



**PLANT PURCHASING  
SPECIFICATION  
HYDERABAD**

**HY19572**

**REV. NO. 06**

**PAGE 1 OF 3**

**ALLOY STEEL CASTINGS FOR STEAM TURBINES  
FOR HIGH TEMPERATURE SERVICE**

**GRADE : G 17 Cr Mo 55  
(Material 1.7357)**

**1.0 GENERAL:**

This specification governs the quality requirements of castings required to operate at high pressure and elevated temperatures in steam turbines.

**2.0 APPLICABLE ADDITIONAL SPECIFICATION:**

General requirements of steel castings shall be as per plant standard HY0851165 Rev.01 (Based on TLV 0100).

**3.0 CHEMICAL COMPOSITION:**

The heat analysis according to EN10213 in weight %.

| Element | Melt analysis |         |
|---------|---------------|---------|
|         | Minimum       | Maximum |
| C       | 0.15          | 0.20    |
| Si      | -             | 0.60    |
| Mn      | 0.50          | 1.00    |
| S       | -             | 0.020   |
| P       | -             | 0.020   |
| Mo      | 0.45          | 0.65    |
| Cr      | 1.00          | 1.50    |
| Ni      | -             | 0.50    |
| V       | -             | 0.05    |
| Cu      | -             | 0.30    |
| Al      | -             | 0.04    |
| Ti      | -             | 0.025   |
| Sn      | -             | 0.025   |

**Revisions:**

**Revised the cross referred standard in cl. 2**

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**Rev. No. 06**

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**Reaffirmed:**

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**Approved:**

**Dt .of 1<sup>st</sup> issue**

**Dt. MAY, 07**

**Dt.**

**Year:**

**MATLS. ENGG.**

**GM (ENGG.)**

**AUG. 1983**

|                    |   |   |
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#### 4.0 WELDING:

The welding filler material shall be in according to the WPR and with following analysis (%).

| C           | Si     | Mn     | Cr          | Mo          |
|-------------|--------|--------|-------------|-------------|
| 0.06 – 0.10 | ≤ 0.50 | ≤ 1.20 | 1.00 – 1.50 | 0.45 – 0.70 |

The use of any other welding filler material is allowed only after written permission from BHEL, Hyderabad.

Weld hardness shall be checked at random and documented accordingly. Values of maximum 320 HV or 304 BHN max. are allowed.

#### 5.0 HEAT TREATMENT:

Heat treatment as per EN 10213.

Hardening at 920 - 960°C, holding time according to the wall thickness.

Tempering at 680 - 730°C, holding time according to the wall thickness.

With respect to optimum long-term properties, a microstructure transformation in the upper bainite range is to aimed.

If the supplier carried out rough machining, the casting has to be stress relieved before delivery. The stress relieving temperature is not allowed to raise above the tempering temperature of the casting. The cooling rate for stress relieving should be ≤ 30°C/hr down to 300°C. The stress relieving after rough machining can be dropped, if quenching and tempering after rough machining or production weldings followed by stress relieving will be carried out.

#### 6.0 MECHANICAL PROPERTIES:

The mechanical properties of each casting shall be determined in the delivery condition. The following properties shall be achieved at room temperature.

| Tensile Strength<br>N/mm <sup>2</sup> | 0.2% Proof stress, N/mm <sup>2</sup><br>min. | Elongation %<br>L=5d<br>min. | Reduction in area %<br>min. | Charpy Impact strength<br>J<br>min. |
|---------------------------------------|--|------------------------------|-----------------------------|-------------------------------------|
| 490-690                               | 315  | 20                           | 40                          | 27 *                                |

\* Average of 3 charpy-V notch specimens, where the smallest value shall be atleast 21J.



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**7.0 SCOPE OF THIRD PARTY INSPECTION:**

Whenever, separate quality plan is not attached, the scope of third party inspection shall be as follows:

1. Review of supplier's declared chemical composition.
2. Selection of test samples for mechanical tests and witness of the mechanical tests.
3. Witness of non-destructive tests as applicable.
4. Review of heat treatment charts.
5. Dimensional inspection.



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**Rev. No. 01**

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## **ALLOY STEEL FORGINGS FOR STEAM TURBINE ROTORS**

**GR: 30 Cr Mo Ni V 511**

**(Material No.1.6946)**

### **1.0 GENERAL :**

This specification governs the technical requirements of steam turbine rotors forged out of steel grade 30 Cr Mo Ni V 511.

### **2.0 APPLICATION :**

Steam turbine rotors having diameters up to 1400 mm..

### **3.0 CONDITION OF DELIVERY :**

The rotor forgings shall be supplied in heat treated and rough machined condition..

### **4.0 COMPLIANCE WITH NATIONAL STANDARD :**

There is no national standard covering this grade of material. However, guidance is taken from KWU TLV 9190/05/06 (June2001).

### **5.0 DIMENSIONS AND TOLERANCES :**

The rotor forgings shall be supplied to the dimensions shown on the ordering drawing. The tolerance shall be as follows unless otherwise specified in the drawing/order.

Upto 500 mm - + 1 mm

Over 500 mm - + 2 mm

### **6.0 MANUFACTURE :**

**6.1** The steel shall be made from basic electric furnace and shall be subsequently refined by Vacuum Carbon Deoxidation (VCD) or Electro Slag refining (ESR) process.

