



1X800 MW COAL BASED NORTH CHENNAI THERMAL
POWER PROJECT STAGE III

EPC TENDER SPECIFICATION FOR BTG PACKAGE



ANNEXURE-VII

MFGR.'s LOGO		SUPPLIER'S NAME AND ADDRESS		FIELD QUALITY PLAN				PROJECT:		
				ITEM :		QP NO.:		PACKAGE:		
				SUB-SYSTEM:		DATE:		CONTRACT NO.:		
						PAGE: OF....		MAIN-SUPPLIER:		
SL. NO	ACTIVITY & OPERATIONS	CHARACTERISTICS/ INSTRUMENTS	CLASS# OF CHECK	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORMS	FORMAT OF RECORD		REMARKS
1	2	3	4	5	6	7	8	9	D*	10
				LEGEND: * RECORDS, IDENTIFIED WITH "TICK" (v) SHALL BE ESSENTIALLY INCLUDED BY SUPPLIER IN QA DOCUMENTATION. LEGEND TO BE USED: CLASS #: A = CRITICAL, B=MAJOR, C=MINOR; 'A' SHALL BE WITNESSED BY THE OWNER FQA, 'B' SHALL BE WITNESSED BY OWNER'S ERECTION / CONSTRUCTION DEPTT. AND 'C' SHALL BE WITNESSED BY ERECTION SUPPLIER (A & B CHECK SHALL BE OWNER CHP STAGE)						DOC. NO.: REV..... CAT.....
MANUFACTURER/ SUB-SUPPLIER		MAIN- SUPPLIER						FOR THE OWNER USE		REVIEWED BY
SIGNATURE										

Chapter 5

Performance Guarantees & LD for shortfall


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CHAPTER 5
PERFORMANCE GUARANTEES AND LIQUIDATED DAMAGES FOR SHORTFALL IN
PERFORMANCE AND GUARANTEE TESTS

1.0 GENERAL

- 1.1 The Bidder shall guarantee that the equipment offered shall meet the ratings and performance requirements stipulated for various equipment covered in these specifications.
- 1.2 The guaranteed performance parameters furnished by the bidder in his offer, shall be without any tolerance values. Only such tolerance or allowance on the test results, which are permitted by the agreed test code, will be permitted for instrument inaccuracies. However for steam generator and ESP, no tolerances on account of instrument inaccuracy or any other cause shall be allowed and all margins required, instrument inaccuracies and other uncertainties shall be deemed to have been included in the guaranteed figures.
- 1.3 The Contractor shall conduct performance test and demonstrate all the guarantees covered herein under Category I, II & III. The various tests, which are to be carried out during performance guarantee / acceptance test, are listed. The Contractor at site shall conduct the guarantee tests in presence of Purchaser on each unit individually.
- 1.4 All costs associated with the tests including cost associated with the supply, calibration, installation and removal of the test instrumentation shall be included in the contract price.
- 1.5 The performance tests shall be performed using only the normal number of Employer supplied operating staff. Contractor, vendor or other subcontractor personnel shall be used only for instructional purposes or data collection. At all times during the Performance Tests the emissions and effluents from the Plant shall not exceed the Guaranteed Emission and Effluent Limits.
- 1.6 It shall be responsibility of the Contractor to make the plant ready for the performance guarantee tests.
- 1.7 The term "Performance Guarantees" wherever appears in this Section shall have the same meaning and shall be synonymous to "Functional Guarantees".
- 1.8 The term "Performance Tests" wherever appears in this Section shall have the same meaning and shall be synonymous to "Guarantee Test(s)"
- 1.9 The term "TMCR" (Turbine maximum continuous rating) appearing in the Technical Specification shall mean 800 MW electrical power output at generator terminals under 0% cycle make-up at design Condenser pressure.



1.10 The term “BMCR” (Boiler Maximum Continuous Rating) appearing in the Technical Specification shall mean 1.02 times the steam flow at turbine VWO condition(105% TMCR) plus continuous auxiliary steam requirement of unit at TMCR, rounded to next integer divisible by 5.

1.11 Test Instrumentation, Flow Measurement and their Calibration

All instruments required for performance testing shall be of the type and accuracy required by the code prior to the test, the Contractor shall get these instruments calibrated in an independent test Institute approved by the Employer. All test instrumentation required for performance tests shall be supplied by the Contractor and shall be retained by him upon satisfactory completion of all such tests at site. All calibration procedures and standards shall be subject to the approval of the Employer. The protecting tubes, pressure connections and other test connections required for conducting guarantee test shall conform to the relevant codes.

1.12 Tools and tackles, thermowell (both screwed and welded) instruments/devices including flow devices, matching flanges, impulse piping & valves etc. and any special equipment, required for the successful completion of the tests, shall be provided by the contractor free of cost.

1.13 The Performance test shall be carried out as per the agreed procedure. The detailed PG test procedure including demonstration tests shall be submitted within 90 days of the date of Notification of Award and finalization of the PG test procedure shall be done within 180 days from the date of Notification of Award.

- a. The P&G test procedures shall be submitted for equipment/ system & subsystem under Contractor's scope for all Guarantees under category I, II & III as mentioned below, as per latest International codes / standard including correction curves, meeting the specification requirements along with sample calculations & detailed activity plan of preparation (including test instrumentation), conductance and evaluation of Guarantees.
- b. The contractor shall submit for Employer's approval the detailed Performance Test procedure containing the following:
 - i. Object of the test
 - ii. Various guaranteed parameters & tests as per contract.
 - iii. Method of conductance of test and test code.
 - iv. Duration of test, frequency of readings & number of test runs.
 - v. Method of calculation.
 - vi. Correction calculations & curves.
 - vii. Instrument list consisting of range, accuracy, least count, and location of instruments.



- viii. Scheme showing measuring points.
- ix. Sample calculation
- x. Acceptance criteria.
- xi. Any other information required for conducting the test. The Performance test shall be carried out as per the agreed procedure.

1.14 Test Reports

After the conductance of Performance test, the Contractor shall submit the test evaluation report of Performance test results to Employer promptly but not later than one month from the date of conductance of Performance test. Preliminary test reports shall be submitted to the Employer after completing each test run. Four (4) hard copies and two (2) soft copies on CD-ROM of each test report of final conducted test on each equipment/plant/system shall be submitted to Employer for approval.

- 1.15 The performance guarantee test will be carried out within three months after the successful completion of Initial Operation of facilities or as per the time frame specified for a particular equipment/ plant/ system in the Technical specifications. Delay in conductance of the test beyond this period will not be normally permitted by the EMPLOYER. In the event of EMPLOYER agreeing to conductance of such tests after three months, for reasons not attributable to the EMPLOYER, as assessed by the Employer, no factor for ageing shall be considered for computing performance of the equipment. Performance Guarantee Tests on the equipment /systems not covered shall be carried out as per the procedure/test codes specified.

1.16 Test Interruptions

In the event of a test interruption resulting from an Event of Force Majeure or Purchaser-Caused-Delay, Contractor shall be entitled to relief as provided in the contract, provided that (except for certain interruptions of a Availability Test as specified below), the interrupted Performance Test must be started again and test data that were collected during the interrupted test must be ignored.

In the event of test interruptions as a result of Force Majeure or Purchaser-Caused-Delay during an Availability test, where.

- a. The total cumulative interrupted time during the test is more than twenty-four (24) hours.
- b. The total number of interruptions during the test is more than four (4). The test shall not be deemed a successful Performance Test.
Except as provided above, the interrupted test resulting from Force Majeure or Purchaser-Caused-Delay shall be extended by an amount of time equal to the length of



the interruptions, including time to return to steady-state operation; the test data for the period of interruptions shall be excluded from analysis; and the test data that were collected both before and after the interruptions shall be included in the analysis.

1.17 Grid Restriction

Any loss in generation in terms of power (KW) or energy (KWH) during Availability Test due to grid restrictions shall be treated as deemed generation. However, the total cumulative deemed generation shall not exceed 5% of the total generation during the test period failing which the test shall be extended to limit the deemed generation to 5% of the total generation.

1.18 In case during performance guarantee test(s) it is found that the equipment/system has failed to meet the guarantees, the Contractor shall carry out all necessary modifications and/or replacements to make the equipment/system comply with the guaranteed requirements at no extra cost to the Employer and re-conduct the performance guarantee test(s) with Employer's consent. In case the specified performance guarantee(s) are still not met by the contractor even after modification and/or replacement, Employer will accept the equipment/system/plant after levying liquidated damages as per clause 2.0 of this chapter. However, if, the demonstrated guarantee(s) continue to be beyond the Limit, even after the modifications/replacements within ninety (90) days or a reasonable period allowed by the Employer, after the tests have been completed, the Employer will have the right to either of the following (at Employer's discretion):

- i. For Category-I Guarantees
Reject the equipment / system / plant and recover from the Contractor the payments already made

OR

- ii. Accept the equipment /system/ plant after levying Liquidated Damages.
For Category-II Guarantees
Reject the equipment / system/ plant and recover from the Contractor the payments already made. Conformance to the performance requirements under Category-II is mandatory.
- iii. For Category-III Guarantees
Reject the equipment /system / plant and recover from the Contractor the payments already made.

OR

Accept the equipment/system after assessing the deficiency in respect of the various ratings, performance parameters and capabilities and recover from the contract price an amount equivalent to the damages as



determined by the Employer. Such damages shall, however be limited to the cost of replacement of the equipment/system, replacement of which shall remove the deficiency so as to achieve the guaranteed performance.

2.0 Amount Of Liquidated Damages (LD) Applicable For Category-I Guarantees

Refer Volume-I

3.0 Specific And Limiting Requirements For Steam Generator Efficiency

- a. Guaranteed Steam generator efficiency shall be calculated as per the requirements of ASME PTC 4 (by loss method) and as per stipulations of Clause 8.0 of this chapter.
- b. The guaranteed efficiency quoted by the Bidder shall comply with following limiting parameters with design coal firing:

Excess air at economizer outlet at 100% TMCR load	20% (min.
Corrected flue gas temperature at air preheater outlet (at 100% TMCR)	125 degree C or as predicted by the Bidder whichever is higher
Unburnt fuel at all efficiency load at 105% & 100% TMCR	1.0% (min)

Bidder/Contractor to note that no credit shall be given in the bid evaluation or in the evaluation of the results of the guarantee tests for performance predictions/ guarantees etc. if the values considered by the Bidder/Contractor for parameters indicated at above are lower than those specified above.

- c. For the purposes of guarantees the ambient air temperature and relative humidity shall be taken as 27 degree Celsius and 72% respectively.
- d. Unless otherwise specified, the guarantees shall be based on design coal firing.

4.0 AUXILIARY POWER CONSUMPTION (PA)



The unit auxiliary power consumption shall be calculated using the following relationship.

$$P_a = P_u + T_L$$

P_a = Guaranteed Auxiliary Power Consumption.

P_u = Power consumed by the auxiliaries of the unit under test.

T_L = Losses of the transformers supplied by bidder based on works test reports.

While guaranteeing the auxiliary power consumption the bidder shall necessarily include all continuously operating auxiliaries under this package. The auxiliaries to be considered shall include but not be limited to the following:

4.1 Steam Generator & its Auxiliaries at 100% TMCR while firing Design Coal

- a. Primary Air (PA) Fans including its lube oil pumps
- b. Coal Feeders.
- c. Seal air fans
- d. Coal mills including its lube oil pumps.
- e. Forced Draft (FD) Fans including its lube oil pumps.
- f. Regenerative Air Preheater including its lube oil pumps.
- g. Electrostatic precipitators (ESP)
- h. Induced Draft (ID) Fans including its lube oil pumps.
- i. Boiler circulation pumps
- j. Scanner air fans

4.2 Steam Turbine Generator & its Auxiliaries at 100% TMCR

- a. Turbine auxiliary oil pump (if applicable)
- b. Turbine control oil pump
- c. Oil Tank Vapour Extractor
- d. Unit lube. oil purification system
- e. Unit control oil purification system
- f. Gland steam exhauster
- g. Seal Oil pump
- h. Seal oil evacuation system
- i. Gas dryer system
- j. Stator water cooling pump
- k. Booster pumps for TDBFP
- l. TDBFP lube. Oil pumps
- m. Oil purifiers of TDBFP
- n. MDBFP Auxiliary Oil pump



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- o. Condensate Extraction Pumps (CEP).
- p. Oil pumps for HP & LP bypass system
- q. Condenser air evacuation equipment (Vacuum pumps)
- r. Condenser online tube cleaning pumps
- s. LP drain condensate pump (if applicable)
- t. Chemical Dosing pumps
- u. Closed cooling water pumps (DMCW)

4.3 Balance of Plant

- a. Cycle make-up pumps
- b. Mill Reject system, Duty Factor 0.5
- c. Air conditioning system, Duty Factor 1.0
- d. Ventilation system, Duty Factor 1.0
- e. Plant lighting, Duty Factor 0.6

4.4 Electrical System at 100% TMCR

- a. Generator Transformer losses (at rated Load Condition)
- b. Unit transformers losses (at rated load conditions)
- c. Station transformer losses (at Unit rated load conditions)
- d. Losses in all other transformers (at rated load conditions)
- e. Losses in Bus ducts (at rated load conditions)
 - Isolated Phase Bus Duct
 - Phase segregated busduct
- f. UPS power consumption (at rated load condition)
- g. DC System power consumption (at rated load condition)

4.5 Any Other items which are running continuously.

5.0 GUARANTEES UNDER CATEGORY-I

The Performance Guarantees which attract Liquidated Damages (LD) are as follows:

5.1 Steam Generator:

Efficiency of the Steam Generator at 100% TMCR (800MW unit load) with 27 degree Celsius ambient temperature and 72% RH, while firing the design coal, at rated steam parameters, rated coal fineness and rated excess air. (To be demonstrated as per clause 8.0 of this chapter). The guaranteed efficiency shall be based on Heat Input GCV of coal.

