor the 'B' and 'C' scan display and identify locations where the defect echo is more than reference echo.

5.5 Unless otherwise specified, noise level should not exceed 50% of the echo signal.

6.0 Any indication more than reference FBH is considered unacceptable.

7.0 INSPECTION REPROT :

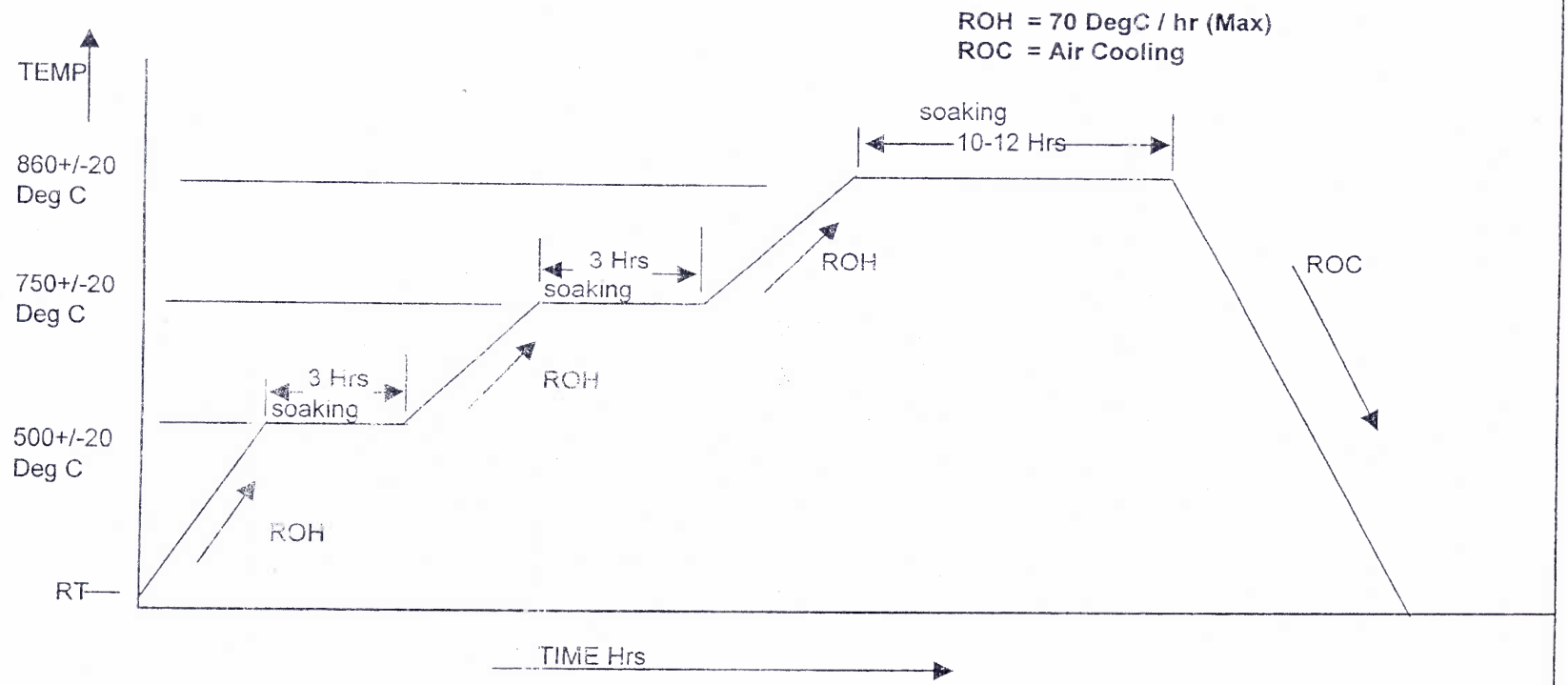
Inspection report shall be prepared in the Format.No: QC(INSP)/REP/19 and signed by ISNT/ASNT level II qualified inspector.

8.0 PERSONNEL QUALIFICATION

Inspection shall be carried out by level I qualified operator of ISNT/ASNT.

28.7.08 (Reviewed) Approved.
(P. K. Nair)
(Approved)

HEAT TREATMENT FOR ALUMINIZATION OF NUT M120



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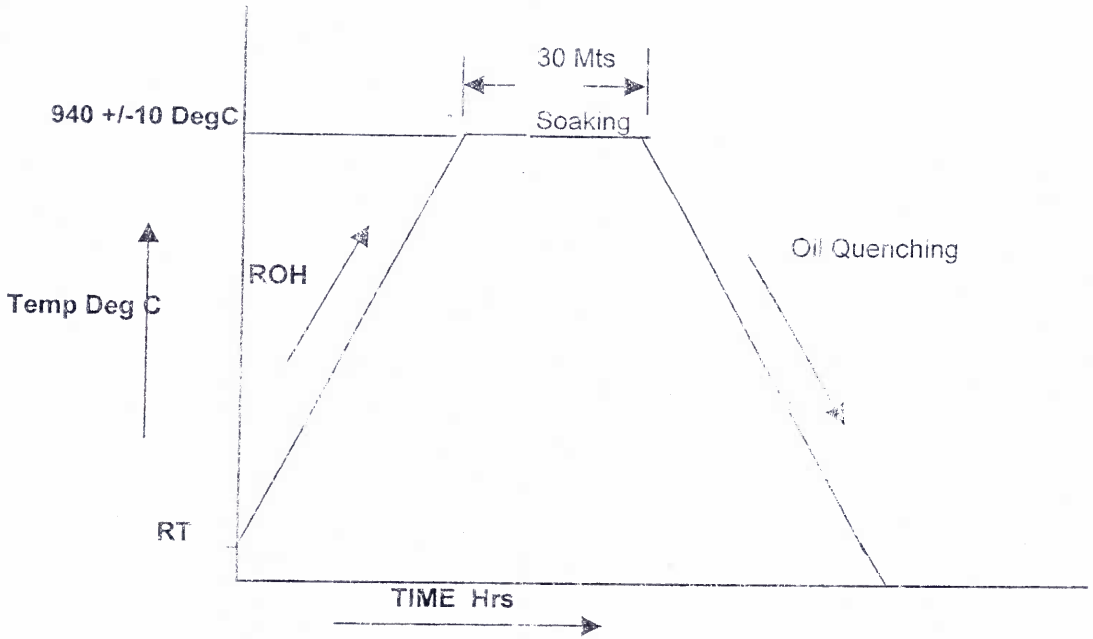
Rev	Date	Prepared	Checked		BHEL	BARC	TIRUCHIRAPPALLI-620 014
00	3/7/2009	KC.Radha	H.N.RAJAN	Fresh			
							HEAT TREATMENT PLAN(ATP)
							HTP.NO:HTP/B1, B2/39/00
							SH.01OF 01

HEAT TREATMENT HARDENING CYCLE AFTER ALUMINIZATION OF NUT M120

ROH = 70 Deg C / hr(Max)



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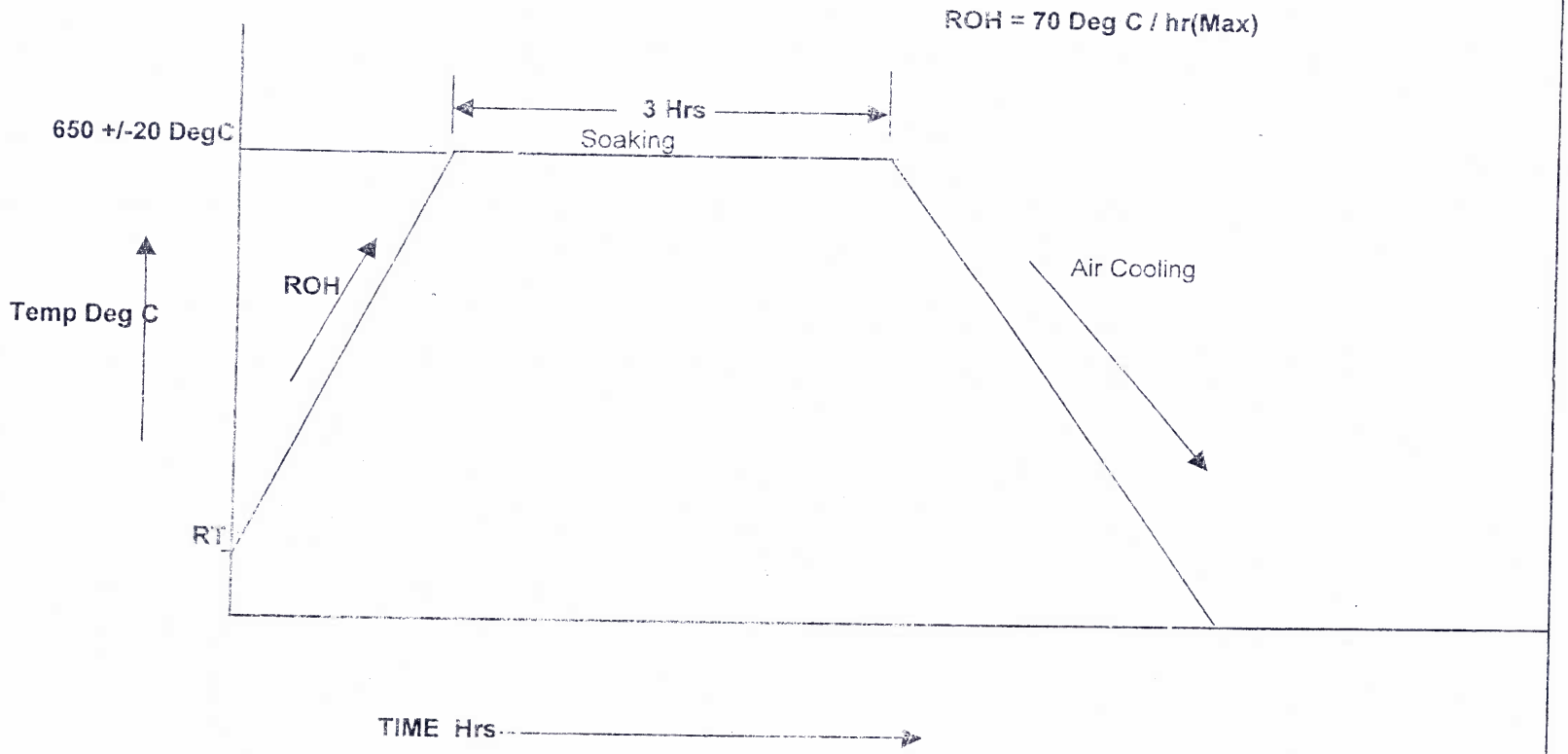
Rev	Date	Prepared	Checked		BHEL	BARC	TIRUCHIRAPPALLI-620 014
00	3/7/2009	KC.Radha	HN.Rajan	Fresh			
							HEAT TREATMENT PLAN(ATP)
							HTP.NO:HTP/B1, B2/40/00
							SH.01OF 01

TEMPERING OF NUT M120



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00	3/7/2009	KC.Radha	HN.Rajan	Fresh			
							HEAT TREATMENT PLAN(ATP)
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							SH.01OF 01