**6.2** Sufficient discard from Top and Bottom shall be made from the ingot to ensure freedom from piping, segregation and other injurious defects.

**6.3** The forging process adopted shall ensure homogeneity of material throughout the section.

**Revisions: Revised as per MOM dtd 30.06.2003  
between MES and ST Engg.**

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DEPARTMENT**

| Rev. No | Rev. Date: | Revised: | Prepared:      | Approved: | Date:    |
|---------|------------|----------|----------------|-----------|----------|
| 01      | SEPT.03    | MES      | MALTS.<br>ENGG | AGM(E&CC) | SEP .93. |

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6.4 It is important to maintain the actual centre of the forging, as far as possible identical with the centre of the ingot.

6.5 Press straightening, if necessary, may be performed before heat-treatment.

## 6.6 CLOCKING SYMBOL :

Before heat-treatment, clocking symbols 3-6-9-12 shall be stamped on the rotor. If the symbols are transferred during manufacture, they shall be restamped in the same clock wise position. The clocking symbols shall be used for reference purposes in recording the position of defects, etc. The clocking symbols shall be encircled with oil paint for easy identification.

6.7 After heat-treatment, the forging shall be rough machined to the dimensions and surface finish shown on the ordering drawing.

6.8 Before starting the production, the manufacturer shall submit Manufacturing and Inspection Sequencing plan (MIP) in accordance to the specification HY 0652099 of BHEL Hyderabad.

## 7 CHEMICAL COMPOSITION:

The chemical composition of the material shall be as follows:

| Element       |             | C            | Si        | Mn           | Cr           | Mo           | Ni           | V            | P          | S          | Al<br>(Total) |
|---------------|-------------|--------------|-----------|--------------|--------------|--------------|--------------|--------------|------------|------------|---------------|
| Heat analysis | Min<br>Max. | 0.27<br>0.31 | -<br>0.10 | 0.30<br>0.80 | 1.10<br>1.40 | 1.00<br>1.20 | 0.50<br>0.75 | 0.25<br>0.35 | -<br>0.007 | -<br>0.007 | -<br>0.010    |

7.1 **Tramp Elements:** The tramp elements shall be within following limits.

Cu = 0.12 max.

As = 0.02 max.

Sb = 0.02 max.

Sn = 0.015 max.

7.2 Small deviations in chemical composition are permissible only after approval from BHEL, provided that the specified properties are not impaired.



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**8.0 HEAT TREATMENT:**

- 8.1** The rotor forging shall be heat treated vertically followed by oil or mist quenching. The heat treatment shall be done to obtain tempered upper bainitic structure uniformly through-out the cross section free of ferrite in the centre. The hardening temperature shall be between 940°C and 960°C but 950°C shall be the target. The tempering temperature shall be selected suitable to achieve the 0.2 % yield strength with the possible toughness. It shall be between 690 and 710° C.

Actual heat treatment cycle followed shall be reported in test certificate

- 8.2** The minimum amount of residual stresses are to be aimed by controlling the rate of cooling and also duration of tempering treatment. The residual stresses are not allowed to be more than 60N/mm<sup>2</sup> on any point. The residual stresses are to be measured on the heat treatment contour according to KWU 'Ring Core' method. The locations of residual stress measurement shall be 120° apart from each other on the periphery of the rotor and in a spiral line at three places. In lieu of KWU-Ring core method residual stress measurement may be carried out by 'Blind hole method' as per ASTM E 837. However, all the other conditions such as location of tests, acceptance criteria etc remains same.

- 8.3** In case the required properties have not been obtained, reheat-treatment of the forging is to be carried out. The maximum number of reheat-treatments permitted are two. However, retempering is not considered as reheat treatment.

**9.0 SELECTON OF TEST SAMPLES:**

- 9.1** The location of the test pieces shall be shown on the ordering drawing. The test samples shall not be removed before heat treatment.
- 9.2** The test samples are to be clearly identified with identification number. The association with the forging is to be conformed by BHEL inspector/ Lloyd's. The balance material shall be delivered along with the forging.

**10. MECHANICAL PROPERTIES:**

- 10.1** The mechanical properties, when tested on the tangential or radial test pieces shall conform to the following at room temperature.

| Tensile Strength<br>N/mm <sup>2</sup><br>Max. | 0.2% proof Stress<br>N/mm <sup>2</sup> | % Elongation<br>L=5d<br>Min. | % Reduction<br>in area<br>Min. | Impact Strength<br>J<br>Min. |
|---|--|------------------------------|--------------------------------|------------------------------|
| 850   | 550 - 700                              | 15                           | 40                             | 24                           |

|                    |   |  |
|--------------------|---|--|
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**Axial core testing:** If specified on the ordering drawing, the axial core shall be taken out by trepanning and the following properties shall be obtained on the samples taken in radial direction.

0.2% Proof Stress : :530 N/mm<sup>2</sup> Min.  
Impact Strength

(Average of 3 samples) : : 55 J min. at +80<sup>0</sup> C  
ISO-V notch

FATT : : ≤ +80<sup>0</sup> C,

T: Tangential Test piece : Q Radial test piece.