5.2 Steam Turbine Generator:



- 5.2.1 Minimum Gross Turbine Cycle Heat rate in kcal/kWhr under rated steam conditions at design condenser pressure with zero make up at 800 MW unit load (i.e. 100% of rated load). (To be calculated as per the stipulation of cl. no. 10.0 of this chapter). The performance test to be conducted and heat rate to be calculated as per the requirements of code ASME PTC 6.
- 5.2.2 Continuous TG output of 840 MW unit load (i.e. 105% of rated load) under rated steam conditions at design condenser pressure with 0% make-up.

Note: The condenser pressure measurement while conducting the guarantee tests shall be measured at 300 mm above the top row of condenser tubes.

5.3 Electrostatic Precipitator

The ESP efficiency at TMCR condition shall be guaranteed while firing design coal with all fields in service (To be conducted as per the stipulation of cl. no. 11.0 of this chapter).

5.4 Auxiliary Power Consumption

Auxiliary Power Consumption at 100% TMCR unit load. The total auxiliary power consumption for all the steam generator auxiliaries, Electrostatic Precipitator, Turbine Generator Auxiliaries, Equipment cooling water pumps, Mill Reject Handling system, Transformer losses, Plant lighting, bus duct losses etc. required for continuous operation at 100% TMCR under rated steam conditions and with ambient air temperature of 27 degree Celsius & RH of 72%, shall be guaranteed in line with the requirements as stipulated.

Note: Power consumption of each of the pump/fan/compressors/coal pulverizer /heater etc. wherever mentioned shall be measured with its own drive.

6.0 Guarantees Under Category II

The Performance Guarantees, conformance to which are mandatory are as follows:

6.1 NOx emission

Contractor shall guarantee that maximum total NOx emission from the unit shall not be more than 260 grams of NOx (from thermal as well as fuel) per giga joule of heat input to the boiler during the entire operating range of steam generator for the range of coals specified. The emission shall be measured during steam generating capacity test. The bidder shall furnish the methodology of measurement and demonstration of variations w.r.t. load upto 50% of total load.

6.2 ESP Air in Leakage



Bidder shall guarantee that ESP air in leakage shall be limited to 1 % of the total gas flow under guarantee point conditions.

6.3 ESP Outlet Emission

ESP Outlet emission shall be limited to the following for various coals

- Best Coal at 100% TMCR : <35mg/Nm³
- Design Coal at 100% BMCR : <40mg/Nm³
- Worst Coal at 100% BMCR : <50mg/Nm³

6.4 Pressure Drop Across ESP

Bidder shall guarantee that the maximum flue gas pressure drop across the ESP under specified guarantee point conditions shall not exceed 20 mm WC.

6.5 Design Condenser pressure in mm Hg (abs) measured at 300 mm above the top row of condenser tubes under VWO conditions, 1% make up, design CW temperature and CW flow.

7.0 Guarantees Under Category-III

The parameters/capabilities to be demonstrated for various systems/ equipments shall include but not be limited to the following:

7.1 Noise

All the plant, equipment and systems covered under this specification shall perform continuously without exceeding the noise level over the entire range of output and operating frequency. The equivalent 'A' weighted sound pressure level measured at a height of 1.5 m above floor level in elevation and at a distance of one (1) metre horizontally from the nearest surface of any equipment/machine, furnished & installed under these specification, expressed in decibels to a reference of .0002 microbar shall not exceed 85 dba except for:

- a. Safety valves & associated vent pipes for which it shall not exceed 105 dba.
- b. Regulating drain valves in which it shall be limited to 90 dba.

Noise level measurement shall be carried out using applicable and internationally acceptable standards. The measurement shall be carried out with a calibrated integrating sound level meter meeting the requirement of IEC 651 or BS 5969 or IS 9779.



A minimum of 6 points around each equipment shall be covered for measurement. Additional measurement points shall be considered based on the applicable standards and the size of the equipment. The measurement shall be done with slow response on the A – weighting scale. The average of A-weighted sound pressure level measurements expressed in decibels to a reference of 0.0002 micro bar, shall not exceed the guaranteed value.

Corrections for background noise shall be considered in line with the applicable standards. All the necessary data for determining these corrections, in line with the applicable standards, shall be collected during the tests.

7.2 STEAM GENERATOR AND AUXILIARIES

7.2.1 Coal Pulveriser capacity at rated fineness

Performance testing shall be conducted on coal pulverisers toward establishing their guaranteed capacity meeting the specification requirement. Corrections may be applied for the variation in coal characteristics i.e. HGI & Total Moisture of test coal with respect to specified design coal.

Capacity demonstration test shall be carried out for the following conditions:

- i. The Contractor shall demonstrate capacity output on one coal pulveriser (of Employer's choice) of Steam Generator for establishing its capacity at 100% mill loading, at rated pulverized coal fineness with specified design coal with new set of grinding elements.
- ii. Further, Contractor shall also demonstrate capacity output on four coal pulverisers (of Employer's choice) of Steam Generator, not less than the 90% of guaranteed value of (a) above, at 100% mill loading with the originally installed grinding elements in nearly worn-out condition or at the end of guaranteed wear life of grinding elements, whichever is earlier.

Capacity test as mentioned above shall be demonstrated at the following conditions occurring simultaneously during testing:

Rated pulverised coal fineness	a. not less than 70% through 200 mesh and b. not less than 99% through 50 mesh screen
Test Coal	Any available coal from the specified range



In case the Contractor successfully demonstrates the guaranteed capacity of coal pulverisers as stated above, remaining coal pulverisers of corresponding steam generator will also be considered to have successfully met the above capacity guarantee requirement. However, in the event of any of the coal pulverisers not meeting the guarantee test, all the coal pulverisers of steam generator will have to be tested by the contractor to demonstrate guaranteed capacity.

During the demonstration of the pulveriser capacity output, manufacturer's operating instructions will be followed and pulveriser will be operated with the specified range of coals without any such readjustment that requires a shutdown of the pulveriser or reduction of the load and/or any replacement of any pulveriser wear parts. For the purpose of testing to demonstrate the capacity, if HGI (grind ability) and total moisture vary from those given in coal characteristics, the above pulveriser measured capacity shall be corrected using the capacity correction curves furnished by the Contractor and approved by the Employer. HGI versus coal pulveriser capacity curve shall be furnished for HGI variation up to a value above which the capacity remain constant.

7.2.2 Start-up time

Start-up time (upto full load), and loading capabilities for the complete unit(boiler, turbine and generator together) for cold start, warm start and hot start conditions as agreed shall be demonstrated, ensuring that the various turbine operational parameters like vibration, absolute and differential expansion, eccentricity and steam metal temperature mismatch etc. are within design limits.

7.2.3 Performance characteristics of fans

Satisfactory operation of FD, ID and PA fans without undue noise and vibration while operating in isolation or in parallel with other fans shall be demonstrated at site.

7.2.4 No fuel oil support shall be required above 30% BMCR

Contractor shall guarantee that oil support for flame stabilization shall not be required beyond 30% of BMCR load when firing the coals from the range identified. The Contractor shall demonstrate that with any combination of mills/ adjacent mills in service (to Employer's choice) the Steam Generator does not require any oil firing for stable and efficient boiler operation at and above 30% BMCR loads.

7.2.5 Run back capabilities

The contractor shall demonstrate automatic runback capability of the unit (boiler turbine-generator) on loss of critical auxiliary equipment (such as tripping of one ID fan/ FD fan/PA fan/ air heater / BFP/ CEP etc.) ensuring smooth and stable runback operation.



7.2.6 Rate of change of load and sudden load change withstand capability

The contractor shall demonstrate capability of boiler-turbine-generator in regards to ramp rate and step load change as specified.

7.2.7 Furnace Exit Gas Temperature (FEGT)

The contractor shall conduct a comprehensive thermal performance test (TPT), by indirect method. Such test should demonstrate that FEGT does not exceed the specified max. Temperature limit.

7.2.8 Steam Temperature Imbalance

The Contractor shall demonstrate that at SH and RH outlets (in case of more than one outlet) the temperature imbalance between the outlets does not exceed 10 deg C under all loads including transients.

7.2.9 SH and RH tube metal temperature

It shall be demonstrated that superheater and reheater tube metal temperature at critical locations remain within maximum tube metal temperature limits as per design of the OEM under various load conditions (i.e. 100%, 80%, 60% & 50%).

7.2.10 Air Preheater air in leakage

Contractor shall demonstrate that the air-heater air-in-leakage and maximum drift in air leakage do not exceed the guaranteed or specified value (whichever is lower) of Technical specifications. Above requirement needs to be complied with recirculation of flue gas from downstream of ESP.

7.2.11 Reheater & Superheater attemperation spray water flow

It shall be demonstrated that the spray water flow of SH attemperation system does not exceed 8% of main steam flow, at superheater outlet, while firing any coal from the range specified with HP heaters in service while maintaining the rated SH outlet steam temperature at all loads up to and including BMCR.

It shall also be demonstrated that the RH temperature is maintained at the rated value without any spray water requirement under normal operating conditions (100% TMCR)

7.2.12 Coal Mill Wear Parts Warranty

Life of coal pulveriser wear parts, in hours of operation, for the entire range of coal characteristics specified. (To be demonstrated as per clause 9.0 of this chapter).



7.3 Generator excitation system

The performance of generator excitation system as specified shall be demonstrated.

7.4 Condenser On Load Tube Cleaning System

Life of sponge rubber balls and number of balls lost during 1000 hours of plant operation shall be as indicated by Bidder in the offer and accepted by the Employer.

7.5 Steam condensing plant

- a. Temperature of condensate, at outlet of condenser, shall be demonstrated to be near to saturation temperature corresponding to the condenser pressure at all loads.
- b. Oxygen content in condensate at hot well outlet shall not exceed 0.015 cc/litre over 50-100% load range and shall be determined according to calorimetric Indigo-Carmine method.
- c. Air leakage in the condenser under full load condition shall not exceed more than 50% of design value taken for sizing the condenser air evacuation system.
- d. When one half of the condenser is isolated, condenser shall be capable of taking at least 60% T.G. load under TMCR conditions.
- e. The design capacity of each vacuum pump in free dry air under standard conditions at a condenser pressure of 25.4 mm Hg (abs) and sub cooled to 4.17 Deg. C below the temperature corresponding to absolute suction pressure shall be demonstrated. Correction curves for establishing the capacity at site conditions shall also be furnished.
- f. The air and vapour mixture from air cooling zone of condenser shall be 4.17 deg. C below the saturation temperature corresponding to 25.4 mm Hg (abs) suction pressure. Correction curves for establishing the same at site conditions shall also be furnished.

7.6 Feed Water Heaters and Deaerator

The following parameters shall be demonstrated:

- a. TTDs and DCAs of feed water heaters shall be demonstrated as per guaranteed heat balance diagram for 100% TMCR condition.
- b. Outlet temperature from final feed water heater(s)



- c. Dissolved Oxygen content in Deaerator effluent at deaerator outlet without chemical dosing at all loads, not to exceed 0.005 CC/litre determined as per ASTM-D-888 – Reference method-A or Indigo Carmine method.
- d. Difference between saturation temperature of steam entering the deaerator and temperature of feed water leaving the deaerator shall be demonstrated as per guaranteed heat balance diagram for 100% TMCR condition.
- e. Continuous and efficient operation and performance of feed heating plant without undue noise and vibrations at all loads and duty conditions

7.7 HP & LP Bypass System Capability

The HP & LP bypass system should satisfy the following functional requirements under automatic interlock action. It should come into operation automatically under the following conditions:

- a. Generator circuit breaker opening
- b. HP & IP stop valves closing due to turbine tripping
- c. Sudden reduction in demand to house load

Under all above conditions, while passing the required steam flows as per the relevant heat balances, the condenser should be able to swallow the entire steam without increasing the exhaust hood temperature and condenser pressure beyond the maximum permissible values. The same shall be demonstrated.

