



DRAFT GUIDELINES FOR MODEL QUALITY ASSURANCE PLAN (MQAP) FOR MAJOR ELECTRICAL & MECHANICAL EQUIPMENT IN THERMAL POWER SECTOR



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ASSURANCE PLAN (MQAP) OF MAJOR ELECTRICAL
& MECHANICAL EQUIPMENT IN THERMAL POWER
SECTOR**

BY

**THERMAL ENGINEERING & TECHNOLOGY DEVELOPMENT
(TE&TD) DIVISION**

Government of India

Ministry of Power

Central Electricity Authority

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1. Background

Quality Assurance aims to keep the quality of a product/ equipment above a specified level and ensures that the product not only meets all customer requirements but also meets the suppliers' objectives and targets. Further, following a good Quality Assurance Plan (QAP) reduces the chance of costly mistakes and mitigates risk. This is specially required for Power Sector for ensuring quality, reliable and economic power supply as it serves billions of people on a daily basis besides serving commercial and industrial sectors in their contribution to economic growth of country. To achieve this, manufacturers and utilities rely on QAP. However, it has often been observed that there is variance in QAPs being followed by different manufacturers, utilities, etc. suiting their requirements. It appears that there is a need for uniform guidelines for QAPs which shall be followed by all stakeholders throughout the country. Further, these Model QAPs (MQAPs) shall be efficient in terms of number and type of tests being performed during the entire cycle from raw material/ sub-component sourcing to production to their commissioning so as to reduce unnecessary testing, avoid redundancy at various stages and consequently save time and cost of the project.

In view of the above, Ministry of Power (MoP) had desired the Standardization of Test Protocols for Electro-Mechanical (E&M) Equipment used in Power Sector. Accordingly, Central Electricity Authority (CEA) had constituted a Committee with members from CEA, Power Sector Utilities, Manufacturers, etc. vide CEA OM dated 01.11.2021 (enclosed as **Annexure-I**) to deliberate on the subject matter. The major decisions taken during the series of meetings (02.11.2021, 05.11.2021 and 30.11.2021) held by the Committee were to standardize the duration of validity of Type Tests conducted on various E&M equipment and preparation of Model Quality Assurance Plan (MQAP) of major E&M equipment in the entire power sector.

Further, five Sub-Groups were constituted for framing the guidelines for validity of Type Test(s) and preparation of MQAP of major E&M Equipment pertaining to different sub-sectors of Power Sector, viz. Thermal Generation, Hydro Generation, Renewable Energy, Transmission and Distribution comprising representatives of Central Power PSUs, State Power PSUs and Private Power utilities.

After detailed discussions amongst the Committee and sub-group members and inputs provided by the manufacturers/ vendors/ utilities, etc. this document has been prepared containing draft guidelines for MQAP of major E&M Equipment in Thermal Power Sector.

2. Quality Assurance Plan (QAP): Introduction

Quality of an equipment can be improved by taking effective steps at the initial stage itself, which include ‘use of high quality raw materials’ and ‘improved manufacturing processes’. The performance of an equipment largely depends on the excellence of design. However, all good designs may not yield good end product unless they are well supported by good materials, good and healthy machines and skilled workmen (operators)/ workmanship. The formulation and implementation of an efficient QAP comprises of a properly designed quality assurance program along with proper documentation at every stage, an efficient quality assurance test and finally implementation of quality assurance plans.

3. Broad Categories of Tests conducted on E&M Equipment in Power Sector

3.1 Type Tests:

- These tests are conducted for validation of design i.e. for confirming the main and basic design expectation of the equipment. These tests are done mainly on a prototype unit and not on all manufactured units in a lot.
 - This is a test conducted on an equipment, which is representative of other equipment, to demonstrate that these comply with specified requirements not covered by routine tests. It needs to be noted here that an equipment is considered to be representative of others, if it is fully identical in rating and construction, but the Type Test may also be considered valid, if it is made on an equipment which has minor deviations of rating or other characteristics. These deviations should be subject to agreement between the manufacturer and the purchaser.
 - In case Type Test Certificate is available for the specified validity period for the same design, the repeat test is not required.
 - The Type Tests are conducted as per relevant applicable Standard.
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3.2 Routine Tests:

- These tests are conducted mainly for confirming the operational performance of the individual unit in a production lot.
- These are at present conducted as per relevant applicable Standard.

3.3 Special Tests:

- These are the tests other than a Type Test and/ or Routine Test as agreed by the manufacturer and the purchaser in the contract.
- These tests are done as per customer requirement to obtain information useful to the user during operation or maintenance of the equipment.
- These are conducted as per relevant applicable Standard (as specified under Contract or to meet certain requirement of Contract).

3.4 These above mentioned tests are further classified on the basis of the stage at which they are conducted, either at the works of the contractor or at site as given below:

1. The Type Tests/ Routine Tests/ Special Tests as the case may be, if conducted at the works of the manufacturer before Manufacture Dispatch Clearance Certificate (MDCC) of the equipment from the works to the site are called as Factory Acceptance Tests (FAT). The objectives of FAT are generally as follows:

a) Factory Acceptance Test (FAT) -

- A FAT helps to verify that newly manufactured and packaged equipment meets its intended purpose. The FAT validates the operation of the equipment and makes sure the customers' purchase order specifications and all other requirements have been met.
- This is a test that runs on the equipment or components before it is delivered to its intended destination.
- FATs are usually done at the factory works to make sure that certain requirements are met. Further, these tests are normally done with the customer, and also, in certain more demanding cases, with a third party inspection agency.
- These are conducted as per relevant applicable Standard.

2. The Routine tests/ Special tests as the case may be, if conducted at the site during erection and commissioning are called as Site Acceptance Tests (SAT).

The objectives of SAT are generally as follows:

b) Site Acceptance Test (SAT)

- These tests are done to make certain that specified quality is met by the equipment at site and to offer customers quality testing and documents, and also further ensuring that nothing has changed or was damaged during shipment from supplier premises, storage and its installation.
- SATs are done at the specific places where usually commissioning is done.
- While FATs can use simulations to demonstrate as to how the equipment will function in its future operating environment, it may be difficult to mimic the actual operating conditions.
- SATs are only conducted after the FAT has taken place and the item/ equipment has been delivered. This is the only way to truly determine whether a piece of new equipment will function as required.
- These are conducted as per relevant applicable Standard.

4. Purpose of Uniform Guidelines for Model Quality Assurance Plan (MQAP):

There is an imperative need to have convergence in the preparation of Model Quality Assurance Plan (MQAP) as this will avoid variance among different stakeholders (manufacturers/ purchaser/ utilities, etc.), significantly save time & money and reduce burden on suppliers & testing facilities and cost to the end consumers by removing redundancies in testing procedures. Therefore, there is an urgent requirement to frame guidelines to make a uniform MQAP.

The major objective behind publication of these guidelines for MQAP of major E&M equipment of Power Sector are broadly as given below:

- i.To prepare Model QAPs, which are efficient and simultaneously have overall coverage of tests.** Unnecessary and repetitive tests at different stages would be optimized and the tests for only important/ major equipment would be included in these MQAPs. The sample size for testing shall also be standardized in the MQAPs. This would help in saving cost, time and conflicts for not only the vendors/ manufacturers but also the purchaser/ consumer.
- ii.To moderate/ optimize Customer Hold Points (CHPs) for non-critical tests.** For this purpose, model QAPs are being framed and accordingly those tests are identified for which only the Test Certificates (TCs) shall be sufficient and acceptable upon its review, thereby reducing the overall number of CHPs in inspections.
- iii.To bring the convergence in QAPs being prepared by various manufacturers or approved by utilities and set uniform guidelines of MQAP for all major Electro-Mechanical equipment manufacturers/ suppliers and purchasers in the country.**
- iv.To avoid overloading of testing facilities.** This shall be achieved in conjunction with the guidelines for the validity period of Type Test(s) for major E&M equipment of Power Sector. Specifying the validity of Type Test(s) and removal of repetition of non-critical tests as per applicable Standards and optimizing CHPs in MQAPs would reduce the burden on the existing testing facilities leading to reduction in waiting time and henceforth optimal utilization of testing facilities which are available with limited number of laboratories.

5. Broad Guidelines for Model QAP of Power Sector

- a) All the utilities/ purchaser/ developers/ suppliers in Thermal Power sector shall prepare and follow the Model QAPs (enclosed as **Annexure II**) of major and critical E&M equipment for which the list is as given below in **Table 1**.

Table 1: List of Major E&M Equipment of Thermal Power Sector for Model QAP Preparation:

Sl. No.	Name of Equipment
1)	1.1 STEAM GENERATOR AND AUXILIARIES a) Pressure Parts b) Boiler water circulation pumps c) Air Preheaters, Steam Coil Air Pre-Heater and Fuel Oil Heaters d) Soot Blowers e) ID, FD and PA fans f) Coal Mills, Pulverised Coal Piping and Burners g) Coal Feeders h) Boiler structure, ducts, hoppers, dampers etc. i) Electro- Static Precipitators (ESPs) 1.2 STEAM TURBINE GENERATOR AND AUXILIARIES a) Steam Turbine b) High pressure (HP) and intermediate pressure (IP) enclosures c) Low pressure (LP) enclosure (fabricated) d) Turbine rotors e) Stator and rotor blades and shroud bands f) Diaphragms g) Exhaust hood h) Stop, control and bypass valves, actuators/ servo-motors and steam strainers i) Cast and forged steel components j) Bolts and nuts for pressure retaining enclosures and rotor couplings k) Governing and protection system equipment l) Inspection of completed turbine 1.3 Integral Auxiliaries of Steam Turbine a) Bearing pedestals, housings and bearings b) Cross around pipes c) Lubricating oil, jacking oil and control oil systems 1.3.1 Steam Condenser

	1.3.2 Feed water heaters, drain coolers, gland steam condenser and deaerator 1.3.3 Boiler Feed Pumps 1.3.4 Condensate Extraction Pumps (CEPs) 1.3.5 Condensate Polishing Unit (CPU) 1.3.6 Condenser On-Line Tube Cleaning System 1.3.7 Debris Filter 1.4 HIGH PRESSURE PIPING, VALVES, THERMAL INSULATION AND MISCELLANEOUS SYSTEMS/ EQUIPMENTS 1.4.1 High Pressure Piping and Fittings 1.4.2 Power Cycle Valves 1.4.3 Metallic expansion bellows 1.4.4 Hangers and Supports 1.4.5 Thermal insulation, refractory, lagging and cladding 1.4.6 Low Pressure Piping, Valves and Fittings etc. 1.4.7 Equipment Cooling Water (ECW) System 1.4.8 EOT Cranes and Hoists 1.4.9 Elevators 1.4.10 Air Conditioning System 1.4.11 Ventilation System 1.4.12 Miscellaneous Items/ Equipments 1.5 FIELD ERECTION CHECKS AND TESTS
2)	ELECTRICAL SYSTEMS
	a. Generator and auxiliary systems
	b. Generator Isolated Phase Busducts and Neutral Grounding equipment
	c. Power Transformers
	d. HT BUSDUCT
	e. Auxiliary Service Transformers
	f. Motors
	g. 11kV, 3.3kV Switchgear
	h. 415V Switchgear and Busduct

	i. Power and Control Cables
	j. Installation of Cables, Earthing system and Lightning Protection system
	k. DC Storage Battery
	l. Battery Charger
	m. Protection and relay panel for generator, generator transformer and UATs
	n. Emergency Diesel Generating Set
	o. Electro Static Precipitator (ESP) – Electrical

b) MQAPs of those E&M equipment which have not been covered in the **Annexure II** shall be subject to the terms of mutual agreement between manufacturer and purchaser.

c) Test Certificates (TCs) of Bought-out items establishing the purchaser's requirement upon review shall be acceptable to the purchaser.

d) Any change in practice or acceptance norms (with reference to various tests / parameters in respective National / International standard) would be suitably incorporated by manufacturer from time to time and submit the same for approval of purchaser / utility.

e) These guidelines of MQAPs specify the maximum numbers of CHPs and highest limit of sampling size that could be included in the specification by the developer/ purchaser while conforming to the applicable Standard.

f) In order to save time, both the supplier and the purchaser shall be free to identify lesser number of tests as CHPs as per specific needs of purchaser subject to the agreement between them.

g) The utilities/ purchaser may request for additional tests which have not been covered in MQAPs of listed E&M equipment, at their own cost. However, the utilities should refrain from making it a regular practice. The utility must clearly specify as to which additional test(s) would be required during the awarding of the contract and quotation for such tests should be invited separately in the price bid. In such case, the utility shall

provide extra time for repetition of such test(s). In case there is change in the governing regulations/ applicable standards, the supplier would conduct the required test at his own cost.

h) The purchaser reserves the right to get the test conducted again at the supplier's works/ accredited laboratory at supplier's cost in case the Test Certificates are not establishing/ meeting the purchaser's requirement.

i) The TCs at initial/ raw material/ in-process stage by customer shall be prepared and maintained by the supplier. Further, the same shall be considered as accepted only after its acceptance by the purchaser upon review at appropriate stage of CHP.

j) The quantum of checks shall be strictly kept as specifically quantified in the column of 'Quantum of Check' and shall be governed by the document referred under column of 'Acceptance Norms' in QAP. However, wherever the quantum of check has been mentioned as 'sample per lot', the same shall be minimum 2 numbers or 5% of the lot whichever is higher except in the case of Type Tests.

k) No material shall be despatched from the manufacturer's works before the same is accepted, subsequent to pre-despatch final inspection including verification of records of all previous tests/ inspections by Purchaser's authorised representative and duly authorised for despatch.

l) Manufacturer shall carry out all tests/ inspection required to establish that the items/ equipment conform to requirements of the specification and the relevant codes/ Standards specified in the specification, in addition to carrying out tests as per the approved quality plan.

m) Quality approval of the results of the tests and inspection will not, however, prejudice the right of the Purchaser to reject the equipment if it does not comply with the specification, when erected or does not give complete satisfaction in service and the above shall in no way limit the liabilities and responsibilities of the manufacturer in ensuring complete conformance of the materials/ equipment supplied to relevant specification, standard, data sheets, drawings (approved by the Purchaser), and minutes of various meetings with customer / Purchaser etc.

- n) Any repair/ rectification procedures to be adopted to make the job acceptable shall be subject to the approval of the Purchaser/ authorised representative.
 - o) All inspection, measuring and test equipment used by manufacturer shall be calibrated periodically depending on its use and criticality of the test/ measurement to be done. The manufacturer shall maintain all the relevant records of periodic calibration and instrument identification, and shall produce the same for inspection by purchaser. In case repair is carried out in the measuring and test equipment it should be compulsorily recalibrated. All calibrated measuring and test equipment must be properly sealed after calibration to stop any kind of manipulation with the equipment. Wherever mutually agreed between manufacturer & purchaser, the manufacturer shall re-calibrate the measuring and test equipment in the presence of the Inspector.
 - p) The latest CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations shall also be complied with for ensuring the minimum technical requirements for construction of Generating Stations, Transmission & Distribution Lines and Substations.
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ANNEXURE I

**CEA OM DATED 01/11/2021 REGARDING CONSTITUTION
OF COMMITTEE FOR STANDARDIZATION OF TEST
PROTOCOLS FOR ELECTRO-MECHANICAL EQUIPMENT IN
POWER SECTOR**



भारत सरकार/Government of India
विद्युत मंत्रालय/Ministry of Power
केन्द्रीय विद्युत प्राधिकरण/Central Electricity Authority
जल विद्युत अधिनियम की वरी को मिला विकास पवार
Hydro Engrg. & Technology Dev. Division
सेवा भवन, भा. के. पुरा-1, नई दिल्ली-110066
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No. 10/3/HE&TD/2021/

Date: 01.10.2021

OFFICIAL MEMORANDUM

Subject: Constitution of Committee for Standardization of Test Protocols for Electro-Mechanical equipment in Power Sector-reg.

As Hon'ble Union Minister of Power has desired to standardize Test Protocols for Electro-Mechanical equipment in Power Sector, a Committee is hereby constituted consisting of the following members:

1.	Member (GO&D & Hydro), CEA	Chairman
2.	Chief Engineer (TE&TD), CEA	Member
3.	Chief Engineer (PSE&TD), CEA	Member
4.	Chief Engineer (DPT), CEA	Member
5.	Chief Engineer (RTD), CEA	Member
6.	Representative of CPRI	Member
7.	Representative of NTPC	Member
8.	Representative of PGCIL	Member
9.	Representative of NHPC	Member
10.	Representative of BHEL	Member
11.	Representative of SECI	Member
12.	Representative of DISCOM	Member
13.	Chief Engineer (HE&TD), CEA	Member & Convener

Further, the Committee may co-opt any other member, if required.

The **Terms of Reference (ToR)** of the Committee shall be as given below:

- 1) Standardization of Type Tests, Routine Tests, Field Acceptance Tests, etc.
- 2) The possibility of using CEA Regulations as part of Test Protocols.
- 3) Incorporation of outcome at Sl. No. 1 in CEA Regulations for making it enforceable.
- 4) Any other issue/ agenda with the consensus of the Committee.

The Committee shall submit a Report within 01 week from the date of receipt of this order.

This issues with the approval of the Competent Authority.


(Sonam Srivastava)
Asstt. Director

File No.CEA-HY-17-145/1/2018-HETD Division

To :

1. Chairman, CEA
 2. Member (GO&D and Hydro), CEA
 3. Chairman & Managing Director, NTPC Limited, NTPC Bhawan, SCOPE Complex, Institutional Area, Lodhi Road, New Delhi - 110003 - with a request to nominate a representative of NTPC (not below the rank of ED/GM)
 4. Chairman & Managing Director, PGCIL, Power Grid Corporate Office, Saudamini, Plot No.2, Sector 29, Near IFFCO Chowk, Gurgaon (Haryana) - 122001 - with a request to nominate a representative of PGCIL (not below the rank of ED/GM)
 5. Chairman & Managing Director, NHPC Ltd., NHPC Office Complex, Sector-33, Faridabad - 121003 (Haryana) - with a request to nominate a representative of NHPC (not below the rank of ED/GM)
 6. Managing Director, SECI, 6th Floor, Plate-B, NBCC Office Block Tower-2, East Kidwai Nagar, Kidwai Nagar, New Delhi, Delhi 110023- with a request to nominate a representative of SECI (not below the rank of ED/GM)
 7. Chairman & Managing Director, Bharat Heavy Electricals Limited, BHEL HOUSE, Siri Fort, New Delhi-110049 - with a request to nominate a representative of BHEL (not below the rank of ED/GM)
 8. Chief Engineer (TE&TD), CEA
 9. Chief Engineer (DPT), CEA - with a request to co-opt a representative from any DISCOM
 10. Chief Engineer (PSE&TD), CEA
 11. Chief Engineer (RTD), CEA - with a request to co-opt members from RE Sector (not below the rank of ED/GM)
 12. Chief Engineer (HE&TD), CEA
 13. DG, CPRI, Central Power Research Institute, Prof.Sir C.V.Raman Road, Post Box No: 8066, SadaShiva Nagar (p.o), Bengaluru, 560080
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(QUALITY ASSURANCE PLAN)

1.1 QUALITY ASSURANCE PROGRAMME

All materials, components and equipments covered under the scope of supply shall be procured, manufactured, erected and tested at all stages as per the comprehensive Quality Assurance (QA) programme. The QA document indicating the specific inspection and testing requirements to be followed shall be subject to the approval of the purchaser. The contractor shall submit his quality assurance programme for review by purchaser and shall generally cover the following:

- i) Organizational structure for management and implementation of the proposed quality assurance programme.
 - ii) Quality system manual.
 - iii) Documentation control system.
 - iv) Qualification and experience data of contractor's key personnel.
 - v) The procedure for procurement of materials, parts, components and equipment.
 - vi) Procedure for inspection at source, inspection of incoming raw-materials/ parts/ components & verification of materials purchased.
 - vii) Procedure for selection of sub-vendors and sub- contractors.
 - viii) System for shop manufacturing including process controls, fabrication and assembly controls, and procedure for product identification & traceability.
 - ix) System for inspection and testing during manufacture, processing, fabrication, welding, assembly and other activities.
 - x) The reference documents, plant standards, acceptance norms, test and inspection procedure etc.
 - xi) Control of calibration and testing of measuring and testing equipments.
 - xii) System for quality audits, documentation to indicate conformance or non-conformance of the product to the specification and testing and inspection requirements; review and control of non- conforming items and system for corrective actions.
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- xiii) System for indication and appraisal of inspection status.
- xiv) System for authorizing release of manufactured product to the purchaser.
- xv) System for packaging, handling, transportation, storage and delivery.
- xvi) System for generation and maintenance of inspection and test records.

1.2 STEAM GENERATOR AND AUXILIARIES

Testing and inspection requirements of major equipment over and above the respective code/standard requirements are given hereunder:

1.2.1 Pressure Parts

Only those materials shall be used in the manufacture of pressure parts which can be identified against mill sheet or manufacturer test certificates. Material shall meet all the mandatory requirements (and supplementary checks, if asked for) of specified specification, Indian Boiler Regulations (IBR), and relevant code/standard. All non destructive testing as detailed against relevant equipment shall meet the requirement of ASTM section 3 Vol. 3.03 or equivalent BIS standard.

1.2.1.1 Drum

- i) Each plate shall be subjected to a 100 % normal and shear ultrasonic at the mill to meet the minimum requirements of BS: 5996 grade LC3/ ASTM or equivalent standards. Elevated temperature tensile tests shall also be carried out on plate material for each heat.
- ii) After cutting to size and removal of cut outs, the plates shall be subjected to magnetic particle examination (MPE) along the edges of the plate and on areas adjacent to the cutouts.
- iii) All forged connections shall be examined by 100% ultrasonic testing (UT) before machining.
- iv) Fully machined connecting pieces of internal diameter 100mm and above, except for forgings, shall be subjected to MPE.
- v) Mechanical tests shall be carried out on specimens prepared from the production control test plates of the longitudinal welds.
- vi) Mechanical tests shall be conducted on the specimens from manhole cutouts of dished ends.

- vii) All butt welds shall be subjected to 100% radiographic test (RT) before stress relieving.
- viii) On completion of welding, the entire drum shall be subjected to stress relieving in the furnace.
- ix) All butt welds shall be subjected to 100% ultrasonic test and magnetic particle examination after stress relieving.
- x) All full penetration welds shall be subjected to ultrasonic examination after stress relief.
- xi) After stress relieving, all welds shall be examined by magnetic particle examination (MPE) methods depending on size and accessibility.
- xii) Complete drum shall be subjected to hydraulic pressure test and all compensating pads shall be pneumatically tested.

1.2.1.2 Headers

- i) Raw material for headers shall be subjected to UT prior to fabrication. Transverse test on headers (greater than 8") from one end (25% of lot). Flattening test on pipe from one end (25% of lot).
- ii) All butt welds shall be subjected to MPE and radiographic examination before stress relieving.
- iii) All full penetration nozzle and attachment welds shall be subjected to UT prior to stress relieving.
- iv) All nozzles, branches, stubs and load bearing attachment shall be examined by MPE techniques after the toes of the weld have been ground smooth and stress relieved.
- v) Non-load bearing welds shall be examined by MPE techniques after the toes of the welds have been ground smooth and stress relieved.
- vi) Completed closed end headers shall be subjected to hydraulic pressure tests and all compensating pads shall be pneumatically tested.

1.2.1.3 Tubes and tube elements

- i) Raw material for tubes for water wall, superheater, reheater, economiser, riser, supply and connecting tubes including nozzle/stubs, connections for drum, headers, pipe work etc., shall be subjected to 100% UT prior to

fabrication as per IBR or ASME E 213 or equivalent with the longitudinal calibration notch of depth 5% of wall thickness (0.3mm minimum and 1.5mm maximum).

- ii) All bent tubes, stubs shall be checked for ovality and thinning by ultrasonic method on first off lot and random checks on subsequent pieces.
- iii) All tubes, stubs, panels, coils shall be checked for clearance by steel ball test and for cleanliness by sponge passage.
- iv) Finished butt welds shall be subjected to RT and UT. Wherever the code/standard/process specifies random sampling, the same shall be minimum 20%. All fillet welds (including fins if any) shall be subjected to MPE or dye penetration test (DPT).
- v) Tubes and fabricated panels, coils shall be subjected to hydraulic pressure test excluding water wall panels and loose tubes but including burner panels, reheaters, superheaters and economizers.

1.2.1.4 Integral piping, valves and fittings

- i) All pipe lengths shall be subjected to 100 % ultrasonic examination as per ASME E 213 or equivalent, with longitudinal calibration notch of depth 5% of wall thickness (0.3mm minimum and 1.5mm maximum) or hydraulic tests and UT or RT on longitudinal welds at the tube mill.
- ii) All mother pipes shall be subjected to 100% UT prior to fabrication as per ASME E 213 or equivalent with longitudinal calibration notch of depth 5% of wall thickness (0.3mm minimum and 1.5mm maximum).
- iii) All forged fittings shall be checked by UT and formed fittings shall be checked by MPE.
- iv) All pressure parts shall be 100 % UT tested. All welded, cast alloy steel and carbon steel fittings for use above 71 bar design conditions shall be 100 % RT tested. However, wherever the code/standard/process specifies random sampling, the same shall be minimum 20%.
- v) All bent pipes shall be checked for ovality and thinning by UT on first off lot and on random samples for subsequent pieces. Outer surface of bends shall be subjected to MPE or DPT.
- vi) The edge preparation for shop and site welds in stainless steel and alloy steel shall be subjected to dye penetration check. Non-destructive examination of welds shall be carried out after post weld heat treatment, if any.

- vii) All butt welds shall be subjected to UT or RT and MPE. For weld on alloy steel piping, UT or RT shall be done after stress relieving. Wherever the code/ standard/ process specifies random sampling, the same shall be minimum 20 %.
- viii) All butt welds in alloy steel piping of P91, X20 and X 22 shall be checked for RT or UT and MPE after stress relieving (SR). UT shall be of digital recordable type.
- ix) All weld joints in alloy steel piping of P 91, X20 and X22 shall be checked for hardness. For preheating and post weld heat treatment (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.
- x) All load-bearing attachment welds shall be subjected to MPE after stress relieving.
- xi) For HP piping, non-destructive examination of welds shall be carried out in accordance with the relevant design/manufacturing codes. However, apart from above, the following requirements shall be met. Further statutory requirement, wherever applicable shall also be complied with the following:
 - a) Temperature > 400⁰C and/ or pressure exceeding 71 bar
 - 100% RT or UT on butt welds and full penetration branch welds.
 - 100% MPE.
 - b) Temperature > 175⁰C upto 400⁰C and/or pressure exceeding 17 bar and upto 71 bar
 - 100% RT or UT on butt welds and full penetration branch welds for pipe diameter more than 100NB.
 - 10% RT or UT on butt welds and full penetration branch welds for pipe diameter upto 100NB.
 - 100% MPE.
 - c) All other pipes not covered above shall be subjected to 100% MPE or DPT in case of under ground pipes and 10% MPE or DPT in case of piping above the ground. Further, 10% of butt welds of underground piping shall be subjected to RT.

1.2.1.5 Valves

- i) Pressure retaining parts of valves shall be subjected to NDT as per Table 8-1.

- ii) Hardened and stellited valve disc and seat shall be subjected to DPT and hardness check.
- iii) 100% UT of stem dia 500mm or more.
- iv) 100% UT of body & bonnet for valves 1500 class or above. 100% MPE for 600 class and above.
- xiii) Color matching of valve disc/plug and seat shall be carried out to ensure minimum 80% contact and no through passage. UT / RT of full penetration welds. & MPE of fillet joints (in case of cast valves).
- v) Hydraulic pressure test and seat leak test shall be carried out as per ANSI 16.34 or IBR.
- vi) Air seat leak test shall be carried out as per applicable standards or codes.
- vii) Functional tests shall be carried out on each valve to check the following as per the approved valve data sheet
 - a. Smooth operation.
 - b. Valve travel, closing and opening time.
 - c. Current drawn by actuators.
- viii) Springs for safety valves shall be tested with suitable NDT and for spring stiffness rate.
- ix) Safety relief valves shall be tested for performance. Lift set pressure, back pressure, reset pressure test in case of safety relief valves.

Table 1-1, NDT requirements for pressure retaining components of valves

Valve size NB in mm	ANSI Class upto300	ANSI Class above 300 upto 600	ANSI Class above 600 below 900	ANSI Class 900 and above but below 4500
Less than 50	Visual	Visual	Visual	MPE (for special class valves)
50 & abovebut below 100	Visual	Visual	MPE (for special class valves)	MPE and RT on 10%of valves on 100% area

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

Note:

- i. For body and bonnet forgings, UT with MPE may be adopted in place of RT.
- ii. For austenitic steel, MPE may be replaced by DPT.

1.2.1.6 Non pressure bearing attachments

Load bearing welds shall be subjected to UT and MPE after stress relieving. Non load bearing welds shall be subjected to MPE after stress relief. The toes of the welds adjoining the drum shall be ground smooth prior to stress relieving before carrying out this examination.

1.2.1.7 Hydraulic test

- i) The drum and all components which are to be subjected to fluid pressure shall be tested to minimum of 150% of the design pressure. The duration of the pressure tests shall be sufficient, as approved by the purchaser, to show any leakage paths and to permit a thorough examination of the component whilst under pressure.
- ii) 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 shall be modified and submitted to the purchaser for approval, before commencing the test.
- iii) The fluid used shall be of a sufficient purity and where relevant, suitable inhibitors shall be used to avoid excessive corrosion and /or damage to temporary parts either during the test or prior to drying and cleaning.

1.2.1.8 Pneumatic test of compensating pads

All compensating pads shall be provided with two-threaded weep holes to test welds at 0.5 kg/cm² (g) with soap solution and no leakage shall be ensured.

1.2.2 Boiler water circulation pumps

- i) Raw material for casing, shaft and impeller shall be checked for high temperature physical properties, apart from mandatory and supplementary check of material specification.
- ii) All forging and castings shall be subjected to 100% UT or RT and MPE or DPT check.
- iii) Static and dynamic balancing of the rotary parts shall be carried out.
- iv) Hydraulic pressure test shall be conducted on pump casing at minimum 1.5 times the design pressure.
- v) Each pump shall be subjected to performance test at the manufacturer's works under as near actual site conditions as possible.
- vi) Following test shall be carried out on assembled units: -
 - A) Type test:
 - a) NPSH test
 - b) Temperature rises test.
 - c) Under voltage test.
 - d) Quality assurance proof test.
 - e) Tests to establish unit functioning of pump at operating temperature and pressure.
 - f) Hot standstill and start up tests.

Note :- Type test if already done on the same model will not be repeated. Documents will be submitted for review and approval of the purchaser.

- B) Routine test:
 - a) Hydrostatic test of complete unit.
 - b) Overspeed test.
 - c) Tests to determine unit characteristics.
 - d) Pump performance.
 - e) Unit run at rated voltage.

- f) Starting current at rated voltage.
 - g) Cold start up test.
 - h) Endurance test of motor windings, joints and terminal seals
 - i) Noise level.
 - j) Inspection of dismantled unit.
 - k) High voltage test.
- vii) For heat exchanger for these pumps, butt welds on pressure parts shall be tested with RT or UT and all other welds shall be tested with MPE or DPT.
 - viii) Hydraulic test shall be carried out both on tube side as well as shell side at minimum 1.5 times the design pressure.

1.2.2 Air Preheaters, Steam Coil Air Pre-Heater and Fuel Oil Heaters

1.2.3.1 Air Preheaters

- i) Forged shafts for air preheater like stub shaft, main rotor forging, housing hub shall be subjected to 100% UT at mill and magnetic particle examination after machining.
- ii) For non-modular design, trial assembly shall be carried out at shop prior to despatch to site.
- iii) Critical welds of rotor post shall be subjected to radiographic examination.

1.2.3.2 Steam coil air pre-heater and fuel oil heaters

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.

1.2.4 Soot Blowers

- i) Butt weld between nozzle and lance tube shall be subjected to 100 % radiography tests.
- ii) Soot blower shall be subjected to operational checks as below:
 - a) Smooth operation
 - b) Long tube travel, closing and opening time.

c) Current drawn.

1.2.5 ID, FD and PA fans

- i) Rotor components shall be subjected to ultrasonic test at mill and magnetic particle examination/dye penetration examination after rough machining.
- ii) Butt welds in rotor components shall be subjected to 100% UT and all welds shall be subjected to MPE or DPT after stress relieving.
- iii) All rotating components of fans shall be dynamically balanced to quality grade 2.5 of ISO 1940.
- iv) Test for natural frequency of all fan components, including fan blades shall be carried out for the fans.
- v) Full range performance test shall be carried out on one fan of each type and size as per BS 848, Part-1.
- vi) Hydraulic coupling of ID fan shall be checked for string test i.e., operational check of one fan assembly using hydraulic coupling to check temperature rise, smooth operation, vibration and noise level. Dry run test shall preferably be carried out during string test.

1.2.6 Coal Mills, Pulverised Coal 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. MPE or DPT shall be carried out to check surface soundness.
- ii) Wear-resistant parts shall be subjected to UT or RT to check soundness after suitable heat treatment. Check for chemical composition and hardness 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 body casing and separator of the mill shall be tested by RT and MPE. All other welds shall be tested by MPE or DPT for acceptance.

- 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 shall be examined by MPE.
- vi) Ceramic/ basalt lined piping and bends etc. 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) All rotating components of fans shall be dynamically balanced.

1.2.7 Coal Feeders

- i) All welds in the casing and pulley fabrication shall be checked with MPE.
- ii) Type tests including degree of protection and routine tests shall be done as per relevant Indian Standards or equivalent International Standards.
- iii) All major items like plates for casings, head pulley, tail pulley, pulley shaft and major castings shall be procured with respective material test certificates.
- iv) 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.
- v) Test for weighing accuracy, calibration and repeatability shall be carried out at various speeds by coal flow on one feeder.
- vi) Calibration check shall be carried out on all feeder cabinet and assemblies prior to dispatch.

1.2.8 Boiler structure, ducts, hoppers, dampers etc.

- i) Only those materials which have been identified against mill sheet or test certificates shall be used for construction. Structural steel and built up plate girders for main boiler shall be fully killed fine grained and normalised. All plates of tension and compression flanges and connection material and plates above 40mm thickness shall be 100% ultrasonically tested.
- ii) Visual inspection of all welds shall be performed in accordance with AWS D.1.1. Also the butt and fillet welds for built up plate girders shall be inspected 100% by magnetic particle examination.
- iii) RT or UT shall be performed on all butt welds of thickness 32mm and above. For thickness below 32mm and upto 25mm, 100% MPE shall be carried out and for thickness below 25mm 10% MPE or DPT shall be performed. Edge preparations for field welding shall be examined by MPE for plate thickness 32mm and above. Field welds ends in ceiling girder shall be subjected to Ultrasonic examination for 100mm depth from the edges.
- iv) Ceiling girders, columns, ducts hoppers and tunnels shall be trial assembled and match marked prior to dispatch/erection. At least two consecutive girders alongwith cross member shall be assembled at a time.
- v) Drum sling rods
 - a) Sling rods forging shall be subjected to ultrasonic examination.
 - b) Welds shall be examined by UT and MPE after stress relief.
 - c) Trial fitment of the rods with the drum shell shall be carried out to ensure proper contact.
 - d) Screw thread of the rods shall be suitably protected to avoid damage during handling and transport.
- vi) Dampers
 - a) All the dampers shall be subjected to operational test/checks.
 - b) Gas tight dampers shall be subjected to shop leakage test to

demonstrate the guaranteed tightness (minimum one damper of each type and size offered). In case such type test is already done, the reports of the same shall be submitted for review.

- c) All dampers shall be checked for sealing dimensions to establish guaranteed tightness.

1.2.9 Electro- Static Precipitators (ESPs)

1.2.9.1 Discharge and collecting electrodes

- i) Work tests for discharge electrodes shall include the following (for the wire type electrodes):
 - a) Chemical and tensile tests.
 - b) Metallographic examination-longitudinal and transverse (250X)
 - c) Surface finish and surface purity from chloride ions.
 - d) Spring back and surface finish after coiling (applicable to helical discharge electrodes)
- ii) Work tests for collecting electrodes and rigid discharge electrode shall include the following:
 - a) Chemical and mechanical properties.
 - b) Check for profile and straightness.
 - c) Check for surface finish and dimensional accuracy.
 - d) Cupping test for deep drawn sheets.

1.2.9.2 ESP structure

- i) Visual inspection of all welds shall be performed in accordance with AWS D1.1.
- ii) Also the butt and fillet welds for built up plates and columns shall be inspected by 100% MPI.

- iii) Radiographic examination shall be performed on butt welds as per AWS D1.1. 100% radiography on tension flange (bottom flange) welds and spot radiography on all joints in compression flange (top flange) of all beams and columns shall be carried out. The minimum length of welds for spot radiography and acceptance criterion shall be as per AWS D 1.1.
- iv) Edge preparation for field welding shall be examined by MPI.

1.3 STEAM TURBINE GENERATOR AND AUXILIARIES

Testing and inspection requirement of major equipment over and above the requirements of respective codes/standards are given hereunder:

1.3.1 Steam Turbine

1.3.1.1 High pressure (HP) and intermediate pressure (IP) enclosures

The following shall be applicable to high pressure cast steel enclosures (for example high pressure and intermediate pressure inner and outer cylinders, steam chests and liners, steam inlet pipes, nozzle boxes):

- i) Test pieces fully representative of the material and condition of the casting shall be provided to the purchaser to enable the determination of the properties of material to be used. Casting suppliers should have established practices to ensure requirements of creep and rupture for long exposure of the component/ equipment to high temperatures and pressures. In case of new or non established vendors, creep data shall be made available by the contractor.
- ii) Tests shall be carried out on the casting material to establish its mechanical properties, chemical composition, and microstructure.
- iii) Each casting shall be subjected to magnetic particle examination on the entire inner and outer surfaces after heat treatment.
- iv) Each casting shall be subjected to visual examination and dimensional check before taking up the machining work on it. Dimensional check shall be carried out after machining also.
- v) Each casting shall be subjected to a 100% examination for internal flaws by UT or RT method after heat treatment and suitable preparation.
- vi) Cast enclosure shall be subjected to a hydraulic pressure test based on established practice of manufacturer.

- vii) Excavated area of all the defects shall be subjected to MPE 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 MPE. Sketches/ reports of location of repair and reports of NDT carried out on repaired areas shall be submitted alongwith certificates. Hardness survey shall be carried out on the repaired areas.
- viii) Where stub pipes and transition pieces are welded to the main body of an enclosure the following shall be carried out:
 - a) RT and MPE or DPT of weld preparations.
 - b) MPE of finished welds after stress relieving.
 - c) RT or UT of finished welds.
 - d) 100% RT or UT and MPE of site weld preparations on the stub pipes and transition pieces before dispatch to site.
 - e) Hardness survey on the weld joint, heat affected zone (HAZ) and parent material.
- ix) Wall thickness measurement for critical and highly stressed zones of the casting shall be carried out by ultrasonic method.
- x) 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.
- xi) Final dimensional check before dispatching should be carried out. Suitable arrangement should be taken care to avoid any distortion during transit/ transportation.

1.3.1.2 Low pressure (LP) enclosure (fabricated)

- i) Tests shall be carried out on the plate material to establish its mechanical properties and chemical composition.
- ii) Plates used for fabrication shall be subject to 100% UT.
- iii) 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.
- iv) Fabricated enclosure shall be subjected to stress relieving as per

manufacturer's standard practice.

- v) Dimensional check shall be carried out on the fabricated enclosure.
- vi) The following minimum requirements shall be met for NDT on the welds:
 - a) Butt welds & full penetration welds : 10% RT or UT and 10% MPE or DPT (100%)
 - b) Fillet welds : 10% MPE or DPT (100%)
 - c) Nozzle welds : 10% MPE or DPT (100%)
 - d) Lifting lug and other load bearing fillet welds : 100% MPE or DPT
 - e) Site weld edge preparations : 10% MPE or DPT
- vii) Fabricated enclosure shall be subject to hydraulic pressure tests. If it is not the manufacturer's practice, the justification for not carrying out hydraulic test shall be furnished for purchaser's approval.
- viii) Feeler gauge tightness check from inside and outside to ensure required joint tightness shall be carried out.
- ix) Suitable arrangement should be taken care to avoid any distortion during transit/ transportation.

1.3.1.3 Turbine rotors

1.3.1.3.1 Forgings

Rotor forgings (mono block and/ or discs), impulse wheel and nozzle box and coupling forgings:

- i) 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 (both transition temperature and room temperature impact values).
- ii) Forging supplier should have established practices to ensure requirements of creep and rupture for long exposure of the component to high temperatures and pressures.
- iii) Heat treatment shall be carried out in such a way so as to ensure minimum

residual stress in the rotor. Residual stress measurement will be carried out.

- iv) Tests shall be carried out on the forging material to establish its mechanical properties, chemical composition and micro structure.
- v) Thermal stability tests shall be carried out on HP and IP rotor forgings to ensure the thermal stability of the rotors in service and at overspeed.
- vi) Each forging shall be subjected to a 100% ultrasonic examination. Normal probes and angular probes with different probe angles shall be used for thorough examination to ensure complete soundness of the forging
- vii) Each rotor shall be subjected to a 100% MPE after final machining on journal areas and before gashing on other areas.
- viii) When a rotor forging is bored, a visual check and magnetic particle examination of the bore shall be carried out.
- ix) Following tests shall be carried out on the rotor welds:
 - a) Ultrasonic examination with normal and angular probes of the weld to ensure complete coverage and freedom from harmful defects.
 - b) Run out of rotor before and after welding.
 - c) MPE on finish welds.
 - d) Hardness survey on the welds.
 - e) Stress relieve annealing.
 - f) Test reports of filler material used.
 - g) Dimensional record of weld preparation.
- x) Dimensional examination of the rotor blade grooves and other important dimensions shall be carried out to ensure the conformance to drawing dimensions and log sheets/records shall be prepared for all important dimensions.

1.3.1.3.2 Complete rotors

- i) Axial & radial run-outs and surface finish checks shall be carried out before and after blading and after overspeed tests. Run out examination shall be carried out at blade shrouds also.

- ii) Check shall be carried out for clearance between rotor groove and blade at the root.
- iii) Rotors shall be dynamically balanced at rated speed.
- iv) An overspeed test shall be carried out during which the rotor shall withstand an overspeed of 120% for five continuous minutes or 125% for two continuous minutes. If bidder's practice is different from that stated above, then the same shall be furnished for purchaser's approval. During overspeed test, vibration measurement and analysis shall also be carried out.
- v) After blading and again after overspeed testing, rotor stages with blades over 225 mm of active length are to be subject to standing vibration tests to determine natural frequencies in various vibration modes to ensure that the ranges are outside operating frequencies.
- vi) In case impulse stage and or blade discs are fitted on the rotor, fit up between such disc and rotor shall be checked up before and after overspeed test.
- vii) Lock blade lift after the overspeed test shall be checked and record for same shall be maintained.

1.3.1.4 Stator and rotor blades and shroud bands

- i) Fully representative test pieces shall be provided to enable mechanical properties of the material to be determined. In case of blades machined from bar stock, mechanical tests shall be carried out on the hardest and softest specimens of each heat treatment batch. Hardness test will be carried out on 100% basis.

- ii) Tests shall be carried out on the materials to establish its mechanical properties, chemical composition and micro structure.
- iii) Each bar stock for machining blades and forging shall be subjected to 100% ultrasonic examination.
- iv) When erosion shielded, the erosion shield and blade joint shall be radiographed.
- v) Dye penetrant test shall be made on the erosion shield and blade joint in manufacture prior to fitting to the wheel and after overspeed tests.
- vi) Magnetic particle examination or dye penetrant test (when MPE is not applicable) shall be carried out on finish machined blade profile, roots and shrouds.
- vii) All moving blades of over 225mm active length are to be moment weighed and assembled on shaft in a prescribed sequence to ensure optimum balancing of rotor.
- viii) Natural frequencies of the LP turbine blades shall be determined before mounting on rotors to ensure that the same are outside operating frequency range.
- ix) Shroud bands after punching and after rivetting shall be subjected to 100% DPT to ensure freedom from harmful surface defects.
- x) In case of cast blades, following testing shall be done:
 - a) Chemical analysis and mechanical testing per heat/heat treatment batch.
 - b) MPE on rough machined and finish machined blade.
 - c) RT on blades.
 - d) Before starting mass productions, following technological tests shall be carried out on the first lot of 10 to 15 blades:
 - 100% RT and 100% MPE on blades
 - 100% hardness testing.
 - Mechanical testing and metallurgical testing.

- Weld repair shall not be permitted.

1.3.1.5 Diaphragms

- i) Welded and fabricated diaphragms
 - a) Concentricity checks shall be carried out on final machined diaphragms to ensure that there are no negative overlaps between guide and moving blades.
 - b) 10% UT and 100% MPE shall be carried out on finished, stress relieved and machined welds. For inaccessible areas, DPT shall be carried out in place of MPE.
- ii) Cast, forged and machined diaphragms
 - a) Tests shall be conducted to determine mechanical properties together with chemical analysis, metallographic/ metallurgical examination, and required heat treatment.
 - b) Concentricity, flatness, blade drop and area checks shall be carried out on finally machined diaphragms to ensure that there are no negative overlaps between guide and moving blades and port wall.
 - c) 100% ultrasonic examination shall be carried out on diaphragm materials. Blade junction areas with the side walls shall be checked by MPE or DPT.
- iii) Colour matching of all the diaphragms by putting two halves together and feeler gauge tightness check shall be carried out.

1.3.1.6 Exhaust hood

All castings shall be subjected to chemical and mechanical tests as per relevant material standards. In case of fabricated construction of exhaust hood, butt welds shall be subjected to 10% RT and 100% DPT. Exhaust hood shall be pressure tested. No repair of welding shall be carried out on cast iron castings. Blue matching shall be carried out on exhaust hood parting planes.

1.3.1.7 Stop, control and bypass valves, actuators/ servo-motors and steam strainers

- i) Test pieces shall be provided to enable the determination of mechanical properties of valve bodies, bonnets, valve disc and seat, and valve spindle. Casting suppliers should have established practices to ensure requirements of creep and rupture for long exposure of the component/ equipment to high temperatures and pressures.

- ii) Tests shall be carried out on the materials to establish their mechanical properties, and chemical compositions.
- iii) Dye penetrant tests shall be carried out on stellited and nitrided areas of components and on stellite components in the finish ground or honed condition.
- iv) Hardness check shall be carried out to ensure required hardness.
- v) Valve body and bonnet castings or forgings shall be subjected to 100% RT or 100% UT. Body and bonnet shall also be subjected to 100% MPE on entire surface.
- vi) All pressure containing welds in body and bonnet shall be subjected to 100% RT or UT and 100% MPE.
- vii) Wall thickness of the body and bonnet after finish machining shall be measured by ultrasonic method and valve seat bore shall be checked for size and concentricity.
- viii) Dimensions of valve spindle shall be measured and valve lift shall be checked.
- ix) Bar stock of 50 mm and above size for valve stem shall be subjected to UT, and finish machined stem shall be subjected to MPE or DPT.
- x) Each valve body and bonnet shall be hydraulically tested at minimum 1.5 times the maximum working pressure after applying temperature corrections for minimum 30 minutes.
- xi) All the actuating cylinders and servomotors shall be performance tested.
- xii) Performance testing shall be carried out on valve operators and actuators to check functional requirements like trip closing and opening time, valve lift and hysteresis.

- xiii) Colour matching of the valve disc and seat to ensure the required contact area is to be carried out.

1.3.1.8 Cast and forged steel components (such as LP casing- in case of cast design, inlet, extraction and exhaust connections, shaft seal covers and rings, governor shaft, breach nut, threaded ring, angle ring, U-ring, servomotor parts such as body, piston, cover, yokes; turning gear casing and other items which are not specifically covered elsewhere)

- i) Results of tests conducted to determine mechanical properties, chemical analysis, metallurgical/ metallographic examination, and heat treatment procedures recommended and actually followed shall be recorded on certificates.
- ii) Each pressure containing enclosure shall be subjected to a hydraulic pressure test at 1.5 times the design pressure and after applying temperature corrections.
- iii) All castings and forgings shall be subject to suitable non-destructive examination by RT or UT and MPE or DPT methods to ensure freedom from harmful defects in line with clause 1.3.1.1.

1.3.1.9 Bolts and nuts for pressure retaining enclosures and rotor couplings

- i) Bar stock for bolts shall be subject to 100% UT.
- ii) Finish machined bolts shall be subject to preferably 100% MPE to detect surface defects. However, DPT can also be done in place of MPE.
- iii) Coupling bolts and nuts shall be suitably identified after weight control checks.

1.3.1.10 Governing and protection system equipment (such as electro-hydraulic controller, hydraulic amplifier, hydraulic controller, electro hydraulic convertors, hydraulic convertors, hydraulic speed governor, trip devices etc.)

- i) All pressure retaining parts shall be subjected to hydraulic testing.
- ii) All the major castings and forgings shall be subjected to suitable NDT methods depending upon their application and criticality to ensure the freedom from harmful defects.
- iii) All the main assemblies and sub-assemblies shall be subjected to functional test.
- iv) All butt welds shall be subjected to minimum 10% RT or UT and all fillet and corner welds shall be subjected to MPE or DPT.
- v) All control equipment shall be subjected to rig testing, if it is not possible to test it on the steam turbine light run. The purpose of rig testing shall be as far as practical to prove that the functioning of the control equipment is in accordance with the approved design.
- vi) Nitrided and stellited components shall be subject to DPT and hardness check.

1.3.1.11 Inspection of completed turbine

- i) HP and IP turbines

The steam turbine shall be assembled in the manufacturer's works to such an extent that a thorough inspection can be carried out. The purpose of this inspection shall be to ensure that the fit between mating components is correct and that all clearances are in accordance with the design requirement. The following minimum checks/ measurements shall be carried out on the assembled turbine:

- a) Check and measurement of clearance between shaft seal casing and shaftseal ring.

- b) Check and measurement of clearance in anti- rotational device in shaft seal casing joint.
- c) Check and measurement of axial and radial alignments of inner and outer casings.
- d) Check and measurement for radial and axial blade clearances in blading section.
- e) Check and measurement for axial and radial clearances in shaft seal.
- f) Check and measurement for tightness and elongation of horizontal joint inner casing bolts.
- g) Check and measurement of minimum axial clearances and minimum radial clearances in completely assembled steam turbine.
- h) Check for alignment of overspeed governor.
- i) Check for axial distances for shroud bands for casings.
- j) No load running test on the steam turbine including functional tests for steam turbine control and emergency control equipments.
- k) Pre- dispatch inspections including clearance check for transportation device.
- ii) LP Turbines

For the LP turbine, the following minimum checks/ measurements shall be carried out on the assembled turbine at the manufacturer's works:

- a) Check and measurement of axial and radial alignments of inner and outer casings.

- b) Check and measurement for radial and axial blade clearance in blading section.
 - c) Check and measurement of minimum axial clearances and minimum radial clearances in completely assembled steam turbine.
 - d) Check and measurement for alignment of stationary blade carriers.
 - e) No load running test on the steam turbine including functional tests for steam turbine control and emergency control equipments.
 - f) Pre- dispatch inspections including clearance check for transportation device.
- iii) No load running tests on complete steam turbine shall be carried out as per manufacturer's standard practice.

1.3.2 Integral Auxiliaries of Steam Turbine

1.3.2.1 Bearing pedestals, housings and bearings

- i) Leakage test shall be conducted on pedestals. For fabricated pedestals and housing, 10% weld shall be checked after stress relieving by magnetic particle test and minimum 10% of the butt welds shall be checked by RT or UT.
- ii) Bearing shell
 - a) The shell shall be subjected to suitable non destructive examination like RT or UT and/or MPE as applicable.

- b) Colour matching of the shell by putting two halves together and feeler gauge tightness checks from inside and outside to ensure required contact area and joint tightness shall be carried out.
- c) The shell shall be subjected to hydraulic pressure test.
- d) Chemical analysis of white metal shall be carried out. The effectiveness of the white metal adhesion shall be checked by UT or other approved method, and the exposed edges of the white metal shall be subject to DPT.
- e) Hydraulic test shall be carried out for bearing oil inlet piping and jacking oil piping.
- f) Alignment check shall be made for bearing in bearing pedestal.

1.3.2.2 Cross around pipes

- i) Weld edge preparation of shop and site welds shall be checked by 100% MPE.
- ii) All butt welds shall be subjected to 100% RT.
- iii) 100% MPE shall be carried out on all welds.
- iv) Check for dimensions and visual inspection shall be carried out on finished pipes.

1.3.2.3 Lubricating oil, jacking oil and control oil systems

- i) Pumps
 - a) Main oil pump shaft shall be subjected to ultrasonic examination. Butt welds shall be subjected to RT or UT.

- b) Pump impeller shall be subjected to suitable NDT method like MPE or DPT for surface defect examination. Impeller of main oil pumps shall also be subjected to an overspeed test at 120% of rated speed for 5 minutes.
 - c) Pump casing shall be subjected to hydraulic pressure test at 2 times the working pressure or 1.5 times the pump shut off head whichever is higher.
 - d) Rotor assemblies shall be dynamically balanced.
 - e) All pumps shall be performance tested at the manufacturer's works. Test shall include check for vibration and noise levels also.
- ii) Coolers and lubricating oil tanks
- a) All raw materials used shall have co-related mill test certificate meeting mandatory and supplementary checks of material specification.
 - b) Material for tube plates shall be ultrasonically tested. Drilled tube plates shall be checked for ovality of holes, ligaments, surface finish etc.
 - c) Dished ends shall be subjected to 100% MPE and RT or UT on welded joints. Knuckle portion shall be checked by MPE for surface defects and thinning shall be checked by UT.
 - d) Butt welds and full penetration welds shall be checked by suitable RT or UT. Fillet welds shall be checked by MPE or DPT.
 - e) Tubes shall be tested as per the relevant codes or standards.
 - f) Before tubes expansion in the tube sheets, the mockup test for expansions shall be carried out, in case not done earlier. Torque setting of expander shall be based on mock up tests. Joints shall be checked for tube thinning.

- g) Completed assemblies shall be pressure tested. The twin oil coolers shall be tested on both tube side and shell side. After hydrotest, the coolers shall be suitably dried.
 - h) Atmospheric tanks shall be tested for leakage by water fill test for atleast 12 hrs.
- iii) Oil purifiers
 - a) All pressure parts shall be subjected to hydraulic pressure test.
 - b) Components/ parts of the equipment shall be subjected to suitable NDT depending upon the criticality of the application to ensure freedom from surface and sub-surface defects.
 - c) All rotating parts like bowl assembly etc. shall be subjected to static and dynamic balancing test.
 - d) The complete purifier shall be tested at manufacturer's works for capacity, mechanical running, sequential operation and interlocks, moisture content, vapour tightness, vibration, noise level, quality improvements etc. Sample shall be drawn from inlet and outlet of purifier after works test and shall be tested for moisture content, chemical tests and particle size of impurities. . In case, type test has already been carried out by the contractor for the offered model of the centrifuge, the test shall not be repeated and certificates of test carried out earlier shall be furnished for review of the purchaser. The validity of the type test carried out earlier shall be limited to five (5) years.

1.3.3 Steam Condenser

1.3.3.1 Condenser

- i) Tests shall be carried out on the materials of plates, tubes and nozzles etc. to establish their mechanical properties, and chemical compositions.

- ii) Plates shall be subject to 100% ultrasonic testing.
- iii) Tubes shall be subject to dimensional check, 100% eddy current test and 100% hydraulic test. In place of hydraulic test, air under water or Helium leak detection test can also be carried out.
- iv) Forgings of the nozzles shall be subject to 100% UT and 100% MPE.
- v) All welds shall be visually examined. Radiographic examination of 10% of butt welds (including T-joints) shall be carried out. However, for vacuum containing welds, RT on atleast 10% of each butt weld shall be carried out. Surface defect examination by MPE or equivalent test method shall be carried out for minimum 10% weldments. Nozzle welds shall be subject to 100% MPE or DPT. These shall apply to site welds also.
- vi) All edge preparations shall be examined for surface defects. Edge preparation for welds to be carried out at site shall be checked by magnetic particle examination method before dispatch.
- vii) In case of fabricated flanges, welds shall be checked by 100% RT or UT and 100% MPE to ensure freedom from internal and surface defects.
- viii) To ensure dimensional control of condenser, parts/ sub assemblies shall be trial assembled at shop. Trial insertion of a few tubes through main tube plates and support plates shall be carried out to ensure alignment of tube plates and proper fitting and matching of parts and sub-assemblies.
- ix) Dimensional check including tube hole diameter, ligament pitch etc. shall be carried out.
- x) Mock-up test for tube to tube sheet expansion shall be carried out. In case such a test is already conducted for similar tube/ tube sheet thickness and materials, record for the same shall be furnished for purchaser's review and approval.
- xi) Tube to tube sheet weld joints shall be subject to 100% DP test.
- xii) Water fill test on shell side of condenser shall be carried out. No leakage shall be permitted.

- xiii) Water fill test of standpipe, Flash tank etc. shall be carried out. No leakage shall be permitted.
- xiv) Hydraulic test of tube side of condenser shall be carried out. No leakage shall be permitted.
- xv) All compensating pads (RF pads) shall be pneumatically tested.

1.3.3.2 Spring assembly

- i) Static load testing of the springs shall be carried out and spring characteristics shall be drawn and verified.
- ii) Surface defect test shall be carried out on all the springs after coiling and heat treatment.

1.3.3.3 Condenser air evacuation system

- i) Vacuum pumps
 - a) Tests shall be carried out on the materials of Head, Body, Rotor/Impeller, Shaft and Bearing Housing etc. to establish their mechanical properties, and chemical compositions.
 - b) Vacuum pump shafts shall be subject to ultrasonic test. After finish machining, shaft shall be subject to 100% MPE or DPT.
 - c) Pump casings and impellers shall be subject to MPE or DPT. Finished pump rotor shall be subject to dynamic balancing.
 - d) Pump casings shall be subjected to hydraulic test at 1.5 times the shut off pressure or twice the maximum operating pressure, whichever is higher.
 - e) The heat exchangers shall be tested on both tube side and shell side. After hydro test, the heat exchangers shall be suitably dried.

- f) Each pump shall be tested at supplier's works at full speed and load conditions to demonstrate successful operation and performance in accordance with the design requirements. Visual cavitation test shall also be carried out to demonstrate that pump shall be operating under all operating condition including blank off condition without any cavitation.
- ii) The complete package shall be subjected to hydraulic pressure and leakage test and shop tested to check interlocks and functional requirements. The one complete unit shall also be subjected to demonstrate successful operation and performance testing, with saturated air conditions at condenser design vacuum point as well as vacuum pump design point with total minimum three points. The test shall be conducted with the respective motors to be supplied. The test shall include check for vibration and noise level also.

1.3.4 Feed water heaters, drain coolers, gland steam condenser and deaerator

1.3.4.1 Heaters, drain coolers and gland steam condensers

- i) Tests shall be carried out on the materials of forgings, plates and tubes etc. to establish their mechanical properties, and chemical compositions.
- ii) Plates shall be subject to 100% ultrasonic testing.
- iii) Nozzle forgings shall be subject to suitable heat treatment and 100% ultrasonic testing and 100% MPE.
- iv) Tubes (U-tubes)
 - a) Tubes shall be subject to dimensional check incl U-bending (bend radius & Mockup), Check for flatness, Min. thickness at minimum radius of bend for each thickness
 - b) 100% eddy current test shall be carried out for tube thickness < 3.6 mm and 100% UT for tube thickness ≥ 3.6 mm, 100% DPT on bend areas.
 - c) Tubes shall be subject to 100% hydraulic test.
 - d) Heat treatment after cold bending, U- bend thickness check, Hardness after bending check.

- e) Check for Residual Chloride contamination on inside & outside of the tube.
 - f) Flattening and flaring tests, IGC (Practice-E), microstructure, residual stress measurement shall also be carried out for the tubes as per applicable codes.
 - g) Before tubes expansion in the tube sheets, the mockup test for expansions shall be carried out. Torque setting of expander shall be based on mock up tests. Joints shall be checked for tube thinning. Also, tube to tube sheet welding qualification tests (mock up) to check leak path.
- v) Tube sheets
- a) Tube sheets shall be subject to visual examination and dimensional check.
 - b) Impact test shall be carried out for the plate materials. Mechanical Properties of heat treated test coupon.
 - c) 100% UT and 100% DP test shall be carried out after overlay and machining. In case overlay is not applicable, only 100% UT shall be carried out.
 - d) For clad plates, bonding shall be checked by UT. Drilled tube plates shall be checked for ovality of holes, ligaments, surface finish etc.
 - e) Tube to tube sheet weld joints shall be subject to 100% DP test. These joints shall also be subject to air test.
- vi) Shell, dished ends and hemi heads
- a) Impact test shall be carried out for the plate materials.

- b) 100% UT shall be carried out on the finished and formed dished ends and hemi heads.
- c) Dished ends shall be subject to dimensional check after dishing.
- d) Knuckle portion shall be checked by 100% MPE or DPT for surface defects and check for thinning shall be carried out by UT.
- e) Testing of production test coupons as applicable.

vii) Welding

- a) Root run of butt welds shall be examined by 100% DPT or MPE.
- b) Butt welded and full penetration joints and nozzle welds shall be checked by 100% RT or UT and 100% MPE or DPT.
- c) Fillet welds shall be checked by 100% MPE or DPT.
- d) All weldments shall be given suitable heat treatment.

viii) Visual check and dimensional measurement shall be carried out on the completed equipment. All compensating pads (RF pads) shall be pneumatically tested.

ix) Completed assembly shall be pressure tested with working-fluid using hydraulic and pneumatic method. The heat exchangers shall be tested on both tube side and shell side. After hydro test, the heat exchangers shall be suitably dried and nitrogen capped.

1.3.4.2 Deaerator

- i) Tests shall be carried out on the materials of forgings, plates and tubes etc. to establish their mechanical properties, and chemical compositions.
- ii) Plates shall be subject to 100% ultrasonic testing.

- iii) Forgings shall be subject to suitable heat treatment and 100% ultrasonic testing and 100% MPE.
- iv) Shell and dished ends
 - a) Impact test shall be carried out for the plate materials.
 - b) 100% UT shall be carried out on the finished/ formed plates.
 - c) Dished ends shall be subject to dimensional check after dishing.
 - d) Knuckle portion shall be checked by 100% MPE or DP test for surface defects and check for thinning shall be carried out by UT.
 - e) Testing of production test coupons as applicable.
- v) Welding
 - a) Root run of the butt welds shall be examined by 100% DPT or MPE.
 - b) Butt welded and full penetration joints and nozzle welds shall be checked by 100% RT or UT and 100% MPE or DPT.
 - c) Fillet welds shall be checked by 100% MPE or DPT.
- vi) Visual check and dimensional measurement shall be carried out on the completed equipment.
- vii) Completed assembly shall be pressure tested with working-fluid using hydraulic method. After hydro test, same shall be suitably dried.
- viii) All weldments shall be given suitable heat treatment.

- ix) All compensating pads (RF pads) shall be pneumatically tested

1.3.4.3 Valves on heaters and deaerator

- i) Tests shall be carried out on the materials of forgings, plates and tubes etc. to establish their mechanical properties, and chemical compositions.
- ii) 100% RT or UT shall be carried out on bodies, bonnets, nozzles and stem of valves of HP heaters.
- iii) 100% DPT or MPE shall be carried out on machined surfaces of valve body, bonnet, stem, disc and springs.
- iv) Valve body shall be subject to hydraulic testing.
- v) Valve seat shall be subject to hydro leak test as per ANSI 16.34.
- vi) Visual check and dimensional measurement shall be carried out on the completed valve assembly.

1.3.5 Boiler Feed Pumps

1.3.5.1 Main pump

- i) Tests shall be carried out on the materials on various components to establish their mechanical properties and chemical composition. Further, heat treatment shall be given as required.
- ii) 100% UT shall be carried out on barrel casing, casing cover, suction & discharge branches, shaft, ring sections, and wearing rings.
- iii) 100% RT shall be carried out on suction branch, impellers and diffusers.
- iv) 100% MPE shall be carried out on barrel casing, casing cover, suction & discharge branches, gland housing, shaft, diffusers, balancing drum and spring disc.

- v) 100% DPT shall be carried out on welds and overlay preparation on barrel casing, and machined components after final machining.
- vi) Hydraulic test shall be carried out on barrel casing, discharge cover, and suction and discharge branches.
- vii) Individual impellers and completed rotor assembly shall be subject to dynamic balancing test. Rotor assembly shall be subject to run out test also.
- viii) Hardness test shall be carried out on wearing rings.
- ix) Visual check and dimensional measurement shall be carried out for all the components and completely assembled pump.
- x) Final tests
 - a) Performance testing shall be carried out as per Hydraulic Institute Standards (HIS) on each pump to determine its characteristic curve at design speed and to ensure compliance with design requirements. Tests shall be carried out with loop water at specified design temperature. Soften quality water shall be used for the performance testing.
 - b) Vibration on all pumps shall be measured in transverse, horizontal and vertical direction at all measuring points.
 - c) Noise Level on each pump shall be measured at a distance of 1.5 m above floor level in elevation and 1 m horizontally from the nearest surface of the equipment as per HIS. The measurement shall be taken at six points around the equipment for each flow condition.
 - d) Type tests
 - NPSH (R) test shall be carried out on one pump using cold water at

pump flows of 25%, 50%, 80%, 100% and 125% of design flow at design speed. This shall be preferably done at 1% and 3% head break by suction throttling procedure. In case, NPSH (R) test has already been carried out by the contractor for the offered frame of BFP, the test shall not be repeated and certificates of test carried out earlier shall be furnished for review of the purchaser. The validity of the type test carried out earlier shall be limited to five (5) years.

- Pressure pulsation and axial thrust measurement shall be carried out on one boiler feed pump at all measuring points. Pressure pulsation shall be measured at suction as well as at discharge in the operating range.
- Thermal shock test shall be carried out on one pump with measurements taken on all critical areas such as barrel, discharge branch, casing cover, casing cover stud.
- Dry running withstand capability shall be demonstrated and established on one pump. The pump shall be capable of accepting complete loss of water and must be capable of being shut down in a controlled manner and brought down to rest after being tripped from design condition with simultaneous closure of suction valve. Coasting down time check to be done.
- Visual cavitation test on one first stage production impeller shall be carried out to demonstrate absence of cavitation at design speed in cold water. The test shall establish the cavitation characteristic to confirm that the cavity length under dynamically scaled site conditions corresponding to design point shall not exceed an acceptable size. This test shall be carried out at 25%, 50%, 80%, 100% and 125% of design flow.

f) Strip down test

Complete strip down of one feed pump which undergoes NPSH test, dry run test, thermal shock test etc. shall be done after completion of all the tests on it. The strip down shall check for the condition of thrust bearing and journal bearing, and problems such as internal rubbing damage, excessive wear on the components. For other feed pumps, strip down examination shall be restricted to inspection of bearings only. However, if excessive vibration, high noise, high bearing temperature etc. is observed during performance test of any feed pump, complete strip down shall be done for such pumps also.

Note: Tested pump parameters shall be within following tolerances.

At design head : + 10% of design capacity

At design capacity : + 5% of design head (for < 152.4 m)
+ 3% of design head (for $\geq$ 152.4 m)

The results of the performance test must show no minus tolerance with regard to flow and head. No minus tolerance on efficiency or positive tolerance on power input at motor terminals shall be allowed.

1.3.5.2 Booster pump

- i) Tests shall be carried out on the materials on various components to establish their mechanical properties and chemical composition. Further, heat treatment shall be given as required.
- ii) 100% UT shall be carried out on shaft and wearing rings.
- iii) 100% MPE shall be carried out on casing, impeller and seal cooling jacket.
- iv) 100% DPT test shall be carried out on machined components after final machining.
- v) Hydraulic test shall be carried out on pump casing at 1.5 times the shut off pressure or 2 times the working pressure whichever is higher.
- vi) Impeller and completed rotor assembly shall be subject to dynamic balancing test. Rotor assembly shall be subject to run out test also.
- vii) Visual check and dimensional measurement shall be carried out for all the components and completely assembled pump.
- viii) Final tests
 - a) Performance testing shall be carried out as per Hydraulic Institute Standards (HIS) on each pump to determine its characteristic curve at design speed and to ensure compliance with design requirements. Tests

shall be carried out with loop water at specified design temperature. Soften quality water shall be used for the performance testing.

- b) Vibration on all pumps shall be measured in transverse, horizontal and vertical direction at all measuring points.
- c) Noise Level on each pump shall be measured at a distance of 1.5 m above floor level in elevation and 1 m horizontally from the nearest surface of the equipment as per HIS. The measurement shall be taken at six points around the equipment for each flow condition.
- d) Type tests
 - NPSH (R) test shall be carried out on one pump using cold water at pump flows of 25%, 50%, 80%, 100% and 125% of design flow at design speed. This shall be preferably done at 1% and 3% head break by suction throttling procedure. In case, NPSH (R) test has already been carried out by the contractor for the offered frame of booster pump, the test shall not be repeated and certificates of test carried out earlier shall be furnished for review of the purchaser. The validity of the type test carried out earlier shall be limited to five (5) years.
 - Dry run withstand capability shall be demonstrated and established on one pump.
- g) After performance testing, thrust bearing and journal bearing shall be subject to visual check.

Note: Tested pump parameters shall be within following tolerances.

At design head	:	+ 10% of design capacity
At design capacity	:	+ 5% of design head (for < 152.4 m) + 3% of design head (for ≥ 152.4 m)

The results of the performance test must show no minus tolerance with regard to flow and head. No minus tolerance on efficiency or positive tolerance on power input at motor terminals shall be allowed.

1.3.5.3 Gear box and hydraulic coupling

- i) Tests shall be carried out on the materials on various components to establish their mechanical properties and chemical composition. Further, heat treatment shall be given to the internal components as required.
- ii) Internal components such as gears, pinions, wheels and shafts shall be examined by 100% UT and 100% DPT or 100% MPE.
- iii) Leak test shall be carried out for the casing.
- iv) Dynamic balancing test shall be carried out for the assembled rotating component.
- v) Full load speed and back to back locked rotor torque test shall be carried out on one gear box.
- vi) Visual check and dimensional measurement shall be carried out for the completely assembled equipment.

1.3.5.4 Strainers

- i) Tests shall be carried out on the materials on various components to establish their mechanical properties and chemical composition.
- ii) In case of fabricated construction, the welds shall be examined for surface defects by 100% DPT.
- iii) The strainer body shall be subject to hydraulic test.
- iv) Pressure drop test shall be carried out for each type and size of the strainer assembly.

1.3.5.5 BFP drive turbine and associated equipment

The QA requirements for BFP drive turbine and associated auxiliaries shall be same

as those applicable for main steam turbine and its auxiliaries described at clause 1.3.1 of this Section.

1.3.6 Condensate Extraction Pumps (CEPs)

1.3.6.1 Pump

- i) Tests shall be carried out on the materials on various components to establish their mechanical properties and chemical composition. Further, heat treatment shall be carried out for materials of shaft and rotor.
- ii) 100% UT shall be carried out on pump shaft.
- iii) 10% RT shall be carried out for butt welds on fabricated components of thickness more than 10 mm.
- iv) 100% MPE shall be carried out on pump shaft.
- v) 100% DPT shall be carried out on welds on casing, suction bell, shaft, impeller and fabricated components.
- vi) Hydraulic test shall be carried out on casing and pressure containing fabricated parts at 1.5 times the pump shut off pressure or 2 times the working pressure whichever is higher.
- vii) Individual impellers and completed rotor assembly shall be subject to dynamic balancing test. Rotor assembly shall be subject to run out test also.
- viii) Visual check and dimensional measurement shall be carried out for all the components and completely assembled pump.
- ix) Final tests
 - a) Performance testing shall be carried out as per Hydraulic Institute Standards (HIS) on each pump to determine its characteristic curve at design speed and to ensure compliance with design requirements. Tests shall be carried out using cold soften quality water.

- b) Vibration on all pumps shall be measured in transverse, horizontal and vertical direction at all measuring points.
- c) Noise Level on each pump shall be measured at a distance of 1.5 m above floor level in elevation and 1 m horizontally from the nearest surface of the equipment as per HIS. The measurement shall be taken at six points around the equipment for each flow condition.
- d) NPSH test

NPSH (R) test shall be carried out on one pump using cold water at pump flows of 25%, 50%, 80%, 100% and 125% of design flow at design speed. This shall be preferably done at 1 % and 3% head break.

In case, NPSH

(R) test has already been carried out by the contractor for the offered frame of CEP, the test shall not be repeated and certificates of test carried out earlier shall be furnished for review of the purchaser. The validity of the type test carried out earlier shall be limited to five (5) years.

- e) Strip down test

Complete strip down of one pump which undergoes NPSH test shall be done after completion of all the tests on it. The strip down shall check for the condition of bearings and problems such as internal rubbing, excessive wear. For other pumps, strip down shall be restricted to inspection of bearings only. However, if excessive vibration, high noise etc. is observed during performance test of any pump, complete strip down shall be done for such pumps also.

Note: Tested pump parameters shall be within following tolerances.

At design head : + 10% of design capacity

At design capacity : + 5% of design head (for < 152.4 m)
+ 3% of design head (for ≥ 152.4 m)

The results of the performance test must show no minus tolerance with regard to flow and head. No minus tolerance on efficiency or positive tolerance on power input at motor terminals shall be allowed.

1.3.6.2 Strainers

The QA requirements for strainers at suction of the CEPs shall be same as those applicable for BFP strainers described at clause 1.3.2.4 of this Section

1.3.7 Condensate Polishing Unit (CPU)

1.3.7.1 CPU service vessels

- i) Tests shall be carried out on the materials of the vessels, internals and rubber used for lining to establish their mechanical properties, and chemical compositions. Heat treatment as required shall be done as per ASME code.
- ii) Plates shall be subject to 100% ultrasonic testing.
- iii) Impact test shall be carried out for the plate materials.
- iv) 100% UT shall be carried out on the finished and formed dished ends and hemi heads. Knuckle portion shall be checked by 100% MPE or DP test for surfacedefects and check for thinning shall be carried out by UT.
- v) Welding
 - a) Root run of butt welds shall be examined by 100% DPT or MPE.
 - b) Butt welds full penetration joints and nozzle welds shall be checked by 100% RT and 100% MPE or DPT.
 - c) Fillet welds shall be checked by 100% MPE or DPT.
- vi) Rubber lining shall be subjected to following tests as per IS-4682 part-I or acceptable equivalent:
 - a) Tensile & Elongation, Specific Gravity, Ash content
 - b) Adhesion test
 - c) Measurement of thickness

- d) Shore hardness test
- e) Visual examination and spark test at 5 kV/mm of thickness
- f) Bleeding resistance test with keeping the sample in 33% HCl, 48% NaOH and DM water for 72 hours.
- g) Ozone resistance test: (50 PPHM) / 40° C / 20 % Strain /70 Hrs
- h) Water Absorption Test, After ageing test & Compression Set test
- vii) Visual check and dimensional measurement shall be carried out on the completed equipment.
- viii) Internals of the vessel shall be subject to dimensional check and applicable tests as per relevant codes.
- ix) The fabricated vessel shall be hydraulically tested at 1.5 times the working pressure before the rubber lining and at the working pressure after the rubber lining.

1.3.7.2 Acid/ alkali handling tanks

- i) Tests shall be carried out on the materials of the tanks to establish their mechanical properties, and chemical compositions
- ii) Plates shall be subject to 100% ultrasonic testing.
- iii) Welding
 - a) Root run of butt welds shall be examined by 100% DPT or MPE.
 - b) Butt welds, full penetration joints and nozzle welds shall be checked by 100% RT and 100% MPE or DPT.

- c) Fillet welds shall be checked by 100% MPE or DPT.
- iv) Rubber lining shall be subject to relevant tests as described for CPU vessels.
- v) Visual check and dimensional measurement shall be carried out on the completed equipment.
- vi) The fabricated tank shall be subject to water fill test to check for the leakage.

1.3.7.3 Dosing pumps/ metering pumps

- i) Tests shall be carried out on the materials of the pumps to establish their properties, and chemical compositions
- ii) Pump casings shall be subject to hydraulic test at 1.5 times the shut off pressure or 2 times the working pressure whichever is higher.
- iii) 100% DPT or MPE shall be carried out for the screw set, shaft and machined surfaces of casing and impellers. UT on screw set, shaft (diameter greater than or equal to 50mm),
- iv) Safety relief valve setting to be checked
- v) Pumps shall be performance tested as per HIS, USA.

1.3.7.4 Horizontal centrifugal pumps

The QA requirements for horizontal centrifugal pumps shall be as per clause 1.4.12.2 of this Section.

1.3.7.5 Rotary blowers

- i) Tests shall be carried out on the materials of the rotary blowers to establish their properties, and chemical compositions.
- ii) 100% DPT or MPE shall be carried out for the rotor and machined surfaces of casing and impellers. UT on shaft (diameter greater than or equal to 50mm).

- iii) The shaft and impellers shall be dynamically balanced.
- iv) Assembly fit up check, and dimensional check shall be carried out for the completed blower assembly.
 - The blower casing shall be subject to hydraulic test at 1.5 times the shut off pressure or 2 times the working pressure whichever is higher.
- v) The blowers shall be performance tested as per relevant code/ standard for Free Air Delivery, Head, Power, Efficiency, Speed including Discharge Pressure and Temperature. The test shall include check for vibration and noise level also.

1.3.7.6 Valves

The QA requirements for high pressure valves such as for service vessels shall be as per clause 1.4.2 of this Section. The QA requirements for other valves shall be as per clause 1.4.6.2 of this Section.

1.3.8 Condenser On-Line Tube Cleaning System

1.3.8.1 Ball recirculation pump

- i) All rotating parts shall be dynamically balanced.
- ii) Pump casing shall be subjected to hydraulic test at 1.5 times the shut off head or twice the maximum working pressure whichever is higher.
- iii) Complete pump assembly shall be subjected to shop performance test at supplier's works.

1.3.8.2 Ball sorter/ fabricated body (housing)

- i) In the case of fabricated design, all butt welds shall be subject to 10% RT or UT. All welds shall also be subjected to 10% MPE to ensure freedom from surface and sub-surface defects.

- ii) Body shall be subject to hydraulic pressure test at 1.5 times the design pressure.
- iii) Performance test shall be carried out on ball sorter assembly.

1.3.8.3 Strainer

- i) Tests shall be carried out on the materials on various components to establish their mechanical properties and chemical composition
- ii) Strainer mesh shall be checked for chemical composition and mesh size.
- iii) Strainer body shall be subject to hydraulic pressure test at 1.5 times the design pressure.
- iv) Strainer assembly shall be checked for its functional performance.

1.3.8.4 Piping and fittings

- i) Butt welds on piping shall be subject to 10% RT and 10% DPT. Butt welds on segmental flanges shall be checked by 100% RT and 100% DPT.
- ii) Fillet welds with load transfer shall be subject to 100% MPE or DPT and fillet welds without load transfer shall be subjected to 10% MPE or DPT.
- iii) Wrought and forged fittings shall be tested as per relevant codes or standards.

1.3.8.5 Coating/ lining

- i) Coating shall be checked for DFT and adhesion. Further, Contractor shall furnish his practice for testing of coating to ensure the uniformity and freedom from pinholes.

- ii) Rubber lined items shall be hydraulically tested before rubber lining. All rubber lining shall be subjected to following tests as per IS-4682 part-I or acceptable equivalent:
 - a) Tensile & Elongation, Specific Gravity, Ash content
 - b) Adhesion test
 - c) Measurement of thickness
 - d) Shore hardness test
 - e) Visual examination and spark test at 5 kV/mm of thickness
 - f) Bleeding resistance test with keeping the sample in 33% HCl, 48% NaOH and DM water for 72 hours.
 - g) Ozone resistance test: (50 PPHM) / 40° C / 20 % Strain /70 Hrs
 - h) Water Absorption Test, After ageing test & Compression Set test

1.3.8.6 Valves

The QA requirements for the valves shall be as per clause 1.4.6.2 of this Section.

1.3.9 Debris Filter

- i) Body, strainer mesh and other components shall be checked for chemical composition.
- ii) Strainer element shall be checked for mesh size.
- iii) Body shall be subject to hydraulic pressure test at 1.5 times the design pressure.
- iv) Filter assembly shall be checked for its functional requirements.
- v) Valves shall be tested as per relevant standards.

1.4 HIGH PRESSURE PIPING, VALVES, THERMAL INSULATION AND MISCELLANEOUS SYSTEMS/ EQUIPMENTS

1.4.1 High Pressure Piping and Fittings

- i) All raw materials used shall have co-related mill test certificate meeting mandatory and supplementary checks of material specification.
- ii) The pipes and fittings shall be subject to visual examination, identification, correlation and stamping.
- iii) For alloy steel pipes (SA 335, P11, P22, & P91), 25% pipes per lot shall be subject to the following tests:
 - a) Product analysis
 - b) Transverse tension test on pipes from one end for pipe size 200 mm and above.
 - c) Flattening test on pipe from one end.
- iv) All pipe lengths shall be subjected to 100% UT or hydraulic tests and UT or RT on longitudinal welds.
- v) All mother pipes used for fittings shall be subject to a hydraulic test or an ultrasonic test. Raw material of all forged fittings shall be ultrasonically tested. Forged fittings shall be ultrasonically tested.
- vi) All alloy and carbon steel pipes shall be subject to 100% UT for pipe thickness $\geq$ 3.6 mm and 100% eddy current test for thickness $<$ 3.6 mm.
- vii) Thickness of all pipe bends (cold/ hot formed) shall be checked by ultrasonic or other acceptable methods on sample basis for high pressure applications. Further, outer surface of bends shall be subject to 100% MPE or DPT.
- viii) Welded and cast fittings, if any, shall be subjected to suitable NDT as per applicable standards. However, as a minimum, 100% RT shall be carried out on all alloy steel fittings and on carbon steel fittings for use above 71 bar design conditions.
- ix) The edge preparation for stainless steel/ alloy steel shall be subject to a 100% DPT. For other piping, the edge preparation for the welds shall be checked by 100% MPE or DPT.
- x) Non-destructive examination of welds shall be carried out in accordance with

the relevant design and/or manufacturing codes. However, as a minimum, the following requirements shall be met (except for oil piping):

- a) For temperature $> 400^{\circ}\text{C}$ and/or pressure exceeding 71 bar, the butt welds and full penetration branch welds shall be subject to 100% RT or UT and 100% MPE.
- b) For temperature $> 175^{\circ}\text{C}$ up to 400°C and/or pressure exceeding 17 bar and up to 71 bar, the butt welds & full penetration branch welds shall be subject to NDTs as below:
 - pipe diameter $> 100\text{ NB}$ 100% RT or UT and 100% MPE
 - pipe diameter $\leq 100\text{ NB}$ 10% RT or UT and 100 % MPE

In addition to above, statutory requirement, wherever applicable, shall also be complied with.

- xi) Finished welding for alloy steel piping, BFP discharge piping, MS piping, HRH piping, CRH piping and associated pipings shall be subject to the following NDTs:
 - a) Butt welds 100% RT and 100% MT or DPT
 - b) Welds for nozzle, branch connections of size $> 100\text{NB}$ 100% RT and 100% MT or DPT
 - c) Welds for all other attachments 100% MT or DPT
 - d) Removal of weld defects 100% MT or DPT
- xii) Finished welding for Carbon Steel Class- I piping having design temperature $> 218^{\circ}\text{C}$ or design pressure for steam $> 17.6\text{ kg/cm}^2\text{ (g)}$ or design pressure for feed water $> 24.6\text{ kg/cm}^2\text{ (g)}$ shall be subject to the following NDTs:
 - a) Butt welds:
 - pipe size $> 100\text{ NB}$ 100% RT and 100% MPE or DPT
 - pipe size $\leq 100\text{ NB}$ 10% RT and 10% MPE or DPT
 - b) Welds for nozzle, branch connections of size $> 100\text{NB}$ and thickness $> 19\text{ mm}$ 100% RT and 100% MPE or DPT
 - c) Welds for all other attachments 10% MPE or DPT
 - d) Removal of weld defects/weld repair 100% MPE or DPT
- xiii) Finished welding for carbon steel class- I piping having design temperature $\leq 218^{\circ}\text{C}$ or design pressure for steam $\leq 17.6\text{ kg/cm}^2\text{ (g)}$ or design pressure

for feedwater $\leq 24.6 \text{ kg/cm}^2 \text{ (g)}$ shall be subject to the following NDTs:

- a) Butt welds:
 - pipe size $> 100 \text{ NB}$ 100% RT and 10% MPE or DPT
 - pipe size $\leq 100 \text{ NB}$ 10% MPE or DPT
 - b) Welds for nozzle, branch attachments 10% MPE or DPT connections/
 - c) Removal of weld defects 100% MPE or DPT
- xiv) Non-destructive examination of welds shall be carried out after post weld heat treatment, if any.
- xv) Pre- heating, stress relieving and post weld heat treatment as applicable shall be carried out as per requirements of ASME B 31.1. For welds in P91, X20 & X22 materials, only induction type of heating shall be deployed for heat treatment.
- xvi) Hardness survey of welds shall be carried out on alloy steel/ stainless steel piping. (100% hardness survey of welds on P91, X20 & X22 material grade pipings).
- xvii) All other pipes not covered above (except oil piping) shall be subjected 100% MPE or DPT in case of under ground piping and 10% MPE or DPT in case of over ground piping. Further, 10% of butt welds of underground piping shall be subjected to RT.
- xviii) Oil piping shall be subjected to following NDTs.
- a) Butt welds of Oil piping shall be subjected to 10% RT and 10% DP Test. For Jacking oil lines 100% RT and 100% DPT shall be carried out on butt welds.
 - b) Fillet welds with load transfer shall be subjected to 100% MPE or DPT and fillet welds without load transfer shall be subjected to 10% MPE or DPT.
- xix) Rubber lined pipes shall be hydraulically tested before rubber lining. All rubber lining shall be subject to following tests as per IS-4682 part-I or acceptable equivalent:
- a) Tensile & Elongation, Specific Gravity, Ash content
 - b) Adhesion test
 - c) Measurement of thickness

- d) Shore hardness test
- e) Visual examination and spark test at 5 kV/mm of thickness
- f) Bleeding resistance test with keeping the sample in 33% HCl, 48% NaOH and DM water for 72 hours.
- g) Ozone resistance test: (50 PPHM) / 40° C / 20 % Strain /70 Hrs
- h) Water Absorption Test, After ageing test & Compression Set test

1.4.2 Power Cycle Valves

1.4.2.1 Valves other than extraction line valves and butterfly valves

- i) Bar stock/forging above 40mm diameter for valve trim shall be subjected to UT.
- ii) Hardened/ stellited valve disc and seat are to be subjected to LPI and hardness check.
- iii) Colour matching of valve disc, plug and seat shall be carried out to ensure contact.
- iv) Hydraulic pressure test and seat leak test shall be carried out as per ANSI 16.34.
- v) Air seat leak test shall be carried out as per applicable standards/ codes.
- vi) Pressure retaining parts of valves shall be subject to NDTs as below:
 - a) Valve size < 50 NB
 - Visual examination for rating below ANSI Class 900
 - MPE for rating above ANSI Class above 900
 - b) Valve size $\geq$ 50 NB and < 100 NB
 - Visual examination for rating upto ANSI Class 600
 - MPE for rating above ANSI Class above 600 and below 900
 - 100% MPE and 100% RT on 10% of valves for rating above ANSI Class above 900 and below 4500
 - c) Valve size $\geq$ 100 NB and < 300 NB
 - Visual examination for rating upto ANSI Class 300
 - MPE for rating above ANSI Class above 300 and below 600

- 100% MPE and 100% RT on 10% of valves on change of section and weld ends for rating above ANSI Class 600 and below 900
 - 100% MPE and 100% RT on valves for rating above ANSI Class 900 and below 4500
- d) Valve size ≥ 300 NB
- MPE for rating upto ANSI Class 600
 - 100% MPE and 100% RT on all valves in the areas of change of section and weld ends for rating above ANSI Class 600 and below Class 900
 - 100% MPE and 100% RT on valves for rating above ANSI Class 900 and below Class 4500

In the above NDTs, MPE may be replaced by DPT for austenitic steels.

- vii) Weld edge preparations shall be subject to MPE or DPT.
- viii) Functional testing shall be carried out on fully assembled valve to check the following:
- a) Smooth operation
 - b) Valve travel, closing and opening time.
 - c) Current drawn by actuators.
- ix) Springs for safety valves shall be tested with suitable NDT and for spring rate.
- x) Safety and safety relief valves shall be tested for performance.

1.4.2.2 Extraction line valves

- i) Surface crack examination and hardness check shall be carried out on all hard faced surfaces and stellite surfaces, if any.
- ii) As a minimum requirement of castings for all valves on cold reheat and extraction lines shall be subjected to 100% MPE on all areas and RT on butt weld ends and change of section. For forgings minimum requirement shall be 100% UT and 100% MPE.
- iii) Bar stock for valves stem shall be subjected to UT. Finish machined valve stem shall be subjected to MPE or DPT.

- iv) Wall thickness measurement by ultrasonic for critical and highly stressed zones of the casting and forging shall be carried out.
- v) Colour matching of the valve disc and seat to ensure required contact area shall be carried out.
- vi) Hydraulic pressure tests shall be carried out on each valve to check body and bonnet strength. Seat leakage and back seat leakage test (wherever applicable) shall be carried out. Air seat leakage test shall also be carried out. Minimum test requirements of pressure shall be as per ANSI B 16.34.
- vii) Functional testing shall be carried out on each valve to check for freedom of movement, adherence to clearance, opening/ closing etc. Type tests for discharge co-efficient and pressure drop co-efficient, shall be carried out. In case the type tests have been carried out in the past and documents generated, the same shall be furnished to the purchaser for approval.

1.4.2.3 Butterfly Valves

- i) Tests shall be carried out on the materials of body, disc etc. for determination of chemical and mechanical properties.
- ii) In case of fabricated valves, the plates used for body, disc and flanges shall be subject to 100% UT.
- iii) Valve body, disc and shaft shall be checked for surface and sub-surface defects by 100% MPE.
- iv) For sea water application valves, austenitic stainless steel welds shall be subject to 100% IGC (inter-granular corrosion) test.
- v) All wetted SS 316 components shall be subject to Molybdenum check.
- vi) Stubs and driving shafts shall be tested for internal defects by ultrasonic method.
- vii) Dye penetration test shall be carried out on shafts, seat rings etc.
- viii) For fabricated components of the valves, all the longitudinal/ circumferential weld seams shall be subject to 100% RT. Further, all welds on magnetic material shall be subject to 100% MPE, and welds on non magnetic material shall be subject to 100% DPT.
- ix) Test samples for rubber seal shall be subjected to tensile, elongation and hardness test for vulcanising and after ageing. Hydraulic stability test (Bleed Resistance) and ozone crack resistance tests also be carried out.

- x) Valve shall be subjected to hydraulic pressure test for body and air seat leakage tests as per AWWA-C504/ BS- 5155.
- xi) Proof of design tests for valves and actuator shall be carried out as per AWWA- C504/ BS- 5155. In case the test has already been carried out on previous supplies, the contractor may submit the test certification of same for approval of purchaser.
- xii) Disc Strength test by Hydro (Forward and Backward) as per EN 12266-1
- xiii) After complete assembly each valve with actuator shall be subject to the performance test by opening and closing the valve from fully closed to fully open position and the reverse, under no flow for at least 25 cycles to check the following:
 - a) Smooth uninterrupted movement of valve.
 - b) Closing and opening time.
 - c) Current drawn by actuator.
 - d) Operation of tripping switch and position indicator.
- xiv) After assembly, one valve of each size with respective actuator shall be shop operated over the full range of movement in both the directions, with the body subjected to the full hydrostatic pressure conditions, to demonstrate that the unit is in working order without any leakage through the joints and torque switches/clutches, limit switches are operating satisfactorily. During the test, hand wheel operation, opening and closing time and current drawn shall also be checked. The test shall be conducted for three consecutive cycles with valve shaft both in vertical and horizontal planes.

1.4.3 Metallic expansion bellows

- i) All raw materials used shall have co-related mill test certificate meeting mandatory checks of material specification.
- ii) Hydraulic pressure test shall be carried out on each pipe and expansion bellow.
- iii) Longitudinal butt weld on bellow shall be subject to MPE or DPT before forming and after forming.

- iv) All welds shall be subject to 100% MPE or DPT. Butt welds shall be subject to 100% RT.
- v) All the bellows subjected to vacuum service shall be vacuum tested.
- vi) 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.
- vii) 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).

1.4.4 Hangers and Supports

- i) All raw materials used shall have co-related mill test certificate meeting mandatory checks of material specification.
- ii) Completed springs shall be tested for sagging test and load versus deflection test. For diameter more than 25mm, MPE shall also be carried out.
- iii) Butt welds of thickness 32mm and above shall be tested for UT, and for butt welds of thickness less than 32mm MPE shall be done. Fillet welds shall be tested for MPE.
- iv) Dampers with viscous fluids shall be checked for viscosity of liquid used, damping resistance of the damper, stiffness of the damper etc.
- v) Turn-buckle, pipe clamps and hangers of thickness greater than 25mm shall be checked by MPE or DPT on bent portions.
- vi) One hanger of each type and size shall be checked for variation in deflection and travel versus load test.

1.4.5 Thermal insulation, refractory, lagging and cladding

- i) Thermal insulation
 - a) Pre-formed fibrous pipe insulation and LRB mattresses/ sections of rock wool/ mineral wool from approved manufacturing sources conforming to and tested as per relevant standards shall be used.
 - b) For resin bonded mineral wool insulation, testing shall be carried out as per IS: 8183.
 - c) For resin bonded rock wool insulation, testing shall be carried out as per IS: 9842.

- d) For sprayed mineral wool, testing shall be carried out as per IS: 9724.
 - e) For ceramic fibre blankets and block insulation, testing shall be carried out as per IS: 15402.
 - f) Type tests except thermal conductivity shall be regularly carried out once in three months.
 - g) Type test for thermal conductivity shall be carried out by the manufacturer minimum once in six months. Thermal conductivity (K value) shall be measured in line with IS: 3346.
 - h) Wire mesh of diameter 0.71mm (minimum) shall only be used.
- ii) Castable refractory
- Fire bricks or castable refractory from approved manufacturing sources conforming to and tested as per relevant standards shall be used. Castable refractory shall have proper identification, supplier name, customer name, batch no., date, material name and net weight in kg with proper instructions for handling.
- iii) Lagging and cladding
- All insulation shall be protected by means of an outer covering of aluminium sheeting conforming to ASTM B-209-1060 temper H14 from reputed manufacturer.

1.4.6 Low Pressure Piping, Valves and Fittings etc.

1.4.6.1 Pipes, fittings and mitre bends

- i) Tests shall be carried out on the materials on various components to establish their mechanical properties and chemical composition. Further, heat treatment shall be carried out for materials as required.

- ii) Dye penetration test of welds of pipes and fittings (including welds of rolled and welded pipes) shall be carried out.
- iii) All pipes and fittings shall be tested as per applicable codes/ standards at manufacturer's works.

1.4.6.2 Valves

- i) Tests shall be carried out on the materials on various components to establish their mechanical properties and chemical composition. Further, heat treatment shall be carried out for materials as required.
- ii) Shaft/ spindle of size ≥ 50 mm diameter shall be subjected to ultrasonic test.
- iii) Machined surfaces of casing, disc and shaft shall be subjected to 100% MPI or DPT as applicable.
- iv) All valves shall be hydraulically tested for body, seat and back seat (wherever provided) at 1.5 times the maximum pressure to which respective valves can be subjected during plant operation. Check valves shall also be tested for leak tightness test at 25% of the specified seat test pressure. For rubber lined valves, hydraulic test shall be carried out before rubber lining.
- v) For butterfly valves, hydraulic test, seat and disc string test and proof of design test (if not carried out earlier) shall be carried out in accordance with latest edition of AWWA-C-504 standard.
- vi) Visual and dimensional check shall be carried out for all valves as per relevant code/ approved drawing.
- vii) Functional/ operational checks for and check for smooth opening and closing of the valves shall be carried out.
- viii) Gate, globe and swing check valves
 - a) Machined surfaces of castings and butt welds shall be subjected to MPE or DPT.

- b) Blue matching, wear travel for gates, valves, pneumatic seat leakage, reduced pressure test for check valves shall be done as per relevant standard.
- ix) Diaphragm valves
 - a) Seat leakage test for actuator operated valves, shall be done with by closing the valves with actuator.
 - b) Tests on rubber parts per batch of rubber mix such as hardness, adhesion, spark test, bleed test and flex test on diaphragm, type test for diaphragm for 50,000 cycles.
- x) Cast butterfly valves
 - a) Machined surfaces of casing, disc and shaft shall be subjected to MPE or DPT.
 - b) 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.
- xi) Fabricated butterfly valves (refer 1.4.2.3)
 - a) UT shall be carried out on plate material for body and disc.
 - b) Machined surfaces of casing, disc and shaft shall be subjected to MPE or DPT.
 - c) Butt welds of thickness above 30mm on body and disc shall be subject to 100% RT alongwith and post weld heat treatment for stress relieving.
 - d) 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.
- xii) Dual plate check valves
 - a) Dry cycle test (spring cycle test) for one lakh cycles shall be carried out as a type test.
 - b) Machined surfaces of casing, disc and shaft shall be subjected to MPE or DPT.

1.4.6.3 Rubber lining of pipes and valves

- i) For rubber lining, the following tests shall be carried out as per IS-4682 part-I or acceptable equivalent standard:
 - a) Tensile & Elongation, Specific Gravity, Ash content
 - b) Adhesion test
 - c) Measurement of thickness
 - d) Shore hardness test
 - e) Visual examination and spark test at 5 kV/mm of thickness
 - f) Bleeding resistance test with keeping the sample in 33% HCl, 48% NaOH and DM water for 72 hours.
 - g) Ozone resistance test: (50 PPHM) / 40° C / 20 % Strain / 70 Hrs
 - h) Water Absorption Test, After ageing test & Compression Set test
- ii) Dimensional check shall be carried out as per relevant code/ approved drawing.

1.4.6.4 Coating and wrapping of pipes

Spark test, adhesion test and material test for primer and enameled and coal tar tapes, as applicable, shall be carried out as per AWWA-C-203-91/ IS 15557/ IS 10221 as applicable.

1.4.6.5 Rubber expansion joints

- i) Rubber compound test slab after vulcanising shall be tested for tensile strength, elongation and shore hardness. Tests on rubber compound shall also include hydro stability test as per ASTM D-3137, ozone resistance test as per ASTM D- 380 and kerosene dip test.
- ii) Fabric strength of synthetic fibre for reinforcement shall be checked, and test for rubber to fabric adhesion as per IS: 3400 or ASTM D- 413, rubber to metal adhesion as per IS 3100 or ASTM D-429 shall be carried out.
- iii) All expansion joints in assembled condition shall be subjected to vacuum test at 730 mm Hg under conditions to ensure its suitability to withstand deflection in each axial transverse and longitudinal direction. Duration of test shall be of minimum 10 minutes.

- iv) All bare bellows shall be subjected to hydraulic pressure test in normal condition at twice the design pressure for a duration of 30 minutes. Additionally, all bare bellows shall be subjected to deflection tests under pressure, pressure being raised from zero to the design value in regular steps and deflection measured at each step.
- v) All expansion joints in assembled condition along with control rod assembly shall be subjected to deflection test (axial compression & expansion test and lateral deflection) under design pressure.
- vi) Either during the hydraulic test or during the vacuum test, change in circumference at the top position of the arch shall not exceed 1.5% of measured circumference at normal position.
- vii) Twenty-four (24) hours after the above tests, the permanent set (variation in dimensions with respect to its original dimension) shall be measured and recorded. The permanent set shall not be more than 0.5%.
- viii) Proof of Design (Life cycle test and burst test) shall be carried out on bellows of each type, design and size.

1.4.7 Equipment Cooling Water (ECW) System

1.4.7.1 Primary side and secondary side pumps

- i) Tests shall be carried out on the materials on various components to establish their mechanical properties and chemical composition. Further, heat treatment shall be carried out for materials of shaft and rotor.
- ii) 100% UT shall be carried out on pump shaft.
- iii) 10% RT shall be carried out for butt welds on fabricated components of thickness more than 10 mm.
- iv) 100% MPE shall be carried out on pump shaft.
- v) 100% DPT shall be carried out on welds on casing, suction bell, shaft, impeller and fabricated components.
- vi) Hydraulic test shall be carried out on casing and pressure containing fabricated parts at 1.5 times the pump shut off pressure or 2 times the working pressure whichever is higher.
- vii) Individual impellers and completed rotor assembly shall be subject to dynamic balancing test. Rotor assembly shall be subject to run out test also.

- viii) Visual check and dimensional measurement shall be carried out for all the components and completely assembled pump.
- ix) Final tests
 - a) Performance testing shall be carried out as per Hydraulic Institute Standards (HIS) on each pump to determine its characteristic curve at design speed and to ensure compliance with design requirements.
 - b) Vibration on all pumps shall be measured in transverse, horizontal and vertical direction at all measuring points.
 - c) Noise level on each pump shall be measured at a distance of 1.5 m above floor level in elevation and 1 m horizontally from the nearest surface of the equipment as per HIS.
 - d) NPSH(R) test shall be carried out on one pump at pump flows of 25%, 50%, 80%, 100% and 125% of design flow at design speed. In case, NPSH (R) test has already been carried out by the contractor for the offered frame of a pump, the test shall not be repeated and certificates of test carried out earlier shall be furnished for review of the purchaser.
 - e) Complete strip down of one pump shall be done after completion of all the tests on it. The strip down shall check for the condition of bearings and problems such as internal rubbing, excessive wear.

1.4.7.2 Plate heat exchangers

- i) The material used for cover plates, heat exchange plates and tie rods shall be subject to chemical and mechanical tests on one per heat basis. For gasket, ageing test, shrinkage test and hardness to be carried out.
- ii) Each plate after pressing shall be subject to light box test, vacuum test or air chamber test as per manufacturer's practice.
- iii) UT shall be done for plates with thickness 25 mm or above.
- iv) DPT shall be conducted for 10% of the lot of heat exchanger plates. However, in case of any defects, entire lot shall be tested and only defect free plates shall be accepted.
- v) 100% DPT shall be conducted on all welds.

- vi) Each heat exchanger shall be subjected to hydraulic test.
- vii) Assembly fit up and dimensional checks shall be carried out for each heat exchanger.

1.4.7.3 Auto clean filters

- i) Tests shall be carried out on the materials on various components to establish their mechanical properties and chemical composition.
- ii) In case of fabricated construction, the welds shall be examined for surface defects by 100% DPT.
- iii) The body shall be subject to hydraulic test at 1.5 times the design pressure.
- ii) Pressure drop, flow and particle size tests shall be carried out for the filter assembly.

1.4.7.4 Pipes, Valves and fittings

The QA requirements for piping, valves and fittings shall be as per clause 1.4.6 of this Section.

1.4.8 EOT Cranes and Hoists

1.4.8.1 Hooks

- i) All tests including proof load test as per relevant IS shall be carried out.
- ii) MPE or DPT shall be done after proof load test.

1.4.8.2 Steels castings

Steel castings shall be subjected to DPT on machined surface.

1.4.8.3 Girders, end carriage, crab, gear-box and rope drum

- i) The plates of thickness 25mm and above for girders, end carriage, crab, gear-box and rope drum shall be ultrasonically tested.

ii) 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 weld in rope drum : 100% RT and 100% DPT
- d) Fillet welds : 10% DPT (random)

1.4.8.4 Forgings

- i) All forgings (wheel, gears, pinions, axles, hooks and hook trunion) greater than or equal to 50mm diameter or thickness shall be subjected to ultrasonic testing.
- ii) DPT or MPE shall be done after hard facing and machining.

1.4.8.5 Wire rope

Wire rope shall be tested as per relevant standard including breaking force and no. of strands.

1.4.8.6 Reduction gear

Reduction gears shall be tested for reduction ratio, backlash and contact pattern. Gear box shall be subjected to no- load run test to check for oil leakage, temp. rise, noise and vibration.

1.4.8.7 Final testing

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.

1.4.8.8 Electric hoists

All electric hoists shall be tested as per IS-3938 and chain pulley blocks shall be tested as per IS-3832.

1.4.9 Elevators

- i) Reduction gears shall be checked for reduction ratio and backlash. Run outs of wheel shafts and work shafts, tooth contact and running test shall also be carried out.

- ii) Breaking load test shall be carried out along with all other tests as per relevant standard for steel wire rope.
- iii) Buffer springs shall be subjected to load test as per relevant specifications.
- iv) All components prior to assembly shall be checked for dimensions.
- v) All rotating components shall be tested for dynamic balancing.
- vi) Car sling and car body in assembled condition shall be checked for position of all major components i.e. car sling, inside depth, width, height, positions of push box, indicator box lights, fans etc.
- vii) Vibration level shall be determined on work geared machine.
- viii) Mechanical balance test and determination of vibration level on lift and accessories shall be carried out.
- ix) In case the lift is provided with pressurized unit, the fan shall be dynamically balanced and complete unit shall be performance tested.

1.4.10 Air Conditioning System

1.4.10.1 Refrigerant compressor (reciprocating/ screw/ centrifugal)

- i) Hydraulic/ pneumatic test of castings for cylinder block, crank case and casing etc. shall be carried out. No leakage shall be permitted
- ii) DPT on connecting rod, piston, crankshaft, screw, impeller with shaft, vanes, crank case, cylinder and casing after machining shall be carried out.
- iii) All rotating parts of reciprocating/ screw and centrifugal compressor shall be statically and dynamically balanced to ISO 1940 Gr. 6.3.
- iv) Leak tightness and vacuum check for chilling units and compressors in assembled condition shall be carried out. No leakage shall be permitted.
- v) Performance test of assembled compressor shall be done to check for following:
 - a) Capacity test for oil pump for reciprocating compressor.
 - b) No load air run (free run) test of all types of compressors and chilling units to check FAD (free air delivery), noise, vibration and temperature rise of bearing and body.

- c) Hydraulic/ leakage test for reciprocating compressor.
- d) Functional run test and capacity control (for part load performance) check shall be carried out

1.4.10.2 Condenser and evaporator

- i) DPT shall be carried out on finish welds.
- ii) 10% RT of butt weld joints on shell shall be carried out.
- iii) Dimensional check including tube hole diameter, ligament pitch etc. shall be carried out.
- iv) Mock-up test for tube to tube sheet expansion shall be carried out. In case such a test is already conducted for similar tube/ tube sheet thickness and materials, record for the same shall be furnished for purchaser's review and approval.
- v) Hydraulic/ pneumatic test of shell side and tube side of condenser and evaporator as applicable shall be carried out. No leakage shall be permitted.

1.4.10.3 Vapour absorption machine (VAM)

- i) All materials used for fabrication shall be of tested quality. Mill test certificates for chemical and mechanical properties shall be furnished by the manufacturer. In absence of correlated mill test certificates, check test shall be carried out.
- ii) Tubes for heat exchangers/ vessels and interconnecting pipes shall be tested as per the requirement of relevant code/standard.
- iii) All welding shall be performed as per approved Welding Procedure Specification and IBR qualified procedure and welders.
- iv) Mock-up test for tube to tube sheet expansion shall be carried out. In case such a test is already conducted for similar tube/tube sheet thickness and materials, record for the same shall be furnished for purchaser's review.
- v) RT on butt weld joints of heat exchangers/ vessels shall be carried out as per the requirement of design code/approved drawing.
- vi) DPT on Root run after back gouging and on finished welds shall be carried out.

- vii) Vessels/ heat exchangers like high temperature and low temperature generator/ condenser/ high temperature and low temperature heat exchanger/ evaporator/ absorber shall be subjected to hydraulic pressure test and leakage test under vacuum with nitrogen gas and helium gas, both tube side and shell side as applicable for individual component prior to assembly. Helium leak test shall also be conducted on complete assembly under suitable cover to detect any leakage into the system.
- viii) The complete assembled unit shall be performance tested in shop for capacity (TR) and steam consumption at the rated conditions and part load conditions. Manufacturer shall furnish a detailed procedure along with calculation for conducting such test for approval and in case of any limitation same shall be clearly brought out in the bids. All the controls shall be tested for proper functioning during the above test.

1.4.10.4 Air handling unit (AHU)

- i) 20% DPT of welding on fan hub, blades, casing and impeller as applicable shall be carried out.
- ii) UT of fan shafts (diameter greater than or equal to 50mm) shall be carried out.
- iii) DPT of fan shafts after machining shall be carried out.
- iv) DPT of welding on shaft (in case of fabricated shaft) shall be carried out.
- v) Blower fan shall be statically and dynamically balanced to ISO 1940 Gr. 6.3.
- vi) One fan of each type and size shall be performance tested as per AMCA / IS for air flow, static pressure, speed, efficiency, power consumption, noise and vibration.
- vii) One per type of assembled AHU (AHU casing and fan assembly) shall be subject to free run test. Noise, vibration and temperature rise of bearing shall be measured during run test.

- viii) All cooling coil shall be pneumatically tested and no leakage shall be permitted.

1.4.10.5 Centrifugal pump

The QA requirements for centrifugal pumps shall be as per clause 1.4.12.2 of thisSection.

1.4.10.6 Cooling towers

- i) UT of fan shaft and drive shaft (diameter greater than or equal to 50mm) shall be carried out.
- ii) DPT of fan hub and shafts shall be carried out after machining.
- iii) Colors of fills shall be as per approved data sheet.
- iv) Fan assembly shall be statically balanced.
- v) Cooling towers being supplied to site in assembled condition shall be subjected to run test at shop to measure FAD, noise and vibration. For cooling towers being supplied in knocked-down condition, these tests shall be done at site.

1.4.10.7 Fans

- i) 20% DPT of welding on fan hub, blades, casing and impeller as applicable shall be carried out.
- ii) DPT of fan shafts shall be carried out after machining.
- iii) UT of fan shafts (diameter greater than or equal to 50mm) shall be carried out.
- iv) Rotating components of all fans shall be statically and dynamically balanced to ISO-1940 Gr. 6.3.
- v) All centrifugal fans shall be subjected to run test for 4 hour or till temperature stabilization is reached. Vibration, noise level, temperature rise and current drawn shall be measured during the run test.

- vi) One fan of each type and size will be performance tested as per corresponding IS code for airflow, static pressure, total pressure, speed, efficiency, power consumption, noise, vibration and temperature rise.

1.4.10.8 Low pressure air distribution system

- i) Functional test for fire damper along with solenoid shall be done.
- ii) Prototype tests for fire resistance rating as per UL-555 of each type and size of damper shall be carried out. In case prototype tests have already been done, the contractor shall submit the test report for verification and approval.

1.4.10.9 Insulation

- i) Insulation material shall be tested for all mandatory tests only as per relevant code or standard.
- ii) Thermal conductivity tests (for thermal insulation only) shall be done once in six months for insulation material manufactured during six months period for the same density, outer diameter and thickness of material as applicable as per IS:3346 or equivalent standard.

1.4.10.10 Air filters

Pre and fine filters shall be tested for initial and final pressure drop versus flow and average synthetic dust weight arrestance as per the requirement of BS 6540 or ASHARE-52-76 or EN779.

1.4.10.11 Packaged, split and window air conditioners

- i) Compressor of packaged air conditioner (PAC) shall be tested as per relevant code/standard.
- ii) PAC shall be subjected to production routine test in accordance with IS: 8148 for the following.
 - a) General running test.
 - b) Pressure or leakage test of refrigerant.
 - c) Insulation resistance test.
 - d) High voltage test.

- e) Performance test on one PAC of each type/size at ambient condition to check for following.
 - DBT and WBT of supply and return air.
 - Air flow
 - Current, voltage measurement and power consumption
 - Noise and vibration measurement
- iii) Manufacturer's standard test certificate or guarantee certificate shall be submitted for split and window air conditioners.

1.4.10.12 Pipes, valves and fittings

The QA requirements for piping, valves and fittings shall be as per clause 1.4.6 of this Section.

1.4.11 Ventilation System

The QA requirements for ventilation system equipments shall be same as those applicable similar equipments of air conditioning system equipments described at clause 1.4.10 of this Section.

1.4.12 Miscellaneous Items/ Equipments

1.4.12.1 Chemical dosing system

- i) Pumps of chemical dosing system shall be performance tested as per relevant codes.
- ii) In case of diaphragm type of pumps, the life cycle test shall be done on pumps.
- iii) Dosing skid shall be subjected to leakage test and functional test.

1.4.12.2 Centrifugal pumps

- i) Tests shall be carried out on the materials of the pumps to establish their properties, and chemical compositions.
- ii) 100% DPT or MPE shall be carried out for the rotor and machined surfaces of casing and impellers.

- iii) UT on pump shaft (diameter greater than or equal to 50mm), MPI or DPT on pump shaft and impeller after machining shall be carried out.
- iv) All rotating components of the pumps shall be statically and dynamically balanced to ISO-1940 Gr. 6.3.
- v) Assembly fit up check, and dimensional check shall be carried out for the completed pump assembly.
- vi) Pump casings shall be subject to hydraulic test at 1.5 times the shut off pressure or 2 times the working pressure whichever is higher for a minimum duration of 30 minutes.
- vii) All pumps shall be tested at manufacturer's works for head, capacity, power and efficiency as per requirements of HIS, USA or equivalent standard.. Pump shall be given running test over the entire operating range covering from the shut-off head to the maximum flow. Acceptance shall be as per approved datasheet and HIS only.
- viii) Pumps shall be subjected to strip down examination visually to check for mechanical damages after testing at shop in case abnormal noise level and/or excessive vibration are observed during the shop test.

1.4.12.3 Blowers and exhausters

- i) Tests shall be carried out on the materials of the rotary blowers to establish their properties, and chemical compositions.
- ii) 100% DPT or MPE shall be carried out for the rotor and machined surfaces of casing and impellers.
- iii) Rotors shall be dynamically balanced.
- iv) Assembly fit up check, and dimensional check shall be carried out for the completed blower assembly.
- v) The blower casing shall be subject to hydraulic test at 1.5 times the shut off pressure or 2 times the working pressure whichever is higher.
- vi) Performance test including noise and vibration tests shall be carried out as per relevant standards and codes.

1.4.12.4 Filters and strainers

- i) Tests shall be carried out on the materials on various components to establish their mechanical properties and chemical composition.
- ii) In case of fabricated construction, the welds shall be examined for surface defects by 100% DPT.
- iii) The body shall be subject to hydraulic test at 1.5 times the design pressure.
- iv) Pressure drop, flow and particle size tests shall be carried out for the filter assembly.

1.4.12.5 Tanks and vessels

- i) Tests shall be carried out on the materials on various components to establish their mechanical properties and chemical composition.
- ii) UT shall be carried out on plate material used for fabrication of tanks and vessels.
- iii) Hydraulic test for pressurised vessels and water fill test for atmospheric tanks shall be carried out as per relevant standards/ codes.
- iv) Butt welds and full penetration welds shall be checked by suitable RT or UT. Fillet welds shall be checked by MPE or DPT.

1.4.12.6 Lube oil system/ hydraulic power pack

Lube oil system/ hydraulic power pack shall be tested for performance.

1.5 FIELD ERECTION CHECKS AND TESTS

The QA requirements for raw materials, in-process tests and NDTs indicated for shop manufacture shall be applicable for site fabrication/erection of the respective item.

1.5.1 Hydraulic Test of Pressure Parts

On completion of erection of pressure parts of each steam generator, the unit with its fittings and mountings in position shall be subjected to hydraulic test pressure in accordance with requirement of Indian Boiler Regulations. Water used for hydraulic test shall be made alkaline by addition of suitable chemical. After the test, all parts shall be drained and suitably preserved.

1.5.2 Turbine Assembly

Bidder shall clearly indicate the extent of assembly to be carried out at site for steam turbine and BFP drive turbine(s). Accordingly, bidder shall submit elaborate erection and assembly inspection programme of turbines for purchaser's approval.

1.5.3 Condenser Assembly

- i) If the condenser sections calls for site assembly, care shall be taken in assembly of sections and correctness of alignment and fit up shall be checked. Site weldings shall be carried out as per the procedure approved by the purchaser.
- ii) All weld seams shall be subjected to magnetic particle examination. At least 10% of butt welds shall be subjected to radiographic examination.
- iii) All welds between condenser neck and LP turbine shall be subjected to 100% radiographic and magnetic particle examination.
 - iv) Condenser tubes shall be visually examined for dents, mechanical damages or any other defects prior to insertion. Both tube ends shall be thoroughly cleaned to a length of 100mm to remove oil, grease etc. and shall be checked for freedom from burrs prior to insertion.
 - v) Tube expansion shall be carried out by electronic automatic torque control expanding unit, which shall be calibrated before use. Tube wall thinning and length of expansion shall be controlled and recorded.
- vi) Hydrostatic testing of condenser steam space shall be carried out after connecting all the pipes with the condenser along with condenser vacuum systems by filling the steam space with water upto the tip of the last stages of blades of LP cylinder.
- vii) Condenser water boxes shall be tested hydraulically at a minimum test pressure of 1.5 times the design pressure.

1.5.4 General

- i) All rotating equipment shall be checked for their direction of rotation and free movement after placing on the respective foundations.
- ii) Piping system shall be tested hydraulically or pneumatically as per application requirement.
- iii) All valves shall be checked for their direction of flow.
- iv) Insulation shall be carried out only after satisfactory inspection of leak test.
- v) After complete installation of air conditioning and ventilation systems, all ducting system shall be tested for air leakage test or smoke tightness test.

1.6 ELECTRICAL SYSTEMS

i) Quality Plan

The indicative list of various tests/ checks for various equipment/ items is given below. The bidder shall draw his own quality plans in line with these requirements, his standard practices and requirements of standards/ codes and implement such programme after approval by the purchaser.

ii) Process checks

Under the 'Process checks', tests which are required to be conducted at works during various stages of manufacturing have been listed.

iii) Type tests

Type tests have been divided into following two categories:

(a) Category-I

The contractor shall carry out type tests listed under Category -I for the respective equipment. The charges for each of these type tests shall be indicated separately and the same shall be considered for the evaluation of the bids. The owner reserves the right to waive conducting of any or all of the specified type tests on submission of type test report conducted on similar equipment during last five (5) years, in which case the type test charges shall not be payable for the type tests which are waived. The type test charges shall be paid only for the test(s) actually conducted successfully under this contract. The Contractor shall supply the equipment to the site only after receiving MDCC (Material Dispatch Clearance Certificate) from the Owner. Without receiving consent / MDCC from Owner, Supply of the equipment at site shall not be considered.

(b) Category-II

The contractor shall only submit the reports of the type tests listed under Category -II for the respective equipment which should have been carried out within last five (5) years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client. In case the contractor is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract free of cost and submit the reports for approval.

iv) Site Tests

Some site tests have also been identified below which shall be carried out by the contractor. The site tests as per the manufacturer's practice, other than those specified herein, shall also be conducted by the bidder :-

1.6.1 Generator and auxiliary systems

1.6.1.1 Process check for static parts of generator/ exciter

[illegible]

Y=Test applicable, Y1=UT on babbitt for bearing

1.6.1.2 Process check for core of generator/ exciter 1/2)							(Table	
Items/ Components/ Process	Tests/ Checks							
	Specific loss before and after ageing	Magnetisation	Anotrophy of losses	Stacking factor	Burr level	Check for varnish, insulation (chemical, electrical, viscosity, cure time, solid content, dielectric	Dimension and surface (uniformity of varnish coat	Spot weld check
Core lamination	Y	Y	Y	Y		Y	Y	
After punching insulatedcore laminations				Y	Y	Y	Y	
Ventilation stamping								Y
Core assembly	Y	Y					Y1	
Y = Test applicable, Y1 = Visual checks								

1.6.1.2 Process check for core of generator/ exciter (Table 2/2)						
Items/ Components/ Process	Tests/ Checks					
	Process check including heating and	Insulation test of core tension bolt and core bar	Functional check of ventilation ducts	Hot spot by infra red camera, ELCID	Location of temperature	Iron loss at rated flux density
Core assembly (additional checks for generator)	Y	Y	Y	Y	Y	Y
Y = Test applicable, Y1 = Visual check						

pressure

1.6.1.3 Process check for stator conductor and winding of generator/ exciter

(Table 1/3)

	Tests/ Checks											
	Mechanical Properties (sample)	Chemical Properties (sample)	Resistivity/ Resistance	Metallography properties	Eddy current and pressure test	Insulation adhesion	Flexibility of bending	Dielectric test	Dimension/ visual	Electric test	Physical properties	Brazing procedure
Winding copper and connecting busbars	Y	Y	Y	Y	Y1				Y			
Insulated conductor						Y	Y	Y	Y	Y		
Insulation material	Y	Y							Y	Y	Y	
Manufacturing winding bar and phase bar								Y	Y	Y		Y
Winding laying								Y	Y	Y		
Water supply hoses	Y	Y						Y	Y			
Winding support ring		Y							Y		Y	
Connection between bars												Y
Wound stator												

Y = Test applicable, Y1 = Visual checks

1.6.1.3 Process check for stator conductor and winding of generator/ exciter					
(Table 2/3)					
Items/ Components / Process	Tests/ Checks				
	X-Ray	Process check	Flow test	Helium leak test and pressure	Check on RTD and location
Winding copper and connecting busbars					
Insulated conductor					
Insulation material					
Manufacturing winding bar and phase bar	Y1	Y	Y1	Y	
Winding laying		Y			Y
Water supply hoses				Y	
Winding support ring					
Connection between bars					
Wound stator				Y1	
Y = Test applicable, Y1 = Visual checks					

**1.6.1.3 Process check for stator conductor and winding of generator/
exciter
(Table 3/3)**

Items/ Components/ Process	Tests/ Checks										
	Tan delta and delta (tan delta upto 1.2	Corona protection resistance	Reactance of stator winding	Magnetic permeability of metallic parts	Magnetic test and Vibration fatigue	Dielectric test at elevated, room	Inter strand Insulation test	Thermal shock and boroscopic examination of brazed water box	Slot wedge tightness and radial	Type test on two bars for heating cycle test, Thermal stability test, Voltage	Support arrangement
Winding copper and connecting bus bars											
Insulated conductor						Y					
Insulation material											
Manufacturing winding bar and phase bar	Y	Y					Y	Y1		Y	
Winding laying	Y										Y
Water supply hoses				Y	Y						Y
Winding support ring											
Connection between bars							Y				
Wound stator	Y		Y						Y		

Y = Test applicable, Y1= Applicable for hollow conductor

1.6.1.4 Process check for rotor and assembly of generator / exciter 1/4)

(Table

[illegible]

1.6.1.4 Process check for rotor and assembly of generator / (Table 2/4 exciter												
Items/ Components/ Process	Tests/ Checks											
	MPI or DP, NDT	Visual, dimension, cleanliness	Adhesion, thickness of coat on silver plating	Electrical conductivity and oxygen content	Mechanical test on casing	Electrical test	Resistance	Purge test on vents	Helium leak test for H ₂ cooled machine	Inter-turn test	Dielectric test	Gas tightness
Rotor forging and slipring shaft	Y	Y										
Rotor end retaining ring and cover, locking ring and slip ring forgings, diode wheel	Y		Y									
Rotor winding copper rotor wedges, damper wedges, CC-bolts and D-leads	Y		Y	Y	Y	Y						
Rotor slot boxes/ insulating material					Y	Y						
Coil manufacture		Y										
Rotor winding	Y	Y				Y	Y	Y	Y	Y	Y	
Winding connection studs and assembly	Y				Y						Y	Y
Complete rotor							Y				Y	
Test on completed rotor at various speed upto rated speed							Y			Y	Y1	
Test on completed rotor before and after over- speed		Y								Y	Y	
Fan hubs/ blades	Y	Y										
Generator assembly		Y										
Rectifier wheel		Y				Y						
Permanent magnet		Y			Y							
Exciter assembly		Y				Y						

Y=Test applicable, Y1= at rated speed only

**1.6.1.4 Process check for rotor and assembly of generator / exciter
(Table 3/4)**

Items/ Components/ Process	Tests/ Checks											
	Insulation Resistance	PI at 5 kV	Radial run out/ alignment	Impedence measurement/ Repetitive Surge	Dynamic balancing ISO 5393, 5406, 2372, 1940 including Air run test	Over speed test (120%) for 2 minute	Functional test	Axial run out, seal ring holder	Metallography examination	Torque on joint bolts	Fitting and locking of balancing weights	Brazer and brazing
Rotor forging and slipring shaft									Y			
Rotor end retaining ring and cover, locking ring and slip ring forgings, diode wheel												
Rotor winding copper rotor wedges, damper wedges, CC-bolts and D-leads										Y		
Rotor slot boxes/ insulating material												
Coil manufacture												Y
Rotor winding												Y
Winding connection studs and assembly	Y											
Complete rotor	Y	Y	Y	Y	Y	Y				Y		
Test on completed rotor at various speed upto rated speed				Y								
Test on completed rotor before and after over-speed	Y		Y	Y								
Fan hubs/ blades											Y	
Generator assembly	Y	Y	Y				Y		Y	Y	Y	Y
Rectifier wheel			Y					Y		Y	Y	

Permanent magnet											
Exciter assembly			Y				Y			Y	Y
Y=Test applicable											

1.6.1.4 Process check for rotor and assembly of generator/ exciter (Table 4/4) (additional checks for exciter)

[illegible]

1.6.1.5 Final acceptance tests for generator/ exciter (Table 1/3)

Item/ Components/ Process	Tests/ Checks										
	Gas tightness for H ₂ cooled	Resistance measurement	Rotor impedance at various	Heat run test	Function check	Voltage regulation	OCC	SCC	Record auxiliary parameters	Steady state reactance	Efficiency by separation of
Works tests on running generator	Y	Y	Y	Y			Y	Y	Y	Y	Y
Without Excitation, OC and SC with rated voltage and current for generator				Y							
On total winding/ phases at interval 0.2Un for generator											
Condition after dismantling											
Works tests on brushless exciter		Y		Y			Y				
PMG works tests		Y		Y		Y					
Full load for PMG and converter assembly				Y							
Converter assembly				Y							
Y = Test applicable											

1.6.1.5 Final acceptance tests for generator / exciter (Table 2/3)

Item/ Components/ Process	Tests/ Checks									
	Insulation resistance at 5 kV	Polarization index at 5 kV	Phase sequence voltage balance	Shaft voltage and current	HV test (except electronic	RTD, BTD Check	Capacitance measurement	Tan delta, delta tan-delta	Rotor journal	Bearing oil catcher
Works tests on running generator	Y	Y	Y	Y	Y	Y	Y	Y		
Without Excitation, OC and SC with rated voltage and current for generator										
On total winding/ phases at interval 0.2Un for generator							Y	Y		
Condition after dismantling									Y	Y
Works tests on brushless exciter	Y				Y					
PMG works tests	Y		Y		Y					
Full load for PMG and converter assembly										
Converter assembly	Y				Y					
Y = Test applicable										

1.6.1.5 Final acceptance tests for generator/ exciter (Table 3/3)

Item/ Components/ Process	Tests/ Checks								
	Seal rings, liners	Winding overhang	Vibration measurement	Reduced voltage running and No load	Load characteristics	Characteristics of search coil,	Ripple content	Visual and dimension	Partial discharge, DLA
Works tests on running generator			Y					Y	Y
Without Excitation, OC and SC with rated voltage and current for generator									
On total winding/ phases at interval 0.2Un for generator									
Condition after dismantling	Y	Y							
Works tests on brushless exciter			Y	Y	Y	Y		Y	
PMG works tests				Y	Y				
Full load for PMG and converter assembly									
Converter assembly									
Y =Test applicable									

Note

- | | |
|---|---|
| 1 | All generators shall be assembled at works and shall be tested to verify/ ensure design and workmanship in accordance with IEC-34, VDE-0530, IEEE-115, IEEE 43. The manufacturer shall submit detailed test procedure which clearly specify test set up, instruments to be used, acceptance norms (wherever applicable), recording of different |
|---|---|

	parameter, interval of recording, precautions, etc.
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1.6.1.6 Type tests

1.6.1.6.1 Type tests (Category-I)

i) Generator

One number assembled generator shall be tested at works as per IEC-34. The tests shall be carried out keeping all conditions/ parameters as close as possible to site conditions with all the built-in instrumentation (like RTD etc.) suitably wired and the readings recorded. During various tests, bearing and shaft overhang vibrations shall also be measured with and without excitation. Recording of various parameters of bearing, seal oil system, gas system, stator water cooling system and environmental conditions (like temperature etc.) shall also be done. The following tests shall be conducted:

- a) Instantaneous short circuit test to determine transient and sub-transient reactance parameters and to ensure stability of winding during sudden short circuit condition
- b) Negative sequence and zero sequence impedance
- c) Voltage waveform factor and Total Harmonic Factor
- d) Short circuit heat run test at rated pressure and cooling parameters with one cooler out of circuit at two third of rated stator current. In case of unsymmetrical cooler configuration, test with all possible variants of one cooler out of circuit shall be carried out.
- e) Vibration measurement on all planes on stator overhang winding at suitable locations on each end and at other critical locations to be decided by purchaser for the following conditions:
 - Open circuit operation
 - Short circuit operation
 - Sudden short circuit conditions
 - Stand still condition - with Hammer test

ii) Brushless excitation system

- a) Exciter - Temperature rise test at peak rating of excitation system. Ceiling duty condition shall also be demonstrated
- b) Permanent magnet generator - Temperature rise test at peak rating of excitation system and ceiling duty condition shall also be demonstrated
- c) Converter assembly (of the exciter field) - Temperature rise test at peak

rating of excitation system. Ceiling duty condition shall also be demonstrated

1.6.1.6.2 Type test (Category-II)

Brushless excitation system

- a) Converter assembly of the exciter field
 - Input and output surge withstand capability test
 - Soak test for Electronic module
- b) Degree of protection test for Excitation system panels

1.6.1.7 Site tests

The tests to be conducted on each generator at site shall include but not be limited to those listed below. Any other test considered necessary by the contractor shall also be carried out :

- a) Electrical
 - i) Measurement of the insulation resistance of the stator and rotor windings to the frame and between phases, after drying out the machine and measurement of the polarisation index
 - ii) Measurement of the DC resistance of all windings and embedded temperature detectors
 - iii) Measurement of the insulation resistance of bearings
 - iv) Capacitance measurement and dissipation factor between the winding and body at rated voltage
 - v) Stator -Partial Discharge test @ 1.3 Phase to Neutral voltage for PRPD & Extinction & inception voltages.
 - vi) Stator- NFT test
 - vii) Open circuit and short circuit tests
 - viii) Measurement of temperature rise at the rated load
 - ix) Performance capability of the machine
 - x) Line charging capacity
 - xi) Short circuit tests on the generator HV end and the generator transformer HV end to check the stability and operation of the generator and the overall (i.e. generator and generator transformer) differential protections and negative phase sequence protection.
 - xii) Rotor-IR, Winding resistance, Impedance & RSO test
 - xiii) Shaft voltage
- b) Mechanical
 - i) Hydrogen leakage test
 - ii) Vibration test
 - iii) Over-speed test

- iv) Hydraulic tests on coolers
- v) Bearing and shaft current test

c) Load throw-off tests.

1.6.2.1 Generator Isolated Phase Busduct (Table 1/2)

Items/ Components/ Sub-systems	Tests/ Checks									
	Visual and Dimensional Checks	Electrical/ Mechanical/ Chemical Properties	WPS and POR	NDT, DP or MPI, RT	Painting shade and adhesion test	Galvanizing test as per IS: 2629/ 2633/	Electrical clearance and Creepage	Functional/ Operational check	Make, Type, Rating, Model, TC, General/physical inspection	Routine test as per relevant standard
Enclosure/ cubicle	Y	Y		Y	Y		Y			
Busbar flexible connector and dis-connector link	Y	Y								
Galvanized steel structure and plate	Y					Y				
Seal of bushing and post insulatorIS:5621, 2544	Y	Y					Y		Y	Y
Welding of enclosure and conductor	Y		Y	Y						
Gasket, silicagel breather, CT, VT, surge capacitor and arrester, NGT, NGR, elastomer spring head								Y	Y	Y
Busbar pressurisation system	Y							Y		
Complete busduct IS:8084	Y				Y					Y
Y =Test applicable										

1.6.2 Generator Isolated Phase Bus ducts and Neutral Grounding equipment					
1.6.2.1 Generator Isolated Phase Bus duct (Table 2/2)					
Items/ Components/ Sub-systems	Tests/ Checks				
	Trial assembly at works : Heat run test and Milli volt drop measurement across bolted	Trial assembly at works : Short circuit withstand test	Trial assembly at works: Impulse withstand test	Trial assembly at works: one minute high voltage power	Trial assembly at works: Air leakage rate and water tightness
Enclosure/ cubicle					
Busbar flexible connector and disconnector link					
Galvanized steel structure and plate					
Seal of bushing and post insulator IS:5621, 2544					
Welding of enclosure and conductor					
Gasket, silicagel breather, CT, VT, surge capacitor and arrestor, NGT, NGR, elastomer spring head					
Busbar pressurisation system					
Complete busduct IS:8084	Y	Y	Y	Y	Y
Y =Test applicable					
Note					
Trial assembly set-up shall include 3-phase straight run, 90 ⁰ bend, set of flexible connection of each type, metallic bellow on enclosure, CTs mounted in position (asapplicable), bolted link and necessary inspection covers.					

1.6.2 Generator Isolated Phase Bus ducts and Neutral Grounding equipment											
1.6.2.2 Neutral Grounding Resistor											
Items/ Components/ Sub-systems	Tests/ Checks										
	Visual and Dimensional check	Mechanical properties	Electrical strength	Chemical Composition	Make, Type, Rating, Model, TC, General physical inspection.	Insulation resistance measurement before and after HV Test	HV Test	Degree of protection test	Routine test as per relevant standard	Galvanizing test	Routine test
Resistor	Y	Y	Y	Y		Y					
Cubicle	Y		Y					Y			
Galvanized steel structures (IS:2633/ 2629/ 6745/ 2062)	Y	Y								Y	
Bushing/ Post and support Insulator (IS:2544/ 5621)	Y	Y	Y		Y	Y			Y		Y
Complete NGR (IEEE-32)	Y					Y	Y	Y	Y		Y
Y =Test applicable											

1.6.2.3 Type Tests

1.6.2.3.1 Type test (Category-I)

The following type tests shall be conducted on one bus-ducts of each rating:

- Heat run test (the set up shall include 3 phase straight run, 90° bend, set of flexible connection of each type, metallic bellow on enclosure, CT's mounted in position, (as applicable), bolted link, and necessary inspection covers. Milli-volt drop across bolted flexible joint shall be measured
- Short circuit withstand test (set up same as for heat run)
- Impulse withstand test (set up shall include typical X-section with flexible

connections, 90⁰ bend, CT's in position, seal off bushing, inspection cover and bellows)

- d) One minute high voltage power frequency withstand test (set up as for shortcircuit test)
- e) Air leakage rate and water tightness test (set up shall include inspection cover, flanged joint and bellow)

1.6.2.3.2 Type test (Category-II)

- a) Panels, cubicles and marshalling boxes shall be type tested for the degree of protection provided by the enclosure as given below :
 - For 5X-it shall not be possible to insert a thin sheet of paper undergaskets and through enclosure joints.
 - For 4X-It shall not be possible to insert a one mm diameter steel wire into enclosure from any direction without force.
 - For 2X-It shall not be possible to insert a twelve (12) mm dia steel wire into the enclosure from any direction without any force.
 - Test for second digit shall be in line with IS:13947 part-1
- b) For the equipment and materials such as current transformers, voltage transformers, lightning arresters, grounding transformers, loading resistors, bushings and surge capacitors for which type test are not specified in this section, successful type tests certificate shall be submitted to the purchaser.

1.6.2.4 Site tests

- i) 10% radiography and 100% DP test on all site welded joints of busbar and enclosure (for Root & Final welding).
- ii) Milli-volt drop test
- iii) Ratio and polarity tests on current and voltage transformers
- iv) Insulation measurement of equipment and all wiring
- v) Functional test on pressurization (Tightness test as per ANSI 37.20)
- vi) One minute high potential power frequency withstand test at 75% of rated test voltage
- vii) Enclosure Isolation test with support frame.
- viii) Air pressurisation test.

1.6.3 Power Transformers														
1.6.3.1 Generator Transformers/ Unit auxiliary transformers/ Station transformers) (Table 1/2)														
Items/ Components/ Sub-systems	Tests/ Checks													
	Visual and dimensional	Mechanical properties	Electrical strength	Thermal properties	Chemical composition	Compatibility with oil	Core Loss, Hot spot	NDT, DPT or MPI, UT	Ageing test.	Voltage Ratio, Vector Group and Polarity,	Make, Type, Rating, Model, TC, General physical	10kV Isolation test on core	WPS and PQR	Routine tests as per relevant standard
Tank	Y	Y						Y					Y	
HV and LV cable box/ Flangethroat	Y	Y												
Conservator/ Radiator/ Cooler/ Pipes	Y	Y						Y						
Copper conductor (IS:191)	Y	Y	Y		Y									
Insulating material	Y	Y	Y	Y	Y	Y								
CRGO lamination and built Core	Y	Y	Y		Y	Y	Y							
Bushing/ Insulator (IS:2544/ 5621)	Y	Y												Y
Gasket	Y				Y	Y			Y					
Air Cell	Y													
Transformer oil (IS:335)														Y
On load/ off-circuit tap changer (IEC:214)	Y													Y
Core coil assembly and Pre-tanking	Y						Y			Y		Y		
Marshalling Box	Y	Y						Y						Y
WTI, OTI, MOG, Buchholz Relay, PRD, Thermister, Breather, Terminal connector, Bushing CT, Fan and Pumps with Drives, Impact Recorder, Globe and Gate Valve, PD Detector, FRA and DGA Equipment Tan Delta & Capacitance											Y			Y
Welding (ASME Sect-	Y							Y					Y	

IX)														
Y = Test applicable														

1.6.3.1 Generator Transformers/ Unit auxiliary transformers/ Station transformers (Table 2/2)								
Items/ Components/ Sub-systems	Tests/ Checks							
	Oil Leakage Test	Jacking test followed by DP Test on loadbearing member	DGA of oil for main tank and OLTC Chamber	Measurement of capacitance and tan	Partial discharge measurement (long duration) as per IEC-76 clause No. 12.4	Routine Tests	Nitrogen dew point measurement before final packing for transportation	Paint shade thickness and adhesion and finish
Complete Transformer (IS:2026/ IEC:76) FDS for Trf & Bushing, LI test	Y	Y	Y	Y	Y	Y	Y2	Y
Y = Test applicable Y2 = Applicable only for Nitrogen filled transformer								
Notes								
Each transformer shall be completely assembled with all fittings and accessories meant for the particular transformer before offering for inspection and testing.								

1.6.3.2 Type Tests (Category-I)

i) Generator transformer

The following type tests shall be conducted on one generator transformer:

- Temperature rise test
- Tank vacuum test
- Tank pressure test
- Short circuit test: The test procedure shall be as per IEC 76-5. All type tests other than tank tests shall be conducted only after short circuit test to ensure delivery of healthy and proven transformer. The time

duration for each shot during short circuit test shall be as per IEC 76-5. The allowed variation in inductance shall be as per IEC 76-5. All dielectric routine tests shall be conducted before and after short circuit test at full value including following also:

- Dissolved gas analysis
 - Frequency response analysis
- e) Test reports for DOP test (IP 55) on cooler control cabinet (CCC)/ OCTC/ common marshalling box (CMB) shall be submitted.

ii) Station transformer and unit auxiliary transformer

The following type tests shall be conducted on one station and one unit auxiliary transformer:

- a) Temperature rise test: Temperature rise test shall be performed at a tap corresponding to maximum losses. The test shall be carried out at minimum 110% of rated current. Oil samples as per IEC-567 shall be taken before and immediately after temperature rise test. DGA shall be conducted on this oil sample and the values shall be recorded in the report. For evaluation of gas analysis in temperature rise test the procedure shall be as per IS 9434 (based on IEC 567) and results will be interpreted as per IS 10593 (based on IEC 599).
- b) Tank vacuum test
- c) Tank pressure test
- d) Lightning impulse test on HV and LV winding for station transformer and unit auxiliary transformer as per clause 14 of IEC 60076-3.
- e) Short circuit test: - The test procedure shall be as per IEC 60076-5. All type tests other than tank tests shall be conducted only after short circuit test to ensure delivery of healthy and proven transformer. All dielectric routine tests shall be conducted before and after short circuit test at full value. All dielectric routine tests shall be conducted before and after short circuit test at full value including following also:
- Dissolved gas analysis
 - Frequency response analysis
- f) The test reports for DOP test – IP55 test on CCC/ CMB/ OLTC/

OCTC cabinet shall be submitted.

iii) Special tests for Generator Transformer, Station Transformer and Unit Auxiliary Transformer

The following special tests shall be conducted on each rating of transformer

- a) Power taken by cooling equipment
- b) No load harmonic measurement
- c) Noise level measurement as per NEMA TR-1
- d) Zero sequence impedance measurement

1.6.3.3 Details of Vacuum test on transformer tank

Each transformer tank shall be subjected to the specified vacuum. The tank designed for full vacuum shall be tested at an internal pressure of 3.33 kN/ m^2 absolute (25 torr) for one hour. The permanent deflection of the plate after the vacuum has been released shall not exceed the values specified below:

Horizontal length of Flat Plate (mm)	Permanent deflection (mm)
Upto and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5
2001 to 2250	11.0
2251 to 2500	12.0
2501 to 3000	16.0
above 3000	19.0

1.6.3.4 Details of Pressure test on transformer tank

Transformer tank of each size shall be subjected to a pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 kN/ m^2 , whichever is lower, measured at the base of the tank and maintained for one hour. The permanent deflection of the plates after the excess pressure has been released shall not exceed the figure specified above for vacuum test.

1.6.3.5 Site tests

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

- a) Colour of silicagel in silicagel breather
- b) Oil level in the breather housing, conservator tanks, cooling system, condenser-bushing etc.
- c) Bushing for conformity of connection to the lines etc. and Capacitance & tan delta test for bushing
- d) Millivolt drop across the connection across lead & winding connection
- e) FDS for Bushing for moisture in Cellulose
- f) Operation of protection devices and alarms:
 - Buchholz relay
 - Excessive winding temperature
 - Excessive oil temperature
 - Low oil flow
 - Low oil level indication
 - OSR for OLTC
 - SPRR
 - PRV
- g) Resistance of all windings on all steps of the tap changer.
- h) Insulation resistance of the following:
 - Control wiring
 - Cooling system motor and control
 - Main windings
 - Tap changer motor and control
 - Tank and turret mounted CTs
 - Core and clamp:
 - Core to earth
 - Core clamp to earth
 - Core to core clamp
- i) The following checks shall also be carried out:
 - Direction and overload setting of cooling accessories
 - Buchholz, oil level indicator, pressure gauges, temp indicators etc. for fitting and operation.
 - Earthing of main tank, marshaling box, tap changer driving gear, pump and fan motor etc.
 - Neutral earthing
 - Calibration of WTI and OTI
 - Earthing of bushing test tap
 - Connection of WTI CT
 - Tightness of CT secondary connection and shorting of unused CTs

- All valves for their correct opening and close sequence

- j) Phase out and vector group test
- k) Ratio test on all taps
- l) Magnetizing current test (HV winding and LV winding)
- m) Capacitance and Tan delta measurement of winding
- n) FDS test on transformer & Bushing
- o) SFRA test on Transformer winding
- p) Noise level
- q) Oil dielectric strength test- The various test on oil shall be conducted prior to filling in main tank at site and prior to energization at site. Oil samples are to be drawn from top and bottom of main tank, cooling system and OLTC.
- r) DGA, PPM & Acidity of oil before commissioning
- s) Core isolation test at designed value (old- 2kV, new -10 kV AC & DC test)
- t) Magnetic balance test, with magnetizing current
- u) Short circuit impedance measurement, without SFRA
- v) Test on tank/ turret mounted CTs
 - IR value between secondary winding & earth and between windings
 - Secondary resistance
 - Polarity
 - Ratio test
 - Magnetization current, Knee point voltage
- w) Test on cooler fan and pump
 - IR Value
 - Starting current
 - Running current
- x) WTI and OTI setting for alarm/trip, fan start/stop and pump start/stop
- y) Final IR value between windings and earth
- z) Continuously observation of the transformer operation at no load for 24 hours with respect to voltage, no load current, temperature rise and noise.
- aa) Gradually put the transformer on load, check and measure increase in temperature in relation to the load and check the operation with respect to temperature rise and noise level etc.

1.6.4 HT BUSDUCT									
1.6.4.1 11kV & 3.3kV Segregated Phase Bus ducts									
Items/ Components/ Sub-systems	Tests/ Checks								
	Visual and Dimensional Checks	Electrical, Mechanical, Chemical	WPS and PQR	NDT, DP or MPI, RT	Paint shade and Adhesion test	Galvanizing Test as per IS: 2629/ 2633/	Electrical clearance and creepage	Functional/ Operational check	Make, Type, Rating, Model, TC, General physical inspection
Enclosure/ cubicle	Y	Y		Y	Y				
Arc test at rated short circuit current									
Busbar flexible connector and disconnector link	Y	Y							
Steel structure and plate IS:2062		Y				Y			
Bushing, post and support insulator (IS:9431 and 2544)	Y						Y		Y
Welding of enclosure and conductor	Y		Y						
Gasket, silicagel breather								Y	Y
Complete busduct IS:8084	Y				Y				Y
Y =Test applicable									

1.6.4.2 Type test (Category-II)

- (a) All bus-ducts supplied shall be of type tested quality.
- (b) Type test reports for the following shall be submitted:
 - One minute power frequency voltage withstand test
 - Temperature rise test. Milli volt drop shall also be measured across bolted flexible joint
 - Impulse voltage withstand test
 - Short time current test
 - Water tightness test (as per IS:8084)

- Arc test at rated short circuit for rated time
- Air leakage test

1.6.4.3 Site tests

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

- Power frequency voltage withstand test
- Air leakage test
- Water tightness test on outdoor portion of bus-duct
- Insulation resistant measurement of equipment and all wiring
- Milli-volt drop
- Tightness test for bus bar joints.

1.6.5 Auxiliary Service Transformers

1.6.5.1 Oil-filled Outdoor Transformers

Items/ Components/ Sub-systems	Tests/ Checks													
	Visual and Dimensional checks	Mechanical properties	Electrical strength	Thermal properties	Chemical Composition	Compatibility with oil	Core Loss (on first Job) Hot Spot	NDT, DP or MPI, UT	Ageing Test	Voltage Ratio, Vector Group and Polarity, Magnetic balance test	Make, Type, Rating, Model, TC, General physical inspection	WPS and PQR	Vacuum and Pressure Test	Routine Tests
Tank, HV and LV Cable Box/ Flange throat	Y	Y						Y				Y	Y	
Conservator/ Radiator/ Cooler/ Pipes	Y	Y						Y				Y		
Copper Conductor (IS:191)	Y	Y	Y		Y									
Insulating Material	Y	Y	Y	Y	Y	Y								
CRGO Lamination and Built Core	Y	Y	Y		Y	Y	Y							
Bushing / Insulator (IS:2544/ 5621)	Y	Y									Y			Y
Gasket	Y				Y	Y			Y					
Transformer oil (IS:335)														Y
Off-circuit tap changer	Y										Y			Y
Core coil assembly and pre-tanking	Y									Y				
Marshalling box	Y	Y						Y						Y
WTI, OTI, MOG, PRD, Breather, Terminal Connector, Bucholz Relay, Globe and Gate Valve,	Y										Y			
Welding (ASME Sect-IX)	Y											Y		
Complete Transformer (IS:2026)	Y									Y				Y
Y =Test applicable														

1.6.5.2 Dry Type Indoor Transformers												
Items/ Components/ Sub-systems	Tests/ Checks											
	Visual and dimensional	Mechanical properties	Electrical strength	Thermal properties	Chemical properties	Core loss (on first job), Hot	NDT, DP or MPI	Voltage ratio, vector group and polarity	Make, Type, Rating, Model, TC, General physical	WPS and PQR	Measurement of capacitance and tan delta	Routine tests
Enclosure door, HV and LV Cable box/ Flange throat	Y	Y							Y			
Copper conductor	Y	Y	Y		Y							
Insulating material	Y			Y	Y							
CRGO lamination and built core	Y					Y						
Bushing/ Insulator (IS:2544/ 5621)	Y								Y			Y
Gasket	Y								Y			Y
Off-circuit tap changer	Y								Y			
Core coil assembly	Y							Y				
Marshalling box	Y											
WTI, Thermister, Terminal connector	Y								Y			
Welding										Y		
Complete transformer (IS:11171)	Y							Y			Y	Y
Y =Test applicable												

1.6.5.3 Type tests

1.6.5.3.1 Type tests (Category-I)

The transformer shall be subjected to the following type tests for rating above 2 MVA.

- Short Circuit test – This test shall be carried out after conducting the routine tests. Rest of the type tests shall be conducted after successful short circuit testing.
- Noise level measurement
- Capacitance & tan Delta test
- Enclosure IP Degree test
- Measurement of zero phase sequence impedance

- vi) Measurement of the harmonics of no load current
- vii) Temperature rise
- viii) Lightning impulse voltage test on all the three limbs as per Cl. 13 of IS:2026 Part-III,1981

1.6.5.3.2 Additional Type tests (Category-I)

1.6.5.3.2.1 Vacuum Test on Transformer Tank - One Transformer tank of each rating shall be subjected to the specified vacuum. The tank designed for full vacuum shall be tested at an internal pressure of 0.35 kg/ cm² (absolute, 250 mm of Hg) for one hour. The permanent deflection of flat plates after the vacuum has been released shall not exceed the values specified below :

Horizontal Length of Flat Plate (mm)	Permanent deflection (mm)
Upto and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5
2001 to 2250	11.0
2251 to 2500	12.0
2501 to 3000	16.0
Above 3000	19.0

1.6.5.3.2.2 Pressure Test on Transformer Tank - One transformer tank of each rating shall be subjected to a pressure corresponding to twice the normal pressure of normal pressure plus 0.35 kg/ cm² whichever is lower measured at the base of the tank and maintained for an hour. The permanent deflection of flat plates after the excess pressure has released shall not exceed the figure for vacuum test.

1.6.5.3.2.3 Oil Leakage Test - All tanks and oil filled compartments shall be tested for oil tightness by oil of a viscosity not greater than that of insulating oil to IS:335, at the specified ambient temperature and subjected to a pressure equal to the normal pressure plus 35 KN/ m² (51 lb/ inch²) measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours, during which time no leakage shall occur.

1.6.5.3.2.4 Tests on associated equipments - Porcelain bushings, bushing current transformers, winding temperature indicating devices, dial thermometers, buchholz relays, ON/OFF load tap changer, auxiliary motors and motor starting contactors, coolers, control device, Insulating oil and other associated equipment shall be tested in accordance with relevant IS. The following checks shall also be made before dispatch:

1.6.5.3.2.4.1 Check for proper packing and preservation of accessories like radiators,

bushings, explosion vent, dehydrating breather, Buchholz relay, conservator etc.

1.6.5.3.2.4.2 Check for proper provision of bracing to arrest the movement of core and winding assembly inside the tank.

1.6.5.3.2.4.3 Test for Gas tightness and derivation of leakage rate to ensure adequate reserve gas capacity during transit and storage.

1.6.5.3.3 Type tests (Category-II)

All indoor transformers below and equal to 2 MVA rating to be supplied shall be of type tested quality. The test reports of the following type tests shall be submitted.

1.6.5.3.3.1 Short Circuit test – This test shall be carried out after conducting the routine tests. Rest of the type tests shall be conducted after successful short circuit testing.

1.6.5.3.3.2 Noise level measurement

1.6.5.3.3.3 Measurement of zero phase sequence impedance

1.6.5.3.3.4 Measurement of the harmonics of no load current

1.6.5.3.3.5 Temperature rise

1.6.5.3.3.6 Lightning impulse voltage test on all the three limbs as per Clause 13 of IS:2026 Part-III,1981

1.6.5.4 Site tests

i) The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

- a) Dry out test
- b) Resistance measurement of windings
- c) Ratio test
- d) Vector group test
- e) Tap changer test
- f) Buchholz relay test
- g) Low oil level alarm.
- h) Temperature indicators
- i) Marshalling kiosk
- j) Protective relays
- k) Magnetizing current
- l) Door interlock tests

ii) The following additional checks shall be made to see the following:

- a) All oil valves are in correct position closed or opened as required
- b) All air pockets are cleared
- c) Thermometer pockets are filled with oil
- d) Oil is at correct level in the bushing, conservator, divertor switch, tanketc.
- e) Earthing connections are made
- f) Colour of silica gel is blue
- g) Bushing arcing horn is set correctly
- h) CT polarity is correct (when bushing mounted CTs are provided)

1.6.6 Motors															
Item/ Components/ Sub-system	Tests/ Checks														
	Visual	Dimensional	Make, Type, Rating, TC, General physical	Mechanical, Chemical properties	NDT, DP or MPI, UT	Metallography	Electrical characteristics	Welding/ Brazing (WPS/ PQR)	Heat treatment	Magnetic characteristics	Hydraulic, Leak, Pressure test	Thermal characteristics	Run out	Dynamic balancing	All tests as per IS:325/ IS:4722/ IS:9283
Plates for stator frame, end shield, spider etc.	Y	Y	Y	Y					Y						
Shaft	Y	Y	Y	Y	Y	Y			Y						
Magnetic material	Y	Y	Y	Y	Y		Y			Y		Y			
Rotor copper/ Aluminium	Y	Y	Y	Y		Y	Y		Y						
Stator copper	Y	Y	Y	Y			Y		Y			Y			
SC ring	Y	Y	Y	Y	Y	Y	Y	Y	Y						
Insulating material	Y		Y	Y			Y					Y			
Tubes for cooler	Y	Y	Y	Y	Y				Y		Y				
Sleeve bearing	Y	Y	Y	Y	Y				Y		Y				
Stator, Rotor coils	Y	Y	Y				Y	Y							Y
Castings, stator frame, terminal box and bearing housing etc.	Y	Y	Y	Y	Y			Y							
Fabrication and machining of stator, rotor, terminal box	Y	Y			Y				Y						
Wound stator	Y	Y					Y	Y							Y

Rotor complete	Y	Y					Y							Y	Y				
Stator, Rotor, Terminal Box assembly	Y	Y					Y												
Accessories, RTD, BTD, CT, Brushes, Diodes, space heater, antifriction bearing, cable glands, lugs, gaskets etc.	Y	Y	Y																
Complete motor (IS: 325/ IS:4722/ IS:9283)	Y	Y	Y				Y									Y	Y	Y	Y 1
Y =Test applicable, Y1 = for 11kV and 3.3kV motors only																			
Notes																			
1)	This is an indicative list of tests/ checks. The manufacture is to furnish the detailed Quality Plan indicating the practices and procedure followed along with relevant supporting documents during QP finalization. However QP approval is not envisaged for 415V motors upto 50 KW.																		

1.6.6.1 Type tests

1.6.6.1.1 Type tests (Category-I)

11kV, 3.3kV motors

The following type tests shall be conducted on each type and rating of 11kV, 3.3kV motor:

- No load saturation and loss curves upto approximately 115% of rated voltage
- Measurement of noise at no load
- Momentary overload test (subject to test bed constraint)
- Full load test
- Temperature rise test at rated conditions (During heat run test, bearing temperature, winding temperature, core temperature, coolant flow and its temperature shall also be measured. In case the temperature rise test is carried at load other than rated load, specific approval for the test method and procedure is required to be obtained. Wherever ETD's are provided, the temperature shall be

measured by ETD's also for the record purpose).

- Impulse Voltage test (on the sample coil after placing it in stator core at $(4U+5kV)$ and with at least five impulse of 1.2/50 micro-second wave, for MV motors only, where U is the line to line voltage in kV).

1.6.6.1.2 Type tests (Category-II)

- i) 11kV and 3.3kV motors

The following type test reports shall be submitted for each type and rating of motor.

- Degree of protection test for the enclosure followed by IR, HV and no load runtest
- Terminal box-fault level withstand test for each type of terminal box
- Type test on Elastimold termination kit as per relevant standard

- ii) 415V motors

415V motors shall be of type tested quality. The type test reports for type tests as per relevant standards shall be submitted for each type and rating of 415V motors.

1.6.6.2 Site Tests

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

- i) Measurement of vibration.
- ii) Measurement of insulation resistance and polarization index.
- iii) Capacitance & Tan Delta & Tip Up till rated voltage
- iv) Measurement of full load current.
- v) Test running of the motors, checking the temperature rise and identifying the hot spot etc.

1.6.7 11kV, 3.3kV Switchgear (Table 1/2)

Items/ Components/ Sub-systems	Tests/ Checks													
	Make, Type, Model, Rating and TC	Electrical Properties	Mechanical properties	Chemical properties	Dimensions and Finish	Functional and operational features	Item to conform to relevant Standards	Pretreatment as per IS 6005	Paint shade, thickness, adhesion and	Functional Checks	HV and IR Test	Degree of Protection - Routine test	CB Operation timing check	All Routine Tests as per relevant
Aluminum busbar material (IS: 5082)	Y	Y	Y	Y	Y		Y							
Copper busbar material (IS:613)	Y	Y	Y	Y	Y		Y							
Bus bar support insulation (IS:9431)	Y	Y	Y		Y		Y				Y			
HT Circuit Breaker (IEC:56)	Y				Y	Y	Y			Y			Y	Y
HT Contactors (IS:9046)	Y				Y	Y	Y			Y				Y
Protection and auxiliary relays(IS:3231/ 8686)	Y				Y	Y	Y			Y				Y
HT CT's and PT's (IS:2705/ 3156)	Y				Y		Y							Y
HT Fuses (IS:9385)	Y				Y	Y	Y							
Surge arrester (IEC:99-4)	Y				Y		Y							Y
LT Contactors (IS:13947)	Y				Y	Y	Y			Y				
Control and selector switches(IS:6875)	Y				Y	Y	Y			Y				
Indicating meters (IS:1248)	Y				Y	Y	Y			Y				Y
Indicating lamps (IS:13947)	Y				Y	Y	Y			Y				
Push buttons (IS: 4794)	Y				Y	Y	Y			Y				
Control transformer (IS:12021)	Y				Y	Y	Y							Y
LT fuses (IS:13703)	Y				Y	Y	Y							
Energy meters (IS:722)	Y				Y	Y	Y							Y
Transducers (IEC:60688)	Y				Y	Y	Y							Y
Y =Test applicable														

1.6.7 11kV, (Table 2/2)				3.3kV				Switchgear						
Items/ Components,/ Sub-system	Tests/ Checks													
	Make, Type, Model, Rating and TC	Electrical properties	Mechanical properties	Chemical properties	Dimensions and Finish	Functional and Operational features	Item to conform to relevant standards	Pretreatment as per IS: 6005	Paint shade, thickness, adhesion and	Functional checks	HV and IR Test	Degree of Protection - Routine test	CB Operation timing check	All Routine Tests as per relevant
Diodes	Y	Y				Y	Y			Y				
Terminal Blocks	Y	Y				Y	Y							
Synthetic Rubber Gasket (IS:11149/ 3400)	Y	Y			Y		Y							
Breaker Handling Trolley	Y				Y	Y			Y	Y				
HT Switchgear Panel (IS:3427)	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Y =Test applicable														

1.6.7.1 Type test (Category-II)

All 11kV and 3.3kV Switchgears supplied shall be of type tested quality.

- a) Type test reports for the following shall be submitted:
 - i) Circuit breaker/ circuit breaker panels, of each voltage class and current rating:
 - Short circuit duty test on circuit breaker, mounted inside the panel offered along with CTs, bushing and separators
 - Short time withstand test on circuit breaker, mounted inside panel offered together with CTs, bushings and separators
 - Power frequency withstand test on breaker mounted in side panel
 - Lightning impulse withstand test on breaker mounted in side panel

- Temperature rise test on breaker and panel together. For this test, the test set up shall include three panels with breakers, the test breaker and panel being placed in the Center.

The adjacent panels shall also be loaded to their rated current capacity. Alternatively the test panel may be suitably insulated at the sides, which will be adjoining to other panels in actual site configuration

- Test to verify pressure relief devices operation of the panel. This shall be done on one panel of each voltage class
- measurement of resistance of main circuit
- Mechanical endurance test on breaker
- Mechanical operation test

ii) Contactor and contactor panels of each type and rating:

- Verification of rated making and breaking capacities of the contactor
- Short time withstand test of panel
- Power frequency test on the contactor mounted in side panel
- Lightning impulse voltage withstand test of the contactor mounted inside panel
- Measurement of resistance of main circuit
- Test to confirm coordination between fuse and contactor

iii) Surge arrestor/ lightning arrestor (as applicable) of each type:

- Standard lightning impulse voltage spark-over test
- Front of wave sparkover test (For surge arrestor used along with motor feeder, this test shall be carried out with a voltage wave having a rate of rise of not less than 142kV/ micro-second for arrestor used in 11kV system and 44kV/ micro-second for arrestor used in 3.3kV system).
- Power frequency sparkover and temporary overvoltage test
- Residual voltage test

- Operating duty test

- Current impulse withstand test (long duration and high current impulse)

- Pressure relief test

iv) Short circuit withstand test of earthing device (truck/ switch)

b) Shop testing of components and bought out items

For various bought out items like CT, VT, relays, meters, surge arrestors etc for which identification can be physically verified and test certificate from manufacturer can be co-related, following shall be indicated in the QP.

- Review of manufacturer's Test Certificate (TC) as per relevant standard and compliance to requirements of this specification
- Physical check and functional/ operational check to ensure that item is fit for assembly on the switch board cubicle.

For all other items where identification has not been envisaged by manufacturers, a certificate of conformance to be obtained from manufacturer, and component identification shall be tagged as per approved drawing/ schematic. Either of the following or both shall be adopted .

- Random sample to be tested either in-house or at an independent laboratory for all tests envisaged in relevant standard.
- Physical check and functional/ operation check to ensure the item is fit for assembly on the switch board cubicle.

1.6.7.2 Site tests

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

a) S.N. General

- i) Check name plate details according to specification
- ii) Check for physical damage
- iii) Check tightness of all bolts, clamps and connecting terminals
- iv) Check earth connections
- v) Check cleanliness of insulators and bushings
- vi) Check heaters are provided
- vii) HV test on complete switchboard with CT and breaker/ contactor in position

- viii) Check all moving parts are properly lubricated
 - ix) Check for alignment of busbars with the insulators to ensure alignment and fitness of insulators
 - x) Check for interchangeability of breakers/ contactors
 - xi) Check continuity and IR value of space heater
 - xii) Check earth continuity for the complete switchgear board
- b) S.N. Circuit Breaker/ Contactors
- i) Check alignment of trucks for free movement
 - ii) Check correct operation of shutters
 - iii) Check slow closing operation (if provided)
 - iv) Check control wiring for correctness of connections, continuity and IR values
 - v) Manual operation of breakers completely assembled
 - vi) Power closing/ opening operation, manually and electrically at extreme condition of control supply voltage
 - vii) Closing and tripping time
 - viii) Trip free and anti-pumping operation
 - ix) IR values, resistance and minimum pick up voltage of coils
 - x) Simultaneous closing of all the three phases
 - xi) Check electrical and mechanical interlocks provided
 - xii) Checks on spring charging motor, correct operation of limit switches and time of charging
 - xiii) Check SF₆ pressure/ vacuum (as applicable)
 - xiv) All functional checks
- c) S.N. Current Transformers
- i) Insulation resistance between windings and winding terminals to body
 - ii) Polarity tests
 - iii) Ratio identification checking of all ratios on all cores by primary injection of current
 - iv) Magnetisation characteristics (Knee point) and secondary winding resistance
 - v) Spare CT cores to be shorted to earth
- d) S.N. Voltage Transformers
- i) Insulation resistance test
 - ii) Ratio test on all cores
 - iii) Polarity test
 - iv) Line connections as per connection diagram
- e) S.N. Cubicle Wiring

- i) Check all switch developments
 - ii) It should be made sure that the wiring is as per relevant drawings. All interconnections between panels shall similarly be checked
 - iii) All the wires shall be meggered to earth
 - iv) Functional checking of all control circuit e.g. closing, tripping interlock, supervision and alarm circuit including proper functioning of component/equipment
 - v) Check terminations and connections
 - vi) Wire ducting
 - vii) Gap sealing and cable bunching
- f) S.N. Relays
 - i) Check internal wiring
 - ii) Insulation resistance between all terminals and body
 - iii) Insulation resistance between AC to DC terminals
 - iv) Check operating characteristics by secondary injection
 - v) Check minimum pick up voltage of DC coils
 - vi) Check operation of electrical/ mechanical targets
 - vii) Check CT connections with particular reference to their polarities for differential type relays
 - viii) Relay pickup & timing test as per Relay settings
- g) S.N. Meters
 - i) Insulation resistance of all insulated portions
 - ii) Check CT and VT connections with particular reference to their polarities for power type meter

1.6.8 415V Switchgear and Busduct													
1.6.8.1 415V Switchgear (Table 1/2) (MCC, PCC, ACDB, DCDB, Local push button station, Local motor starters)													
Items/ Components/ Sub-system	Tests/ Checks												
	Make, Model, Type, Rating and TC	Dimensions and Finish	Electrical properties	Mechanical properties	Chemical properties	Functional and Operational features	Item to conform to relevant standards	Pretreatment as per IS 6005	Paint shade, adhesion, thickness and	Functional checks	Milli-volt drop Test	IR – HV – IR Test	Degree of protection Routine test
													All Routine tests as per relevant
Sheet steel (IS:513)	Y	Y		Y	Y		Y						
Aluminum bus bar material (IS:5082)	Y	Y	Y	Y	Y		Y						
Copper bus bar material (IS:613)	Y	Y	Y	Y	Y		Y						
Support insulator (IS:943, IS:10912, IEC: 660)	Y	Y	Y	Y			Y						
Air circuit breaker(IS:13947)	Y	Y				Y	Y			Y	Y		Y
Energy meters (IS:722)	Y	Y				Y	Y			Y			Y
Power and auxiliary contactor (IS:13947)	Y	Y				Y	Y			Y			
Protection and auxiliary relays (IS:3231)	Y	Y				Y	Y			Y			Y
Control and selector switches (IS:6875)	Y	Y				Y	Y			Y			
CT and VT (IS 2705/ 3156)	Y	Y					Y						Y
MCCB (IS:13947)	Y	Y					Y			Y			
Indicating meters (IS:1248)	Y	Y				Y	Y			Y			Y
Indicating lamps (IS:13947)	Y	Y				Y	Y			Y			
Air break switches (IS:13947)	Y	Y				Y	Y			Y			

Control terminal blocks	Y	Y				Y	Y						
Y =Test applicable													

(Table

[illegible]

1.6.8.2 415V Busduct

Items/ Components	Tests/ Checks														
	Dimension and surface finish	Make, Type, Rating and Test certificate (TC)	Electrical properties	Mechanical properties	Chemical properties	Item to conform to relevant IS	WPS approval, Welder qualification	Weld quality check (DP test and X-ray)	Paint shade, Thickness, Adhesion and	Tightness by torque measurement	Electrical clearances	Galvanizing test as per IS 2629/ 2633	IR – HV – IR test	Phase sequence check	Degree of protection routine test
Aluminum sheets/ plates/ strips/ flexibles/ tubes (IS:5082/ 737)	Y	Y		Y	Y	Y	Y	Y							
CRCA flats/ ISMC (IS:2062)	Y	Y		Y	Y	Y									
Neoprene/ synthetic rubber gaskets (IS:11149/ 3400)	Y	Y		Y	Y										
Rubber bellows (IS:3400)	Y	Y		Y	Y										
Support insulator (BS:2782, IEC:660, IS:10912)	Y	Y	Y	Y											
Galvanized structure and GI earthing flat (IS:2629/ 2633/ 4749)	Y	Y				Y						Y			
Space heater and Thermostat		Y	Y												
LT busduct (IS:8623 Part 2)	Y	Y				Y	Y	Y	Y	Y	Y		Y	Y	Y
Y = Test applicable															

1.6.8.3 Type test (Category-II)

All 415V Switchgears and bus duct supplied shall be of type tested quality.

- a) Type test reports for the following tests shall be submitted on each type and rating of 415V switchgear and AC, DC distribution boards:
 - i) Short time withstand test with circuit breaker mounted inside the switchgear panel
 - ii) Temperature rise test
 - iii) Arc test at rated short circuit capacity
 - iv) Type II - Short circuit co-ordination test for any three ratings of MCC module
 - v) Test sequence-1 and combined test sequence shall be carried out on each rating of circuit breaker mounted inside the panel
 - vi) Degree of protection test
- b) Type test reports for the following tests shall be submitted on each type and rating of 415V bus duct:
 - i) Heat run test on an assembly of representative sections and fittings
 - ii) Short circuit test for a duration and current on an assembly of representative section
 - iii) One minute high potential power frequency voltage withstand test
 - iv) Air and water tightness test on a typical section

1.6.8.4 Site tests

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

- a)

S.N.	General
i)	Check name plate details according to specification
ii)	Check for physical damage
iii)	Check tightness of all bolts, clamps and connecting terminals
iv)	Check earth connections

- v) Check cleanliness of insulators and bushings
 - vi) Check heaters are provided
 - vii) HV test on complete switchboard with CT and breaker/contactor in position
 - viii) Check all moving parts are properly lubricated
 - ix) Check for alignment of busbars with the insulators to ensure alignment and fitness of insulators
 - x) Check for interchange ability of breakers/ contactors
 - xi) Check continuity and IR value of space heater
 - xii) Check earth continuity for the complete switchgear board
- b) S.N. Circuit Breaker/ Contactors
- i) Check alignment of trucks for free movement
 - ii) Check correct operation of shutters
 - iii) Check slow closing operation (if provided)
 - iv) Check control wiring for correctness of connections, continuity and IR values
 - v) Manual operation of breakers completely assembled
 - vi) Power closing/ opening operation, manually and electrically at extreme condition of control supply voltage
 - vii) Closing and tripping time
 - viii) Trip free and anti-pumping operation
 - ix) IR values, resistance and minimum pick up voltage of coils
 - x) Simultaneous closing of all the three phases
 - xi) Check electrical and mechanical interlocks provided
 - xii) Checks on spring charging motor, correct operation of limit switches and time of charging
 - xiii) Check SF₆ pressure/ vacuum (as applicable)
 - xiv) All functional checks
- c) S.N. Current Transformers
- i) Insulation resistance between windings and winding terminals to body
 - ii) Polarity tests
 - iii) Ratio identification checking of all ratios on all cores by primary injection of current
 - iv) Magnetisation characteristics (knee Point) and secondary winding resistance
 - v) Spare CT cores, if any to be shorted and earthed
- d) S.N. Voltage Transformers
- i) Insulation resistance test
 - ii) Ratio test on all cores

- iii) Polarity test
 - iv) Line connections as per connection diagram
- e) S.N. Cubicle Wiring
 - i) Check all switch developments
 - ii) It should be made sure that the wiring is as per relevant drawings. All interconnections between panels shall similarly be checked
 - iii) Insulation resistance of all wires with respect to earth
 - iv) Functional checking of all control circuit e.g. closing, tripping interlock, supervision and alarm circuit including proper functioning of component/equipment
 - v) Check terminations and connections
 - vi) Wire ducting
 - vii) Gap sealing and cable bunching
- f) S.N. Relays
 - i) Check internal wiring
 - ii) Insulation resistance between all terminals and body
 - iii) Insulation resistance between AC and DC terminals
 - iv) Check operating characteristics by secondary injection
 - v) Check minimum pick up voltage of DC coils
 - vi) Check operation of electrical/ mechanical targets
 - vii) Check CT connections with particular reference to their polarities for differential type relays
 - viii) Relay pickup & timing as per Relay settings
- g) S.N. Meters
 - i) Insulation resistance of all insulated portions
 - ii) Check CT and VT connections with particular reference to their polarities for power type meter
- h) S.N. Bus duct
 - i) Visual inspection
 - ii) Power frequency voltage withstand test
 - iii) Insulation resistant measurement of equipment and all wiring
 - iv) Milli-volt drop

1.6.9 Power and Control Cables :														
1.6.9.1 11kV, 3.3kV Power Cables (Table 1/2)														
Item/ Components/ Sub-system	Tests/ Checks													
	Make, Type, Rating and TC	Dimension/ surface finish	Mechanical properties	Chemical composition	Spark test	Curing properties	Electrical properties	Hot set test, Eccentricity and Ovality	Lay length and sequence	Armour coverage, cross over, looseness, gap between two wire	Sequential marking/ surface finish/ cable length	Tensile strength and elongation before and after ageing on outer sheath and	Thermal stability on outer sheath	Metallic screening (if applicable)
Aluminium (IS-8130)	Y	Y	Y	Y			Y							
Semi conducting compound	Y		Y			Y	Y							
XLPE compound (IS-7098- Part-II)	Y		Y			Y	Y					Y		
FRLS HR PVC compound (IS- 5831, ASTM-D2843, ASTM-2863, IEC-754 Part-1)	Y		Y									Y	Y	
Triple extrusion and curing/Manufacturing of core		Y			Y			Y	Y					
Copper tape	Y	Y	Y				Y							
Polyster tape	Y	Y												
Armour wire/strip	Y	Y	Y											
Copper tapping	Y	Y						Y						
Inner sheath	Y	Y												
Armouring										Y				Y
Outer sheathing		Y									Y	Y	Y	
Power cable (Finished) (IS : 7098 Part-II) IEC:332, IS-5831, ASTM-D2843,	Y								Y	Y	Y	Y	Y	

ASTM-2863, IEC-754 Part-1) Cable Drum Rewinding														
Wooden drum (IS:10418)/ Steel drum		Y												
Y =Test applicable														

1.6.9.1 11kV, 3.3kV Power cables				(Table 2/2)
Item/ Components/ Sub-system	Tests/ Checks			
	Anti termite coating on wooden drums	Constructional requirements features as per specification	Routine and acceptance test as per relevant standard and	FRLS tests
Aluminium (IS-8130)				
Semi conducting compound				
XLPE compound (IS-7098- Part-II)				
FRLS HR PVC compound (IS-5831, ASTM-D2843, ASTM-2863, IEC-754 Part-1)				Y
Triple extrusion and curing/ Manufacturing of core				
Copper tape				
Polyster tape				
Armour wire/strip				
Copper tapping				
Inner sheath				
Armouring				
Outer sheathing		Y		Y
Power cable (Finished) (IS : 7098 Part-II) IEC: 332, IS-5831, ASTM-D2843, ASTM-2863,IEC-754 Part-1)		Y	Y	Y
Cable Drum Rewinding				
Wooden drum(IS-10418) /Steel Drum	Y			
Y =Test applicable				
Notes				
1)	Additional acceptance tests like FRLS, thermal stability, tensile strength and elongation after ageing shall be done on one sample/ lot			

2)	Length measurement/ surface finish/ eccentricity/ ovality shall be checked on one length/size/ lot
3)	Routine test shall be carried out on each drum length as per specifications.

1.6.9.2 1.1 kV PVC and XLPE CABLES		(Table 2/2)			
Item/ Components/ Sub-system	Tests/ Checks				
	Anti termite treatment on wooden drums	Constructional/ requirement as per specification	Routine and acceptance test as per relevant standard and specification	FRLS Tests	
Aluminum (IS-8130)					
PVC Compound (IS-5831)					
XLPE Compound (IS-7098 Pt-I)					
FRLS PVC Compound (IS-5831) ASTM-D-2843/ ASTM-D-2863 IEC-754 Part-I					Y
Armour wire/strip (IS-3975)					
Insulated Core					
Laid up core					
PVC Inner sheath					
Armouring					
Outer sheath					Y
Finish cable (IS-1554 & 7098 – Part-1) ASTM-D-2843/ ASTM- D-2863 IEC-754 Part-I Swedish Chimney SS 4241475 for (F3 category) Flammability test IEC-332 Part –3 Cat-B Cable Drum Rewinding		Y	Y		Y
Wooden drum (IS-10418) / Steel drum	Y				
Y =Test applicable					
Notes					
1)	(*) Not applicable for XLPE insulation				
2)	Additional acceptance tests like FRLS, thermal stability, tensile strength and elongation after ageing shall be done on one sample / lot.				
3)	Length measurement / surface finish shall be checked on one length/ size/ lot				
4)	Routine test shall be carried out on each drum length as per specifications.				

1.6.9.3 1.1 kV PVC Control cables		(Table 2/2)			
Item/ Components/ Sub-system		Tests/ Checks			
		Anti termite treatment on wooden drums	Constructional feature as per specification	Routine and Acceptance test as per relevant standard and	FRLS test
Copper conductor (IS-8130)					
PVC compound (IS-5831)					
FRLS PVC compound IS-5831 ASTM-D-2843/ ASTM-D-2863 IEC-754 Part-1					Y
Armour wire/strip (IS-3975)					
Insulated core					
Laid up core					
PVC Inner sheath					
Armouring					
Outer sheath					Y
Finished cable (IS-1554) ASTM-D-2843/ ASTM-D-2863 IEC-754 Part-1 Swedish Chimney: SEN SS 4241475 (F3 category) Flammability test IEC-332 Part-3 Cat-B Cable Drum Rewinding			Y	Y	Y
Wooden drum(IS : 10418) / Steel drum		Y			
Y =Test applicable					
Notes					
1)	Additional acceptance tests like FRLS, thermal stability, tensile strength and elongation after ageing shall be done on one sample/ lot				
2)	Length measurement / surface finish shall be checked on one length/ size/ lot				
3)	Routine test shall be carried out on each drum length as per specifications.				

1.6.9.4 Type tests (Category-I)

The type tests on one drum out of every ten (10) drums or less for each type and size of cables shall be conducted.

- a) Annealing test (for copper) as per IS:8130

b) Tensile test (for Aluminium) as per IS:8130

- c) Wrapping test (for Aluminum) as per IS:8130
- d) Conductor resistance test as per IS:8130
- e) Test for armour wires/ strips as per IS:3975 - The hard drawn aluminium wires armour (in case of single core cables) shall also comply with the tensile test and wrapping test as per IS:8130.
- f) Test for thickness of insulation and sheath - Requirement and methods of test for the thickness of insulation and sheaths shall be as per relevant IS. The calculated diameter over stranded core and “Calculated nominal diameter under outer sheath” shall, however, be determined by the method given in Appendix “A” of IEC-60502.
- g) Tensile strength and elongation test for insulation and sheath - The value of tensile strength and elongation at break-point shall not be less than 125kg/cm² and 150% respectively for the type ‘A’ and type ST1 PVC compounds. For XLPE insulation these tests shall be carried out in accordance with IS:7098 (Part-III). The tensile strength and elongation at a break shall not be less than 125kg/cm² and 200% respectively.
- h) Ageing test for insulation and sheath - The ageing test shall be carried out as per the procedures laid down in relevant IS, however the period of test shall be 168 hours, instead of 120 hours. The test value obtained for the tensile strength and elongation must not differ from the corresponding values obtained before ageing by more than $\pm 25\%$ in case of type ST2 PVC and XLPE compounds and by more than $\pm 20\%$ in case of type A, and type ST1 PVC compound.
- i) Loss of mass test - This test is to be carried out on the PVC insulation and sheaths as per IEC-60540. The maximum permissible loss of mass shall be 2mg/cm².
- j) Shrinkage test - This test shall be carried out on the PVC insulation and sheath. The test procedures and test values shall comply with IS:5831.
- k) Cold bend test - This test is to be carried out upto 6mm² cables size in accordance with IS:5831.
- l) Cold impact test - This test shall be carried out on the PVC insulation and sheath in accordance with IS-5831.
- m) Heat shock test for PVC insulation and sheath - This test shall be carried out as per IEC-60540 and IEC-60502.

- n) Thermal stability test for PVC insulation and sheath - This test shall be carried out in accordance with IEC-60540/60540A and shall pass the minimum requirement of 100minutes.

- o) Test for bleeding and blooming of pigments for PVC - This test shall be carried out as per IS :5831.
- p) Fire resistance test - This test shall be carried out in accordance with relevant clause of IS:5831.
- q) Measurement of insulation resistance - This test shall be carried out as per IS:5831. The volume resistivity of the PVC insulated cables shall not be less than 1×10^{14} ohm-cm at 27°C and 1×10^{11} ohm-cm at 70°C.
- r) High voltage test - This test shall be performed as per IS:1554 (Part-I).

The cable with insulation/ sheath material other than PVC shall be subject to all the tests mentioned in their respective Indian or International Standards to which they are conforming. In that case if any of the above test is not applicable, the same will not be carried out.

- s) Hot set test for insulation - This test shall be carried out as per IEC-60540 and shall pass the requirement given in IEC-60502.
- t) Partial discharge test - This test shall be carried out in accordance with IEC-60540 and IEC-60502. The test requirements are as given in IEC-60502.
- u) Bending test - The method and test requirement shall be as per IEC-60502 and on completion of this test, the sample be subject to partial discharge measurement and comply with the requirements.
- v) Tan delta measurement as a function of voltage and capacitance measurement - This test shall comply with clause 16.1.6 of IEC-60502.
- w) Tan delta measurement as a function of temperature - This test shall comply with clause 16.1.7 of IEC-60502.
- x) Heating cycle test plus partial discharge test - This test shall be carried out as per IEC-540 and IEC-502.
- y) Impulse withstand test - This test shall be carried out as per IS:7098 (Part-II). The impulse withstand voltage shall be 75 kV.
- z) High voltage test - This test shall be performed as per IS:7098 (Part –II). The normal sequence of electrical test shall be as per clause 16.1.1 of IEC-60502.

1.6.9.5 Type test (Category-I) - Additional type tests on flammability

- a) The oxygen index test shall be carried out as per ASTM-D-2863. The minimum oxygen index shall be 29.
- b) Accelerated water absorption test and dielectric retention test - This test shall be carried out in accordance with NEMA-WC-5 irrespective of thickness of insulation (applicable for the thermoplastic material only).
- c) Temperature index test for sheath - As per ASTM-D-2863 at different temperature upto 250⁰C. However, the test shall be carried out by extrapolation method beyond temperature at which the material of sheath may start deformation as per BICC Hand Book Chapter-6 on cables in fire. The number of measurements up to 200⁰C (room temperature, 50⁰C, 100⁰C, 150⁰C and 200⁰C) plotted on a graph and then extrapolated. The minimum temperature index shall be 250⁰C.
- d) Flammability of finished cables - The test shall be carried out as per requirement of Swedish Standards SS-4241475 class-F3, IEEE-383, IEC-60332 and IEC- 60331 (for fire survival cables only) and cables should meet the requirement of all the above standards as mentioned in the respective category of cables.
- e) Acid gas generation during fire of sheath - The test shall be carried out as per IEC-60754-1 as well as per BS or other standard applicable for evaluation of halogen gases and the requirement of maximum halogen gases liberated shall be less than as mentioned elsewhere in the respective category of cables.
- f) Smoke generation by sheath under fire - The test shall be carried out as per ASTM-D-2843.
- g) Test for rodent and termite repulsion property of sheath - The details to be given by the manufacturer.

1.6.9.6 Site tests

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

- a) Insulation resistance test
- b) High voltage test

1.6.10 Installation of Cables, Earthing system and Lightning Protection system

Items/ Components/ Sub-systems	Tests/ Checks													
	Make, Type, Model, Rating and TC	Dimension	Pre-treatment of sheet	Paint shade, paint thickness, adhesion	IP protection	Bought out items/ Bill of material	HV and IR	Galvanize test	Functional test as per specification	Proof load	Deflection test	Constructional feature as per	All Routine and acceptance tests	Item conform to relevant standard
Switch box/ Junction box/ Receptacles (IS-513, IS:5, IS:2629, IS:2633, IS:6745)	Y	Y	Y	Y	Y	Y	Y	Y	Y			Y	Y	
Cable glands (BS:6121)	Y	Y												Y
Cable lug (IS:8309)	Y	Y												Y
Lighting wire (IS:694)	Y	Y										Y		Y
Flexible conduits	Y	Y										Y		Y
Conduits (Galvanize and Epoxy) IS:9537, IS:2629, IS:2633 and IS:6745	Y	Y	Y					Y					Y	
RCC hume pipe (IS:458)	Y	Y												Y
Cable termination and Straightthrough joint (VDE-0278)	Y	Y			Y	Y						Y	Y	
Cable Trays, Flexible supports system and accessories IS:513, IS:2629, IS:2633 and IS:6745	Y	Y	Y			Y		Y		Y	Y	Y	Y	
Trefoil clamp	Y	Y												Y
GI flats for earthing and lightning protection (IS:2062, IS:2629, IS:6745 and IS:2633)	Y	Y	Y					Y						Y
GI wire (IS-280)	Y	Y	Y					Y						Y
Y =Test applicable														

1.6.10.1 Type test (Category-II)

- i) All cable trays, supports and accessories etc supplied shall be of type tested quality.
- ii) Cable termination kit and straight through joints shall be tested as per IS:3573 for 3.3kV and 11kV class.
- iii) Fire proof cable penetration system shall be tested for the following tests:
 - Accelerated ageing test
 - Water absorption test
 - Fire rating test
 - Hose stream test
 - Vibration test followed by fire rating test

iv) Galvanizing tests

The quality of galvanizing shall be inspected visually and shall be smooth, continuous, free from flux stains.

In addition following tests shall be conducted :

- Uniformity of coating – The coating of any article shall withstand for 1 minute dips in standard copper sulphate solution without the formation of an adherent red spot of metallic copper upon the basic metal.
- The quality of cadmium/ zinc plating on items with screw threads shall be inspected visually and shall be free from visible defects such as unplated areas, blisters and modules.
- In addition, the plating thickness shall be determined microscopically/ chemically or electronically.

v) Welding

The quality of welding shall be visually inspected, particular attention being paid to the following points.

- The welded joints shall be continuous along its length on both sides and of uniform width and thickness. It should be free from blow holes.
- The weld metal shall be properly fused with the parent metal without undercutting.
- The outside surface of the weld shall be clean. All slag shall have been removed. All welding shall be regularly checked for cracking using

magnetic particle inspection or their equivalent technique.

- vi) Physical and dimensional checks for all items
- vii) Deflection test for cable trays
- viii) Following tests shall also be carried out on each type of equipments, devices and materials/ items supplied:
 - Physical and Dimensional checks
 - Check/ measurement of thickness for Nickel chrome plating for cable glands and tinning for cable lugs.
 - Check chemical composition of brass parts for cable glands
 - Hardness check on gaskets
 - Test for uniformity of galvanization

1.6.10.2 Site tests

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

- i) Cables
 - a) Check for physical damage.
 - b) Check for insulation resistance before and after termination/ jointing.
 - c) HT cables shall be pressure tested (test voltage as per IS:7098) before commissioning.
 - d) Check of continuity of all cores of the cables.
 - e) Check for correctness of all connections as per relevant wiring diagrams. Any minor modification to the panel wiring like removing/ inserting, shorting, change in terminal connections, etc shall be carried out.
 - f) Check for correct polarity and phasing of cable connections.
 - g) Check for proper earth connections for cable glands, cable boxes, cable armour, screens etc.
 - h) Check for provision of correct cable tags, core ferrules, tightness of connections.

- ii) Cable trays/ supports and accessories
 - a) Check for proper galvanizing/ painting and identification number of the cable trays/ supports and accessories.
 - b) Check for continuity of cable trays over the entire route.
 - c) Check that all sharp corners, burrs, and waste materials have been removed from the trays supports.
 - d) Check for earth continuity and earth connection of cable trays.
- iii) Earthing and Lightning protection system
 - a) Earth continuity checks.
 - b) Earth resistance of the complete system as well as sub-system.

1.6.11 DC Storage Battery

1.6.11. Lead-Acid type batter,
1

Item/ Components/ Sub-system	Tests/ Checks										
	Dimensions and finish	Conformance to relevant drawing	Chemical composition	Lead coating thickness (minimum 25 microns, IS:6848 and Adhesion check	Conformance to CPWD Specification for teak	Paint process checks, paint shade, thickness, adhesion and finish	Constructional requirements as per	Insulation Resistance	Marking (Routine and Acceptance test)	Checking of polarity and absence of short circuit (Routine and Acceptance test)	Test for capacities for 10 hours discharge rate along with the test for voltage during discharge (Acceptance test)
Container and Lids (IS:1146)	Y	Y									
Vent plugs	Y	Y									
Sealing compound (IS:3116)		Y	Y								
Positive and Negative plates		Y	Y								
Separators (IS:6071)	Y	Y									
Electrolyte (water/ sulphuric acid) (IS:1069/ 266)		Y	Y								
Inter-cell connectors and fasteners	Y	Y		Y							
Battery stand	Y	Y			Y	Y					
Cell insulators	Y	Y					Y				
Stack assembly	Y	Y									
Lead-Acid battery (IS:1652)	Y						Y		Y	Y	Y

Y =Test applicable

Ni - Cd type battery

(Table

Items/ Components/ Sub-systemassembly	Tests/ Checks									
	Dimensions and finish	Impact strength	Conformance to relevant part drawing and Manufacturer's standards	Resistance to alkali	Chemical composition	Nickle plating thickness	Paint shade, thickness, adhesion and finish	Air pressure test after heat sealing	Marking and mass (Routine and Acceptance	Air pressure test (Acceptance test)
Container and Lids (IS:1146)	Y	Y	Y	Y						
Vent Plugs	Y		Y	Y						
Perforated steel strips	Y		Y	Y		Y				
Active material for positive and negative Plates			Y		Y					
Separators	Y		Y	Y						
Electrolyte			Y		Y					
Inter-cell connectors and fasteners	Y		Y	Y		Y				
Battery stand	Y			Y			Y			
Cell Insulators	Y		Y	Y						
Stack assembly	Y		Y					Y	Y	
Ni-Cd Battery (IS:10918)	Y								Y	Y
Y =Test applicable										

1.6.11.2 Ni- Cd type battery (Table 2/2)				
Items/ Components/ Sub-system assembly	Tests/ Checks			
	Retention of charge test (Acceptance test)	AH test (Acceptance test)	Insulation Resistance (Acceptance test)	Polarity and absence of short circuit (Routine and Acceptance test)
Container and Lids (IS:1146)				
Vent Plugs				
Perforated steel strips				
Active material for positive and negative Plates				
Separators				
Electrolyte				
Inter-cell connectors and fasteners				
Battery stand				
Cell Insulators				
Stack assembly		Y		Y
Ni-Cd Battery (IS:10918)	Y	Y	Y	Y
Y =Test applicable				

1.6.11.3 Type test (Category-II)

All batteries supplied shall be of type tested quality.

1.6.11.3.1Lead -Acid Plante battery

- i) Type test reports for the following shall be submitted for purchaser's approval :
 - a) Container (Rubber and Plastic containers)
 - High voltage test

- Drop ball test
- Plastic Yield test

- Acid resistance test
- Hydraulic thrust endurance test.

b) Cells and batteries

- Tests for capacities for 10 hr and 30 minutes discharge rates and test for voltage during discharge.
- Ampere hours and watt-hour efficiency test.
- Tests for retention of charge.
- Endurance tests.

ii) Acceptance Tests - All acceptance tests as listed below shall be carried out on sample cell selected at random by the purchaser before dispatch and at site after completion of installation.

- Verification of markings.
- Verification of dimensions.
- Test for capacities for 10 hrs discharge rate along with the test for voltage during discharge.

If a battery fails to meet the guaranteed requirements, the purchaser shall have the option of asking to replace the same.

1.6.11.3.2 Nickel-Cadmium battery

i) Type test reports for the following shall be submitted for purchaser's approval :

- Life cycle test
- Tests for capacities for 5 hr and ½ hr. discharge rates and test for voltage during discharge
- Ampere hours and watt-hour efficiency test
- Tests for retention of charge
- Endurance tests
- Discharge performance at low temperature

ii) Acceptance Tests - All acceptance tests as listed below shall be carried out on sample cell selected at random by the purchaser before dispatch and at site after completion of installation.

- a) Physical examination
- b) Dimensions, mass and layout
- c) Marking
- d) Polarity and absence of short circuit.
- e) Air pressure test

- f) Ampere - hour capacity
- g) Retention of charge
- h) Insulation resistance

If a battery fails to meet the guaranteed requirements, the purchaser shall have the option of asking to replace the same.

1.6.11.4 Site tests

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

- Physical examination
- Dimensions, mass and layout
- Marking
- Polarity
- Insulation resistance
- Impedance measurement

1.6.12 Battery Charger

Item/ Components/ Sub-system	Tests/ Checks												
	Make, Model, Type, Rating and Finish	Chemical and Mechanical tests	Sheet steel pretreatment and painting	Conform to relevant standard	Dimensional check and paint shade, thickness,adhesion and finish checks	Complete physical examination for constructionalfeatures of battery charger as per specification	Temperature rise test	Dynamic response test	Ripple content test, load limiter and Annunciator and AVR operation test	Operational and functional checks	HV and IR test	Burn-in test at 50°C for 48 hrs	Degree of protection test .
Rectifier transformer (IS:2026)	Y			Y			Y				Y		
Electronic components including potentiometer (vernier type)	Y			Y									
PCB and electronic cards	Y			Y									
19”standard racks for electronic card	Y					Y							
Control and selector switches (IS:6875)	Y			Y						Y			
Indicating meters (IS:1248)	Y			Y						Y			
Indicating lamps (IS:13947)	Y			Y						Y			
Air break switches/ Fuses (IS:13947/ 13703)	Y			Y						Y			
Control terminal blocks (IS:13947)	Y			Y									
Control transformer (IS:12021)	Y			Y						Y			
Push buttons (IS:4794)	Y			Y						Y			
MCB (IS:8828)	Y			Y						Y			
PVC insulated copper control wires (IS:694)	Y			Y									
Sheet steel (IS:513)	Y	Y	Y	Y									
Synthetic rubber gaskets	Y	Y		Y									
Annunciator	Y									Y		Y	
Battery charger	Y				Y	Y	Y	Y	Y		Y	Y	Y
Y =Test applicable													

1.6.12.1 Type test (Category-II)

All battery chargers supplied shall be of type tested quality.

Type test reports for the following shall be submitted for purchaser's approval :

- i) Complete physical examination
- ii) Temperature rise test at full load.
- iii) Temperature rise test of rectifier assembly at 200% of full load.
- iv) Insulation resistance test.
- v) High voltage (power frequency) test on power and control circuits except low voltage electronic circuits.
- vi) Ripple content test at no load, half load and full load
- vii) Automatic voltage regulator operation test at specified AC supply variations at no load, half load and full load
- viii) Load limiter operation test
- ix) Efficiency and power factor measurement.
- x) Input and output surge withstand capability test. Surge voltage as per ANSI-C37.90a shall be applied for period not less than 2 second at the following points of the charger operating at 50°C at full load :

- Across each AC input phase
- Across AC input line to ground.
- Across DC output terminals.
- Across each DC output terminal to ground

The charger shall not exhibit any component damage and there shall be no change in performance as per tests at (vii) and (viii).

- xi) Environmental tests - Steady state performance tests (vii) and (viii) shall be carried out before and after each of the following tests.
 - a) Soak Test - The electronic modules shall be subjected to continuous operation for a minimum period of 72 hours. During last 48 hours, the ambient temperature shall be maintained at 50°C. The 48 hour test period shall be divided into four equal 12 hour segments. The input voltage during each 12 hours shall be nominal voltage for 11 hours followed by 110% of nominal voltage for 30 minutes, followed by 90% of nominal voltage for 30 minutes.
 - b) Degree of protection test.

1.6.12.2 Site tests

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

- i) Complete physical examination
- ii) Checking of proper operation of annunciation system
- iii) Temperature rise test at full load for 30 min

- iv) Insulation resistance test
- v) Automatic voltage regulator operation
- vi) Load limiter operation.
- vii) Dynamic response test - overshoot/ undershoot in output voltage of the charger as a result of sudden change in load from 100% to 20% and 20% to 100% shall be measured with the batteries connected and disconnected. Output voltage of the charger connected with battery shall be within 94% to 106% of the voltage setting in above conditions and shall return to, and remain, within the limits specified as mentioned elsewhere, in less than 2 seconds (as applicable).
- viii) Regenerative / pumping back to grid test.

1.6.13 Protection and relay panel for generator, generator transformer and UATs

Items/ Components/ Sub-systems	Tests/ Checks														
	Make, Type, Model, Rating and TC	Electrical Properties			Dimensions and Finish	Functional and operational features	Item to conform to relevant Standards	Pretreatment as per IS 6005	Paint shade, thickness, adhesion and	Functional checks	HV and IR test	Degree of Protection - Routine test		All Routine tests as per relevant	
Protective relays (IS:3231/ 8686)	Y				Y	Y	Y			Y		Y		Y	
Auxiliary relays (IS:3231/ 8686)	Y				Y	Y	Y			Y		Y		Y	
Control and selector switches(IS:6875)	Y				Y	Y	Y			Y					
Indicating meters (IS:1248)	Y				Y	Y	Y			Y				Y	
Indicating lamps (IS:13947)	Y				Y	Y	Y			Y					
Push buttons (IS: 4794)	Y				Y	Y	Y			Y					
Control transformer (IS:12021)	Y				Y	Y	Y							Y	
LT fuses (IS:13703)	Y				Y	Y	Y								
Energy meters (IS:722)	Y				Y	Y	Y							Y	
Transducers (IEC:60688)	Y				Y	Y	Y							Y	
Diodes	Y	Y				Y	Y			Y					
Terminal Blocks	Y	Y				Y	Y								
Synthetic Rubber Gasket (IS:11149/ 3400)	Y	Y			Y		Y								
Complete Panel (IS:3427)	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Test realy kit	Y									Y				Y	
Y =Test applicable															

1.6.13.1 Type test (Category-II)

The Protection and Relay panels shall be of type tested quality.

- i) For various bought out items like CT, VT, relays etc for which identification can be physically verified and test certificate from manufacturer can be co-related, following shall be indicated in the QP.
 - Review of manufacturer's TC as per relevant standard and compliance to requirements of this specification
 - Physical check and functional/ operational check to ensure that item is fit for assembly on the switch board cubicle.
- ii) For all other items where identification has not been envisaged by manufacturers, a certificate of conformance to be obtained from manufacturer, and component identification shall be tagged as per approved drawing/ schematic. Either of the following or both shall be adopted .
 - Random sample to be tested either in-house or at an independent laboratory for all tests envisaged in relevant standard.
 - Physical check and functional/ operation check to ensure the item is fit for assembly on the panel.

1.6.13.2 Site tests

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

- a) Cubicle Wiring
 - i) It should be made sure that the wiring is as per relevant drawings. All interconnections between panels shall similarly be checked
 - ii) Insulation resistance of all the wires with respect to earth
 - iii) Functional checking of all control circuit e.g. closing, tripping interlock, supervision and alarm circuit including proper functioning of component/equipment
 - iv) Check terminations and connections
 - v) Wire ducting
 - vi) Gap sealing and cable bunching
- b) Relays
 - i) Check internal wiring
 - ii) Insulation resistance between all terminals and body
 - iii) Insulation resistance between AC and DC terminals
 - iv) Check operating characteristics by secondary injection

- v) Check minimum pick up voltage of DC coils

- vi) Check operation of electrical/ mechanical targets
- vii) Check CT connections with particular reference to their polarities for differential type relays
- viii) Pickup & timing test as per Relay settings
- ix) Configuration checks & communication checks.

c) Meters

- i) Insulation resistance of all insulated portions
- ii) Check CT and VT connections with particular reference to their polarities for power type meter

d) General

- i) Wiring check in conformity with schematics.
- ii) Insulation check.
- iii) Primary injection test.
- iv) Secondary injection test.
- v) On load test.
- vi) DC sequential test.

1.6.14 Emergency Diesel Generating Set

1.6.14.1 Diesel Engine	
	Tests/ Checks

[illegible]

Alternator

(Table 1/2)

Items/ Components	Tests/ Checks													
	Visual	Dimension	Make, Type, Rating, TC, General electrical inspection	Mechanical, Chemical inspection	NDT, DP or MPI, UT	Metallography	Electrical characteristics	Welding/ Brazing (WPS/	Heat treatment	Magnetic characteristics.	Hydraulic, Leak, Pressure	Thermal characteristics	Run out	Dynamic balancing
Plates for stator frame, end shield, spider etc.	Y	Y	Y	Y					Y					
Shaft	Y	Y	Y	Y	Y	Y			Y					
Magnetic material	Y	Y	Y	Y	Y		Y			Y		Y		
Rotor copper/ aluminium	Y	Y	Y	Y		Y	Y		Y					
Stator copper	Y	Y	Y	Y			Y		Y			Y		
SC ring	Y	Y	Y	Y	Y	Y	Y	Y	Y					
Insulating material	Y		Y	Y			Y					Y		
Tubes for cooler	Y	Y	Y	Y	Y				Y		Y			
Sleeve bearing	Y	Y	Y	Y	Y				Y		Y			
Stator, Rotor, Exciter coils	Y	Y	Y				Y	Y						
Castings, stator frame, terminal box and bearing housing etc.	Y	Y	Y	Y	Y			Y						
Fabrication and machining of stator, rotor, terminal box	Y	Y			Y				Y					
Wound stator	Y	Y					Y	Y						
Wound exciter	Y	Y					Y	Y						
Rotor complete	Y	Y					Y						Y	Y
Exciter, Stator, Rotor, Terminal box	Y	Y					Y							
Accessories, RTD, BTD, CT, AVR. Brushes, Diodes, Space heater, antifriction, bearing, cable glands, lugs, gaskets etc.	Y	Y	Y											
Alternator (IS:4722)	Y	Y	Y				Y							
Y =Test applicable Y1 = for HT Machines only														

1.6.14.2 Alternator		(Table 2/2)			
Items/ Components	Tests/ Checks				
	All tests as per IS:4722	Vibration	Overspeed	Tan delta, shaft voltage and polarization index	
Plates for stator frame, end shield, spider etc.					
Shaft					
Magnetic Material					
Rotor copper/ aluminium					
Stator copper					
SC Ring					
Insulating material					
Tubes for cooler					
Sleeve bearing					
Stator/ Rotor, Exciter coils					
Castings, stator frame, terminal box and bearing housing etc.					
Fabrication and machining of stator, rotor, terminal box					
Wound stator					
Wound exciter					
Rotor complete					
Exciter, Stator, Rotor, Terminal box					
Accessories, RTD, BTD, CT, AVR. Brushes, Diodes, Space heater, antifriction, bearing, cable glands, lugs, gaskets etc.					
Alternator (IS:4722)	Y	Y	Y	Y1	
Y =Test applicable Y1 = for HT Machines only					

1.6.14.3 Final assembly										
Items/ Components	Tests/ Checks									
	Material test	Dimension	WPS, PQR, Welding	NDT, DP or MPI, UT	Check completeness	Hydraulic, Leak, Pressure test	Functional test	All Routine test as per Specification /IS	No load test for one hour of the DG set	Clearances and alignment
Base frame	Y	Y	Y	Y	Y					
Fuel tank	Y	Y	Y	Y	Y	Y				
Battery (IS:1691)								Y		
Battery charger								Y		
Control panel								Y		
Assembled DG set		Y			Y		Y	Y	Y	Y
Y =Test applicable										

1.6.14.4 Type test (Category-II)

All DG sets and accessories supplied shall be of type tested quality.

Type test reports for the following shall be submitted for purchaser's approval :

- Measurement of resistance and air gap
- Phase sequence test
- Regulation test
- Measurement of open circuit and short circuit characteristics
- Efficiency test
- Temperature rise test
- Momentary overload test
- Overspeed test
- High Voltage test
- Insulation resistance test (both before and after high voltage test)
- Noise level as per IS:12065
- Vibration as per IS:12075

- m) Determination of deviation of voltage waveform from sinusoidal
- n) Degree of protection test on control panel for IP-52

1.6.14.5 Site Tests

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

- a) Visual Test
- b) Electrical Tests
 - i) Calibration of instruments, relays etc.
 - ii) Primary and secondary injections tests of protective devices.
 - iii) Function, interlock test of control panel
 - iv) Insulation resistance measurement of power and control circuits.
- c) Mechanical Tests
 - i) Trial run of engine
 - ii) Governor testing
 - iii) Overspeed trip test
 - iv) Load pick up and load rejection tests
 - v) Load test and temperature rise measurement of engine and alternator

1.6.15 Electro Static Precipitator (ESP) – Electrical				
1.6.15.1 General				
Items/ Components	Tests/ Checks			
	Visual	Make, Type, Rating etc.	Final Inspection as per IS/ IEC	Remarks
TR Set	Y	Y		Refer table for TR
ESP insulator (IEC 168/ 273, IS 2544)	Y	Y	Y	ESP insulators shall be additionally subjected to high temperature test on sample basis as per mutually agreed upon procedure.
Electrostatic Precipitation Management System	Y	Y		Refer table for annunciation, control, PLC Panel
Microprocessor based rapper controller	Y	Y		Refer table for annunciation, control, PLC Panel
Disconnecting switch (IS 13947)	Y	Y	Y	
Heaters (IS 4159/ BS 6351)	Y	Y	Y	

1.6.15.2 Transformer Rectifier (TR) Set (Table 1/2)											
Items/ Components	Tests/ Checks										
	Visual	Dimensional and physical	Make, Type, Rating	Mechanical, chemical Properties	Electrical	Electronics	Welding	NDT	Pretreatment of tank	Painting	All tests as per IEC-146
Thyristor	Y	Y	Y			Y					Y
Contactors	Y	Y	Y		Y						
Switch Fuse Unit	Y	Y	Y		Y						
HRC Fuse	Y	Y	Y		Y						
Current Transformer	Y	Y	Y		Y						
Overvoltage Protector	Y	Y	Y		Y						
Measuring Instruments	Y	Y	Y		Y						
Control Transformer	Y	Y	Y		Y						
Bushings	Y	Y	Y		Y						
Dial Thermometer	Y	Y	Y		Y						
Resistor wire wound	Y	Y	Y		Y						
Sudden Pressure Relay	Y	Y	Y		Y						
PVC insulated copper wire (ISI Marked)	Y	Y	Y		Y						
Terminal Block	Y	Y	Y		Y						
Gasket	Y	Y	Y	Y							
Electrolytic copper	Y	Y	Y	Y							
Capacitor, Resistor	Y	Y	Y	Y	Y	Y					
PCB	Y	Y	Y		Y						
Insulated conductor	Y	Y	Y	Y	Y						
Laminations	Y	Y	Y	Y	Y						
Press board, paper	Y	Y	Y	Y	Y						
Insulating oil (Silicon)	Y		Y	Y	Y						

1.6.15.2 Transformer Rectifier (TR) Set (Table 2/2)												
Items/ Components	Tests/ Checks											
	Visual	Dimensional and physical	Make, Type, Rating	Mechanical, Chemical Properties	Electrical	Electronics	Welding	NDT	Pretreatment of tank	Painting	All tests as per	All tests as per IEC-146
Radiator	Y	Y	Y	Y				Y				
Transformer Tank	Y	Y	Y	Y			Y	Y		Y		
Panel Fabrication	Y	Y	Y	Y			Y		Y	Y		
Electronic Cards	Y	Y	Y		Y	Y						
Linear Reactor, Choke	Y	Y	Y	Y	Y							
Transformer Assembly	Y	Y		Y	Y							
Control Panel	Y	Y	Y	Y	Y	Y				Y		
HV, TR Set	Y	Y	Y		Y	Y				Y	Y	
ESP Controller (Separate QP)	Y	Y	Y		Y	Y	Y		Y		Y	

1.6.15.3 Annunciation, Control, PLC Panel													
Items/ Components	Tests/ Checks												
	Visual	GA, BOM ,Lay out of components	Dimensions, General physical inspection	Paint shade, thickness, adhesion	Component Rating, Make, Type	Wiring	IR and HV	Review of TC for instruments	Accessibility of devices	Illumination	Functional check for control element ,	Test as per IEC:1131 *	Routine and acceptance tests as per IS 8623
Annunciation, Control,PLC Panel	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Notes													
1)	Detailed procedure of Burn-in and Elevated temperature test shall be as per Quality Assurance Programme												
2)	(*) Applicable for PLC												