**Note:** a) Tensile test shall be carried out as per IS :1608 or any National Standard.

b) Impact test shall be carried out as per IS:1757 ISO-V notch or any National standard the minimum impact strength value specified above is the average of three samples at the same location. Only one value is permitted below the specified min. value, but in no case shall be lower than the 2/3 of the same. All values shall be reported in certificate..

c) The location of tensile and impact specimens shall be in a distance of 40mm from the heat treated surface.

## **11.0 NON-DESTRUCTIVE TESTS: (outer and Inner quality)**

### **11.1 UT- EXAMINATION:**

Ultrasonic test and evaluation shall be carried out as per siemens PA standard 14/24. 51

### **11.2 Magnetic particle test:**

Magnetic particle test and evaluation shall be carried out as per siemens standard PA 14/24. 51

## **12.0 METALLOGRAPHIC TEST:**

Metallurgical test shall be conducted on samples taken from broken tensile test pieces. photo micrographs at 500x shall show tempered upper bainitic structure and the photomicrograph (original) shall be submitted to BHEL along with test certificates.



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## 13. THERMAL STABILITY TEST:

If mentioned in the drawing or purchase order, Thermal Stability test shall be carried out at 30<sup>0</sup> C Below the tempering temperature according to BHEL, Hardwar Standard . A and D type swings will not be considered when they are explainable due to surface effect. In case of occurrence of B type swing the test shall be conducted till no more stresses are left to be released. C type swing greater than or equal to 0.05 mm shall not be allowed. BHEL Hyderabad reserves right to participate for verification

## 14. FIRST PIECE QUALIFICATION TESTS:

When ever the supplies are made for the first time to BHEL the requirements of BHEL specification HY0800099 shall also be applicable in addition to this specification.

## 15. INSPECTION AT SUPPLIER'S WORKS:

BHEL representative shall have all reasonable facilities offered to him, at any time, by the supplier to satisfy himself that the material is being furnished in accordance with this specification. The representative shall have free access at all times while the work on the contract is being performed, to all parts of the manufactures works.

## 16. TEST CERTIFICATE:

16.1 Five copies of test certificates giving the following details shall be furnished.

- a) HY 19473      Rev .01
- b) BHEL Order No.
- c) Item Description and Drawing No. of the forging.
- d) Supplier's Name.
- e) Melt No. and Forge No.
- f) Results of chemical analysis alongwith trace elements.
- g) Results of Mechanical Tests & FATT (if applicable)
- h) Results of residual stresses.
- i) Report of ultrasonic testing giving details of probe type and size, frequency, sensitivity, sketch showing the areas covered etc.
- j) Report of Metallographic test alongwith microphotographs (original).
- k) Actual Heat treatment charts
- l) Results of thermal stability test, if called for in the drawing/purchase order.
- m) Report magnetic particle inspection.
- n) Copy of approved MIP duly attested by BHEL representative.



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**16.2** The certificate shall be attested by chief of inspection/chief metallurgist of the supplier and BHEL representative.

## **17.0 MARKING :**

The following details shall be punched clearly on one end of the forging.

- a) HY 19473 Rev.01
- b) Forging No. and Melt No.
- c) Drawing NO.
- d) Manufacturer's Stamp.
- e) BHEL Inspector's stamp
- f) Clocking symbols.
- g) Top and Bottom sides of ingot.

## **18. PACKING AND TRANSPORTATION:**


Rotor forgings shall be properly protected from corrosion and damage during transit, journal portions shall be protected with anti-corrosive compound.

## **19. REJECTION AND REPLACEMENT:**

In the event of any forging proving defective in machining, testing erection and operation such forging shall be rejected notwithstanding any previous acceptance. The supplier shall replace the rejected forging at his own cost.

## **20. CROSS REFERRED STANDARDS:**

- 1 TLV 9190/05/06
- 2 HY 06520999 (for MIP)
- 3 HY0850188 (UT & MPI)
- 4 HW0850197 (Thermal stability test)
- 5 HY0800099 (First piece qualification)

|  |  |               |                                     |  |                     |
|--|--|---------------|-------------------------------------|--|---------------------|
|  |  | TD-218 Rev 00 | <b>PLANT STANDARD<br/>HYDERABAD</b> |  | <b>HY 080 00 99</b> |
|  |  |               |                                     |  | <b>REV.NO. 00</b>   |
|  |  |               |                                     |  | <b>PAGE 1 OF 4</b>  |

**PROCEDURE FOR FIRST PIECE QUALIFICATION OF STEAM TURBINE ROTOR FORGINGS**

**1.0 SCOPE**

This testing procedure is valid for all turbine shafts and turbine shaft parts at the supplier works for quality assurance and/ or supplier qualification. These tests are in addition to the tests already specified in the order drawing and specification.

**2.0 REFERENCED DOCUMENTS**

EN 10291, PA 14/24.21 of SIEMENS.

**3.0 INSPECTION PERSONNEL**

Inspections and correction of the punching is only allowed for qualified and named personnel.