7.8 Power Cycle Pumps

Satisfactory operation of BFPs and CEPs without undue noise and vibration while operating in isolation or in parallel with other pumps shall be demonstrated at site.

7.9 Condensate Polishing Unit

- a. Effluent quality at outlet of each vessel at its rated design flow and design service length between two regenerations.
- b. Pressure drop across the polisher service vessel in clean and dirty condition of resin at rated design flow.

7.10 Power Cycle Piping

Actual hanger readings under cold and hot condition (at rated parameters) to match with those of design cold and hot hanger readings for MS/CRH/HRH/HP & LP bypass piping system



7.11 Passenger & Goods Elevator

Over load tests, travel and hoist speed checks.

7.12 Mill Reject System

- a. Continuous effective discharge and conveying at the rated capacity of the mill rejects without spillage or blockage in the system.
- b. Power consumption, Capacity and discharge pressure of air compressor shall be demonstrated at shop.
- c. Parallel operation of air compressor shall be demonstrated at site.
- d. Vibration level and noise level of each air compressor, blowers and any other rotating equipment shall be demonstrated at site.

7.13 Equipment Cooling Water System

- a. Vibration, parallel operation and noise level of all the pumps at the rated duty point shall be demonstrated at site
- b. Design heat load of plate type heat exchangers and Inlet & Outlet temperatures of the Plate type heat exchangers on the primary and secondary side to be demonstrated at site.
- c. Pressure drop across the Plate type heat exchanger on the primary & secondary water circuit to be demonstrated at site.

7.14 EOT Crane: Over load test, travel & hoist speed checks etc., shall be demonstrated as per IS: 3177 (latest edition).

7.15 Air Conditioning and ventilation System:

7.15.1 Following shall be demonstrated at shop

- i) Capacity and discharge pressure of chilled water pumps, condenser water pumps and pumps of air washer and unitary air filtration units at its rated duty point of Air conditioning and Ventilation system.



- ii) Capacity and static pressure of air washer unit fans, Unitary air filtration unit fans, roof exhausters of TG building and AHU fans at its rated duty point of Air conditioning and Ventilation system.

7.15.2 Following shall be Demonstrated at Site

- i) AC plant capacity of each area and guaranteed room conditions during summer for all the Air conditioned areas.
- ii) Parallel operation, Vibration & Noise level of all rotating equipment.

7.16 Control & Instrumentation System Requirements

7.16.1 Availability Tests

The Bidder shall guarantee 99.7 percent system availability for a continuous period of 180 days. An availability guarantee test shall be conducted to assure this level of availability. If the accrued down time exceeds 0.3 percent of 180 days, during availability test run, a new 180 days test run shall start at the time when the system becomes available again. Loss of availability (unavailable system) shall be defined as the loss of the system's guaranteed accuracy and repeat ability or of any system function, except however, that the loss of a function for not more than five percent of the points shall not be considered loss of availability instead it shall be treated as partial unavailability and the corresponding outage time shall be weighted with respect to the function and the percentage of the points for which the function is unavailable. Loss of each function shall have one weighing factor and unavailability of each equipment, peripheral device or process I/O card etc. shall have another weighing factor. The guaranteed accuracy and repeatability and system parametric requirements specified in clauses on system parametric requirements shall be maintained for the entire 180 days run without any manual recalibration or any other changes made to the DDCMIS.

Downtime shall start upon loss of a system function and shall end upon full restoration of the affected system function. A minimum of one hour's down time shall be charged for each loss of availability in determining system availability.

The Bidder shall submit the Availability Test procedure for Purchaser's approval. The details regarding outage time, weighing factors for various system functions equipment to calculate the down time, test duration etc., shall be discussed and finalized during detail engineering.

7.16.2 Performance Requirement of the Closed Loop Control System

- (i) The closed loop Control System shall permit the performance of the following dynamic load tests while maintaining safe furnace conditions, major process parameters and without endangering other equipment. All tests will be performed with the system in automatic mode:



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- Drop 50 percent of maximum load capability from approximately full load at a rate of 10 percent per minutes.
- Drop load from full rated output to the lowest runback limit, at a rate corresponding to the fastest run back rate
- Pick up 50 percent of the maximum load capability from approximately 50 percent load at a rate of 10 percent per minute.

During transient conditions causing deviation of process variables, the control system furnished under the specification shall not permit deviations which exceed those permitted by the manufacturers of the controlled process equipment, for load changes as indicated above. The exact parameters to be monitored for this test are given in the following table- (The Bidder as per the data shall also fill up the deviation limits from main equipment suppliers in the technical data sheet. For the test, more stringent of the two shall be applied). The control loops shall perform to return the controlled variable to the set point in a stable manner without cycling in the shortest possible time and without any loop interactions or cycling of generation when generation matches unit load demand.

PERFORMANCE REQUIREMENTS FOR CLOSED LOOP CONTROL SYSTEM (TABLE-I)

S.no.	Range	Load / Rate of load Change (% of MCR	Maximum Deviation Of Parameters from Set Point				
			Throttle pressure Deviation (kg / cm 2	Flue gas oxygen Deviation (% O2)	Furnace pressure deviation (mmwc)	S.H. steam temperatur e deviation	R.H. steam temperatur e deviation
A	Steady state condition						
1.	90% to	0	+3.0	+0.5	+3.0	+4.0	+6.0
2.	60% to 90%	0	+3.0	+0.5	+3.0	+4.0	+6.0
B.	Ramp test (change for max. duration of five minutes)						
1.	30% to 50%	+3%	+3.0	+0.6 / -	+7.0	+10.0	+ 10.0
2.	50% to 90%	+5%	+5.0	+0.8 / -	+12.0	+10.0	+14.0
3.	90% to	+10%	+7.0	+1.0 / -	+12.0	+10.0	+14.0
C.	Step load changes						
1.	From 100% to 80%	at the rate of 10% per	+7.0	+1.5 / - 0.5	+20.0	+15.0	+20.0

Notes:

- a. Sufficient time shall be allowed as setting period between conducting the tests.
- b. Plant operating condition, i.e. main equipment status, availability of auxiliaries,



operational and equipment constraints, which can influence the test, shall also be recorded.

- c. Control system shall be running in the coordinated master control (CMC) mode i.e. boiler master, fuel flow, air flow, feed water and turbine load control shall be in automatic mode. Load set point, maximum and minimum load set point, rate of raise / lower of load shall be set through the OWS, keyboard / conventional console.
- d. These tests will be conducted within 30 days of attaining 80% load.

The Bidder shall also guarantee that the control system provided by him will be responsive and stable and will maintain the deviation of controlled variables from set point within the limits specified so that the equipment being controlled will operate as specified over the range required. The controls shall operate automatically, with no assistance from the operator. The controller shall successfully demonstrate the performance of Closed Loop Control Systems before acceptance and taking over of this system by the Purchaser.

- (ii) The following parametric tests shall also be conducted under worst case loading conditions (which is basically equivalent to a trip condition - details of which shall be as approved by Purchaser during detailed Purchasing.

- (a) For control system
 - CPU loading, Cycle time/controller reaction time and memory spare capacity
- (b) For MMIPIS
 - CPU loading, spares duty cycle, spare memory capacity
- (c) Spare duty cycle for system bus
- (d) Various display response time
- (e) System accuracy
- (f) LED update time

- (iii) For the parametric test, the following requirements shall be met

- (a) Processor Spare Duty Cycle (Free Time)
 - Under worst case loading of MMIPIS and system bus each MMIPIS processor shall have 40% free time when measured over any two second period and 50% free time when measured over any one minute period.
 - Under worst case loading conditions of control system control system processor shall have 20% free time when measured over any one minute period.

- (b) System Bus Spare Duty Cycle (Free Time). The Bidder shall furnish all



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necessary data to fully satisfy the Purchaser that the processor spare duty cycle figures quoted by the Bidder are realistic and based on configuration and computation capability of the offered system and these shall be actually achieved in the fully implemented system as commissioned at project site.

The system bus shall have min. 50% free time during the worst case loading conditions of control system, MMIPIS and the system Bus, measured over any 2 seconds interval.

(c) Display Response Time

The system shall acknowledge all operator requests in one of the following manner within one second of pressing of the last button:

Commencement of the requested display

OR

Acknowledgment of operator request in a suitable manner.

The display response time as defined above, under the worst case loading conditions shall not be worse than the following:

1	All control related displays	1 sec
2	Point Details Display(Single point)	1-2 secs
3	Bar chart display (20 points, Current data)	1-2 secs
4	Operator guide / plant start-up Guide message display (full Screen of alphanumeric Information and a maximum Of ten numbers of dynamic Data items)	1-2 secs
5	Plant mimic display of fair Complexity with a minimum of 120 numbers of dynamic data Items e.g., values, macros, Line segment, etc.	2-3 secs
6	Group review display (current Values of twenty points)	2-3 secs
7	X-Y plot display (2 X-Y- plots And a single display requiring Both historical as well as Current data)	3-4 secs
8	X-T plot display (Trend of 6 Analog points and a single Display requiring both historical As well as current data)	3-4 secs
9	Plant Summary display (e.g.,Bad point summary, limit check Removed point summary. Assume the whole data base search is Required and the summary	3-4 secs



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	display Contains ten points only).	
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The response time for screen update after the execution of the control command from the time the command is issued (for example command to start a motor to the time the screen is updated) shall be two seconds (excluding the drive actuation time).

(d) System Accuracy Requirements

The overall system accuracy from signal input terminals to output presentation on LED display and printers for the least accurate input range and maximum scan rate shall be no worse than $\pm 0.2\%$ of full scale of the process range.

(e) LED Updated Rates

All LED displays shall be updated at least every two seconds.

(f) The spare capacities of working and bulk memory shall meet the requirements indicated in the technical specification.

(iv) The operating capabilities of the plant as listed out under relevant clause shall also be demonstrated along with other parameters/ capabilities specified under category-III guarantees. The treatment of these operating capabilities of compliance/ non-compliance shall be the same as given to other Cat.-III guarantees.

8.0 Major Requirements/ Method Of Steam Generator Efficiency Tests

1	Test Code	As per PTC 4
2	Test Loads	105% TMCR (VWO unit Load) 100% TMCR (800 MW unit Load)
3	Test Conditions	Boiler operating with rated excess air, coal fineness and firing design coal.
4	Ambient air condition	27 degree Celsius temperature (Dry bulb) and 72% relative humidity. The reference air temperature for the efficiency guarantee/ testing shall be taken as the temperature of air (i.e. 27 degree Celsius) entering PA and FD fans.
5	No. of readings	Two sets of consistent readings for each of test loads. Average of the test efficiencies based on above two readings for each load shall be considered for guaranteed efficiency.
6	Measurement and computation of heat losses will include but not be limited to the following: As Per PTC 4	
7	The guaranteed steam generator efficiency shall be without any heat credit.	



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8	The Steam Generator efficiency shall be guaranteed based on ambient air temperature of 27 degree Celsius and relative humidity of 72%.
9	Correction to tested efficiency shall be applicable for variation in following parameter only :
i	Ambient air temperature.
ii	Relative humidity of ambient air.
iii	Hydrogen in coal.
iv	Moisture in coal.
v	GCV of coal.
vi	Percentage of ash in coal.
10	The duration of the test shall be at least four hours. No soot blowing shall be allowed during the test period or during stabilization period of four hours prior to commencement of the test.
11	The Bidder shall furnish the correction curves, for Employer's approval covering the expected ranges of variations for all these parameters for the range of coal specified
12	For all other aspects, not spelt out above, or in the specifications, where BS code stipulates the agreement between the parties concerned before commencement of the test, the Bidder shall get these approved by the Employer. However no correction to SG efficiency on account of variation in turbine cycle parameters, or vice versa shall be allowed.
13	The number, location, type and accuracy of the test grade thermocouples and pressure gauges shall be to Employer's approval
14	The Steam Generator efficiency testing shall be carried out with any combination of mills in operation to Employer's choice, with fineness of pulverized coal not exceeding 70% through 200 mesh.
15	Steam generator efficiency shall be with guaranteed or actual air heater leakages, whichever is higher.

9.0 MAJOR REQUIREMENTS FOR COAL PULVERISER WEAR PART WARRANTY

9.1 The Contractor shall warrant the wear life of all wear parts of the coal pulveriser when grinding the specified range of coal(s). Pulveriser wear parts are defined as those parts of the pulveriser which are in contact with coal or coal dust and are likely to wear out during the operation of the pulveriser. The guarantee/warranty shall be demonstrated on each pulveriser during the Guarantee Trial Period (GTP).

9.2 Minimum Guaranteed Life for various coal pulveriser wear parts shall be as indicated in Volume II, Section 2, Part 2.1 Mechanical Works, Clause no 2.1.1.73(n).



- 9.3 The wear parts shall be considered to have passed their warranted operating life when they have successfully demonstrated their capability to meet the full load rated capacity of the pulveriser (as per requirements of Technical Specification) during the guaranteed life of the wear part. No weld build-up or reversing of grinding elements will be permitted for achieving the guaranteed wear life. In case any of the wear part has worn out to such an extent that either the normal or safe operation of the pulveriser is jeopardized if this part is not replaced/repared, or continuous use with this part may lead to exposure or wear of other parts which are not meant for the purpose of checking the shortfall in wear life, even if there is no reduction in pulveriser rated capacity, then the part shall be deemed to have outlived its wear life. The rated capacity of pulveriser is defined in subsequent section of Technical Specification. If any of the wear parts fail to meet the warranted life, additional quantities of these wear parts shall be supplied on pro-rata basis as defined in Clause 9.7 below.
- 9.4 **Computation of Credit for GTP**
For the duration of this warranty period, the replacement wear parts shall be available to the Owner at the spare part price indicated in the Contract, adjusted as per terms and conditions of the Contract. For wear parts that do not fulfill warranty requirements, credit shall be provided at the end of GTP to the Owner at the rate of one and a half times the shortfall worked out on item wise pro-rata basis. For example should an individual wear part or set of wear parts taken together have a price of INR 10,000 (Rupees ten thousand) and any of the wear part or any part of wear parts set that failed to meet the warranty test lasts only 6000 hrs, a credit of 1.5 times of 2000 hrs out of guaranteed 8000 hrs or INR $(10000 \times 1.5 \times 2000) / 6000$ would apply towards Owner and shall be provided by the Contractor. This credit shall be worked out for each replaced wear part/wear part set, throughout the GTP. This credit shall apply to all the affected mandatory spare parts purchased under original Contract.
- 9.5 **Computation of Liquidated Damages for remaining plant life**
On the expiry of GTP (minimum 2 years), deficiency in the life of each wear part that has not fulfilled the warranty will be worked out on an item wise basis and shortfall so established due to reduced wear life and its implications for the remaining plant life shall be worked out. The contractor at no extra cost to the Owner shall provide one and half times the wear parts needed to make good the shortfall in the wear life during the plant operation period of 23 years from the successful completion of GTP or the remaining of 25 years of plant life period after completion of GTP for the respective wear part.
- 9.6 The shortfall part settlement (SPS) will be calculated based on the actual wear life at the parts that have worn-out in the GTP on a pulveriser-by-pulveriser basis. In this connection the procedure given below in clause 9.7 shall be followed.
- 9.7 **Pulveriser Warranty Shortfall Part Settlement (SPS) Procedure (With Example):**
For all wear parts of each vertical coal pulveriser:



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S. No.	Description	Procedure	Example
(i)	Guaranteed wear life of wear part	(say X hours)	X=15000 Hrs.
(ii)	Total life achieved by failed wear part for two similar parts 1 & 2 (say X1 & X2 hours)	X1=12000 Hrs X2=13000 Hrs	Life of wear parts replaced during guarantee trial period (GTP)
(iii)	Average wear life (AWL) of failed wear parts	$AWL = \frac{X1 + X2}{2}$	$AWL = \frac{12000 + 13000}{2}$
(iv)	Short fall in Hrs Total shortfall for wear part during 2 year GTP	$S = (X - X1) + (X - X2)$	$(15000-12000) + (15000-13000)$ = 5000
(v)	Shortfall part settlement (SPS)	$= \frac{S \times (25 - GTP)}{AWL \times GTP}$	$= \frac{5000 \times (25 - 2)}{12500 \times 2}$ = 4.6 = 5.0 (say) (To be rounded off to next higher whole number)

9.8 The Contractor shall provide to OWNER either the wear parts of original or better quality material in number equivalent to one and a half times the quantity worked out based on the



method explained in the above example so as to compensate for the shortfall in wear life for a plant life of 25 years as has been established above, or the cost of such number (i.e. one and half times the quantity worked out as per the above example) of wear parts based on the prices agreed for mandatory spares. The final mode of compensation for such shortfall viz by means of additional quantities of spares worked out or by cost thereof shall be as per Owner's discretion. The total cost of such replacements shall be without any limit to the maximum amount recoverable subject to the provisions of Clause 3.2 note (d) of this chapter.

- 9.9 Average Wear Life (AWL) during GTP, to be considered for pulveriser wear part warranty shall be as arrived at from the station record for each pulveriser, and as corrected for variation in YGP index of the coal being fired during GTP. For this purpose the coal YGP shall be the average tested value during GTP. The Contractor shall collect the coal samples and get them tested for YGP index at recognized, Owner's approved test lab, periodically. (The frequency of sampling and testing shall be mutually agreed between Contractor & Owner). The YGP index testing shall be done as per the Standard specified. A jointly signed record shall be maintained during GTP.

10.0 Method of Computing Heat Rate:

Turbine Cycle Heat Rate shall be calculated as follows & indicated in all computed heat balance diagrams:

$$\text{HEAT RATE} = \frac{M1 (H1-h1) + M2 (H3-H2) + Mis (h1-his) + Mir (H3 - hir)}{Pg}$$

The expression "Mis (h1-his)" in the numerator of the formula is not applicable if spray water to superheater is completely internal to the boiler (i.e. tapped from a location downstream of economizer inlet).

Where,

M1 - Quantity of live steam entering the turbine stop valve including any live steam supplied to valve stems, or glands etc. in Kg/hr.

M2 - Quantity of steam from turbine to reheater in Kg/hr.

Mir - Quantity of desuperheating water flowing into reheater system for regulation of steam temperature in Kg/hr.

Mis - Superheater desuperheating spray flow in Kg/hr.

H1 - Enthalpy in kcal/kg of live steam.

H2 - Enthalpy in kcal/kg of steam to reheat.



H3 - Enthalpy in kcal/kg of reheated steam.

h1 - Enthalpy of feed water in kcal/kg at the downstream of the junction of feed flow and bypass flow of HP heaters.

hir - Enthalpy of desuperheating water flowing into reheat system in Kcal/Kg.

his - Enthalpy of superheater desuperheating spray water in Kcal/Kg.

Pg - Unit output after deducting the power consumption by auxiliaries as listed below

- a. Power taken by Excitation system (KW) including transformer losses, as applicable for various guarantee points, in case of static excitation system is offered. (The transformer losses at various points shall be based on factory test to be conducted).
- b. Power required for ventilation of oil and control fluid tanks, if ventilating fans are separately driven (KW).
- c. Power required for lubrication, if lubricating pumps are separately driven (KW).
- d. Power required for control fluid pumps, if control fluid pumps are separately driven (KW).
- e. Power required for hydrogen, seal oil auxiliaries, if separately driven (KW).
- f. Power required for stator water cooling system, if cooling pumps are driven separately (KW).
- g. Power required for motors, heaters etc. of any other auxiliary service for the turbine generator (KW).

It may be noted that the heat balance diagrams and guarantees shall be furnished considering zero spray water quantity for superheater and reheater spray. During Performance Guarantee Testing, in case water is required for superheater and/or reheater temperature control, the contractor shall be entitled to heat rate correction as per correction curves to be submitted by him with his offer

11.0 Method of Computing Test Efficiency of ESP

- 11.1 The performance test on electrostatic precipitator will commence after a minimum period of three thousand (3000) hours of continuous operation after completion of initial operation. During the interval between the commencement of initial operation and the commencement of performance test only routine maintenance shall be carried out. No physical or chemical



cleaning of ESP shall be permitted during this period or immediately before the conductance of the performance tests.

- 11.2 The test efficiency shall be based on the overall performance of the electrostatic precipitator over a mutually agreed period of operation under the conditions given in this specification and allowing the normal operation of the unit including rapping and normal soot blowing and/or when fuel oil is being fired in the igniters and/or warm up guns.

The overall test efficiency and test temperature/inlet dust burden for one set of ESP passes (stream) serving Steam Generator shall be worked out as follows:-

- a. V_m (guarantee point test flow) shall be the total of inlet gas flows to the six gas streams at the time of test.
- b. Test inlet dust burden (D_i) shall be weighted mean of the inlet dust burdens for the individual streams i.e.:
- $$(V_{m1} \times D_{i1}) + (V_{m2} \times D_{i2}) + (V_{m3} \times D_{i3}) + (V_{m4} \times D_{i4}) + (V_{m5} \times D_{i5}) + (V_{m6} \times D_{i6})$$

$$D_i = \frac{\text{-----}}{(V_{m1} + V_{m2} + V_{m3} + V_{m4} + V_{m5} + V_{m6})}$$

Where suffix 1, 2, 3, 4, 5 & 6 represent the six gas stream.

Similarly the test outlet dust burden (D_o) will be calculated based on outlet gas flow.

- c. The weighted test inlet gas temperature (T_i) shall also be worked out in a similar manner i.e.:

$$(T_{i1} \times V_{m1}) + (T_{i2} \times V_{m2}) + (T_{i3} \times V_{m3}) + (T_{i4} \times V_{m4}) + (T_{i5} \times V_{m5}) + (T_{i6} \times V_{m6})$$

$$T_i = \frac{\text{-----}}{(V_{m1} + V_{m2} + V_{m3} + V_{m4} + V_{m5} + V_{m6})}$$

- d. The measured test efficiency shall be :

$$D_i - D_o$$

$$E_m = \frac{\text{-----}}{D_i} \times 100 (\%)$$

- e. The corrections for the variation in flue gas flow, inlet dust burden and ESP inlet flue gas temp. Shall be based on the above computed test values and the procedure indicated in the next para.

Note: 5th & 6th gas stream if applicable

- 11.3 At the time of performance testing if the inlet flue gas conditions are not consistent with the specified conditions, due to variation in coal characteristics from the design coal and boiler operating conditions the precipitator performance conforming to this specification, shall be



determined using performance curves and correction factors accepted at the time of award of contract. However, the test efficiency shall be corrected to the guarantee point conditions in the following manner: -

a. $E_c = 1 - e^z$

Where E_c = Corrected test efficiency to guarantee point conditions.

$Z = C \cdot \ln(1 - E_g)$ and

$C = \frac{1}{Ca \cdot Cb \cdot Cc \text{ etc.}}$

Ca.Cb.Cc are Correction factors for flue gas at temperature, ESP inlet dust loading & sulphur based on correction curves furnished by the Bidder and approved by the Owner.

b. $E_g = 1 - e^y$

Where

$Y = (V_m/V_g)^{0.5} \ln(1 - E_m)$

E_g = Measured test efficiency corrected to the specified guarantee point flow.

V_g = Specified Guarantee point gas flow (m³/sec).

V_m = Measured gas flow (m³/sec).

E_m = Measured test efficiency

$\ln$ = Logarithm, natural base.

The correction curves should be realistic for expected range of operation and variation in characteristics specified.

The test efficiency shall be the average of at least two corrected test efficiencies.

11.4 The Performance tests shall be carried out in accordance with method-17 of EPA (Environmental Protection Agency of USA) code. The details of the test shall, however be mutually agreed upon between the Owner and the Bidder.

12.0 METHOD OF COMPUTING AUXILIARY POWER CONSUMPTION FOR ESP

For guarantee purpose, total maximum continuous Auxiliary power consumption will be the power consumption of corona power (Excluding power consumption by hopper heaters, insulator heaters, rapping system, ventilation fans etc.) of all fields of all passes of ESP. Corona power of TR sets will be computed at the input terminals of the TR sets when all ESP fields of all ESP passes are working and rapping system is in normal operation at the guarantee point condition as specified. The measurement for guaranteed auxiliary power consumption shall be carried out during ESP collection efficiency test. The method for computing the corona power shall be as described below:-



- i) Power consumption of TR sets will be measured pass wise and for one pass (Say ESP-A) at a time with the help of energy meter in ESP MCC.
- ii) Power consumption of TR sets will be measured pass wise and for one pass (Say ESP-A) at a time with the help of energy meter in ESP MCC.
- iii) Before starting collection efficiency test, switch off all the TR sets serving to one pass (ESP-A) temporally and note down energy meter readings for period t1 i.e. E1. Power consumed by hopper heaters, shaft and support insulator heaters and rapping systems shall be $W1 = E1/t1$. The time period t1 shall be minimum 4 hours.
- iv) During the collection efficiency test the total energy fed in to ESP MCC of one pass (say ESP-A) will be measured during entire period of collection efficiency test i.e. E2. Total time period (t2) of test shall be noted. The power consumption shall be $W2=E2/t2$. During this period, no change in the status of hopper heaters, insulator heaters, rapping system, ventilation fans etc. will be allowed w.r.t. the condition at clause (iii) above. In case there is any change in the status of hopper heaters, insulator heaters, rapping system, ventilation fans etc., then auxiliary power consumption test will be repeated again.
- v) Measured corona power consumption for one pass (say ESP-A) = $(W2-W1)$
- vi) Measured corona power of all six pass = Corona power of (ESP-A + ESP-B + ESP-C + ESP-D + ESP-E + ESP-F).
- vii) Number of fields shall be as per the PG test of ESP as detailed elsewhere.

13.0 Turbine Generator Performance/ Acceptance Test

- 13.1 Performance test for the turbine generator set will be conducted in accordance with the latest edition of ASME PTC-6. Such test shall be binding on the parties to the contract to determine compliance with the guaranteed heat balance conditions at 840 MW (105% TMCR) and 800 MW (100% TMCR) output corresponding to the conditions stipulated under Clause 2.1.3.31 of Volume II, section-2 (Turbine Generator and Auxiliaries). Power consumed by the auxiliaries mentioned under clause 4.0 of this chapter which is to be deducted from electrical power generated, shall be measured during the performance / Acceptance Test. Wherever the measurement is not possible, design values of power consumption by an auxiliary shall be considered.
- 13.2 The essential mandatory requirements for instruments, methods and precautions to be employed shall be in accordance with the requirements specified in the respective codes. All the necessary instruments (in duplicate) required for the tests shall be furnished by the contractor so as to meet the accuracies specified in the codes. Any advanced class instrument



system such as those using electronic devices or mass flow technique shall be arranged by the contractor, if required. For determination of primary flow to the turbine, a calibrated low Beta-ratio throat-tap nozzle assembly including required machined straight lengths meeting the requirement of ASME PTC-6 shall be provided. The test procedures, Calibration Standards, Calibration procedures etc., shall be subject to Employer's approval. All the instruments including the flow nozzle shall be calibrated by the contractor before and after the test, in a reputed international institute as approved by the Employer.

However, post-test calibration of flow nozzle shall not be mandatory. These calibrations shall be performed in the presence of the Employer. All calibrations shall be made available prior to the test and calibration certificates in original submitted to Employer at least 15 days before conductance of the test for Employer's approval.

The instruments shall be sealed after calibration by calibrating lab. The percentage calibration error/deviation should not be more than accuracy class of the instrument. Calibration low beta ratio throat tap nozzle assembly including flow straightener, upstream and downstream machined straight lengths, for main condensate flow measurements shall be as per ASME PTC-6. Secondary flow devices shall be calibrated flow nozzle / orifice plate as per ASMEPTC 19.5.

13.3 Corrections to the test results for steam turbine shall be applied as per the correction curves listed in technical specification. When the system is properly isolated for a performance test, the unaccounted for leakages should not be more than 0.1% of the design throttle flow at that load. To achieve the above value of unaccounted for leakages, the Bidder shall prepare the unit during pretest available shutdown. However, during the test, if it is found that the unaccounted leakage is more than 0.1% of design throttle flow at that load, then heat rate will be increased by an amount equal to half the difference between actual unaccounted for leakage expressed as percentage of design throttle flow at that load and 0.1% (allowed by the code).

13.4 The performance guarantee test will be carried out after successful completion of initial operation. Ageing allowance will be given during evaluation of PG test results and hence guaranteed heat rates shall be increased by the amount calculated as per the formula given in Cl.No.3.07, Sub-Section-3 of ASME PTC-6 Report 1985 (Reaffirmed 1991). Period of ageing shall be considered from the date of successful completion of initial operation to the date of conductance of PG test,

In calculating the above factor any period(s) during which the turbine has not been in operation at a stretch for more than a week shall not be considered.

13.5 The tests shall be arranged in a manner that the EMPLOYER's operation is not disrupted. Duplicate test runs shall be performed at 840 MW and 800 MW loads. The results of corrected heat rate shall agree within 0.25%. If they differ by more than 0.25%, third test shall be run at



the same point. The corrected result of any one of the three test runs, which deviates from the corrected averaged result of all the runs by more than 0.25%, shall be eliminated; otherwise the results of all the three tests runs shall be accepted.

- 13.6 During Performance/ Acceptance test, following tests shall be carried out for T.G. set with test grade instruments as per ASME code:
- Guarantee Turbine Cycle Heat rate test at 800MW corresponding to the heat balance diagram specified in the tender specification.
 - Guarantee Output test of 105% rated load corresponding to the heat balance diagram specified in the tender specification.
 - Maximum continuous output corresponding to both strings of HP heaters out of operation, under rated steam conditions at design condenser pressure with 1% makeup.

14.0 Performance test for the condensers

- 14.1 Performance test for design condenser pressure shall be conducted in accordance with latest edition of ASME PTC- 12.2.
- 14.2 Condenser pressure will be measured at 300 mm above the top row of tubes under VWO conditions, 1% make-up and design C.W. flow & design temperature. The condenser pressure shall be measured with a vacuum grid utilizing ASME basket tips. The grid is fitted at 300 mm above top row of condenser tubes.
- 14.3 Tube plug margin of 5%, as per design condition, shall be considered for condenser performance calculation at design condition.
- 14.4 If tube side fouling resistance for actual test condition is not measured as per methodology given in PTC 12.2, the tube cleanliness factor corresponding to the same shall be appropriately assessed considering the aspect of actual tube cleaning prior to conducting the test.

15.0 Test Reports

The Contractor shall prepare test reports for Efficiency Test, Capacity Test and the Emissions test, in which the methods followed, instrument readings, graphs, observations, final results obtained, etc., shall be recorded.



TAMILNADU GENERATION AND DISTRIBUTION CORPORATION LIMITED
1X800MW COAL BASED SUPERCRITICAL NORTH CHENNAI THERMAL POWER PROJECT
STAGE III IN THE PREMISES OF EXISTING NCTPS TAMILNADU, INDIA

EPC BID SPECIFICATION

FOR

**DESIGN, ENGINEERING, MANUFACTURE, ASSEMBLY, TESTING AT WORKS, SUPPLY, ERECTION,
TESTING AND COMMISSIONING OF STEAM GENERATOR, STEAM TURBINE GENERATOR AND
OTHER AUXILIARY EQUIPMENTS INCLUDING CIVIL WORKS**

BID SPECIFICATION NO. SE/E/T& H (P)/OT No.02/2015- 16

INTERNATIONAL COMPETITIVE BIDDING



VOLUME-II SECTION 2

PART 2.5 - QUALITY ASSURANCE PLAN

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1	VOLUME I	SECTION 1 – INSTRUCTION TO BIDDER'S SECTION 2 – GENERAL CONDITIONS OF CONTRACT SECTION 3 – ERECTION CONDITIONS OF CONTRACT SECTION 4 – SPECIAL CONDITIONS OF CONTRACT SECTION 5 – FORMATS & SCHEDULES
2	VOLUME II	SECTION 1 – DESIGN BASIS CHAPTER 1 – INTENT OF SPECIFICATION CHAPTER 2 – PROJECT INFORMATION CHAPTER 3 – SCOPE OF SUPPLY & SERVICES CHAPTER 4 – TERMINAL POINTS CHAPTER 5 – PERFORMANCE GUARANTEES & LD FOR SHORTFALL CHAPTER 6 – GENERAL TECHNICAL REQUIREMENT CHAPTER 7 – PROJECT MANAGEMENT CHAPTER 8 – PAINTING CHAPTER 9 – DRAWING/ DOCUMENTS TO BE SUBMITTED SECTION 2 – TECHNICAL SPECIFICATION PART 2.1 – MECHANICAL WORKS PART 2.2 – ELECTRICAL WORKS PART 2.3 – CONTROL & INSTRUMENTATION WORKS PART 2.4 – CIVIL WORKS PART 2.5 – QUALITY ASSURANCE & INSPECTIONS SECTION 3 – TECHNICAL DATA SHEET PART 3.1 – MECHANICAL WORKS PART 3.2 – ELECTRICAL WORKS PART 3.3 – CONTROL & INSTRUMENTATION WORKS SECTION 4 – TENDER DRAWING PART 4.1 – MECHANICAL DRAWING PART 4.2 – ELECTRICAL DRAWING PART 4.3 – CONTROL & INSTRUMENTATION SECTION 5 – MANDATORY SPARES PART 5.1 – MECHANICAL PART 5.2 – ELECTRICAL PART 5.3 – CONTROL & INSTRUMENTATION

Section 2

Technical Specification

Part 2.5 Quality Assurance Plan

Quality Assurance Plan

Part 2.5.1 Mechanical Works



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2.5.1 QUALITY ASSURANCE PLAN-MECHANICAL WORKS

2.5.1.1 GENERAL REQUIREMENTS

a. Shop Tests

Shop tests shall include all tests to be carried out at Contractor's works, at works of his sub-contractor and at works where raw material supplied from manufacture of equipment is manufactured. Testing requirement of major equipment over and above the respective code / standard requirements are given

b. Site Tests

The Contractor shall prepare and submit detailed field quality plans by setting out the quality practice and procedures to be adopted by him for assuring quality for each equipment of material at this specification from the receipt of material at site, during storage erection, pre-commissioning to final commissioning of the plant. These procedures shall necessarily include all checks/tests conducted at site for preservation, assembly, alignment, positioning of the equipment, foundation preparation, welding/bolting heat treatment, non-destructive examination, hydraulic test, running test, performance test etc. The Contractor shall also furnish detailed quality procedure proposed by him for storage, preservation, painting, acid cleaning, alkali boil out, steam blowing, hydraulic test air/gas tightness test etc. to the Employer. The same shall be discussed and finalized with the Employer and six numbers of such finalized copies shall be submitted.

2.5.1.2 SHOP TESTS FOR STEAM GENERATOR

I. PRESSURE PARTS

- (i) The material which can be identified against mill sheet or manufacturer test certificate only shall be used in the manufacture of pressure parts. Material shall meet all the mandatory requirements (and supplementary checks if asked for) of specified specification.
- (ii) All Plates above 40mm & all bar stock / forgings above 40mm dia shall be ultrasonically tested. For pressure parts, plates of thickness equal to or above 25 mm shall be ultrasonically tested.

A. Separator

- (a) Each plate shall be subjected to a 100% normal ultrasonic at the mill to meet the minimum requirements of EN 10160 1999 / equivalent ASTM standards. Elevated temperature tensile tests shall also be carried out on plate material for each heat.
- (b) After cutting to size and removal of cut outs, the plates shall be subjected to magnetic particle test along the edges of the plate and on areas adjacent to the cutouts.
- (c) All forged connections shall be examined by 100% UT before machining.
- (d) Fully machined connecting pieces of internal diameter 100mm and above, shall be subjected to magnetic particle examination.
- (e) Mechanical tests shall be carried out on specimens prepared from the production control test plates of the longitudinal welds.



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- (f) Mechanical tests shall be conducted on the specimens from manhole cutouts of dished ends.
- (g) All butt welds shall be subjected to 100% radiographic examination before stress relief.
- (h) On completion of welding, the entire Separator shall be subjected to stress relieving in the furnace.
- (i) All butt welds shall be subjected to 100% ultrasonic and magnetic particle examination after stress relief.
- (j) All full penetration welds shall be subjected to ultrasonic examination after stress relief.
- (k) After stress relieving (SR) all welds, internal and external shall be examined by MPI methods depending on size and accessibility and all butt welds shall be subjected to 100% radiography.
- (l) All connecting tubes & pipes shall be subjected to UT prior to fabrication as per BS 3602 or equivalent with longitudinal calibration notch of depth 5% of wall thickness (0.3mm min. and 1.5mm max.)
- (m) **Hydraulic Test and Pneumatic Test:** Complete Separator shall be subjected to hydraulic pressure test and all compensating pads to be pneumatically tested.

B. Headers

- (a) Raw material for headers shall be subjected to UT prior to fabrication as per BS 3602 or equivalent with longitudinal calibration notch of depth 5% of wall thickness (0.3mm min. and 1.5mm max.) shall be adhered to.
- (b) All butt welds shall be subjected to RT examination. Also MPI after SR.
- (c) All full penetration nozzle and attachment welds shall be subjected to UT prior to stress relieving.
- (d) All nozzles, branches, stubs and load bearing attachment shall be examined by MPI techniques after the toes of the weld have been ground smooth and stress relieved.
- (e) Non-load bearing welds shall be examined by MPI techniques after the toes of the welds have been ground smooth and stress relieved.
- (f) Completed closed end headers shall be subjected to hydraulic pressure tests and all compensating pads to be pneumatically tested.
- (g) All weld joints in alloy steel headers of P 91, X20 and X22 & other material of P5B group and above shall be checked for Hardness. 3% hardness check shall be carried out on welds of other alloy steel Headers.

C. Tubes & Tube Elements

- (a) Raw material pipes/ tubes for water wall, superheater, reheater, Economiser, riser, supply and connecting tubes including nozzle/stubs, connections, headers Pipe work etc. shall be subjected to 100% UT prior to fabrication as per EN 10246:7 1996 or equivalent with longitudinal calibration notch of depth 5% of wall thickness (0.3 mm min. and 1.5mm max.) shall be adhered to.
- (b) All bent tubes/stubs shall be checked for ovality and thinning by ultrasonic method on first off and random checks on subsequent pieces.
- (c) All tubes/stubs/panels/coils shall be checked for clearance by steel ball test and for cleanliness by sponge passage.



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- (d) Finished butt welds shall be subjected to RT or UT. Wherever the code/standard/process specifies random sampling, the same shall be minimum 20%.
- (e) Minimum 10 % of the fillet joints shall be subjected to MPI/LPI. However Fillet welds of material grades P 5B and above or any other equivalent new material grade subject to the acceptance by Client/ Consultant shall be subjected to 100% MPI/ LPI.
- (f) Tubes and fabricated panels/coils shall be subjected to hydraulic pressure test excluding loose tubes but including burner panels, reheaters, super heaters & economizers.
- (g) 10% hardness survey on butt welds of P5B material group and above.
- (h) In case of RT of tube welds with DWDI (elliptical view) number of exposure shall be as per relevant code/ plant standard and will not be less than two exposures for each weld.

D. Boiler Piping

- (a) All raw materials used shall have co-related mill test certificate meeting material specification.
- (b) All pipe lengths shall be subjected to 100 % ultrasonic examination as per EN 10246:7 1996 or equivalent with longitudinal calibration notch of depth 5% of wall thickness (0.3mm min. and 1.5mm max.) shall be adhered to.
- (c) All bent pipes shall be checked for ovality and thinning by UT on first off lot & on random samples for subsequent pieces. Outer surface of bends shall be subjected to MPI/LPI.
- (d) The edge preparation for shop and site welds in stainless steel /alloy steel shall be subjected to a dye penetrant check. Non-destructive examination of welds shall be carried out after post weld heat treatment, if any.
- (e) All butt welds in alloy steel piping of P91, X20 and X 22 shall be checked for RT/ UT and MPI after SR. UT shall be of Digital Recordable Type.
- (f) All weld joints in alloy steel piping of P 91, X20 and X22 & other material of P5B group and above shall be checked for Hardness. For PWHT Induction Heating shall be deployed. However PWHT can be done in furnace also. 3% hardness check shall be carried out on welds of other alloy steel piping.
- (g) All load bearing attachment welds shall be subjected to MPI after SR.
- (h) Non-destructive examination of welds shall be carried out in accordance with the relevant design/manufacturing codes. However, as a minimum, the following requirements shall be met. Further statutory requirement, wherever applicable shall also be complied with.
 - 1 Temperature > 400 Deg, C and/or pressure exceeding 71 bar.
 - i. 100% RT/UT on butt welds and full penetration branch welds.
 - ii. 100% MPI.
 - 2 Temperature > 175 Deg, C upto 400 Deg. C and/or pressure exceeding 17 bar and up to 71 bar.
 - i. 100% RT/UT on butt welds and full penetration branch welds for pipe dia more than 100 NB.
 - ii. 10% RT/UT on butt welds and full penetration branch for pipe dia upto 100NB.
 - iii. 100% MPE.



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- 3 For all other pipes not covered above, shall be subjected 100% MPE/ DPT in case of underground pipes and 10% MPE/DPT in case of piping above the ground. Further, 10% of butt welds of underground piping shall be subjected to RT.
- i. Wherever SR/PWHT is envisaged for alloy steel, above NDTs shall be after SR/PWHT.

E. Fittings

- (a) Raw material of all forged fitting shall be ultrasonically tested. All mother pipes used for formed fitting shall be ultrasonically tested as per BS 3602 or equivalent with longitudinal calibration notch of depth 5% of wall thickness (0.3mm min. and 1.5mm max.) shall be adhered to.
- (b) Fittings shall be subjected to suitable NDT as per applicable standards. However following minimum. NDE requirement shall also be applicable / met.
- i. 100% RT/UT shall be carried out both on alloy steel fittings and on carbon steel fittings.
- For use above 71 bar design condition.
- For use above 400°C design condition.
- ii. For fittings X20, P-91 and material group 5B & above
- 100% MPI &
- 10% hardness check &
- For fittings of 200 NB & above 100% UT/RT
- iii. 100% UT/RT for fittings of 200 NB & above for boiler feed discharge, recirculation and spray piping of boiler feed system.
- iv. 100% UT/RT for fittings of all other piping of size OD 508mm & above.

F. VALVES

- (a) Pressure retaining parts of valves shall be subjected to (min.) NDT as per Table A.
- (b) Hardened/stellitted valve disc and seat are to be subjected to LPI and hardness check.
- (c) Color matching of valve disc/plug and seat shall be carried out to ensure min. 80% contact and no through passage.
- (d) Hydraulic pressure test and seat leak test shall be carried out as per ANSI 16.34/ IBR.
- (e) Air seat leak test shall be carried out as per applicable Standards/Codes.
- (f) Functional testing shall be carried out on each valve to check the following as per the approved valve data sheet.
1. Smooth operation
2. Valve travel, closing and opening time.
3. Current drawn by actuators.
- (g) Springs for safety valves shall be tested with suitable NDT and for spring rate.
- (h) Safety and safety relief valves shall be tested for performance.
- (i) All forgings rounds above diameter 40 mm shall be ultrasonically tested

Table - A

NDT REQUIREMENTS FOR PRESSURE RETAINING COMPONENTS OF VALVES

Valve size NB in mm	ANSI Class up to 300	ANSI Class above 300 up to 600	ANSI Class above 600 below 900	ANSI Class 900 & above & below 4500
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Less than 50	Visual	Visual	Visual	MPI
50 & above But below 100	Visual	Visual	MPI	MPI & RT (on 10% of valves on 100% area)
100 & above but less than 300	Visual	MPI	MPI & RT (on 10% of valves on change of section & weld ends)	MPI & RT (on 100% area)
300 and above	MPI	MPI	MPI & RT (on change of sections & weld ends)	MPI, RT on 100% area)

Note:

For body and bonnet forgings UT with MPI may be adopted in place of RT.
For austenitic steel MPI may be replaced by LPI.

G. Non Pressure Bearing Attachments

Load bearing welds shall be subjected to examination by ultrasonic testing (UT) and magnetic particle inspection (MPI) techniques after stress relief (SR). No load bearing welds shall be subjected to MPI after stress relief. The toes of the welds adjoining the /separator shall be ground smooth prior to stress relieving before carrying out this examination.

H. Fuel oil heater

Hydraulic pressure test shall be carried out on the heating coils. All pipes, valves steam traps and mountings shall be subjected to hydraulic test as called for under IBR, BS or other approved codes.

I. Soot Blowers

- (a) Butt weld between nozzle and lance tube shall be subjected to 20% radiography tests.
- (b) Hydraulic test on valve body
- (c) Soot blower shall be subjected to operational checks as below:
 - 1. Smooth operation
 - 2. Long Tube travel, closing and opening time.
 - 3. Current drawn.

J. Steam Generator Boiler Start up Drain Re-circulation Pump

- (a) Raw material for casing, shaft and impeller shall be tested for high temperature physical properties, apart from mandatory & supplementary check of material specification.
- (b) All forging and castings shall be subjected to 100% UT/RT and MPI/DP check.
- (c) Static and dynamic balancing of the rotary parts shall be carried out.
- (d) Hydraulic pressure test shall be conducted on pumps casing at min. 1.5 times the Design Pressure.
- (e) Interchangeability shall be maintained and checked.
- (f) Each pump shall be subjected to a performance test at the manufacturer's works under as near actual site conditions as possible.
- (g) Following test shall be carried out on assembled units : -

Type Test:

- i. NPSH test



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- ii. Temperature rise test.
- iii. Under voltage test.
- iv. Quality assurance proof test.
- v. Tests to establish unit functioning of pump at temp and pressure.
- vi. Hot standstill and start up tests.

Routine Test:

- i. Hydrostatic test of complete unit.
- ii. Overspeed test.
- iii. Tests to determine unit characteristics
- iv. Pump performance.
- v. Unit run at rated voltage
- vi. Starting current at rated voltage.
- vii. Cold start up test.
- viii. Endurance test of motor windings, joints and terminal seals
- ix. Noise level.
- x. Inspection of dismantled unit.
- xi. High voltage test.
- xii. For heat exchanger for these pumps, butt welds on pressure parts shall be tested with RT/UT and all other welds shall be tested with MPI/LPI. Hydraulic test shall be carried out both on tube side as well as shell side at min. 1.5 times the design pressure.

K. Hydraulic Test

- (a) All components which are to be subjected to fluid pressure shall be tested to minimum of 150% of the design pressure. In determining the value of the maximum attainable pressure for any component the contractor shall take in to account all relevant factors (e.g. safety valve blow off pressure, fluid surges, etc.) which may cause an elevation in the pressure. The contractor shall furnish details of the basis of the calculation of maximum attainable pressure tests. The duration of the pressure tests shall be sufficient, as approved by the Engineer, to show any leakage paths and to permit a through examination of the component whilst under pressure.
- (b) The temperature of the fluid used for the pressure test shall be such as to avoid any possibility of brittle fracture at a low temperature and the same to be modified and submitted to the Engineer for approval, before commencing the test.
- (c) The fluid used shall be of a sufficient purity and where relevant, inhibits to avoid excessive corrosion and /or damage to temporary parts either during the test or prior to drying and cleaning.

L. Pneumatic Test of Compensating Pads:

All compensating pads shall be provided with two-threaded weep holes to test welds at 0.5Kg/sq.cm (g) with soap solution and "no leakage" shall be ensured.

2.5.1.3 ROTATING AND OTHER EQUIPMENTS/ITEMS FOR STEAM GENERATOR

- (a) The material which can be identified against mill sheet or manufacturer test certificate only shall be used in the manufacture of pressure parts. Material shall meet all the mandatory requirements (and supplementary checks if asked for) of specified specification.



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- (b) For sleeve bearing, UT shall be carried out on the babbitting of bearing. Dye penetrant check shall be done on edges.
- (c) Blue matching is to be performed between components.
- A. Air Preheater**
 - (a) Forged shafts coming under air preheater like stub shaft, main rotor forging, housing hub shall be subjected to 100% UT at mill and magnetic particle inspection after machining.
 - (b) For non-modular design trial assembly is to be carried out at shop prior to dispatch to site.
 - (c) Critical welds of rotor post shall be subjected to radiographic examination.
 - (d) Trial run of Air preheater Rotor drive assembly (Gear Box + pinion + Electric motor + air motor) needs to be carried out at shop
- B. Fans: Induced Draft, Forced Draft and Primary Air fans and GR fans**
 - (a) Rotor components i.e. shaft and hub shall be subjected to ultrasonic test at mill and magnetic particle examination after rough machining.
 - (b) 10% of Butt and fillet welds both in rotor and static components of the fan shall be subjected to MPI /DPT after stress relieving.
 - (c) Fan impeller shall be balanced dynamically to quality grade 2.5 of ISO 1940.
 - (d) **Test for Natural Frequency of Fans**
Full range performance test shall be carried out on one fan of each type and size as per BS 848, Part-1.
- C. Fans: Seal air Fan, Scanner air fans**
 - (a) Rotor components i.e. shaft and hub shall be subjected to ultrasonic test at mill and magnetic particle examination after rough machining.
 - (b) 10% of Butt and fillet welds both in rotor and static components of the fan shall be subjected to MPI / DPT after stress relieving.
 - (c) Fan impeller shall be balanced dynamically to quality grade 2.5 of ISO 1940.
- D. Coal Mills, PF Piping and Burners**
 - i. Raw material for shaft, coupling, gears and pinions, top and bottom races and other rotating components shall be subjected to UT. MPI/LPI shall be carried out to check surface soundness.
 - ii. Wear-resistant parts shall be UT/ RT tested to check soundness after suitable heat treatment. Check for chemical composition, hardness and microstructure shall be carried out. For ceramic materials check for various properties including hardness, density, wear rate and composition shall be carried out.
 - iii. Butt welds in the tube/ separator /body casing of the mill shall be tested by RT and MPI. All other welds in main tube/separator shall be tested by MPI/LPI for acceptance. The tube shall be statically balanced.
 - iv. All gearboxes shall be run tested for adequate duration to check rise in oil temperature, noise level and vibration. Check for leak tightness of gear case also shall be performed.
 - v. Fabricated pipe welds should be examined by MPI.



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- vi. Ceramic/basalt lined piping/bends shall be checked for proper layout.
- vii. Weldments on burner components shall be checked with suitable NDT. The burner assemblies shall be tested for operation at shop.
- viii. Trial assembly (stacking) of at least one Mill complete with all major components needs to be carried out at shop.

E. Coal Feeders

- (a) Any welds in the casing/ pulley fabrication shall be checked with MPI.
- (b) Type tests including degree of protection and routine tests shall be done as per relevant Indian Standards or equivalent International Standards.
- (c) All major items like plates for casings, head pulley, tail pulley, Pulley shaft and major castings shall be procured with respective material test certificates.
- (d) Explosion proof test at 50 psi as per NFPA code shall be done as type test. Leak tightness test shall be done on individual feeder casing. Endurance test for load cell shall be carried out.
- (e) Test for weighing accuracy, calibration and repeatability shall be carried out at various speeds by a coal flow on one feeder.
- (f) Calibration check shall be carried out on all feeder cabinet/assemblies prior to dispatch

F. EOT Cranes

- 1 Hooks
 - i. All Tests including Proof Load Test as per relevant IS shall be carried out.
 - ii. MPI/DPT shall be carried out after proof load test.
- 2 Steel Casting
 - i. DPT on machined surface shall be carried out.
- 3 Girders, End Carriage, Crab, Gear Box, and Rope
 - i. The plates of thickness 25mm and above shall be ultrasonically tested.
 - ii. 3.02 NDT requirements on weldments shall be as follows:

a.	Butt Welds in Tension	100% RT and 100% DPT
b.	Butt Welds in Compression	10% RT and 100% DPT
c.	Butt Welds in Rope	100% RT and 100% DPT
d.	Fillet Welds	Random 10% DPT

- 4 FORGINGS (wheel, gears, pinions, axle, hooks & hook trunion).
 - i. All forgings greater than or equal to 50 mm diameter or thickness shall be subjected to Ultrasonic test.
 - ii. PT/MPI shall be done after hard facing and machining.
- 5 Wire rope shall be tested as per relevant standard.
- 6 Reduction gears shall be tested for reduction ratio, backlash & contact pattern. Gear box shall be subjected to no load run test to check for oil leakage, temperature rise, noise and vibration.



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- 7 The cranes shall be completely assembled at shop for final testing. All tests for dimension, deflection, load, overload, hoisting motion, cross travel etc. as per IS-3177 shall be carried out at shop.
- 8 All electric hoists shall be tested as per IS-3938 and chain pulley blocks shall be tested as per IS-3832.

G. Lube Oil systems/ Hydraulic Power Pack

Lube Oil system/ hydraulic power packs shall be tested for performance.

Fans & pumps which are not mentioned in other clauses above shall be dynamically balanced and functionally tested at Manufacturer's works. Complete performance tests shall be carried out on first pump/fan of each type and capacity to verify its output against total head, power input, efficiency, vibration and noise level. Head/volume, efficiency and power input curves corrected for site conditions shall be furnished.

H. Dampers

- (a) All the dampers shall be subjected to operational test/checks.
- (b) Leak tightness of test of Dampers / Gates.
- (c) All dampers shall be checked for sealing dimensions to establish guaranteed tightness.

I. Boiler Structure, Ducts, Hoppers etc.

Steel Structure of Boiler, Mill Bunker building including Coal bunkers, Coal transfer points. Coal conveyor galleries and supporting trestles, Ducts, Hoppers, etc

- (a) Only material which has been identified against mill sheet or test certificates shall be used for construction. All plates above 40mm thickness shall be 100% ultrasonically tested.
- (b) Visual inspection of all welds shall be performed in accordance with AWS D.1.1.
- (c) NDT requirements of structural steel welds (other than Coal Bunkers) shall be as under:-
 - i. 100% RT/UT on butt-welds of plate thickness > 32 mm.
 - ii. For plates of thickness > 25mm & < 32mm - 10% RT and 100% MPI
 - iii. For plates of thickness < 25mm - 10% MPI/LPI.
 - iv. All fillet welds of built up plate girders shall be inspected 100% by MPI.
- (d) (Edge for field weld shall be examined by MPI for plate thickness > 32mm. Edge for field weld for ceiling girders shall be examined by UT for 100mm from the edge).
- (e) Ceiling girders/columns, ducts hoppers & tunnels shall be trial assembled and match marked prior to dispatch/erection. At least two consecutive girders along with cross member shall be assembled at a time.
- (f) Production test coupons for Butt and fillet welds of Main columns, ceiling grinders shall be carried out.
- (g) Coal Bunkers / Bins
 - i. 10% DPT after back gouging.
 - ii. 5 % spot radiography test on butt welds. Where access not available, UT shall be carried with prior approval of Client/Consultant.
 - iii. Full penetration welds (other than butt welds) shall be subjected to 10% Ultrasonic testing.

J. Hangers & Supports:



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- (a) All major raw materials used shall have co-related mill test certificate meeting mandatory checks of material specification.
- (b) Completed springs shall be tested for Scragging Test & Load vs Deflection Test and for dia. > 25mm MPI shall be carried out.
- (c) Butt Welds shall be tested for UT and fillet welds shall be tested for MPI.
- (d) Turn buckle/ pipe clamps/ Hangers of thickness > 25mm shall be checked by MPI/DPT on bent portion.
- (e) Assembled Hangers shall be checked for Variation in deflection and Travel vs Load test and shall meet the requirements of specification.

K. Metallic Expansion Joint (if applicable)

- (a) Hydraulic pressure test shall be carried out on each pipe and expansion bellow.
- (b) Longitudinal butt weld on bellow shall be subjected to suitable NDT examination before forming, and after forming MPE / DP test shall be carried out.
- (c) All welds shall be subjected to 100% magnetic particle/dye penetrant check and butt welds shall be subjected to 100% radiographic testing.
- (d) All the bellows subjected to vacuum service shall be subjected to vacuum test.
- (e) The bellows shall be subjected to movement test to establish suitability to perform satisfactorily in site conditions. During this test spring rate shall also be measured.
- (f) Life cycle test, meridional yield rupture test and squirm test to be carried out on a prototype/expansion bellow as per Sec.D clause 3.2 of standards of Expansion joint Manufacturer Association (EJMA). In case these tests have already been accepted by Client/Consultant on a prototype expansion bellow, as defined in Sec.D Clause 3.2 of Expansion Joints Manufacturers Association (EJMA) test reports may be furnished by manufacturer for consideration and approval of Employer.

L. Thermal Insulation, Lagging & Cladding:

(a) Lightly resin bonded mineral wool:

LRB mattresses/sections of Rockwool/ Glass wool shall confirm to & tested as per relevant clauses of Indian Standards. Type tests except Thermal Conductivity shall be regularly carried out once in three months, Thermal Conductivity Type Test shall be carried out minimum once in twelve months by the manufacturer. Requirements of various components like Binding wires, Lacing wires, Wire mesh, etc. shall be as per specification.

(b) Castable Refractory:

Fire Bricks / Castable Refractory confirming to & tested as per relevant clauses of Indian Standards and shall meet the requirements of specification. Castable Refractory shall have proper identification, supplier name, customer name, Batch No., Date, material name & Net weight in Kgs. with proper instructions for handling.

(c) Lagging & Cladding:

All insulation shall be protected by means of an outer covering of Aluminium sheeting confirming to ASTM B-209-1060 temper H14 from reputed manufacturer meeting the requirements of specification



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2.5.1.4 FIELD /ERECTION CHECKS FOR STEAM GENERATOR & AUXILIARIES.

Raw Material, In process and Non Destructive Testing indicated during manufacture shall be applicable for site fabrication/erection of the respective item.

- (a) All rotary equipment's shall be checked for its direction of rotation and free movement after placing it on the foundation.
- (b) All Valves shall be checked for its direction of flow.
- (c) Insulation shall be carried out only after satisfactory inspection of leak test.
- (d) Erection checks, tolerance limits and Quantum of NDE are indicated in respective Drawing, Field Quality plan and Field Welding Schedule.

A. Hydraulic Tests of Pressure Parts

On completion of erection of Steam Generator, Piping and Auxiliaries, the unit with its fittings and mountings in position shall be subjected to hydraulic pressure test in accordance with requirements of Indian Boiler Regulations.

Water used for hydraulic test shall be made alkaline by addition of suitable chemicals. After the test, the steam generator shall be drained and suitably preserved.

2.5.1.5 POWER CYCLE PIPING

H.P.PIPING FOR STEAM GENERATOR AND AUX.

1. Piping:

- a. All raw materials used shall have co-related mill test certificate meeting material specification. All test, as given in respective material code (other than supplementary requirements), shall be carried out as minimum. This includes the tests wherein it is specified in the ASTM code that the tests is to be carried out when specified by the purchaser or any such indication, in the code.
- b. All pipe lengths shall be 100 % ultrasonic tested. However for critical piping applications (Main Steam, CRH, HRH, Feed water, spray to superheater and Reheater, HP/LP Bypass, Upstream of Aux PRDS and any other system in which alloy steel is used) shall be subjected to 100% ultrasonic examination as per EN 10246:7 1996 or equivalent with longitudinal calibration notch of depth 5% of wall thickness (0.3 mm min. and 1.5mm max.) shall be adhered to.
- c. The edge preparation for shop and site welds in stainless steel /alloy steel shall be subjected to a dye penetrate check.
- d. Pipe bend shall be checked for ovality and thinning by ultrasonic or other acceptable methods on first off lot & on random samples for subsequent pieces for high pressure applications. Outer surface of bends shall be subjected to magnetic particle examination/LPI.
- e. Non-destructive examination of welds shall be carried out after post weld heat treatment, if any.
- f. All butt welds in alloy steel piping of P-91, X -20, X-22 & material P-5B group & above shall be checked for RT/ UT & MPI after SR.



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- g. For welds in P91, X20 & X22 and material P5B group & above Materials requiring heat treatment, induction type of heating shall be deployed for post weld heat treatment, or heat treatment can be carried out in furnace.
- h. Non-destructive examination of welds shall be carried out in accordance with the relevant design/manufacturing codes. However, as a minimum, the following requirements shall be met. Further statutory requirement, wherever applicable shall also be complied with
1. Temperature > 400 Deg, C and/or pressure exceeding 71 bar.
 - i. 100% RT/UT on butt welds and full penetration branch welds.
 - ii. 100% MPE.
 2. Temperature > 175 Deg, C up to 400 Deg, C and/or pressure exceeding 17 bar and up to 71 bar.
 - i. 100% RT/UT on butt welds and full penetration branch welds for pipe dia more than 100 NB.
 - ii. 10% RT/UT on butt welds and full penetration branch for pipe dia up to 100NB.
 - iii. 100% MPE.
 3. For all other pipes not covered above, shall be subjected 100% MPE/ DPT in case of underground pipes and 10% MPE/DPT in case of piping above the ground. Further, 10% of butt welds of underground piping shall be subjected to RT.
 - i. Wherever SR/PWHT is envisaged for alloy steel, above NDTs shall be after SR/PWHT.
- j. Hardness survey of welds shall be carried out on alloy steel/stainless steel piping (100% Hardness survey of welds on P91, X20 & X22 & above material grade of P5B above piping) and 3% hardness survey on welds of other alloy steel).

2. Fittings:

- a. Raw material of all forged/formed fitting shall be ultrasonically tested. All mother pipes used for fitting shall be ultrasonically tested or hydraulic tested. Forged fitting shall be ultrasonically tested and formed fittings shall be MPI tested.
- b. Fittings shall be subjected to suitable NDT as per applicable standards. However, following minimum NDE requirements shall be applicable / met.
 - i. 100% RT/UT shall be carried out both on alloy steel fittings and on carbon steel fittings.
 - For use above 71 bar design condition.
 - For use above 400°C design condition.
 - ii. For fittings X20, P-91 and material group 5B & above
 - 100% MPI &
 - 10% hardness check.
 - Also 100% UT/RT, For fittings of 200 NB & above
 - iii. 100% UT/RT for fittings of 200 NB & above for boiler feed discharge, recirculation and spray piping of boiler feed system.
 - iv. 100% UT/RT for fittings of all other piping of size OD 508mm & above.

3. Hangers & Supports:



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- a. All raw materials used shall have co-related mill test certificate meeting mandatory checks of material specification.
- b. Completed springs shall be tested for Scragging Test & Load vs Deflection Test and for dia. > 25mm MPI shall be carried out.
- c. Butt Welds shall be tested for UT and fillet welds shall be tested for MPI.
- d. Turn buckle/ pipe clamps/ Hangers of thickness > 25mm shall be checked by MPI/DPT on bent portion.
- e. Assembled Hangers shall be checked for Variation in deflection and Travel vs Load test.

4. Thermal Insulation & Lagging, Cladding:

a. Insulation:

Insulation shall confirm to and tested as per relevant clauses of Indian Standards and shall meet the requirements of specification. Type tests except Thermal Conductivity shall be regularly carried out once in three months, Thermal Conductivity Type Test shall be carried out minimum once in twelve months by the manufacturer. Requirements of various components like Binding wires, Lacing wires, Wire mesh, etc. shall be as per specification.

5. Lagging & Cladding:

Aluminium sheeting confirming to ASTM B-203-1060 temper H14 from reputed manufacturer meeting the requirements of specification.

6. Valves:

- a. Pressure retaining parts of valves shall be subjected to (min.) NDT as per Table 1.
- b. Hardened/stellitted valve disc and seat are to be subjected to LPI and hardness check.
- c. Color matching of valve disc/plug and seat shall be carried out to ensure min. 80% contact and no through passage.
- d. Hydraulic pressure test and seat leak test shall be carried out as per ANSI 16.34/IBR.
- e. Air seat leak test shall be carried out as per applicable Standards/Codes.
- f. Functional testing shall be carried out on each valve to check the following as per the approved valve data sheet
 - i. Smooth operation
 - ii. Valve travel, closing and opening time.
 - iii. (Current drawn by actuators.
- g. Springs for safety valves shall be tested with suitable NDT and for spring rate.
- h. Safety and safety relief valves shall be tested for performance.
- i. All forgings rounds above diameter 40 mm shall be ultrasonically tested

Valve size NB in mm	ANSI Class up to 300	ANSI Class above 300 up to 600	ANSI Class above 600 below 900	ANSI Class 900 & above & below 4500
Less than 50	Visual	Visual	Visual	MPI
50 & above But below 100	Visual	Visual	MPI	MPI & RT (on 10% of valves on 100% area)



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100 & above but less than 300	Visual	MPI	MPI & RT (on 10% of valves on change of section & weld ends)	MPI & RT (on 100% area)
300 and above	MPI	MPI	MPI & RT (on change of sections & weld ends)	MPI, RT on 100% area)

NOTE: For body and bonnet forgings UT with MPI may be adopted in place of RT for austenitic steel MPI may be replaced by LPI.

7. Metallic expansion Joint (if applicable)

- Hydraulic pressure test shall be carried out on each pipe and expansion bellow.
- Longitudinal butt weld on bellow shall be subjected to suitable NDT examination before forming, and after forming MPE / DP test shall be carried out.
- All welds shall be subjected to 100% magnetic particle/dye penetrant check and butt welds shall be subjected to 100% radiographic testing.
- All the bellows subjected to vacuum service shall be subjected to vacuum test.
- The bellows shall be subjected to movement test to establish suitability to perform satisfactorily in site conditions. During this test spring rate shall also be measured.
- Life cycle test, meridional yield rupture test and squirm test to be carried out on a prototype/expansion bellow as per Sec.D clause 3.2 of standards of Expansion joint Manufacturer Association (EJMA).
Expansion Joints Manufacturers Association (EJMA) test reports may be furnished by manufacturer for consideration and approval of Employer.

8. CHEMICAL DOSING SYSTEM

- Pumps of chemical dosing system shall be performance tested as per relevant international codes.
- Dosing skid shall be subjected to leakage test and functional test.
- Oxygen cylinders shall be as per relevant standard meeting statutory requirements.



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Low Pressure Piping

	Tests/Check Items / Components	Material Test	DPT/ M PL	Ultrasonic Test	WPS/ WQS/ PQR	Balancing	Hydraulic / Water Fill Test	Pneumatic Test	Assembly Fit up	Dimensions	Functional / Operational Test	Performance test	Other tests	All Tests As per relevant Std	Adhesion / Spark Tests	Remarks
1.	Pipes & Fitting And Metered Bends	Y ^a	Y ^b		Y		Y			Y			Y ¹⁵			
2.	Diaphragm Valves	Y ^a					Y ⁵			Y				Y ⁶		
3.	Butterfly Valves(Low Pressure)															
a)	Casted Butterfly Valves						Y		Y	Y	Y		Y ⁷			
i.	Body (Cast)	Y ^a	Y ^b													
ii.	Disc (Cast)	Y ^a	Y ^b													
iii.	Shaft	Y ^a	Y	Y ^c												
b)	Fabricated Butterfly Valves															Refer Note 14
4.	Gate/Globe/Swing Check Valves	Y ^a	Y ^b	Y ^c			Y ⁵	Y	Y	Y	Y		Y ⁸			



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5.	Dual Plate Check Valves	Y ^a	Y ^b	Y ^c			Y	Y	Y	Y	Y		Y ⁴			
6.	Rolled & Welded Pipes	Y ^a	Y ³		Y		Y ¹			Y						
7.	Coating & Wrapping Of Pipes	Y ²											Y ²			
8.	Tanks & Vessels	Y ^a	Y ^b		Y		Y						Y ¹¹			
9.	Strainers	Y ^a	Y ^b				Y									
10.	Rubber Expansion Joints	Y ^a					Y ¹²		Y				Y ¹³			
	Tests/Check Items / Components															
11.	Rubber Lining of Pipes	Y ^a	X		X		Y			Y				Y ⁹	Y	
12.	Hangers & Supports	Y ^a								Y						
13.	Fasteners	Y ^a		X				X								
14.	Site Welding		Y ¹⁰		Y		Y									

Notes:

1. Weld Joints not Subjected to hydraulic test shall be subjected to 100% RT.
2. Spark Test, Adhesion Test and Material Test for primer and enameled & Coal Tar Tapes as per AWWA0-C-203-91
3. DPT on route run and after back gouging and on finish welds.
4. Dry Cycle Test (Dual Plate Check Valve) for one lakh Cycles shall be carried out as a type test.
5. Seat Leakage Test for Actuator Operated Valves, shall be done with by closing the valves with actuator.



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6. Test on rubber parts per batch of rubber mix such as hardness, adhesion, spark test, bleed test and flex test on diaphragm for 50,000 cycles.
7. Hydraulic Test of Body, Seat and disc-strength shall be carried out in accordance with latest edition of AWWA-C-504 in presence of Employer's representatives. Actuator operated valves shall be checked for Seat Leakage by closing the valves with actuator. Seat Leakage Test shall be carried out in both directions.
8. Blue matching, wear travel for gates, valves, pneumatic seat leakage, reduced pressure test for check valves shall be done as per relevant standard. Maximum allowable vacuum loss is 0.5 mm of Hg abs. for valves to be tested for vacuum operation for internal pressure 25 mm of Hg abs. for a period of 15 minutes.
9. Hardness, Bleeding Test and Ozone resistance test shall be done on rubber material.
10. Dry film thickness check, humidity check, pipe temperature check, adhesion check and Holiday Detection test shall be done.
11. 10% of welds shall be subjected to DPT.(100% DPT for compressed air line and boiler & deaerator fill line.)
12. Pressure drop across the strainer for each type and size as a special test shall be carried out. In case of already carried out, the test report shall be submitted for review and acceptance by Client/Consultant.
13. During hydraulic and vacuum test at 25mm Hg abs in 3 positions, the change in the circumference of arch should not be more than 1.5%. 24 hrs after the test permanent set in dimension should not exceed 0.5%.
14. Tests on rubber for tensile, elongation, hardness, hydraulic stability check as per ASTM D 471, ozone resistance test as per ASTM D 1149 aging test and adhesion strength of rubber to fabric, rubber to metal adhesion shall be carried out.
15. In addition of all tests as indicated for cast Butter Fly valve being applicable for fabricated butterfly valves, following test shall be done for fabricated butter fly valves:"
 - i. UT as per ASTM A-435 on plate material for body and disc shall be carried out for plate thickness 20mm and above.
 - ii. 100% RT and DPT as per ASTM, section-VIII, Division-I, on butt Joints of body and disc. 10% DPT on other welds shall be done.
 - iii. Post weld heat treatment as per ASME, Section-VIII, Division-I on butt Joints of body and disc if thickness is more than 30mm
 - iv. Welders and WPS shall be qualified as per ASME`-section IX.
 - a) One per heat/heat treatment batch/lot.
 - b) On machined surfaces only for castings and on finished butt welds.
 - c) For shaft/spindles > or =50mm



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16. If applicable: Segmented flange exceeding 30 mm thickness shall be stress relived and not more than 4 segments is allowed. For stainless segmented flanges and stainless steel fabricated fitting. 100% radiography of all weld seams including mother pipe weld seam shall be employed.
17. If applicable: For pressure vessel welds RT shall be done as per design code requiremen



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2.5.1.6 STEAM TURBINE AND ASSOCIATED EQUIPMENT

A. High Pressure & Intermediate Enclosure

High pressure Cast Steel Enclosures (for example High pressure and Intermediate Pressure Inner and Outer Cylinders, Steam Chests and liner, Steam Inlet Pipes, nozzle boxes).

Test pieces fully representative of the material and condition of the casting shall be provided to enable the properties of material to be determined. Creep requirements:

- a. Steels chosen for design metal temperatures less than 400°C are exempt from creep /stress rupture testing.
- b. Steels chosen for design metal temperatures between 400°C to 540°C and having less than 3% chromium, shall require 5 years performance feedback experience in the absence of which, creep rupture test will be required to be carried out for maximum test duration of 1000 hrs/mutually agreed parameters for employer's approval.
- c. Steels chosen for design metal temperatures above 540°C and/or having more than 3% chromium, shall require 10 years performance feedback experience OR adequate stress rupture data, in the absence of which, creep rupture test will be required to be carried out for maximum test duration of 1000 hrs/mutually agreed parameters for employer's approval.
- d. Unspecified alloying elements shall be controlled as per the applicable standard.

Each casting shall be subjected to magnetic particle examination on the entire inner and outer surfaces after heat treatment.

Each casting shall be subjected to a 100% examination for internal flaws by ultrasonic/ radiographic method after heat treatment and suitable preparation.

Cast enclosure shall be subjected to a hydraulic pressure test based on established practice of manufacturer. Bidder to furnish their practice in this regard for Employer's approval.

Excavated area of all the defects shall be subjected to MPI to ensure excavation up to sound area. All the areas repaired/upgraded by welding shall be examined by UT, RT (to confirm findings of UT wherever required) and MPI. Sketches/reports of location of repair and reports of NDT carried out on repaired areas shall be submitted along with certificates. Hardness survey shall be carried out on the repaired area.

Where stub pipes and transition pieces are welded to the main body of an enclosure the following shall be carried out:

- i. Radiographic examination and Magnetic particle or dye penetrant examination of weld preparation.
- ii. Magnetic particle examination of finished welds after stress relief.
- iii. Radiographic or ultrasonic examination of finished welds.



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- iv. Before dispatch to site, the site weld preparations on the stub pipes and transition pieces shall be subjected to 100% RT/UT and magnetic particle examination.
- v. Hardness survey on the weld joint, HAZ and parent material.
Wall thickness measurement by ultrasonic for critical and highly stressed zones of the casting shall be carried out.
Colour matching of castings by putting two halves together and feeler gauge tightness check from both sides, i.e. inside and outside to ensure required contact area and joint tightness shall be carried out.

B. Low Pressure Enclosure (Fabricated)

- a. Where welds are made by chipping and grinding back to the first side weld before completing the weld from second side, a magnetic particle or dye penetrant examination of the chipped area shall be carried out.
- b. Bidder to furnish their practice regarding stress relieving of the fabricated enclosures for Employer's approval.
- c. Bidder to furnish their standard practice regarding NDT on welds for Employer's approval, however following are minimum NDT requirements:

a.	Butt welds	10% RT or UT and 10% MPE/DP test
b.	Fillet welds	10% MPE/DPT
c.	Nozzle welds	10% MPE/DPT
d.	Lifting lug & other load bearing fillet welds	100% MPE/DPT
e.	Site weld edge preparations	10% MPE/DPT

- d. Bidder to furnish his proven practice for hydraulic pressure tests. If it is not their practice, the justification for not carrying out hydraulic test shall be furnished for Employer's approval.
- e. Feeler gauge tightness check from inside and outside to ensure required joint tightness shall be carried out.

C. Rotors

Forgings

Rotor forgings (monoblock and/or discs), Impulse Wheel & Nozzle Box and coupling forgings:

- 1. Fully representative tangential, radial and axial test pieces shall be provided at each end of the body, at each shaft end and from the trepanned core (when a core is trepanned) to determine mechanical properties including impact, brinell hardness etc. and tests for notch toughness i.e. FATT / NDTT (both transition temperature and room temperature impact values).
- 2. Creep requirements: