


Rev. No.	Date of Rev.	Remarks	Approved			
04	11.05.2016	Completely reviewed	V. S. Rao, AGM HOD - (HTE, HME, HPE & STE)			
05	09.09.2022	Completely reviewed	Checked			
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<u>PURCHASE SPECIFICATION FOR CAST STAINLESS STEEL</u> <u>RUNNER BLADES FOR KAPLAN/PROPELLER TURBINES</u>		

When the blades are for spherical shaped runner hubs a machining allowance of 9 mm approx. shall be left on the inner radius but the machining allowance to be left on the outer radius shall be at the rate of 18 mm radial per 2.5 meter of runner radius but in no case shall the allowance be less than 9 mm.

Note: See Para 2 of clause 5.2 for non-spherical hubs.

All holes shall be left undrilled and keyways will not be machined except when instructions to carry out these operations are given in the purchase order.

5.2 Semi finish grinding

The casting shall be semi-finish ground to drawing dimensions by the vendor in accordance with the following instructions and to the tolerances stated in this specification and on the Runner Blade Inspections Sheet (Annexure-V).

When the blades are for non-spherical shaped runner hubs the inner radius shall be ground to a 'swinging arm' template gauge which shall be located relative to the datum face and lined up with the true axis of the blade and which allows 12 mm m/cing allowance on the face for finishing at BHEL. The datum face for the templates shall be indicated in the drawing of runner blade (see Annexure III) but the method to be employed for achieving the line up with the blade axis shall be agreed between the vendor and BHEL immediately after the order is placed.

The outer edge of the seal diameter, i.e the throat of the blade, shall be marked off by means of a 'wrap-around' template gauge located as indicated in the relevant drawing and positioned to a datum line which has been transferred from the inner finger of the swinging alarm template and scribed around the seal diameter (Annexure III & IV). The same machining allowance shall be left on the outer radius as that called for in clause 5.1 above.


The blade shall be semi-finish ground all over to the dimensions stated in the drawing. All blade surface undulation shall be removed by a method which will avoid producing bumps and hollows. Blade thicknesses shall be within +5% to - 3% of the thicknesses stated in the drawing at each reference point (Annexure II).

The profile of the suction side of the blade shall be semi-finish ground to templates within the tolerance of $\pm 0.10\%$ of the length of the lettered section on which the check is being made (Annexure II). Corrections shall be effected by employing a method which will not produce bumps and hollows.

The blade fillets and throat at the junction of the blade and the trunnion shall be semi finish ground to templates to ensure that they are in correct position relative to the rest of the blade within a tolerance of +2 to +5mm so that accurate blending with the hub can be achieved on assembly. These templates shall be located relative to the line scribed on the trunnion from the wrap around template in the case of non-

spherical blades and located relative to the marked off inner spherical radius in the case of spherical blades (Annexure III & IV).

The shape of the inlet and outlet edges shall be obtained by grinding the pressure side and nose of the blade using a hinged profile template in conjunction with a 3.2 mm feeler gauge applied between the template and the pressure side of the blade. The templates shall be located on the semi-finish ground suction side of the blade (Annexure I, Fig.2).

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The length of template will be 8% of the blade chord length and will be hinged at a point on the profile centre line 0.6% of the chord in front of the leading edge. The blade nose shall be ground so that jaw of the template registers with the blade faces and blade nose as shown in Annexure-I Fig. 2. Maximum tolerance on the nose profile shall be $\pm 0.1\%$ of blade chord length. Note that blade profile and waviness tolerance shall also be maintained over the area of the suction face covered by the nose templates.

The position of the inlet and outlet edges relative to the blade centre line shall be within +0.5% to 0% of design dimension.

The surface finish of all semi-finish ground surfaces shall be 6.3 micron or better.

The centers which have been used during the manufacture of the blades shall be completely removed and new centers (or horizontal/vertical center line markings) which shall be used for finish machining at BHEL, shall be marked off by vendor from the datum plane of the 'box' template when the contour of the blade is finally checked after semi-finish grinding.

5.3 **Heat treatment**

The casting shall be heat treated to give the mechanical properties specified in the material specification mentioned in the drawing. For additional requirements/processes refer purchase order/drawing. Subsequent stress-relieving heat treatment after rough machining may be given at the discretion of the vendor.

The times and temperature of all heat treatments shall be recorded for inclusion in the test certificate.

6. **NON DESTRUCTIVE TESTS:**

Castings shall be examined by "Ultrasonic method", "Magnaflux test" & "Dye Penetrant test" as mentioned in Table-1.

The defects which cannot be definitely interpreted by "UT", shall be further examined by "Radiography".


PROCEDURE & ACCEPTANCE STANDARD: (Unless otherwise specified in the drawing)

Table-1

Type of NDT	Procedure	Acceptance standard
Dye penetrant test	CCH70-3	CCH 70-3, PT 70-3, Class-2 cracks and linear discontinuities are not allowed
Magnaflux test	CCH70-3	CCH 70-3, MT 70-3, Class-2
Ultrasonic test	CCH70-3	CCH 70-3, UT 70-3, Class 2 (up to 50 mm thickness) Class-3 (above 50 mm thickness)
Radiography test	ASTM E 1030	ASTM E186, E 280 & E446. Level-2

7. **REPAIR OF CASTING:**

No major defect shall be repaired or welded without written sanction from BHEL or its representative. Defect shall be considered major if it exceeds 20% of wall thickness or 25mm (whichever is smaller) in

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depth, or that which exceeds 6400 mm² in area. A cluster of minor defects shall be considered a major defect. All other defects shall be considered minor.

The defects must be chipped down to sound metal and tested using appropriate NDT method such as magnetic particle/dye penetrant etc. When defects have been removed the supplier shall submit a drawing detailing the nature, location, shape & size of each defect to BHEL for approval along with proposed procedure for weld repair (electrodes to be used, preheating temp., post weld heat treatment etc.).

Before starting of the runner blade manufacturing, welding procedure specification (WPS) shall be established by the steel foundry and the WPS with the supported PQR shall be submitted to Purchaser for approval.

The repair welding shall be performed in accordance with the approval WPS. All welders assigned to the repair welding shall be qualified as ASME Sec. IX.

When the repair has been completed (after consent of the purchaser), non-destructive tests previously carried out shall be repeated together with any additional tests (NDT) considered necessary by the purchaser's representative. It is preferable to carry out weld repair prior to carrying out normal heat treatment of the casting. In case the weld repair is carried out after normal heat treatment; the casting shall be re-tempered. Heat treatment other than tempering after weld repairing shall be performed only when agreed upon between the manufacturer and the purchaser. Record of all weld repair (including minor repairs) shall be furnished to BHEL along with the details of post weld heat treatment & NDT.

8. MEASUREMENT OF THICKNESS:

When direct measurement of thickness is not possible ultrasonic method will be used to measure and record the thickness as per drawing.

9. PAINTING:

Casting shall be supplied unpainted.

10. INSPECTION

Inspection shall be carried out at vendor's works by BHEL's inspector and / or by BHEL's appointed third party inspection agency and / or customer's inspection agency as specified in enquiry / PO. All test samples shall be removed in the presence of inspection agency.

Vendor has to compulsorily supply 2 nos. test pieces per heat, removed in the presence of inspection agency and subjected to proper identification (hard punched), for testing at BHEL works.


BHEL quality assurance plan wherever supplied along with PO / enquiry, shall be applicable. Else, vendor shall submit his QA Plan for approval by BHEL / BHEL's customer.

11. TEST SAMPLES:

Test pieces for mechanical tests shall be prepared from integrally cast keel blocks from each casting.

Size of test piece: 150x400x35 mm

Quantity: 2 Nos for each blade casting

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Retesting

If the results of mechanical tests are found unsatisfactory, retesting shall be performed on double the number of specimens which gave unsatisfactory results. In case of unsatisfactory results shown by even one specimen on retesting, reheat-treatment is allowed after which the casting shall be treated as a new one.

12. **TEMPLATES:**

The vendor shall manufacture two sets of stainless steel templates. One set of templates shall be used by vendor for checking the profile at his works. Other set shall be supplied to BHEL along with first casting.

Templates shall be punch marked with: (a) Drawing. No. (b) Pressure side/Suction side (c) Section No.

13. **CHARPY IMPACT VALUE (2mm V-Notch):**

At 0 °C the test pieces shall show an average Charpy impact value of 50 joules minimum over three test pieces. (However, the minimum value of one test piece shall not be less than 35 joules). The test will be conducted on a 2mm V-Notch as per ASTM A 370 & ASTM A 781.

14. **SURFACE ROUGHNESS TEST**

All surfaces shall be checked visually and confirmed to be without any mechanical damage, scratch, crack and injurious defect. The surface roughness of runner blade shall be checked after semi finish grinding and shall comply to design requirements.

15. **HARDNESS TEST**

The hardness test shall be conducted for all grades (Clause S-14 for ASTM A743 CA6NM). For standards AA 19542 and EN 10283 Gr. GX4CrNi13-4 the tests shall be conducted as per the provisions laid down in the respective standards.

Hardness of repair welded areas (as pointed out by the inspector) is also to be checked.

16. **MICROSCOPIC TEST**


The micro structure of blade shall be investigated and photographs shall be taken with 100 times magnification to confirm the normal structure as required for the specified material. For blade the martensitic structure shall be free from the delta-ferrite

a) For repair welded portions:

The repair welded portion shall be selected from the hardest portion by the hardness test of the product and the photographs shall be taken from three zones, base metal, heat affected zone and weld deposit metal.

b) For base metal:

Both side surfaces of blade shall be checked.

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17. IDENTIFICATION MARKS:

Each casting shall be clearly stamped on the trunnion with reference no. HT00243 / Drg. No. as stated in the purchase order, which will identify beyond doubt the corresponding chemical analysis & physical test.

For location of stamping see Annexure-I, Fig1 or Annexure II.

This reference no. shall be quoted on all relevant test certificates. The numbers shall be transferred under responsible supervision before being removed by machining or grinding.

18. TEST CERTIFICATES:

Following test certificates shall be supplied unless otherwise stated on the order.

- i) Dimensional inspection
- ii) Details of heat treatment, AOD / VOD
- iii) Chemical composition
- iv) Results of mechanical tests including impact testing at 0 °C.
- v) Results of NDT and additional tests called for in the drawing / purchase order.
- vi) Surface roughness test
- vii) Hardness test
- viii) Microscopic test

19. PACKING & MARKING:

Castings shall be suitably packed to prevent corrosion and damage during transit. Each package or casting (when supplied separately) shall be legibly marked with the following information:

BHEL purchase order no.	:	Identification no.	:
BHEL Drg. no.	:	Vendor's Name	:
Heat No.	:	Weight	:
Casting sl. no.	:		:


NOTE:

- Identification details to be painted on the casting.
- Stamped test pieces to be dispatched along with the casting.

20. REJECTION AND REPLACEMENT:

In the event of any casting proving defective from foundry causes in the course of preparation, machining, testing or erection, such casting shall be rejected, notwithstanding any previous certification of satisfactory testing and/or inspection.

The vendor shall undertake to replace the rejected castings at his own cost and the rejected castings shall be sent back to the vendor after fulfilling the commercial terms and conditions.

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21. GENERAL

In case of any contradiction between the clauses of PO, this document & material specification, QA plan or drawing, the following hierarchical order of overriding will be applicable.

1. Drawing - **(most important)**
2. P.O.
3. HT 00224
4. QA plan
5. Material specification

Before start of manufacturing, vendor has to get confirmation of latest revision of the drawing and this product std. from HT Engg. / BHEL. Vendor must also have the QA plan approved before manufacturing starts.

22. DEVIATION FROM SPECIFICATION:

Any deviation from the BHEL specifications shall be intimated by the vendor for approval by BHEL, Bhopal before placement of purchase order. In the absence of this, it /will be deemed that all our requirements given in the drawing and specification are acceptable to the vendor in totality.



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ANNEXURE-I

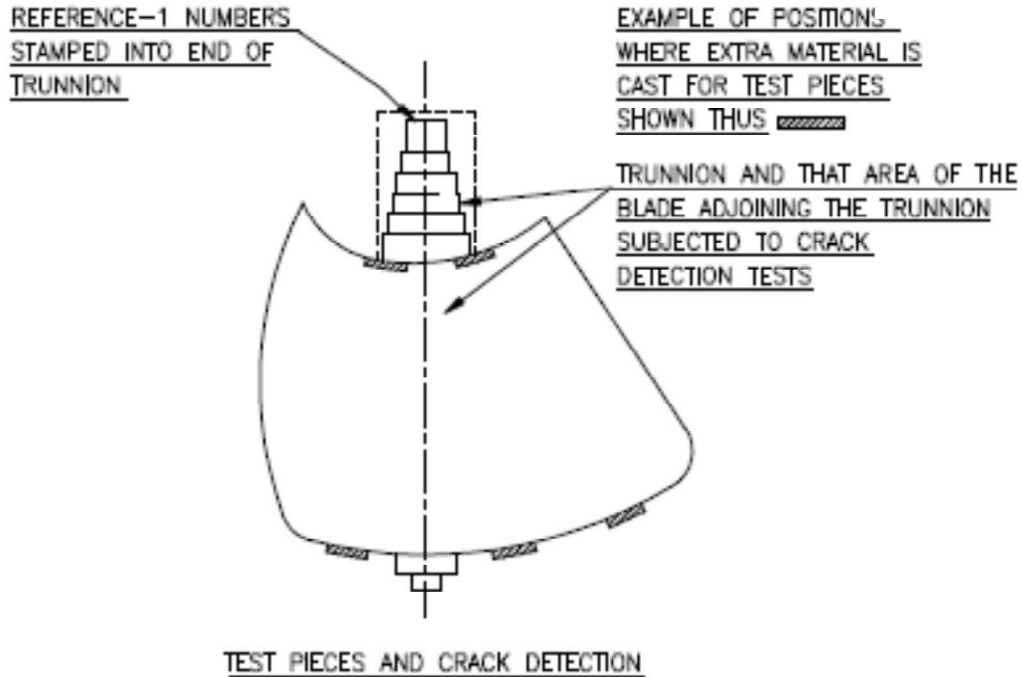
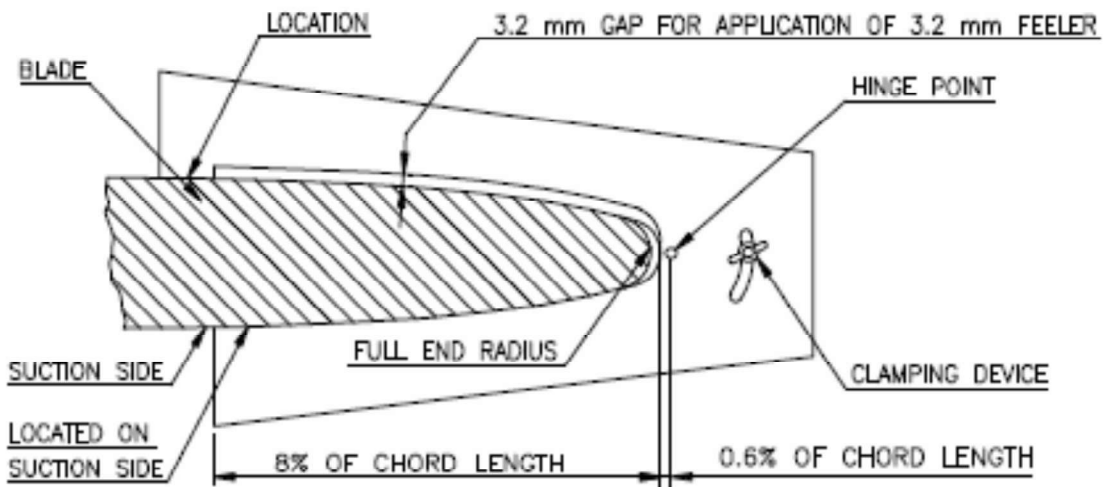


FIGURE 1



CROSS SECTIONAL SHAPE OF INLET & OUTLET EDGES CHECKED
BY MEANS OF HINGED TEMPLATE LOCATED ON THE SUCTION
SIDE OF THE BLADE AND USED IN CONJUNCTION WITH 3.2 mm FEELER

FIGURE 2



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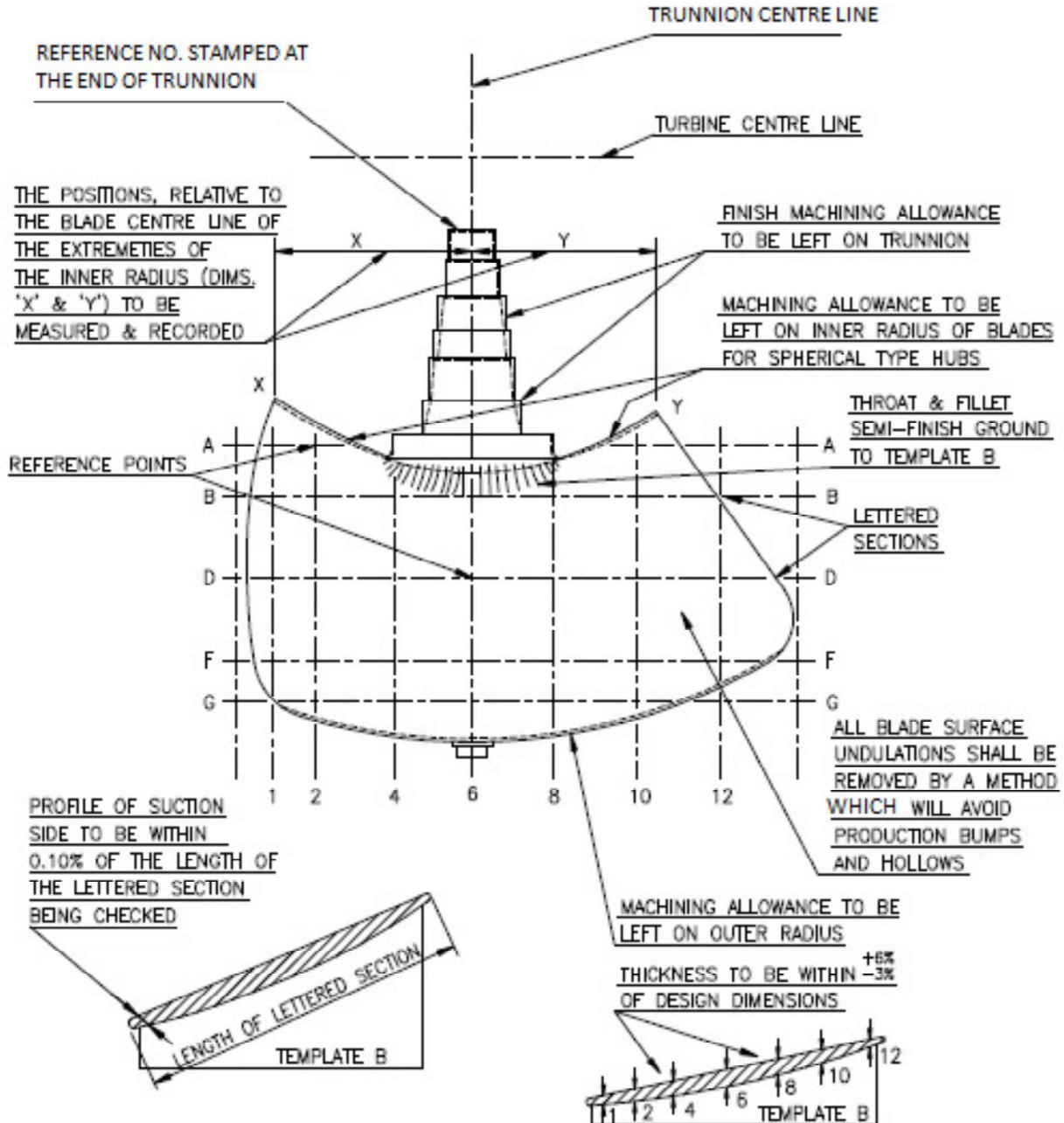
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ANNEXURE-II





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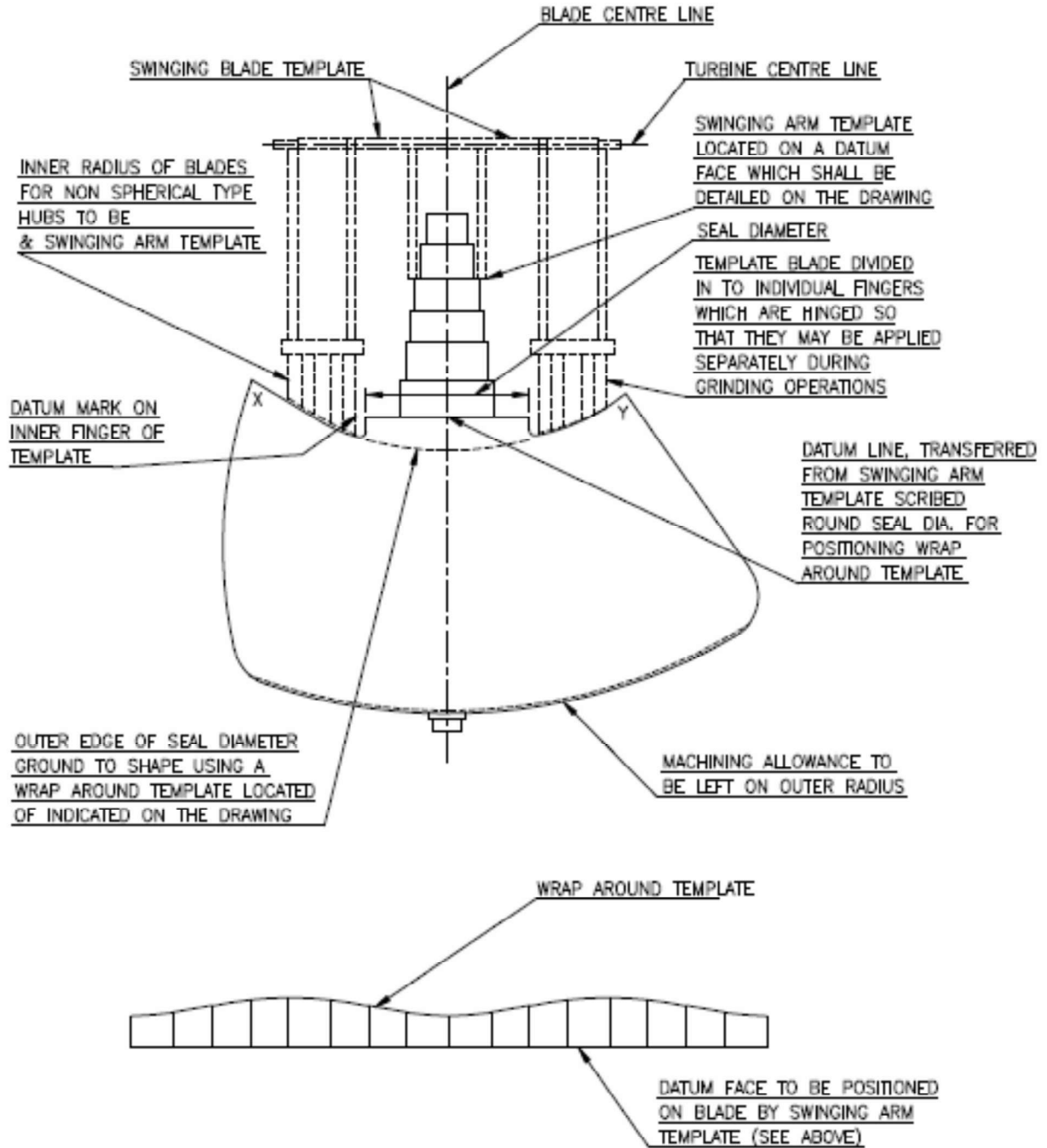
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ANNEXURE-III





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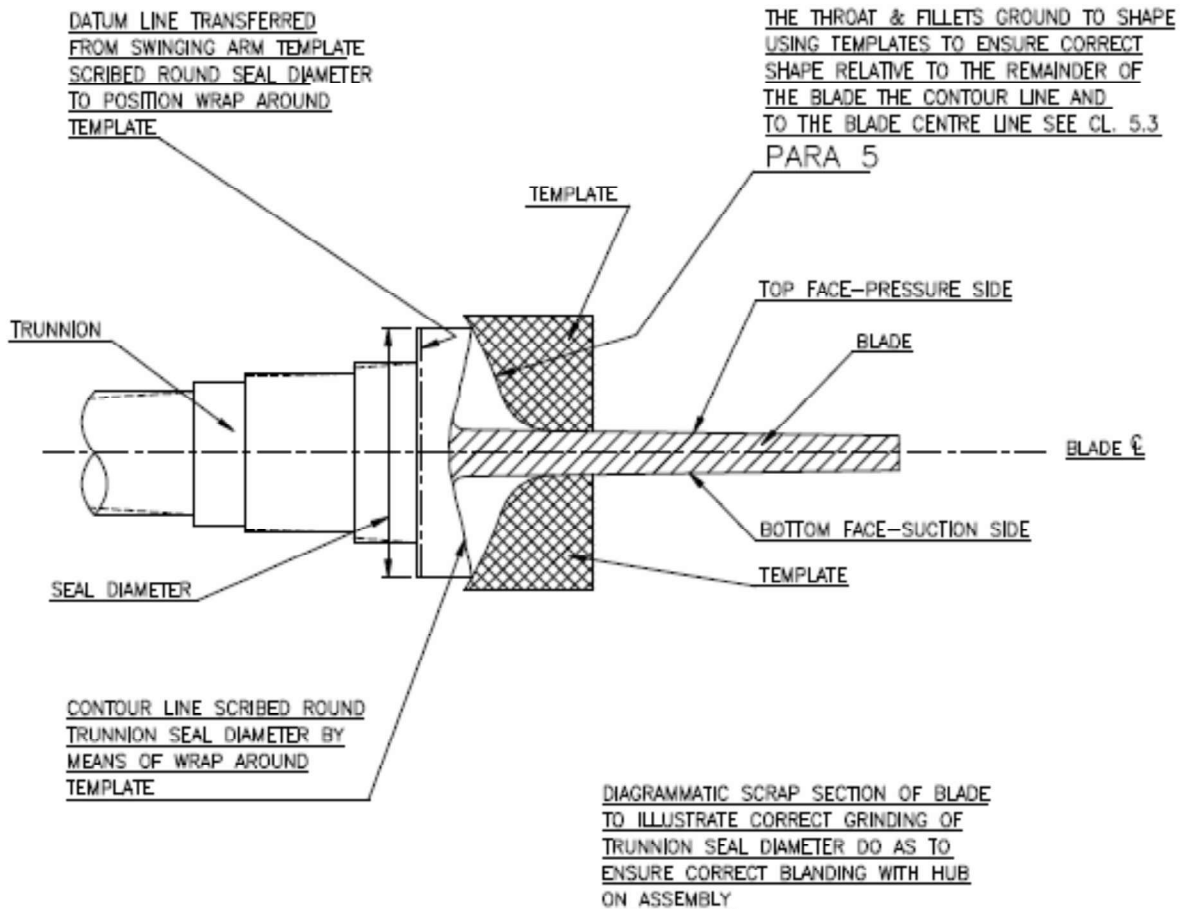
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ANNEXURE-IV





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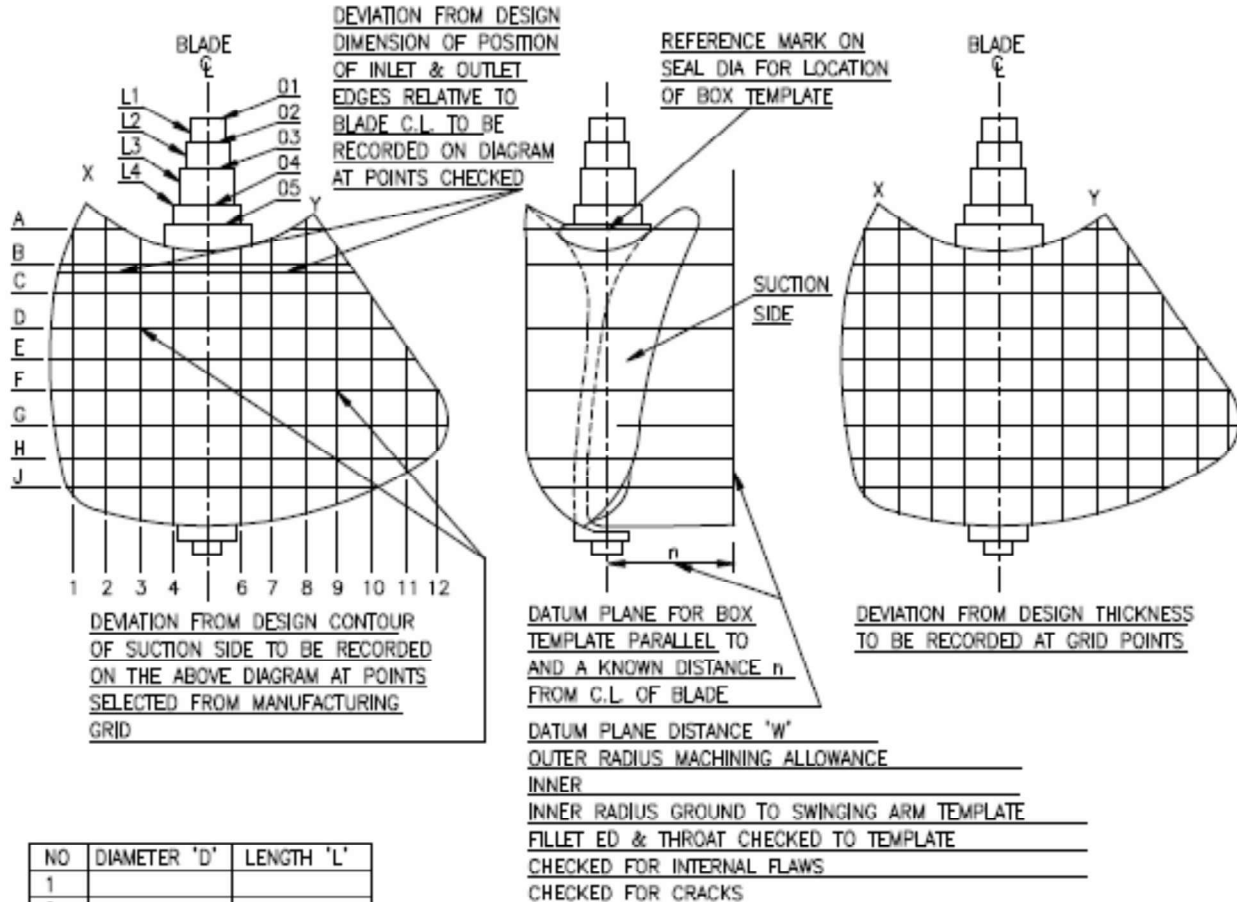
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ANNEXURE-V

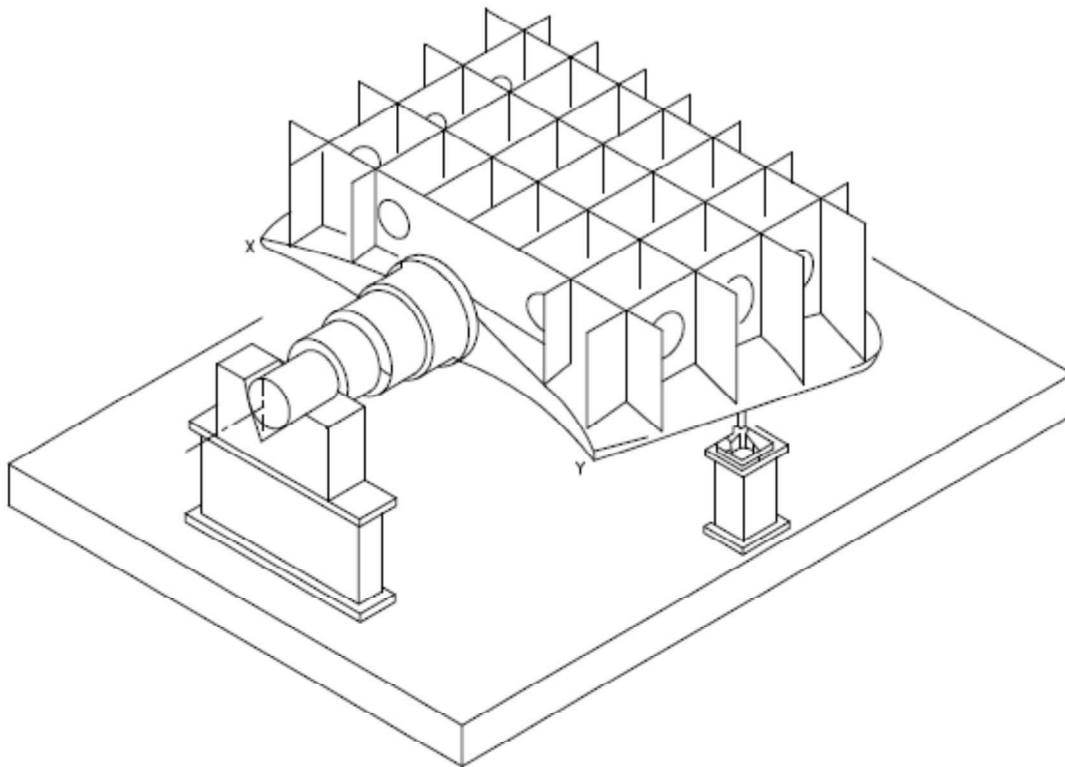


RUNNER BLADE INSPECTION SHEET.


DRAWING NUMBER _____ ORDER NUMBER _____
PURCHASING SPEC. _____ NUMBER _____ MATERIAL _____
CASTING NUMBER _____ BLADE NUMBER _____
MANUFACTURED BY _____
MANUFACTURER'S INSPECTOR _____
BHEL INSPECTOR _____
MEASURED/INSPECTED AT _____ ON _____ (DATE)

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ANNEXURE-VI



DIAGRAMMATIC ILLUSTRATION OF BOX TEMPLATE

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CHECK LIST

(Check list to be filled in and submitted along with the offer)

- | | |
|---|-----------|
| 1. Material shall be as per drg. | YES / NO |
| 2. Dimensions shall be as per drg. | YES / NO |
| 3. Heat treatment shall be done as per spec. of material | YES / NO |
| 4. NDT shall be done as per drg. | YES / NO |
| 5. Impact testing shall be done | YES / NO |
| 6. Hardness test shall be done | YES / NO |
| 7. Microscopic test shall be done | YES / NO |
| 8. Mechanical testing shall be done as per material specification | YES / NO |
| 9. Chemical composition shall be done as per material specification | YES / NO |
| 10. Type of furnace used | EAF / IF |
| 11. Secondary refining shall be done by | AOD / VOD |
| 12. What secondary refining facility vendor has got in-house | _____ |
| 13. TCs shall be submitted as per clause 18 | YES / NO |
| 14. Keel blocks shall be cast integral with each casting (as per clause 11.0) | YES / NO |
| 15. Blades shall be supplied in rough m/ced semi finish ground condition | YES / NO |
| 16. Before dispatch each casting shall be properly marked with hard punching | YES / NO |
| 17. Suction & pressure side templates shall be supplied with first casting | YES / NO |
| 18. QA plan shall be submitted for approval | YES / NO |
| 19. Nature of packing in which casting shall be shipped | _____ |
| 20. Deviations, if any (as per clause 22.0) | YES / NO |

Date: _____

Vendor's Name and authorized signature

		MANUFACTURER'S NAME AND ADDRESS BHARAT HEAVY ELECTRICALS LIMITED, BHOPAL			MANUFACTURING QUALITY PLAN					PROJ: MEIL POLAVARAM HEP (12X 80 MW) PACKAGE: ELECTROMECHANICAL CONTRACT NO.: MEIL/POLAVARAM HEP/BHEL/3180/E&M/001 DTD:17.05.2021			
					ITEM(S): KAPLAN TURBINE, GOVERNOR, COOLING WATER & DRAINAGE DEWATERING SYSTEM	QAP NO.: QA/HT/2131 REV. NO.: 03 DATE: 26.09.2023 PAGE: PAGE 1 OF 7	REFERENCE DOCUMENT		ACCEPTANCE NORMS	FORMAT OF RECORD	AGENCY M C B A		REMARKS
SL NO	COMPONENT & OPERATIONS	CHARACTERISTICS	CLASS	TYPE OF CHECK	QUANTUM OF CHECK(**)	M/C	B / A	7	8	9	D*	10	11
1	2	3	4	5	6								
1.0 RAW MATERIAL													
1.1	Plate material for top cover, pivot ring, regulating ring, pit liner, turbine guide bearing housing, runner envelope, shaft seal, pressure receiver, Stay ring (any other CAT-ii item missed out)	Chemical composition	Major	CT	Sample	Sample	Relevant material standard as per Drg.	TC	✓	P	R	R	R
		Mechanical properties	Major	MT	Sample	Sample	-do-	TC	✓	P	R	R	R
		UT of plates (for thickness above 25 mm)	Major	NDT	100%	100%	-do-	TC	✓	P	R	R	R
1.2	Runner blade casting	Chemical composition	Major	CT	Sample	Sample	Relevant material standard as per Drg	TC	✓	P	R	R	R
		Mechanical properties	Major	MT	Sample	Sample	-do-	TC	✓	P	R	R	R
		NDT on casting	Major	UT/ MPI	100%	100%	-do-	TC	✓	P	W	R	R
		Profile check with template & surface finish check	Major	M / VIS	100%	100%	Drawing	TC	✓	P	W	W	W
CHP of any 1 unit for MEIL & APGENCO & TC review for other units													
				LEGEND: * D: RECORDS, IDENTIFIED WITH "TICK" (✓) SHALL BE ESSENTIALLY SUBMITTED BY SUPPLIER IN QA DOCUMENTATION. M: MANUFACTURER/SUB-SUPPLIER, C: MAIN SUPPLIER FOR EM PACKAGE (BHEL), B-EPC CONTRACTOR (MEIL) A: OWNER (APGENCO)/OWNER'S AUTHORISED REPRESENTATIVE, P: PERFORM W: WITNESS AND V: VERIFICATION AS APPROPRIATE, CHP: CUSTOMER HOLD POINT TC: TEST CERTIFICATE, QCR: QUALITY CONTROL REPORT, JIR: JOINT INSPECTION REPORT, ET- ELECTRICAL TEST, M- MEASUREMENT, CT-CHEMICAL TEST, MT-MECHANICAL TEST, VIS-VISUAL CHECK					DOC. NO.:	REV. NO. CAT...B			
				FOR APGENCO USE	REVIEWED BY 	APPROVED BY 	APPROVAL SEAL 						
MAIN SUPPLIER (EM PACKAGE)		EPC CONTRACTOR											