**4.0 TESTING**

**4.1 General**

If tangential and axial cores are given in the order drawing, it is essential that the purchaser is contacted and an agreement is reached with reference to the taking of the specimens. If tangential or axial cores are not specified in the order drawing, same is to be mutually agreed between the BHEL and the manufacturer before placement of purchase order.

**4.2 Testing at the tangential core**


For the determination of the basic mechanical properties tangential cores are planned (see order drawing).

The creep rupture properties are to be determined from specimens of a separate additional tangential core.

The test position can be seen in attachment 1; the specimens shall be taken from the middle of the core at the maximum radial depth.

|                          |                 |                |  |                                    |   |
|--------------------------|-----------------|----------------|--|------------------------------------|---|
| <b>Revisions :</b>       |                 |                | <b>Issued :</b><br><b>STANDARDS ENGINEERING DEPARTMENT</b> |                                    |   |
| <b>Rev.No.</b><br><br>00 | <b>Rev.Date</b> | <b>Revised</b> | <b>Prepared</b><br><b>MATLS</b><br><b>ENGG.</b>            | <b>Approved</b><br><b>DGM / TS</b> | <b>Dt.of 1<sup>st</sup> Issue</b><br><br><b>OCT. 2003</b> |

|                     |                     |                                     |  |
|---------------------|---------------------|-------------------------------------|--|
| <b>HY 080 00 99</b> | TD-218<br>D. 00. 00 | <b>PLANT STANDARD<br/>HYDERABAD</b> |  |
| <b>Rev.No. 00</b>   |                     |                                     |  |
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Testing specimens according to EN 10291, section 7

The following requirements are to be fulfilled:

1.  $T = 560^{\circ}\text{C}$ ,  
Initial stress  $\sigma_o = 230 \text{ MP}_a$ ,  
Rupture time  $t_u = >1000\text{h}$
2.  $T = 560^{\circ}\text{C}$ ,  
Initial stress  $\sigma_o = 127 \text{ MP}_a$ ,  
Plastic elongation  $A_p 1000\text{h} < 0.3\%$   
Plastic elongation  $A_p 3000\text{h} < 0.5\%$
3.  $T = 530^{\circ}\text{C}$ ,  
Initial stress  $\sigma_o = 210 \text{ MP}_a$ ,  
Plastic elongation  $A_p 1000\text{h} < 0.27\%$

#### **4.3 Testing at the axial core**

The testing position is to be seen at attachment 1.

Testing specimens according to EN 10291, section 7

The following requirements are to be fulfilled:

1.  $T = 560^{\circ}\text{C}$ ,  
Initial stress  $\sigma_o = 230 \text{ MP}_a$ ,  
Rupture time  $t_u = >1000\text{h}$
2.  $T = 560^{\circ}\text{C}$ ,  
Initial stress  $\sigma_o = 127 \text{ MP}_a$ ,  
Plastic elongation  $A_p 1000\text{h} < 0.3\%$   
Plastic elongation  $A_p 3000\text{h} < 0.5\%$
3.  $T = 530^{\circ}\text{C}$ ,  
Initial stress  $\sigma_o = 210 \text{ MP}_a$ ,  
Plastic elongation  $A_p 1000\text{h} < 0.27\%$ .



TD-218 Rev.00

**PLANT STANDARD  
HYDERABAD****HY 080 00 99****REV.NO. 00****PAGE 3 OF 4****5.0 Test report**

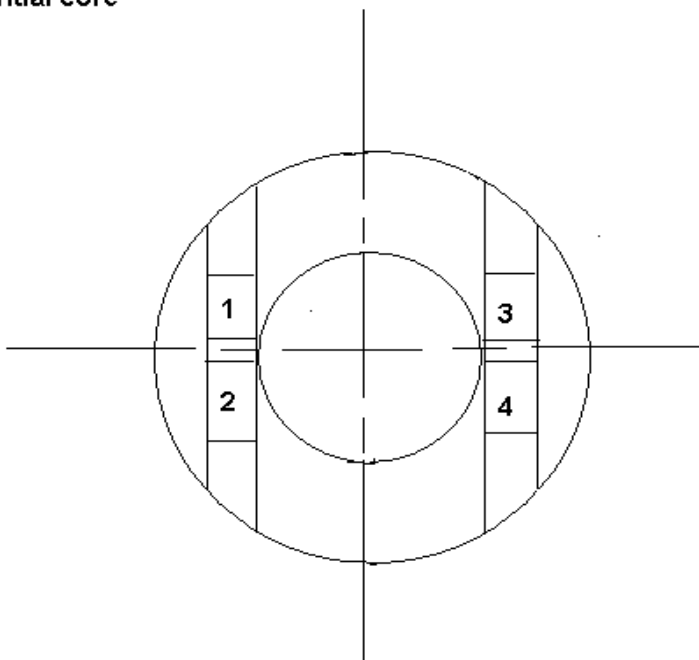
The test report has to included the following results according to EN 10291 section 11.1:

- Testing temperature
- Initial stress  $\sigma_0$
- Rupture time  $t_U$
- Rupture elongation  $A_U$  (for specimen 1)
- Rupture reduction area  $Z_U$  (for specimen 1)
- Plastic elongation  $A_P$  for 1000h and 3000h (for specimen 2)
- Plastic elongation  $A_P$  for 1000h (for specimen 3)

At continuous elongation measurement the whole creep curve is to reported.

**6.0 DEVIATIONS**

Any deviation has to be reported to BHEL for review and acceptance.

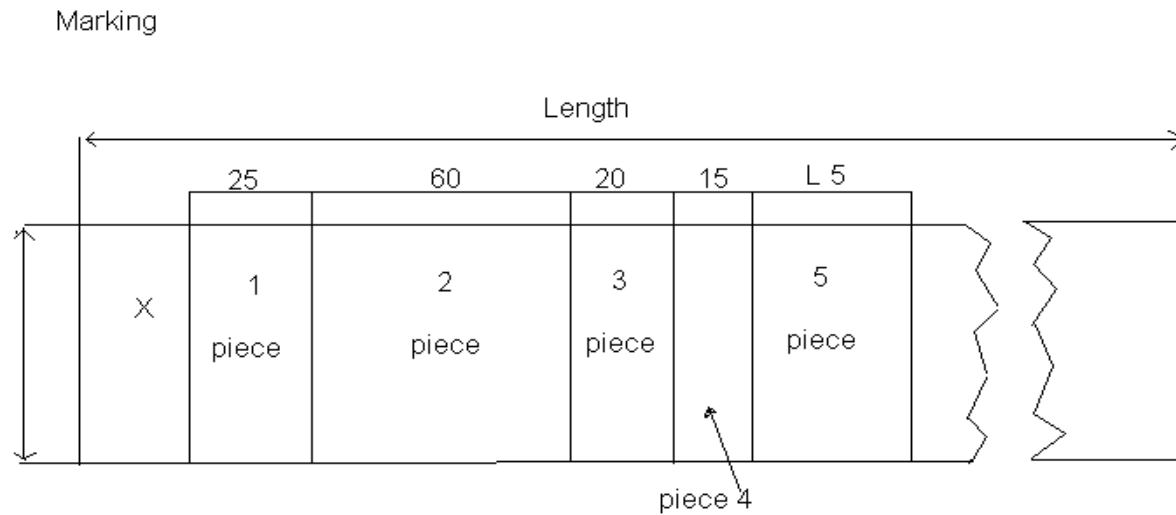
**ATTACHMENT-1****Test position in the tangential core****Supplier testing**

**3 creep-rupture test specimens according to EN 10291 (specimen 4 for reserve)**

# PLANT STANDARD HYDERABAD

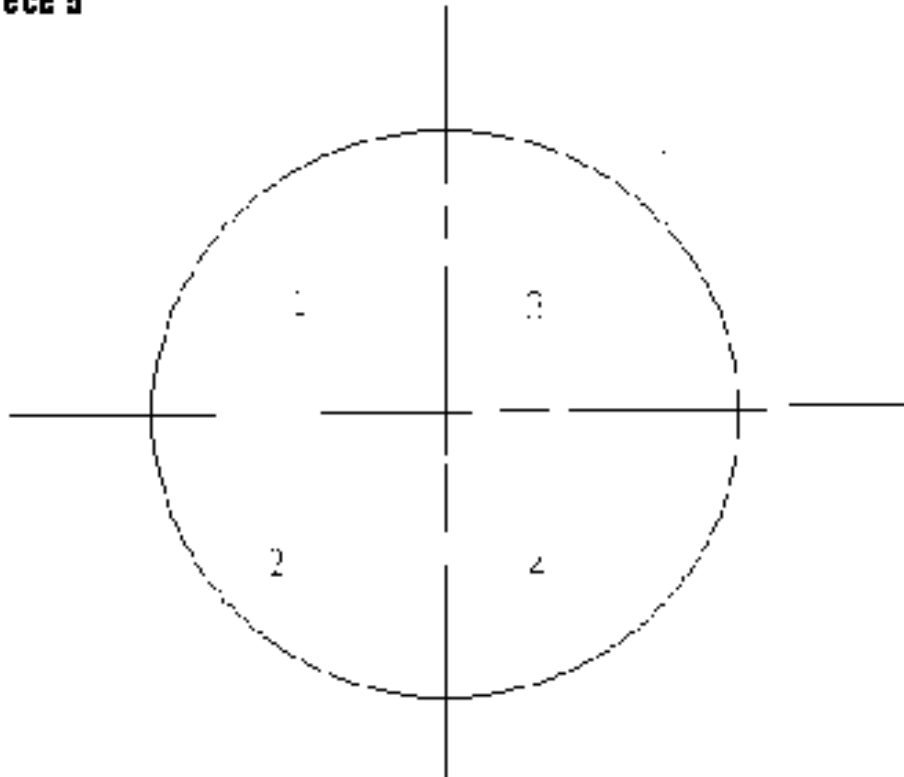


## Test Position in the axial Core



L 5... The length of piece 5 depends on the length of the creep-rupture specimens.

## Piece 5



**3 Creep rupture test specimens according to EN 10291 (specimen 4 for reserve)**



# PLANT STANDARD

## HEEP-HARDWAR

HW 0850197

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### HEAT-STABILITY TEST

#### 1.0 SCOPE:

This specification is valid for heat stability test for H.P and I.P rotor shaft forging of steam turbine.

#### 2.0 REFERENCE DOCUMENTS:

Assistance has been taken from SEP 1950, 5/87.

#### 3.0 REASON FOR TESTING :

The heat stability test gives information of proper heat-treatment in respect of

- unsymmetrically distributed residual stresses remaining after the tempering operation, which may get relaxed during the service time and thus may cause bending of rotor (B type deflection).
- A rotationally symmetrical microstructure ( C-Type deflection )

#### 4.0 SHAFTS TO BE TESTED :

The heat stability test is carried out on shafts only, which have a service temperature of  $> 450^{\circ}\text{C}$ . The rotors which have to work at temperature much lower than  $150^{\circ}\text{C}$  from tempering temperature, insignificant stresses will be released & hence no stability test is required. In addition to these for low service temperature, the shafts are of material having excellent hardenability.

A heat stability test will be carried out in case of

- prototypes
- new suppliers
- special service conditions or service stresses (decision by design/calculation department)

SUPERCEDES THE ~~REV~~ SHEET  
UNDER THE SAME NO. 301  
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| INVENTORY No. | SIGN & DATE | SIGN & DATE |           |                           |            |                    |         |
|               |             | TSX         | R. BHATIA | R.Bhatia/29-1-99          | DRAWN      |                    |         |
| P-22          | 21/1/99     | QAX         | TSK with  | TSK with                  | WORKED     | A.K.SARKAR         | 12.1.99 |
|               |             | STE         | A.S.      | 4.1.99                    | CHECKED    | J.P. MEENA         | 12.1.99 |
|               |             | AGREED DEPT | NAME      | SIGN & DATE               | SUPERVISED | V.B. ARORA         | 12.1.99 |
| REVISION :    |             |             |           | APPROVED:                 |            |                    |         |
|               |             |             |           | PLANT                     |            |                    |         |
|               |             |             |           | STANDARDIZATION COMMITTEE |            |                    |         |
|               |             |             |           | 6.48                      |            |                    |         |
|               |             |             |           | PREPARED :                |            | ISSUED :           |         |
|               |             |             |           | MTE                       |            | STANDARDS DIVISION |         |
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# PLANT STANDARD HEEP—HARDWAR

HW 0850197

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## 5.0 TYPES OF DEFLECTION:

The possible types of deflection which can appear during the heat stability test are represented in Annexure : 01 (REFER SEP-1950)  
5/87

## 6.0 PERFORMANCE OF TEST :

The heat stability test is carried out in the rotational symmetrically machined condition after the completed heat-treatment operation as per the cycle given in Annexure:02.

### 6.1 Rate of heating up and Temperature Cycle:

About 50°C / hr

### 6.2 Testing Temperature:

Tempering temperature minus 30°C.

In special cases other temperatures can be agreed upon.

The testing temperature should lie above the service temperature as high as possible to assure that during the later turbine operation possibility of rotor deflection is avoided. The cycle ( Ref. Ann:02) marked as firm/dark line is mandatory i.e. one dip of about 150 °C is essential as shown in sketch.

### 6.3 Cooling Rate:

To avoid new stresses during cooling from testing temperature to room temperature a cooling rate of about 15°C/h till approximately 200°C is to be applied; than a quicker cooling rate can be used.

C

SUPERCEDES THE OLD SHEET  
UNDER THE SAME N - 301  
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NAME AKS - SIGN [Signature] - DATE 24-1-99

REVISION :

WORKED BY

AKSARKAR

[Signature]

12-1-99

CHECKED BY

JPMEENA

[Signature]

12-1-99



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## 6.4 Location of Deflection:

On the coupling a clockwise numbering is to be provided in direction of power run which makes possible the fixing of an appeared deflection on the circumference.

## 6.5 Readings:

Temperature, deflection and location of deflection are to be checked each hour and documented.

## 7.0 ACCEPTANCE CRITERIA :

A and D type deflections are caused by radiation and have no influence on the later turbine operation; here exists convection only. These are acceptable.

In case of detection of B - type deflections the cycling of testing temperature shall be continued till the rotor becomes stable, i.e. after the temperature dip of about 150 °C the deflection of the shaft shall lie approximately at the same level in each case at the end of the holding times at testing temperature. After reaching heat stability the shaft is acceptable, independent of the value of the B-type deflection.

C-type deflections  $\geq 0.05$  mm are not acceptable.

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SUPERCEDES THE OLD Dwg SHEET  
UNDER THE SAME NO. 304  
CHANGE ADV. CE NO. TSX-MTE-98-452  
NAME AKB S. CH DATE 12-1-99

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12-1-99





# PLANT STANDARD

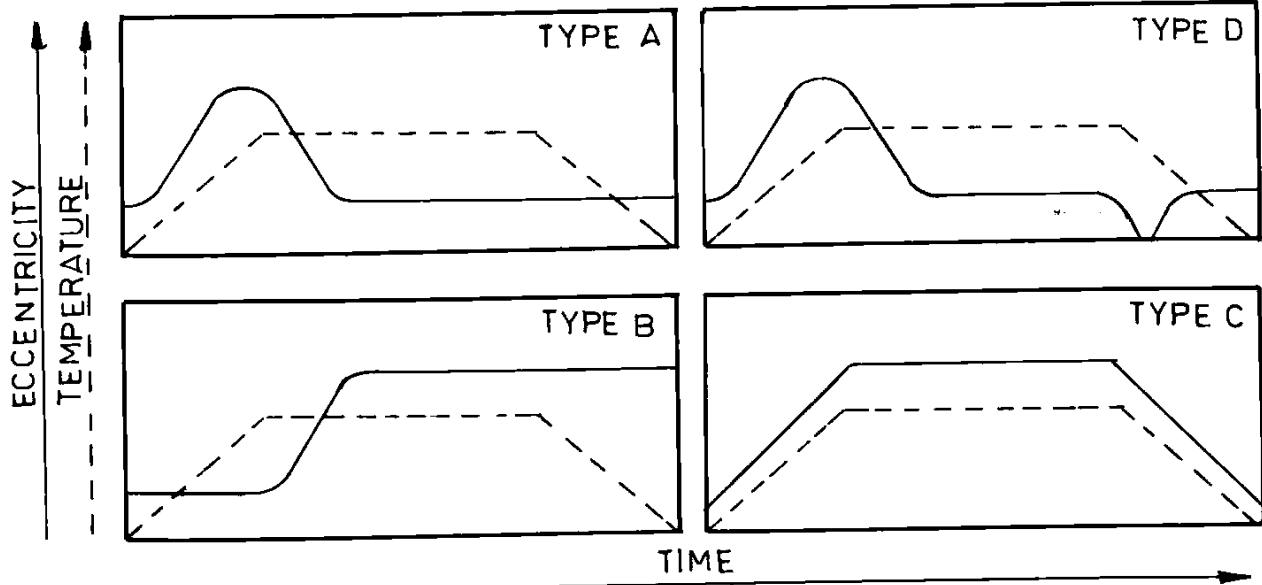
HEEP—HARDWAR

HW 0850197

PAGE 4 OF 6

ANNEXURE-01

## TYPES OF DEFLECTION



SUPERCEDES THE OLD Dwg. SHEET  
 UNDER THE SAME NUMBER  
 CHANGE ADV. NO. TSX-MTE-98-452  
 NAME A.K.S. SIGN [Signature] DATE 29.1.99

|            |             |                    |         |
|------------|-------------|--------------------|---------|
| WORKED BY  | A.K. SARKAR | <u>[Signature]</u> | 12.1.99 |
| CHECKED BY | J.P. MEENA  | <u>[Signature]</u> | 12.1.99 |



## PLANT STANDARD

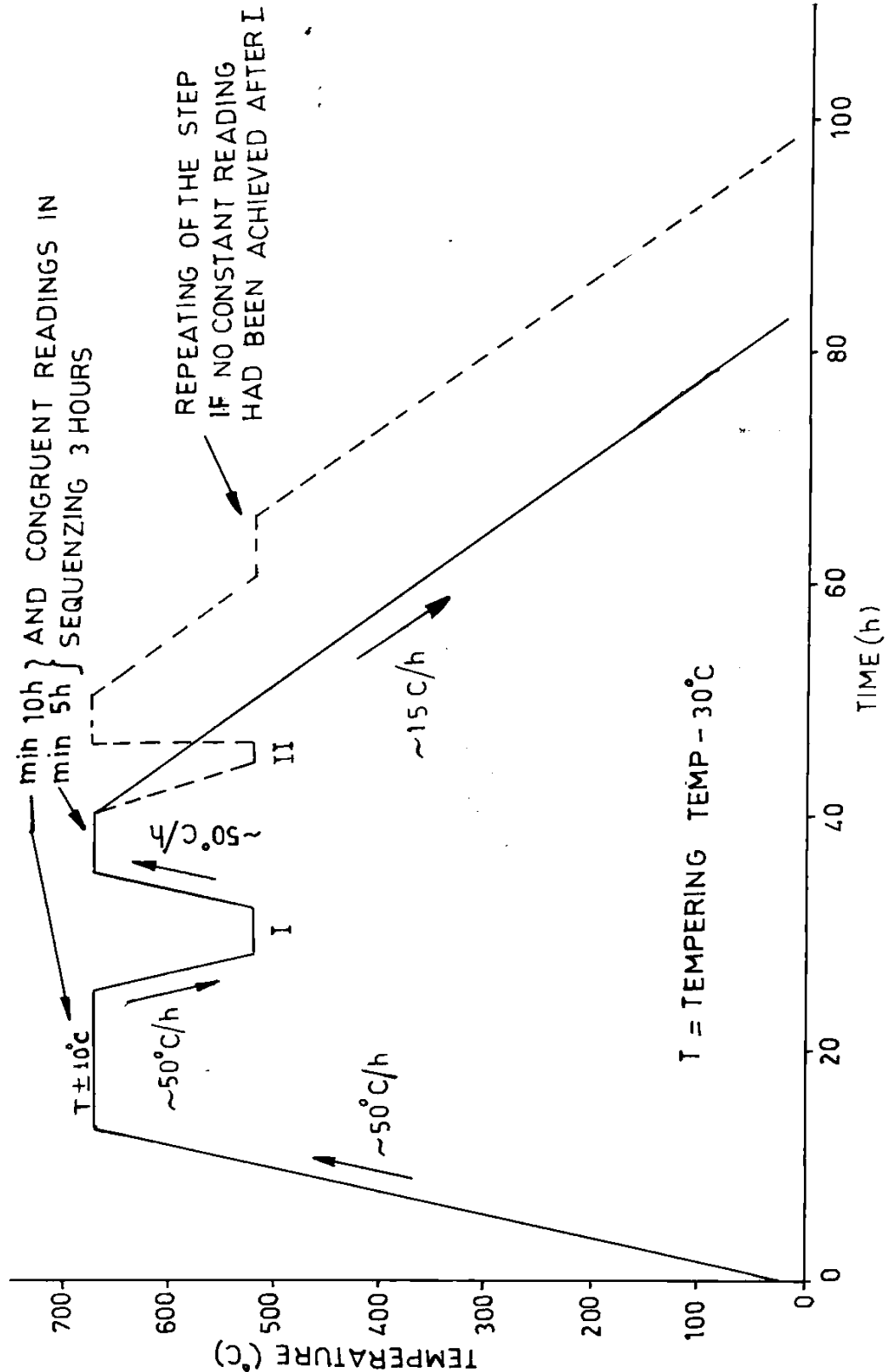
# HEEP--HARDWAR

ANNEXURE-02

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## HEAT STABILITY CYCLE



T = TEMPERING TEMP - 30°C

EXPERIMENTAL DATA SHEET  
 DATE: 10/1/81  
 BY: J. M. B. / J. M. B.  
 TITLE: AKS-1000  
 PROJECT: AKS-1000  
 DRAWING: AKS-1000  
 SCALE: 1/2" = 1'-0"

WORKED BY A.K.SARKAR

A.K. SARKAR

of the


12-01-98

|            |            |
|------------|------------|
| CHECKED BY | J.P. MEENA |
|------------|------------|

J.P.MEENA

My

12-01-99

|             |  |  |                   |  |  |  |  |  |  |  |  |  |             |  |  |  |  |
|-------------|--|--|-------------------|--|--|--|--|--|--|--|--|--|-------------|--|--|--|--|
| SIGN & DATE |  |  | PLANT STANDARD    |  |  |  |  |  |  |  |  |  | HW 0850197  |  |  |  |  |
|             |  |  |                   |  |  |  |  |  |  |  |  |  | PAGE 6 OF 6 |  |  |  |  |
|             |  |  | RECORD OF CHANGES |  |  |  |  |  |  |  |  |  | ANNEXURE-I  |  |  |  |  |

| REV CODE | NO OF CHGS | DOCU NO        | SHEET NO                                   | SIGN        | DATE    | REV CODE | NO OF CHGS | DOCU NO | SHEET NO | SIGN | DATE |
|----------|------------|----------------|--|-------------|---------|----------|------------|---------|----------|------|------|
| C        | -          | TSX-MTE-98-452 | SUPERSEDES OLD SPEC. UNDER THE SAME NUMBER | [Signature] | 12.1.99 |          |            |         |          |      |      |

(C) SUPERCEDES THE OLD DATA SHEET UNDER THE SAME NUMBER. CHANGE ADVISED TO TSX-MTE-98-452. NAME AKS S.L.N. DATE 12.1.99

| DISTRIBUTION OF PRINTS |           |           |           |           |           |           |                |           |           |           |             |     |     |     |        |        |        |  |  |
|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|----------------|-----------|-----------|-----------|-------------|-----|-----|-----|--------|--------|--------|--|--|
| DEPTT                  | TGE       | STE       | AME       | DME       | HGE       | HTE       | ACE            | HXE       | MTE       | MRL       | IN-SUL SYS  | HLE | TSX | THC | PPX    | MCX    | CSX    |  |  |
|                        |           | ✓         |           |           |           |           |                |           | ✓         | ✓         |             |     | ✓   |     |        |        |        |  |  |
| DEPTT                  | AIX       | OSX       | CCX       | FAX       | TFX       | TLX (J&T) | TTX-GTX        | TTX-ST    | TTX-HT    | TTX-EM    | WT          | QAX | QCX | PCM | WC 202 | WC 205 | WC 227 |  |  |
|                        |           |           |           |           |           |           |                | ✓         |           |           |             | ✓   | ✓   |     |        |        |        |  |  |
| DEPTT                  | FBM BL II | HTM WC276 | STM WC236 | TLM WC832 | ACM WC291 | CIM WC330 | FGM WC356 /361 | SUM WC370 | WWM WC386 | HXM WC390 | WEX WC 6100 | ESX | TRX | TAX | AVP    | BP 6FE | HY     |  |  |
|                        |           |           |           |           |           |           |                |           |           |           |             |     |     |     |        | ✓      | 4      |  |  |

|               |      |              |         |          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|---------------|------|--------------|---------|----------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| INVENTORY NO. | P-22 | SIGN. & DATE | 12/1/99 | REVISION |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|               |      |              |         | DRAWN    |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|               |      |              |         | WORKED   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CHECKED       |      |              |         |          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A.K. SARKAR   |      |              |         |          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| J.P. MEENA    |      |              |         |          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 12.1.99       |      |              |         |          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 12.1.99       |      |              |         |          |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |