Bharat Heavy Electricals Ltd
Electronics Division
Mysore Road, Bangalore – 560 026

Tender Documents for 10 MW Solar Photo Voltaic Plant at NTPC Talcher,Odisha.

RFQ Ref: HBS0000444 RFQ Date : 10.05.2013
RFQ Due Date: 29.05.2013

This Tender Document Contains:

(1) Request For Quotation
(2) Pre-Qualification Criteria
(3) Technical Specifications : PS- 439-832
(4) Annexure-1: List of Exhibits
(5) Enclosures 1,2, 3 & 4 : Unpriced Bid Format, Commercial Terms & Conditions, Price Bid Format and Activity Milestones for Civil Works
(6) General Terms and Conditions (Doc Ref : EDN/IND/ENQ-01)
(7) Integrity Pact Format
(8) PBG Format

Note:
Part – I: **To be submitted in a separate sealed cover.**
Part – II: **To be submitted in a separate sealed cover**.
Part-I & Part-II sealed covers should be put in outer envelope and super scribed with RFQ No., RFQ date and due date along with the Name & Address of the tenderer.
Tender document should be dropped in Tender drop box super scribed **"SC&PV-MM, Wednesday",** kept in reception area of BHEL – Electronics Division, Bangalore.

For any clarification, the following may be contacted:

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REQUEST FOR QUOTATION

MMI:PU:RF:003

BHARAT HEAVY ELECTRICALS LIMITED
Electronics Division
PB No. 2606, Mysore Road Bangalore - 560026
INDIA

RFQ NUMBER: HBS0000444

RFQ DATE : 10.MAY.2013

Due Date 29.MAY.2013 Time: 13:00 HRS

VENUE : **NEW ENGG. BLDG**

(for all correspondence)
Purchase Executive : SRINIVAS H B
Phone : 26998452
Fax : 00918026989217
E-mail: srinivasahb@bheledn.co.in

Please submit your lowest quotation subject to our terms and conditions attached for the material mentioned below. The quotation must be enclosed in a sealed envelope / Fax superscribed with RFQ no.and due date, should reach us on or before the due date by **13.00** hours IST and will be opened on the same day at **13.30** hours at the venue mentioned above. **PLEASE DROP THE OFFER IN THE BOX PROVIDED AT RECEPTION.**

Sl No.	Description	Qty	Unit	Delivery qty	Delivery Date
1	PS0679031723 BOS for 10MWp Talcher solar plant AS PER SPECS.PS-439-832 for NTPC-Talcher. Certificate as per BHEL Norms	1	ST	1	06.AUG.2013
2	PS0679031731 Supply & Establish of Inveter Enclosure & Facilities AS PER SPECS.PS-439-832 for NTPC-Talcher. Certificate as per BHEL Norms	1	ST	1	15.SEP.2013
3	PS0679031740 I&C of 10 MWp Talcher solar plant AS PER SPECS.PS-439-832 for NTPC Talcher	1	ST	1	21.AUG.2013
4	PS0679031758 O&M of 10MWp Talcher Solar Plant As per spec PS-439-832 For 10MWp NTPC-Talcher.	1	ST	1	25.AUG.2013
5	PS0679031782 Erection of Inverter Enclosure & Facilities As PER SPEC PS-439-832 For NTPC-Talcher.	1	ST	1	21.AUG.2013
6	PS0679031898 Mandatory Spares for Talcher AS PER SPECS.PS-439-832 FOR NTPC-Talcher Certificate as per BHEL Norms	1	ST	1	06.AUG.2013

Total Number of Items - 6

Please note that the tender will be opened in the presence of the bidders or his authorised representatives (maximum two per organisation) who choose to be present with authorisation letters. Refer annexure for the terms and conditions.

Preference will be given to vendors who accepts our standard payment terms i.e.100% payment - 30 days after receipt of material at our works subject to acceptance.

Please specify Terms of delivery, Excise duty, sales tax, Ex-BHEL, Ex-works surcharge, Insurance,P&F, Freight and other taxes very clearly .

For evaluation,exchange rate(TT selling rate of SBI) as on scheduled date of tender opening (Part-I bid incase of two part bid) shall be considered.

The offers of the bidders who are on the banned list as also the offer of the bidders, who engage the services of the banned firms, shall be rejected.The list of banned firms is available on BHEL web site www.bhel.com

i). This is only RFQ not an order.
ii). In all correspondence quote RFQ No. & due date.
iii). In Quotation BHEL material code / RFQ Sl. No. should be mentioned clearly.
iv). Quotation Envelope / Fax not superscribed with RFQ No.and due date is liable for rejection.
v). Quotation should remain valid for a minimum peiod of 90 days from due date.

For and On behalf of BHEL.

REQUEST FOR QUOTATION

MMI:PU:RF:003

BHARAT HEAVY ELECTRICALS LIMITED
Electronics Division
PB No. 2606, Mysore Road Bangalore - 560026
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vi). In case of non-receipt of Quotation or regret letter for 3 consecutive RFQs you are liable to be removed from our vendors list.
vii). All Prices should be written in words and numbers.
viii). Excise Chapter Heading should be mentioned for all items where VAT is applicable .

For and On behalf of BHEL.

1.0 PRE-QUALIFICATION CRITERIA FOR EVALUATION:

The EPC contractor shall meet the qualifying requirement stipulated as below:

1.1 **AA)** The bidder shall be manufacturer of any one of the following major electrical equipment of solar PV power plant in India along with established service facilities in India for a minimum period of 1 year as on date of bid opening viz,

i. Grid connected PV inverter (Min. 500 KW)
ii. MV switchgear (11KV and above)
iii. Power Transformer (Min. 11 KV and Min. 1 MVA)

AND

BB) The bidder shall have executed electrical, civil and mechanical package of a single, minimum of 3 MWp SPV power plant within India. Bidder shall be an executor and not a project developer. Bidder shall furnish the details of project executed such as a) Project location & details b) Customer details c) Satisfactory performance certificate of the installed plant issued by customer.

OR

1.2 **AA)** Bidder shall have executed a single, minimum of 3MWp grid connected SPV plant within India on EPC basis and shall submit proof of such execution from the end user detailing the start date of the project, end date of the project and with all the details of the scope undertaken under this EPC.

AND

BB) The bidder shall have a firm tie-up in the form of JV/MoU/Working arrangement with any of the major Indian equipment manufacturer as per 1.1 AA (i),(ii)and (iii) above with the commitment of delivery and also support for completion of scope of work as per tender specification.

2.0 OTHER INFORMATION:

The bidder shall submit the following details along with the bid:

1) Audited balance sheets for last three years
2) Number of persons employed (Category wise: Professional, skilled, unskilled etc.)

	PURCHASE SPECIFICATION **GROUP : PHOTOVOLTAICS**	PS-439 - 832 REV NO: 00

TECHNICAL SPECIFICATIONS FOR DEVELOPMENT OF 10 MWp (8 MWp+ 2MWp) SPV GRID CONNECTED POWER PLANT ON EPC BASIS AT NTPC TALCHER – KANIHA, ANGUL DIST, ODISHA

Approved by :			
Revision details :R 00	Prepared	Issued	Date

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PART - A
SCOPE OF WORK AND SUPPLY

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1.0 INTRODUCTION

1.1 PROJECT INTRODUCTION:

BHEL-EDN Bangalore is setting up a 10MWp grid-connected SPV power plant at Talcher – Kaniha town for NTPC. This technical specification provides details of supply of materials to site, safe storage of materials at site, receipt, unloading and safe storage of BHEL supplied materials, erection, installation, system integration, pre-commissioning checks, commissioning of the entire plant. Contractor is also responsible for the associated engineering activity in execution of this 10 MW plant. This specification defines the scope of EPC (Engineering, procurement and Construction). BHEL based on site survey has collected certain site pertinent data, the same are attached along with this specification.

1.2 PROJECT INFORMATION

The proposed Solar Photo Voltaic plant shall be located at NTPC Talcher –Kaniha in the Angul district of Odisha. It is well connected by rail and road route. It is approx. 65 kms from district headquarter. The station has total coal based installed capacity of 3000 MW. It is having latitude and longitude of 21°6'N and 85°4'E respectively.

This 10 MWp solar PV project is to be developed at two sites at Talcher-Kaniha viz. 08 MWp and 02 MWp as an EPC work. Both 2 MWp (Pathermuda site) & 8 MWp (PTS stage-II site) SPV projects will be considered as part of single 10MWp SPV project and are around 8 km apart.

1.3 LAND

A total 45.2 Acre land is available at site at Pathermunda and PTS-2 sites. Out of 45.2 acre land, 9.2 acre land is at village Pathermuda adjacent to NTPC plant and 36 acre land is in PTS of stage-II. This land belongs to NTPC Talcher-Kaniha and will be provided for the construction of PV plant by NTPC. **These two sites are around 8 km apart.** Prior to submission of bid, Contractor may visit the site for first hand experiences of the project sites.

1.4 WATER & POWER REQUIREMENT:

Power supply and water requirement during construction will have to be arranged by the Contractor at his own cost.

2.0 INPUTS PROVIDED BY BHEL

1. Land details and topographical Survey for the proposed area
2. Brief Geotechnical investigation Report of proposed site.
3. Indicative Single Line Diagram of the plant
4. Indicative PV array layout showing the distribution of inverter rooms for locating inverters and Compact Sub-Station (CSS) /Open Switch Yard.
5. Site photos

3.0 SCOPE OF WORK:

In brief:

Design, engineering, supply, packing and forwarding, transportation, unloading, storage, installation and commissioning of 10 MWp (DC) grid connected (export of power to grid) solar PV based power project (the required solar PV modules will be supplied by BHEL to site, Unloading of PV modules and safe storage is in contractor's scope) on turnkey basis at NTPC Talcher- Kaniha along with associated power evacuation at 11 kV network including laying/ replacement of 11 kV cable as per site requirement and completion of left out overhead portion of ring mains system.

All the plants and facilities are to be developed & completed for each site separately including meteorological equipments etc. (unless otherwise specified) along with associated power evacuation at 11 kV network.

Contractor shall provide comprehensive operation & maintenance of the plant for a period of one year from the date of successful completion of trial run.

Contractor shall post adequate number of operators for O & M activity at site. All the required spares shall be stocked so as to have trouble-free operation. O & M shall include:

a) Trained and licensed (for HT and LT operation) operators to be posted at site

b) Module water washing shall be strictly carried out at least once in 15 days. If the site condition demands, higher frequency of cleaning, the same shall be implemented.

c) Maintenance of all the transformers including oil filtration once a year and maintenance of 11 kV evacuation network.

d) Collection of daily, monthly and annual data of the plant from SCADA and carrying out remedial action for any fault in the plant so that generation is not affected.

SCOPE MATRIX :

Note:
Scope of supply and works shall be entirely governed by NTPC approved vendor list & NTPC approved Quality Plans.

There are two separate sites situated 8 km apart. Part of 8 MW site is having low lying area (approx. equivalent to 2 MW area) which is being filled and leveled by BHEL/NTPC. Vendor shall commence the work in clear area and during the course of execution, balance area shall be provided.

TABLE:

Sl.No.	ITEM DESCRIPTION	Qty	SUPPLY	WORKS	E&C	O&M	MAKE/ REMARKS
01	PV modules - 240W	For 10MW	**By BHEL**	**-**	√	√	Receipt, Unloading & safe storage, transportation to site.
02	Civil pedestals for PV module mounting structure	For 10MW	√	√	√	√	Design to be furnished for approval.
03	PV module mounting structure (As per approved vendor list)	For 10MW	√	√	√	√	Design to be furnished for approval
04	DC cables	As per requirement for both the sites	√	√	√	√	DC cables as per TUV specs and Size of the cable to be decided based on voltage drop and approval by BHEL

05	AC cables LT (1100V)& HT (11.0 KV)- Inverter to CSS/Conventional Open Switchyard, CSS to common HT panels	As per require ment for both the sites	√	√	√	√	
06	Containerized Compact substation (CSS) – Transformer XXXV/ 11.0KV, LT panel(If reqd.) and VCB panel) **OR** conventional open switchyard (Indoor LT Panel, Outdoor transformer and outdoor VCB Panel)	1 No. per each PV quadran t	√	√	√	√	Block as per detailed design. Use of CSS will be subject to NTPC approval. If CSS is not approved by NTPC, conventional switchyard shall be considered. **Vendor to quote for both options.**
07	For 2 MW, Integrated HT panel – VCB based (2 incomers from SPV plant, 2 Outgoers for Misc. switch gear, 2 outgoers for Ash pond transformer, 2 outgoers for spare, 1 out goer for Aux. transformer, 1 bus coupler and 2 BUS PT Panel) and Remote annunciation panel (located in CMCS building) for controlling the breakers of each CSS and also the breakers of integrated HT panel.	1 No.	√	√	√	√	No. of I/Cs and O/Gs to be finalized based on detailed design however indicative SLD is enclosed.
08	For 8 MW, Integrated HT panel – VCB based(2 incomers from SPV plant, 2 Outgoers for colony feeders, 4 Outgoers for spare, 1 bus coupler and 2 BUS PT Panel) and Remote annunciation panel (located in CMCS building) for controlling the breakers of each CSS and also the breakers of integrated HT panel.	1 No.	√	√	√	√	No. of I/Cs and O/Gs to be finalized based on detailed design however indicative SLD is enclosed.
09	For 8 MW, SPV plant HT Panel – VCB based (7 incomers from SPV plant, 2 Outgoers to 8 MW integrated HT panel, 1 outgoer for auxiliary transformer and 1 BUS PT panel) and Remote annunciation panel (located in CMCS building) for controlling the breakers of 8 MW SPV plant HT panel. No. of incomers and outgoer panels given are	1 No.	√	√	√	√	No. of I/Cs and O/Gs to be finalized based on detailed design. **The variation in quantity of I/C's and O/G's panels is due to configuration of PV blocks only which is as per the indicative SLD enclosed– This is applicable for sl. No.**

	tentative and may vary as per the final design.						**7, 8 and 9.**
10	For 8 MW site power evacuation, 7 runs of 1 C 300 sq mm Al 11 kV XLPE armored cable shall be supplied over a length of 3 km. RCC cable trench to be constructed and the above said cable to be laid in the cable trench with trefoils.	1 Set	√	√	√	√	
11	For 2 MW site power evacuation, 7 runs of 1 C 300 sq mm Al 11 kV XLPE armored cable shall be supplied over a length of 2.5 km. Above said cable is to be laid in a separate cable tray of existing cable trestle with trefoils.	1 Set	√	√	√	√	
12	Power Conditioning unit greater than 500 KVA.	As per design for both the sites	√	√	√	√	
13	SCADA System- OPC version 2.0a	2 sets	√	√	√	√	**SCADA for both SPV plants is to be integrated and made available at each CMCS through OFC line.**
14	SCADA cables- signal, CAT-5e, LAN cable, paired cable	2 sets	√	√	√	√	1 set for each site
15	Battery with FCBC and DCDB- As per spec	2 sets	√	√	√	√	1 set for each site
16	SCADA interfacing system including remote communication – Routers, connecting cables and accessories	2 sets	√	√	√	√	1 set for each site
17	Weather monitoring station- Pyranometer (1 Nos), Anemometer (1 No), temperature sensors (2 Nos) integrated on a common structure	2 sets	√	√	√	√	1 set for each site . Data to be integrated with SCADA
18	String Monitoring Unit	2 sets	√	√	√	√	1 set for each site. Two strings can be paralleled. Only fuse, no string blocking diode required. **SMU**

							data shall be integrated with SCADA.
19	Centralized monitoring and control station (CMCS) building with associated facilities as per spec	2 sets	√	√	√	√	Detailed drawing to be furnished for approval. RAPs, SCADA, FCBC, Battery banks will be housed in CMCS. 1 set for each site
20	ESE type lightening arrestor and earthing	2 set	√	√	√	√	Quantity based on design calculations to be approved by BHEL. 1 set for each site
21	Earthing of – support structure, PCUs, all DC/LT/HT electrical panels, transformers and other electrical equipment	2 set	√	√	√	√	Detailed drawing shall be submitted for approval. 1 set for each site
22	a) 11 KV Earth mat and earthing for PV Plant & 11 KV switchyard	2 set	√	√	√	√	Earth mat design shall be furnished for approval. 1 set for each site
23	For 8 MW, Auxiliary transformer – 200 KVA (approx.) with ACDB for power distribution, associated power cable For 2 MW, Auxiliary transformer – 63 KVA (approx.) with ACDB for power distribution, associated power cable	1 set	√	√	√	√	Detailed scheme, GTP, drawings to be submitted.
24	Roads, pathways and drainage system and security cabin	2 set	√	√	√	√	Design philosophy and drawings shall be furnished for approval - Works to be carried out at 2 MW and 8MW sites hence qty is 2 sets.
25	Site office	2 No	√	√	√	-	Office space with the required furniture and the associated office equipment-this shall be available at site till the project completion
26	Storage and security	2 set					Storage area has to be identified by the

							contractor. All materials including BHEL supplied materials shall be received, unloaded and stored in contractor identified area by the contractor. Contractor shall also organize to shift the materials from storage area to site. Contractor shall ensure safe custody and storage at site till the project completion.
27	Inverter Rooms shall be of Pre-Fabricated type **OR** Standard RCC buildings	2 Set	√	√	√	√	Use of pre-fabricated inverter rooms shall be subjected to approval by NTPC. **Vendor to quote for both options.** Works to be carried out at 2 MW and 8MW sites hence qty is 2 sets.

3.1 PLANT EQUIPMENT AND ASSOCIATED WORKS

3.1.1 Civil Works

1. Site grading, leveling of the identified area and cutting and clearing of vegetation including trees. Permission from authorities for cutting the trees shall be obtained by BHEL/NTPC.
2. Requisite foundation and structures wherever required (PV Array foundation, platform for:
a) Inverter rooms (if pre fab rooms are employed, else refer 3.1.1: Sl. No. 5),
b) Outdoor PV plant HT panels and Integrated HT panels,
c) Compact Sub Station (CSS) or Conventional switchyard
3. Cable trench in the a) PV array field
b) Inverter rooms
c) CSS or Conventional switchyard
d) Control Monitoring and Control Station (CMCS) building
e) Outdoor PV plant HT panels and Integrated HT panels
f) RCC cable trench of 3 km length approx. (only for 8 MW site)
4. Main and service roads, with suitable drainage arrangements wherever necessary as per BHEL/NTPC approved drawings.
5. Construction of CMCS and RCC buildings for inverter rooms (if employed instead of pre fab inverter rooms) and other facilities.

6. Design and construction of storm water drainage system.

7. Civil structure for water storage tanks, PV module water washing system.

8. Fencing of complete SPV plant boundary including control room, switch yard. Wherever the existing boundary wall of NTPC also forms a boundary of full or part of the solar plant, no separate fencing shall be required to be installed by contractor for that portion.

3.1.2 Solar PV Plant

The system shall consist of (but not limited to) following equipment:

(a) Module Mounting structures (MMS)
(b) String Monitoring Unit (SMU) system
(c) Cables and hardware
(d) Power conditioning unit (PCU) / Grid connected Inverter
(e) Compact Sub-station (CSS) (LT Panel, Transformer and VCB Panel) OR conventional switchyard (Indoor LT panel (if required), outdoor transformer and outdoor VCB Panel) / HT equipment.
(f) 8 MW PV Plant HT Panel and Integrated HT Panel in 8 MW plant. 2 MW Integrated HT Panel in 2 MW site.
(g) For 8 MW site, ABT compliant HT energy meters to be provided in each outgoer of PV plant HT panel and also in each incomer of Integrated HT panel as shown in the Indicative SLD.
(h) For 2 MW site, ABT compliant HT energy meters to be provided in each outgoer of PV plant CSS/conventional HT panel and also in each incomer of Integrated HT panel as shown in the Indicative SLD.
(i) SCADA. **SCADA for both SPV plants is to be integrated and made available at each CMCS through OFC line.**
(j) Remote Annunciation Panel (RAP) for control and monitoring of all the HT breakers in the plant. RAP shall be located in CMCS building.
(k) DC Battery bank (Tubular Gel or Tubular Lead acid type) with FCBC for 11 kV HT Panels in SPV plant to be supplied and commissioned.

(l) AC Distribution boxes and DC distribution boxes
(m) Earthing kits & Earth mat
(n) Lightning arrestors in Solar array and 11 kV switchyards
(o) Tool Kits for maintenance along with personal protective equipment
(p) Weather monitoring equipment
(q) Mandatory spares
(r) Furniture
(s) Illumination system for the plant including array, control room, switchyard and plant periphery
(t). Consumable for Modules washing and Office stationary during O & M.

3.1.3 Grid interfacing including all equipment required for the same such as transformers, breakers, Lightning arrestor, panels, protection equipment, current transformers, potential transformers, DC system with batteries, cables, conductors, earthing of transformer and SPV Panel yard etc. as per statutory requirements and comply to CERC Grid code.

3.1.4 Metering of outgoing energy at the 11 kV outgoing feeder(s).

3.1.5 Design & construction of Centralized Monitoring & Control System (CMCS) to house control panels, protection panels, SCADA system for remote monitoring & controlling the plant etc. **The SCADA for both SPV plants is to be integrated and made available at each CMCS through optical fibre cables.**

3.1.6 Fire protection and fire fighting equipment with state licensed agency.

3.1.7 Permanent arrangement of water supply by ground water or alternate arrangement and laying of suitable pipe lines etc. with isolating valves to make permanent arrangement for module washing and service water and their drainage arrangement.

3.1.8 Permanent arrangement of auxiliary power supply system with auxiliary transformer of specified rating (refer Sl.No 23 of scope table).

3.1.9 Supply & providing suitable compound fencing (typical drawing attached), illumination along the peripheral roads, gates, including CMCS building, inverter rooms, CSS/ conventional switch yard, 11 kV HT panel yard etc. and other facilities inside the plant.

3.1.10 Comprehensive operation & maintenance of the plant(s) for a period of one year from the date of successful completion of trial run.

3.1.11 Other infrastructure works such as drainage, security room and gate etc. Providing drainage system for the plant and connection to discharge system as per applicable pollution norms.

3.1.12 Along with power evacuation arrangement, existing 11 kV network in Permanent Township (PTS) stage-II site is to be strengthened by laying/ replacement of 11 kV cable as per site requirement along with required accessories. The existing left out ring main arrangement in PTS stage-II is to be completed as per site requirement.

At Pathermuda (2MW) site, 11 kV feeder cable from existing 11 kV miscellaneous switchgear to ash water recirculation system (AWRS) transformer to be disconnected from AWRS transformer and to be connected to 11kV indoor switchgear (to be erected & commissioned by the Contractor). The AWRS transformer is to be fed from this new 11kV Integrated HT panel switchgear

by 1C x 300 sq.mm armoured cable.

For 8 MW site power evacuation, 7 runs of 1 C 300 sq mm Al 11 kV XLPE armored cable shall be supplied over a length of 3 km. RCC cable trench (900 mm width x 500 mm depth) to be constructed and the above said cable to be laid in the cable trench with trefoils. This cable is to be laid from Integrated HT panel to PTS ATM counter through the underground RCC cable trench as explained above. Further it may be noted that road crossing at two locations shall be done through laying of hume pipe. For bridge crossing, the cable shall be laid by clamping along the side of the bridge. The cable dimensions shall be (3 x 300 sq mm for each circuit + 1 x 300 sq mm for spare). Contractor has to provide overhead sectionalizer joint at every 1 km.

For 2 MW site power evacuation, 7 runs of 1 C 300 sq mm Al 11 kV XLPE armored cable shall be supplied over a length of 2.5 km. Above said cable is to be laid in a separate (new) cable tray of existing cable trestle with trefoils.

11 kV HT cabling work involves laying/ replacement of cable in the existing/ new trenches and/ or trestles. Refer Exhibit -2 for additional information and scheme of 11 kV evacuation system.

3.1.13 Any other material and services (whether specifically mentioned in the document or not) required to fulfil the stated scope of work shall be deemed to be included in the scope of work.

3.2 ENGINEERING DATA & DRAWINGS

3.2.1 Engineering drawing, data etc including calculations shall be prepared by the contractor and got approved from BHEL/NTPC before commencement of the job.
3.2.2 Successful contractor shall furnish operation and maintenance manual in seven (07) sets prior to commencement of warranty period in hard as well as soft form.

3.3 TRAINING OF EMPLOYERS PERSONNEL

The contractor shall provide training to at least six personnel of B H E L /NTPC for a minimum period of 10 days at his works and at site for erection, testing, commissioning and O & M. Expenses towards travel, stay, lodging, and boarding and other expenses for the personnel shall be borne by BHEL/NTPC.

3.4 TERMINAL POINTS & EXCLUSIONS

The terminal point under the scope of this assignment shall be upto 11 kV switchgear at each site for evacuation of power and cable termination on outgoing feeders at each site. In addition, 11 kV HT cable laying/ replacement work in trench/ trestles along with accessories and commissioning work at PTS stage-II and Pathermuda village site as per scope of work. Cable termination work along with material/accessories is in the scope of Contractor at interface point.

3.5 The scope of the contractor shall be deemed to include all such items which although are not specifically mentioned in the bid documents and/ or in contractor's proposal but are needed to make the system complete in all respects for its safe, reliable, efficient and trouble free operation and the same shall be furnished and erected unless otherwise specifically excluded in the bid document.

4.0 SPV AND ITS AUXILIARIES

4.1 SPV Module

SPV modules of required capacity shall be supplied by BHEL. Drawings of module shall be provided to the Contractor for use in design of array layout and module mounting structure design.

4.1.1 MODULE MOUNTING STRUCTURE

The indicative design of module mounting structure shall be provided by BHEL. In case if the Contractor proposes to use any other design of structure, BHEL shall decide based on the economics and technical strength of the design.

1. Modules shall be mounted on a non-corrosive support structures
2. All the Panels shall have provision to adjust at three angular positions i.e. latitude angle, latitude angle – 15 deg, latitude angle + 15 deg. The locking arrangement for adjusting the angle of module shall be accessible from the ground. Contractors to bring out the season wise angles in the data sheet.
3. The minimum clearance between the lower edge of the modules and the developed ground level shall be 500 mm.

Contractor has to choose type of foundation depending on soil conditions, geographical condition, regional wind speed, bearing capacity, slope stability etc. The detailed foundation design should be proof checked by IIT/NIT and have to be got approved from BHEL/NTPC before actual start of work.
Foundation design shall be Pile, Ramming of structure legs, Ramming Re-bars so as to suit the site requirements based on the soil conditions. Subject to deign proof check as above. Contractor shall furnish detailed design calculation through soft tools for according approval. Irrespective of type of foundation employed by the contractor, Contractor has to organize multiple machineries, tools, tackles and patterns so as to have maximum throughput. Mobile Mini batching plant shall be organized by the contractor for concrete mixing. Volumetric mixing at site is not permitted.

4. In case offered support structure is of MS type then, the frames and leg assemblies of the array structures shall be made of MS hot dip galvanized. Galvanization coating shall as per IS 4759 or equivalent standards.
5. All fasteners shall be of Stainless steel - SS 304. Nut & bolts, supporting structures including module Mounting Structures shall have to be adequately protected against all climatic condition.

4.2 Instruments for Meteorological Measurements:

Contractor shall provide following measuring instruments with all necessary software & hardware required to make it compatible with SCADA.

4.2.1 Pyranometer:

Contractor shall provide minimum one no. pyranometer for measuring incident global solar radiation. The specification is as follow:

1. Spectral Response: 0.31 to 2.8 micron.
2. Sensitivity: 7-14 micro-volt/ w/ m2
3. Zero offset thermal radiation: ±7 w/ m2
4. Zero offset temperature change ±2 w/ m2
5. Operating temperature range: -40 deg C to +80 deg. C
6. Resolution: Min +/ - 1 W/ m2

Each instrument shall be supplied with necessary cables. Calibration certificate traceability to

World Radiation Reference (WRR) or World Radiation Centre (WRC) shall be furnished along with the equipment. The signal cable length shall not exceed 20m. Contractor shall provide Instrument manual in hard and soft form.

4.2.2 Thermometer:

Contractor shall also provide two Nos. of RTD type/ semiconductor type ambient temperature measuring instrument at suitable place in PV arrays. Instrument shall have a range of 0 deg. C to 80 deg. C of accuracy ±0.2 deg. C.

4.2.3 Anemometer:

Contractor shall provide at least one no anemometer of tubular type made up of hot dipped Galvanized iron or anodised aluminium. Velocity range- upto 25 m/ s, accuracy limit of 0.2 m/ s upto 10 m/ sec.

All the above sensors (Cl. 4.2.1 to 4.2.3) shall have valid calibration certificates which should be produced within one month after the installation.

Note : The above sensors (Cl. 4.2.1 to 4.2.3) shall be erected as a Single weather monitoring unit at each site (8MW and 2MW plants). This unit shall provide data signal so as to integrate to SCADA without loss of accuracy.

4.3 Power Conditioning Unit (PCU)/ Grid Connected Inverter:

Power Conditioning Unit (PCU) consists of an electronic Inverter along with associated control, protection and data logging devices. The system shall incorporate a uni-directional inverter designed to supply the AC power to the grid at load end conforming to IEC 61727 or equivalent standard. The power conditioning unit shall adjust the voltage & frequency levels to suit the Grid.

Rating of each PCU shall be greater than **500 kVA** and the combined kVA rating of all PCUs shall not be less than **10000 kVA at standard temperature**.

All three phases shall be supervised with respect to rise/fall in programmable threshold values of frequency. PCU must have provision to be isolated from grid through Air Circuit Breaker.

4.3.1 General Requirements:

a. The efficiency of the PCU shall be equal to or more than 97 % at 75% load as per IEC 61683 or equivalent standard. The contractor shall specify the conversion efficiency at different load say 25%, 50%, 75% and 100% in his offer.

b. The PCU shall have internal protection arrangement against any sustained fault in the feeder line and against lightning in the feeder line.

c. The PCU shall have the required protection arrangements against earth leakage faults.

d. Specifically, the PCU should be three phase power conditioning unit using static solid state components. DC lines shall have suitably rated isolators to allow safe start up and shut down of the system. DC lines side of PCU should have isolator of suitable rating.

e. Each Sub-Array Junction Box/SMU will have suitably rated fuse with suitable rating for its connecting.

f. Electrical surge protection shall be provided with surge protection device (SPD). SPD shall consist of three Metal Oxide Varistor (MOV) type arrestors connected from positive and negative to earth with inbuilt fuse or thermal disconnector. During earth fault condition SPD shall safely disconnect the healthy system.

g. The PCU should be suitably designed for parallel operation. Each solid state electronic device shall have to be protected to ensure long life of the inverter as well as smooth functioning of the

inverter. As 2 Nos of Inverters are taken through a 3 winding transformer (double LV winding), PCU shall be suitable to work with such combination.

h. The PCU shall have anti islanding protection.

i. The PCU must have the feature to work in tandem with other similar PCU's and be able to be successively switched "ON" and "OFF" automatically based on solar radiation variations during the day.

j. The system shall tend to balance unequal phase voltage (with 3-phase systems) with reference to the red phase (line-1).

k. The PCU front panel shall be provided with a display (LCD or equivalent) of all important parameter such as DC input voltage, DC input current, AC input voltage, AC input current, AC output power, frequency etc.

l. Nuts & bolts and the PCU enclosure shall have to be adequately protected taking into consideration the atmosphere and weather prevailing in the area.

m. The PCU shall include appropriate self protective and self diagnostic feature to protect itself and the PV array from damage in the event of PCU component failure or from parameters beyond the PCU's safe operating range due to internal or external causes. The self-protective features shall not allow signals from the PCU front panel to cause the PCU to be operated in a manner which may be unsafe or damaging.

Faults due to malfunctioning within the PCU, including commutation failure, shall be cleared by the PCU protective devices.

n. It should have local LCD (Liquid Control Display) and keypad for system control, monitoring instantaneous system data, event logs, data logs and changing set points. Control and read-out should be provided on an indicating panel integral to the Inverter. Display should be simple and self-explanatory display to show all the relevant parameter relating to PCU operational data and fault condition in form of front Panel meters / LED's or two line LCD Display.

MODES OF PCU

- **STANDBY MODE**:

The control system shall continuously monitor the output of the solar power plant until pre-set value is exceeded & that value to be indicated in datasheet.

- **BASIC SYSTEM OPERATION (FULL AUTO MODE)**:

The system shall automatically 'wake up' in the morning and begin to export power provided there is sufficient solar energy and the grid voltage and frequency is in range.

- **MAXIMUM POWER POINT TRACKER (MPPT):**

MPPT control algorithm shall adjust the voltage of the SPV array to optimise solar energy fed into the grid.

- **SLEEP MODE**

Automatic 'sleep' mode shall be provided so that unnecessary losses are minimized at night. Contractor to provide threshold dc voltage of the inverter to enter in sleep mode and back to standby mode in the technical datasheet

The power conditioner must also automatically re-enter standby mode when threshold of standby mode reached.

4.3.2 Maximum Power Tracking

Maximum power point tracker shall be integrated in the power conditioner unit to maximize energy drawn from the Solar PV array. The MPPT should be microprocessor based to minimize power losses. The details of working mechanism of MPPT shall be mentioned by the contractor in his offer. The MPPT must have provision for constant voltage operation. .Pan details of BHEL PV module attached base on this contractor shall decide the number of PV modules to be connected in series.

4.3.3 Central Inverter

The inverter output shall always follow the grid in terms of voltage and frequency. This shall be achieved by sensing the grid voltage and phase and feeding this information to the feedback loop of

the inverter. Thus control variable then controls the output voltage and frequency of the inverter, so that inverter is always synchronized with the grid. The inverter shall use self- commutated device.

Output frequency	**50 Hz +/- 0.5% Hz** (Inverter to follow grid frequency upto +/- 3 Hz of the nominal output frequency during normal operation)
Power Factor Control Range	**>0.95 lead or lag**
Maximum Input voltage	**1000 V DC**
THD	**Less than 4 %**
Ambient temperature	**0 to 50 deg C**
Humidity	**95 % non- condensing**
Enclosure	**IP 20 (Indoor rated)** **IP 54 (Outdoor type)**

The Inverter shall have following features:

a. No load loss<1% of rated power and maximum loss in sleep mode shall be less than 0.05%

b. Sinusoidal current modulation with excellent dynamic response.

c. Unit wise & integrated Data logging.

d. Dedicated Profibus / Ethernet for networking

e. Protection against

- Over current
- Sync loss
- Over temp.
- DC bus over voltage
- Cooling Fan failure (If provided)

f. Power regulation in the event of thermal overloading

g. Set point pre-selection for VAR control

h. Inverter should communicate SCADA via open protocol.

i. Remote monitoring via telephone modem or mini web server

j. Integrated protection in the DC and three phase system

k. Insulation monitoring of the PV array with sequential fault location

l. Ground fault detector – which is essential for large PV generators in view of appreciable discharge current with respect to ground.

m. Over voltage protection against atmospheric lightning discharge to the PV array is required.

The power conditioner must be entirely self-managing and stable in operation. A self diagnostic system check should occur on start up. Functions should include a test of key parameters on start up.

4.4 EARTHING OF STRUCTURE

Each array structure of the PV yard shall be grounded properly as per IS 3043 - 1987. All metal casing/ shielding of the plant shall be thoroughly grounded in accordance with Indian electricity act/ IE Rules.

4.5 Control, Automation and Data Acquisition System (SCADA)

The complete Solar PV plant shall be integrated with SCADA which should communicate with all the inverters and combiner box (SMU) and displaying parameters as mentioned below. SCADA shall also have provision to control turning ON and OFF of any inverter of the grid connected Solar PV plant.

There shall be data logging and display system for continuous monitoring of data.

SCADA shall provide instantaneous data of following parameters.

1. Power at 11 kV terminal
2. Ambient temperature
3. Wind Speed
4. AC and DC side Power of each inverter
5. Solar irradiation/isolation
6. Voltage of the HT Side
7. Current and voltage of each sub-array/string.
8. Any other parameter considered necessary by supplier based on current prudent practice.

In addition to the real time trend, SCADA shall also have provision for offline viewing and retrieving of historical daily, monthly and yearly averaged value of all above parameters. SCADA shall store the daily energy produced by the plant, monthly energy and the annual energy. Further SCADA shall also display the Performance Ratio (PR) of the plant. All the trend and cumulative graphs shall be able to view and store. Also all the events including outages and faults shall be logged and stored with time and date stamped. SCADA should also have provision for offline viewing of daily, monthly and annual average of the above parameters

SCADA shall provide 15 minute interval daily, monthly and annual average of following parameters:

1. Exported Energy
2. Energy of each inverter

The SCADA shall have the feature to be integrated with the Network system as well as remotely via the web using either a standard modem or a GSM/WIFI modem. The contractor shall provide compatible software and hardware so that data can be transmitted via standard modem.

Fixed and variable Charges (during O&M period) payable to the telecom company shall be borne by the contractor.

'The SCADA shall be OPC version 2.0a compliant and implement a OPC-DA 2.0a server as per the specification of OPC Foundation. All data should be accessible through this OPC server.'

SCADA shall be provided with a reliable power supply along with a backup supply for at least one hour to cater to outage of grid.

4.5.1 STRING MONITORING UNIT (SMU)

Combiner box shall house string monitors which shall give operational status of each sub array/string by current and/or power and shares the information with SCADA. Foot print of PV array showing the location of each SMU shall be displayed as a screen shot on the SCADA screen so that operator can identify the faulty SMU and the string from the SCADA screen. The enclosure shall be Flammability Fire Retardant with Self-Extinguishing property and free from Halogen. It should be UV resistant in accordance with UL 746C suitable for outdoor application. The mechanical impact resistance of IK 07 or better as per IEC 62262 or equivalent standard.

The enclosure rating shall be IP65 or better.

The control PCB housed in each SMU shall be rugged and proven for reliable performance. Each SMU shall be provided with properly rated Surge Protection Device (SPD). Either precision shunt or Hall sensor can be employed for sensing of string. Maximum of 2 (two) PV strings can be paralleled per channel of SMU for current measurement. SMU shall measure string voltage and shall be displayed in SCADA as real time parameter. SMU shall also provide the SPD status on the SCADA screen. Contractor shall arrange to draw data communication cables (Like RS-485), from each SMU to SCADA.

Integrated SCADA shall be provided for the entire plant which includes SMU data and weather station parameters.

5.0 ELECTRICAL WORK

The power evacuation system shall comprise of at least two (02) transformers at each site of cumulative kVA rating of not less than 10000 kVA (for both sites) feeding 11 kV switchgear. 11kV switchgear shall also have two (02) no. 11 kV outgoing feeders at each site to evacuate power. Also 11 kV HT cable laying/ replacement work in trenches/ trestles (as per site requirement in attached Exhibit 2) along with accessories and commissioning work at PTS stage-II and Pathermuda village site is in the scope of the Contractor. The existing left out ring main arrangement in PTS stage-II is to be completed as per site requirement. Total 11 kV Al armored XLPE HT cable of size 1C x 300 sq.mm laying work for power evacuation is estimated to be around 21 km for 8 MW and 17.5 km for 2 MW systems. However the Contractor has to accordingly organize the cable lengths as per the site requirements.

At Pathermuda (2 MW) site, 11 kV feeder cable from existing 11 kV miscellaneous switchgear to ash water recirculation system (AWRS) transformer to be disconnected from AWRS transformer and to be connected to 11kV indoor switchgear (to be erected & commissioned by the Contractor). The AWRS transformer is to be fed from this new 11kV Integrated HT Panel switchgear by 1C x 300 sq.mm armoured underground cable.

Contractor to submit the Single line diagram and layout diagram of the electrical system to NTPC for approval during detailed engineering.

COMPACT SUB-STATION (CSS) or conventional switchyard:

Each PV quadrant shall have a pre-fabricated, Pre-wired Compact Sub-station or conventional switchyard. Use of Compact Substation will be subject to NTPC approval. This unit is an interface between Inverter power output to 11 kV PV plant switchyard.

The enclosure for compact substation shall be made of **stainless steel or Aluminum-Zinc**.

CSS shall confirm to the following standards:

Title	**Standards**
High Voltage Low Voltage Pre-Fabricated Substation in line with LSC-2B-PM as per IEC 62271-202	IEC:62271-202
High Voltage Switches	IEC 60265
Metal Enclosed High Voltage Switchgear	IEC 60298/ IEC62271-200
High Voltage Switchgear	IEC 60694
Low Voltage Switchgear and Control gear	IEC 60439
Power Transformers	IEC 60076

Compact Substation (CSS) shall comprise of:

(a). 3 Winding Transformer – 2 LV windings and 1 HV (11kV) winding. LV windings voltage is

decided based on the PCU output voltage. The rating of transformer (MVA) is decided based on combined rating of Inverters. Referring to plant SLD, with 2x630kVA Inverter, Transformer rating shall be 1.5MVA or a standard size greater than 1.26 MVA. However cumulative size of the transformers shall be aggregating to 10.15 MVA. Rating of each transformer shall be standard type so that the required Type Test certificates are readily available. The percentage impedance of the Transformer shall be selected in such a way that the harmonics produced will be minimum (Less than 4 %) at low loads (less than or equal to 40%). XX volts / 11kV Transformer shall conform to IS: 2026. Suggested % impedance between LV windings = 10%. Between HV winding and LV winding shall be 5 %. Contractor shall furnish Guaranteed No load and Cu loss. However the total loss of each transformer shall not be more than 1.5%.

For other details, please refer to 5.4.

Contractor shall organize for the Routine test and Type test, if any. Type test and Routine Test shall be carried out in accordance with IS: 2026. In addition to this Tank vaccum test and Tank pressure test shall also be carried out as Type test. In case of contractor/Sub-contractor has conducted such specified Type test within last 10 years, (reckoned as on March 2013). He may submit the Type Test reports to BHEL/NTPC for waiver of conductance of such Type tests. The Test should have conducted by an Independent Laboratories. For further details about tests, please refer to Clause 5.4.

(b) 11 kV HT PANEL: This is Part of CSS if CSS is employed subject to approval by NTPC else conventional outdoor HT panel shall be employed.

HT panel shall consist of VCB and the associated C & R Panel for each PV quadrant. VCB shall conform to IEC-62271-100. Please refer to clause 5.5 for the detailed description of 11 kV switch gear. Detailed design of Bus bar calculations for current density, Temperature rise and limiting temperature functionality for approval. HT panel shall have an Multi-Function Meter (MFM) of class 0.2 accuracy.

For details of Numerical relays (**confirming to IEC 61850 for protection, metering and monitoring**) please refer to 5.7 for detailed description of relays and protection. Each HT panel shall have of minimum

(a). earth fault relay

(b). Over current relay

(c). Under voltage relay

(d). Over voltage relay.

GA drawing and GTP shall be submitted for approval before taking up with manufacturing. Battery and battery charger required for each HT panel and the plant HT switchyard shall be supplied, erected and commissioned. Type of battery shall be Tubular Lead Acid/Tubular Gel/Plante batteries/NI-CD Batteries. Detailed design calculation of Battery size, capacity considering all the loss factors shall be furnished for approval by BHEL/NTPC. If Tubular Lead Acid batteries are employed, contractor shall provide separate enclosure close to Inverter room, observing all the NTPC norms. The battery backup time of minimum 1 hour is envisaged.

(C) LT Panel (If required): Please refer to clause 5.1 for further details.

ALL THE NUMERICAL REALYS SHALL BE MULTI FUNCTIONAL TYPE.

5.1 AC SWITCH BOARD (Part of CSS if CSS is employed subject to approval by NTPC or conventional indoor panels shall be considered)

The PCU shall have provision for galvanic isolation or transformer isolation. Parallel operation of PCUs shall be done with Air circuit breaker of suitable rating for connection and disconnection of PCU from grid. The connection between ACDB and transformer shall be either bus bar or cable. It shall have provision to measure bus voltage, current and power feeding the transformer. The ACB shall be Motor operated so as to control the operation from SCADA. Further contractor shall furnish kA rating and other technical details of the ACB for approval.

CONSTRUCTIONAL DETAILS OF SWITCHBOARDS
(Common to all types of switch boards)

5.1.1 All Switchboards i.e., 415 V Switchgears, Motor Control Centres (MCCs), ACDBs, DC Distribution Boards (DCDBs) and Solenoid Valve Distribution Boards, shall be of metal enclosed, indoor, floor-mounted, free-standing type.

5.1.2 All switchboard frames and load bearing members shall be fabricated using suitable mild steel structural sections or pressed and shaped cold-rolled sheet steel of thickness 2.0 mm (nominal). Frames shall be enclosed in cold-rolled sheet steel of thickness 1.6 mm (nominal). Doors and covers shall also be of cold rolled sheet steel of thickness 1.6 mm (nominal). Stiffeners shall be provided wherever necessary. The gland plate thickness shall be 3.0 mm (nominal) for hot/ cold-rolled sheet steel and 4.0 mm (nominal) for non-magnetic material.

5.1.3 All panel edges and cover/ door edges shall be reinforced against distortion by rolling, bending or by the addition of welded reinforcement members. The top covers of the panels should be designed such that they do not permanently bulge/ bend by the weight of maintenance personnel working on it.

5.1.4 The complete structures shall be rigid, self-supporting, and free from flaws, twists and bends. All cutouts shall be true in shape and devoid of sharp edges.

5.1.5 All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with a degree of protection of IP: 5X as per IS: 13947. However, the busbar chambers having a degree of protection of IP: 4X are also acceptable where continuous busbar rating is 1600A and above. Provision shall be made in all compartments for providing IP: 5X degree of protection, when circuit - breaker or module trolley has been removed. All cutouts shall be provided with synthetic rubber gaskets.

5.1.6 Provision of louvers on switchboards would not be preferred. However, louvers backed with metal screen are acceptable on the busbar chambers where continuous busbar rating is 1600 A and above.

5.1.7 All switchboards shall be of uniform height not exceeding 2450 mm.

5.1.8 Switchboards shall be easily extendable on both sides by the addition of vertical sections after

removing the end covers.

5.1.9 Switchboards shall be supplied with base frames made of structural steel sections, alongwith all necessary mounting hardware required for welding down the base frame to the foundation/ steel insert plates. The base frame height shall be such that floor finishing (50 mm thick) to be done by owner after erection of the switchboards does not obstruct the movement of doors, covers, withdrawable modules etc.

5.1.10 All switchboards shall be divided into distinct vertical sections (panels), each comprising of the following compartments:

5.1.11 Bus Bar Compartment

A completely enclosed bus bar compartment shall be provided for the horizontal and vertical busbars. Bolted covers shall be provided for access to horizontal and vertical busbars and all joints for repair and maintenance, which shall be feasible without disturbing any feeder compartment. Auxiliary and power busbars shall be in separate compartments.

The hot spot temperature of bus bars including joints at design ambient temperature shall not exceed 95 deg C under normal operating conditions. However for silver plated joints, the allowable maximum temperature shall be 115 deg C.

5.1.12 Switchgear/ Feeder Compartment

All equipment associated with an incomer or outgoing feeder shall be housed in a separate compartment of the vertical section. The compartment shall be sheet steel enclosed on all sides with the withdraw able units in position or removed. Insulating sheet at rear of the compartment is also acceptable. The front of the compartment shall be provided with the hinged single leaf door with captive screws for positive closure.

5.1.13 Cable Compartment or Cable Alley

A full-height vertical cable alley of minimum 250mm width shall be provided for power and control cables. Cable alley shall have no exposed live parts and shall have no communication with busbar compartment. Cable terminations located in cable alley shall be designed to meet the Form IVb Type 7 (as per IEC 61439 part 2 Annex AA) for safety purpose. The termination for each module shall have its own integral glanding facility. Wherever cable alleys are not provided for distribution boards, segregated cable boxes for individual feeders shall be provided at the rear for direct termination of cables. For circuit breaker external cable connections, a separately enclosed cable compartment shall also be acceptable. The contractor shall furnish suitable plugs to cover the cable openings in the partition between feeder compartment and cable alley. Cable alley door shall be hinged.

5.1.14 Control Compartment

A separate compartment shall be provided for relays and other control devices associated with a circuit breaker.

5.1.15 Sheet steel barriers shall be provided between two adjacent vertical panels running to the full height of the switchboard, except for the horizontal busbar compartment. Synthetic rubber gasket shall be provided between the panel sections to avoid ingress of dust into panels. Each shipping section shall have full metal sheets at both ends for transport and storage.

5.1.16 After isolation of power and control circuit connections it shall be possible to safety carryout maintenance in a compartment with the busbar and adjacent circuit live. Necessary shrouding arrangement shall be provided for this purpose. Wherever two breaker compartments are provided in the same vertical section insulating barriers and shrouds shall be provided in the rear cable compartment to avoid accidental touch with the live parts of one circuit when working on the other circuit.

5.1.17 All 415V switchgear (circuit-breaker) panels shall be of single-front type. MCCs and DBs shall be of single-front/ double-front construction. All single-front switch boards shall be provided with single-leaf, hinged or bolted covers at the rear. The bolts shall be of captive type. The covers shall be provided with "DANGER" labels. All panel doors shall open by 90 deg or more. In case of double-front MCCs, if this cannot be achieved for panels adjacent to a breaker panel, suitable dummy panel shall be provided by the Contractor wherever necessary.

5.1.18 All ACDBs, DCDBs and Solenoid Valve DBs shall be of fixed module type. All 415V circuit-breaker modules and MCC modules shall be of fully drawout type having distinct 'Service' and 'Test' positions. The equipment pertaining to a drawout type incomer or feeder module shall be mounted on a fully withdrawable chassis which can be drawn out without having to unscrew any wire or cable connection. Suitable arrangement with cradle/ rollers and guides shall be provided for smooth movement of the chassis. For modules of size more than half the panel height, double guides shall be provided for smooth removal or insertion of module. All identical module chasis of same size shall be fully interchangeable without having to carryout any modifications.

5.1.19 All disconnecting contacts for power and control circuits of drawout modules shall be of robust and proven design, fully self aligning and spring-loaded. Both fixed and moving contacts shall be silver-plated and replaceable. The spring-loaded power and control drawout contacts shall be on withdrawable chassis and the same on fixed portion shall not be accepted. Detachable plug and socket type control terminals shall also be acceptable.

5.1.20 Individual opening in the vertical bus enclosure shall permit the entry of moving contacts from the drawout modules into vertical droppers.

5.1.21 Contractor shall supply & mount two (2) coupling relays in the DDC/ PLC controlled modules and breakers.

5.1.22 All equipment and components shall be neatly arranged and shall be easily accessible for operation and maintenance. The internal layout of all modules shall be subject to owner's approval. The Contractor shall submit dimensional drawings showing complete internal details of busbars and module components, for each type and rating for approval of owner.

5.1.23 The tentative power and control cable entries (top/ bottom) required. However, the owner reserves the right to alter the cable entries, if required during detailed engineering, without any additional commercial implication.

5.1.24 Each switchboard shall be provided with undrilled, removable type gland plate, which shall cover the entire cable alley. Contractor shall ensure that sufficient cable glanding space is available for all the cables coming in a particular section through gland plate. For all single core cables, gland plate shall be of non-magnetic material. The gland plate shall preferably be provided in two distinct parts for the easy of terminating addition cables in future. The gland plate shall be provided with gasket to ensure enclosure protection. Recommended drilling chart of gland plates for all power

and control cables in the vertical panels shall be indicated by the Contractor in the respective G.A. drawings of the boards.

5.1.25 The Contractor shall consider layout of panels in a switchboard consisting of various feeder modules. The actual composition and disposition of various modules in a switchboard shall be finalised during detailed engineering. The Contractor shall include in his quoted price the cost of any adopter panel/ dummy panel required to meet various configuration/ arrangement of busbars adopted by the Contractor. The Switchboards fed from indoor transformer will be flange connected to the same and the same shall be located as close as desirable to the transformer. The details of transformer flanges shall be given to the successful Contractor for matching the connections. The switchboards fed from outdoor transformers shall be connected through cables/ busducts. Busduct connections wherever applicable shall be preferably in a straight line alignment. The centre line of the busduct will be finalized during detailed engineering. Adopter panels and dummy panels shall be included in the quoted price. Unit rates quoted for adopter/ dummy panels shall be used for any addition or deletion during detailed engineering.

5.1.26 CLEARANCES

The minimum clearance in air between phases and between phases and earth for the entire run of horizontal and vertical busbars and bus-link connections at circuit- breaker shall be 25 mm. For all other components, the clearance between "two live parts", "a live part and an earthed part", shall be atleast ten (10) mm throughout. Wherever it is not possible to maintain these clearances, insulation shall be provided by sleeving or barriers. However, for horizontal and vertical busbars the clearances specified above should be maintained even when the busbars are sleeved or insulated. All connections from the busbars upto switch/ fuses shall be fully shrouded/ insulated and securely bolted to minimise the risk of phase to phase and phase to earth short circuits.

5.2 CABLES

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS: codes, standards, etc.) referred to herein, the former shall prevail. All the cables shall conform to the requirements of the following standards and codes:

TUV specification 2 Pfg 1169/08.2007	DC cable for photovoltaic system
IS :1554 - I	PVC insulated (heavy duty) electric cables for working voltages up to and including 1100V.
IS : 3961	Recommended current ratings for cables
IS : 3975	Low carbon galvanised steel wires, formed wires and tapes for armouring of cables.
IS : 5831	PVC insulation and sheath of electrical cables.
IS:7098 (Part -I)	Cross linked polyethylene insulated PVC sheathed cables for working voltages upto and including 1100V.

IS : 8130	Conductors for insulated electrical cables and flexible cords.
IS : 10418	Specification for drums for electric cables.
IS : 10810	Methods of tests for cables.
ASTM-D -2843	Standard test method for density of smoke from the burning or decomposition of plastics.
IEC-754 (Part-I)	Tests on gases evolved during combustion of electric cables.
IEC-332	Tests on electric cables under fire conditions. Part-3: Tests on bunched wires or cables (Category-B).

TECHNICAL REQUIREMENTS

The cables shall be suitable for laying on racks, in ducts, trenches, trestles, conduits and under ground buried installation with chances of flooding by water.

All cables including EPR cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses developed under steady state and transient operating conditions as specified elsewhere in this specification.

All cables of module area if laid on cable trays should be covered. If cables are to be laid underground, laying shall be as per latest relevant IS code.

Copper/aluminium conductor used in power cables shall have tensile strength as per relevant standards. Conductors shall be stranded.

Conductor of control cables shall be made of stranded, plain annealed copper.

XLPO insulation shall be suitable for a continuous conductor temperature of 120 deg. C and short circuit conductor temperature of 200 deg C for 5 secs.

XLPE insulation shall be suitable for a continuous conductor temperature of 90 deg. C and short circuit conductor temperature of 250 deg C. PVC insulation shall be suitable for continuous conductor temperature of 70 deg C and short circuit conductor temperature of 160 deg. C.

For single core armoured cables, armouring shall be of copper/aluminium wires/formed wires.

The aluminium used for armouring shall be of H4 grade as per IS: 8130 with maximum resistivity of 0.028264 ohm mm2 per meter at 20 deg C. The sizes of aluminium armouring shall be same as indicated above for galvanized steel.

The gap between armour wires / formed wires shall not exceed one armour wire / formed wire space and there shall be no cross over / over-riding of armour wire / formed wire. The minimum area of coverage of armouring shall be 90%. The breaking load of armour joint shall not be less than 95% of that of armour wire / formed wire. Zinc rich paint shall be applied on armour joint surface of G.S.wire/formed wire.

Outer sheath of DC cable as per TUV specification 2 Pfg 1169/08.2007.

Outer sheath shall be of PVC as per IS: 5831 & black in colour. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS properties.

(a.)Oxygen index of min. 29 (as per IS 10810 Part-58).
(b.)Acid gas emission of max. 20% (as per IEC-754-I).
(c.)Smoke density rating shall not be more than 60 % (as per ASTMD-2843).
(d)Cable drum no/ Batch no - To be embossed/printed at every one meter.
Cores of the cables shall be identified by colouring of insulation. Following colour scheme shall be adopted:

1 core	-	Red, Black, Yellow or Blue
2 core	-	Red & Black
3 core	-	Red, Yellow & Blue
4 core	-	Red, Yellow, Blue and Black

For control cables having more than 5 cores, core identification shall be done by numbering the insulation of cores sequentially, starting by number 1 in the inner layer (e.g. say for 10 core cable, core numbering shall be from 1 to 10). The number shall be printed in Hindu-Arabic numerals on the outer surfaces of the cores. All the numbers shall be of the same colour, which shall contrast with the colour of insulation. The colour of insulation for all the cores shall be grey only. The numerals shall be legible and indelible. The numbers shall be repeated at regular intervals along the core, consecutive numbers being inverted in relation to each other. When the number is a single numeral, a dash shall be placed underneath it. If the number consists of two numerals, these shall be disposed one below the other and a dash placed below the lower numeral. The spacing between consecutive numbers shall not exceed 50 mm.

For reduced neutral conductors (in case of power cable), the core shall be black.
In addition to manufacturer's identification on cables as per IS, followingmarking shall also be provided over outer sheath.

(a.)Cable size and voltage grade - To be embossed

(b.)Word 'FRLS' at every 5 metre - To be embossed

(c.)Sequential marking of length of the cable in metres at every one metre -To be embossed / printed

The embossing shall be progressive, automatic, in line and marking shall be legible and indelible. For EPR cables identification shall be printed on outer sheath.

All cables except DC cable shall meet the fire resistance requirement as per Category-B of IEC 332 Part-3.

Dc cable shall meet the fire resistance requirement as per TUV specification 2 Pfg 1169/08.2007.

Allowable tolerances on the overall diameter of the cables shall be +\-2 mm maximum.

Repaired cables shall not be accepted. Pimples, fish eye, blow holes etc. are not acceptable.

Cable selection & sizing

Cables shall be sized based on the following considerations:
(a)Rated current of the equipment
(b)The voltage drop in the cable, during motor starting condition, shall be limited to 10% and during full load running condition, shall be limited to 3% of the rated voltage
(c)Short circuit withstand capability

This will depend on the feeder type. For a fuse protected circuit, cable should be sized to withstand the letout energy of the fuse. For breaker controlled feeder, cable shall be capable of withstanding the system fault current level for total breaker tripping time inclusive of relay pickup time.

Cable employed for series connection of PV modules through MC4 connectors shall be of 4/6 sq mm size subject to voltage drop value acceptance – only TUV approved cable shall be employed.
Tool required for MC4 connectors shall be organized by contractor. Number of tools required per site shall be minimum 8 sets.

Control cables shall be sized based on the following considerations:
(a)The minimum conductor cross-section shall be 1.5 sq.mm.
(b)The minimum number of spare cores in control cables shall be as follows: No. of cores in cable Min. No. of spare cores

2C, 3C	NIL
5C	1
7C-12C	2
14C & above	3

De-rating Factors

De-rating factors for various conditions of installations including the following shall be considered while selecting the cable sizes:

a)Variation in ambient temperature for cables laid in air

b)Grouping of cables

c)Variation in ground temperature and soil resistivity for buried cables.

Cable lengths shall be considered in such a way that straight through cable joints are avoided.

Cables shall be armoured type if laid in switchyard area or directly buried.

All LT power cables of sizes more than 120 sq.mm. shall be XLPE insulated and preferable sizes are 1Cx150, 1Cx300, 1Cx630, 3Cx150 & 3Cx240 sq.mm.

CONSTRUCTIONAL FEATURES

1.1 KV Grade Cables

(a)1.1 KV grade XLPE power cables shall have compacted aluminium conductor, XLPE insulated, PVC inner-sheathed (as applicable), armoured/ unarmoured, PVC outer-sheathed conforming to IS:7098. (Part-I).

(b)1.1KV grade PVC power cables shall have aluminium conductor(compacted type for sizes above 10 sq.mm), PVC Insulated, PVC inner sheathed (as applicable) armoured/ unarmoured, PVC outer-sheathed conforming to IS:1554 (Part-I).

(c)1.1 KV grade Trailing cables shall have tinned copper(class 5)conductor, insulated with heat resistant elastomeric compound based on Ethylene Propyline Rubber(EPR) suitable for withstanding 90 deg.C continuous conductor temperature and 250deg C during short circuit, inner-sheathed with heat resistant elastomeric compound, nylon cord reinforced, outer- sheathed with heat resistant, oil resistant and flame retardant heavy duty elastomeric compound conforming to IS 9968.

d)1.1 KV Grade Control Cables shall have stranded copper conductor and shall be multicore PVC insulated, PVC inner sheathed, armoured/ unarmoured, FRLS PVC outer sheathed conforming to IS: 1554. (Part-I). Minimum conductor size shall be 2.5 sqmm.

TESTS

1.0All equipments to be supplied shall be of type tested design. During detailed engineering, the contractor shall submit for Owner's approval the reports of all the type tests as listed in this specification and carried out within last ten years from the date of bid opening. These reports should be for the test 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.

2.0However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client/ owners representative and submit the reports for approval.

3.0All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.

4.0 The type test reports once approved for any projects shall be treated as reference. For subsequent projects of NTPC, an endorsement sheet will be furnished by the manufacturer confirming similarity and "No design Change". Minor changes if any shall be highlighted on the endorsement sheet.

Type Tests

The reports for the following type tests shall be submitted for one size each of LT XLPE, LT PVC Power cables and control cables. Size shall be decided by the employer during detailed engineering:

S. No.	Type Test	Remarks

For Conductor		
1.	Resistance test	
2.	Tensile test*	For circular non compacted conductors only
3.	Wrapping test*	For circular non compacted only
For Armor Wires/ Formed Wires		
4.	Measurement of Dimensions	
5.	Tensile test	
6.	Elongation Test	
7.	Torsion test	For round wires only
8.	Wrapping test	For Aluminum wires/formed wires only.
9.	Resistance test	
10 (a)	Mass of zinc coating test	For GS Formed wires/ wires only
10 (b)	Uniformity of zinc coating	For GS Formed wires/ wires only
11.	Adhesion Test	For GS Formed wires/ wires only
For PVC/ XLPE insulation & PVC Sheath		
12.	Test of thickness	
13.	Tensile strength and elongation tests before ageing and after ageing	
14.	Ageing in air oven	
15.	Loss of mass test	For PVC Insulation and sheath only
16.	Hot deformation test	For PVC Insulation and sheath only
17.	Heat shock test	For PVC Insulation and sheath only

18.	Shrinkage test	
19.	Thermal stability test	For PVC Insulation and sheath only
20.	Hot set test*	For XLPE insulation only
21.	Water absorption test*	For XLPE insulation only
22.	Oxygen index test	For outer sheath only
23.	Smoke density test	For outer sheath only
24.	Acid gas generation test	For outer sheath only
For completed cables		
25.	Insulation resistance test (Volume resistivity method)	
26.	High Voltage test	
27.	Flammability test as per IEC-332 Part -3 (Category – B)	

*Not Applicable for Control Cable

Indicative list of tests/ checks, Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of LT power and control cables enclosed at relevant section.

5.3 PROTECTION CLASS OF CABINET/ PANELS, ENCLOSURES etc.

All switch board shall be provided with adequately rated Aluminium busbar, incoming control, outgoing control etc. as a separate compartment inside the panel to meet the requirements of the Chief Electrical Inspector. All live terminals and busbars shall be shrouded. The out going terminals shall be suitable to receive suitable runs and size of cables required for the Inverter/ Transformer rating.
The degree of protection for following equipment shall be

1.Indoor Junction box : IP 20

2.Outdoor Junction Box: IP 65

Unless specified the degree of protection shall be

1. In door air-conditioned areas: IP 20

2. In-door Non A.C. areas

a. Ventilated enclosure : IP 42
b. Non-Ventilated : IP 54

3. Out-door Switchgear equipments : IP55

The Switchboard shall be designed and manufactured in accordance with the relevant International and Indian standards suitable for the site conditions, and the specific code number and validity should be mentioned. Separate control and power panels shall be provided with separate power circuit for isolated operation of control circuit.

The design of panels, cabinet enclosures and packaging density of components mounted therein shall be such that the temperature rise does not exceed 10 deg C above the ambient under the worst conditions.

5.3.1 METERING SYSTEM

(a)Two no. Energy Meter (main & check) of 0.2S accuracy class, bi-directional, suitable for ABT requirement shall be provided for each 11 kV incomer from solar plant at each site.

(b)Meter shall be suitable for interfacing for synchronizing the built-in clock of the meter by GPS time synchronization equipment existing at the station.

(c) Meters of accuracy class 0.2s shall be provided for measurement of auxiliary power for SPV plant at each site.

(d)Suitable details about meters shall be provided to successful Contractor during detailed engineering.

Type Test Requirements for ENERGY METER

All type test reports as per IEC 62052-11/ IEC 62053-22

5.4 TRANSFORMERS
(Part of CSS if CSS is employed which is subjected to approval by NTPC else outdoor transformer shall be employed):

Each step up transformer shall be 3 phase, 50 Hz. The combined kVA rating of all the transformers at each site connected at 11 kV bus shall not be less than equivalent combined kWp capacity of the PV modules at corresponding site. The noise level shall be in accordance to NEMA TR-1. Transformer shall have Off Circuit Tap Changer with tapings of at least +/ - 5% with individual steps of 2.5%. The vector group, impedance, bushing rating, HV/ LV termination & neutral earthing shall also meet the system requirement & shall also be in line with standards as mentioned in this specification. Air clearance shall be in line with Central Board of Irrigation and Power (CBIP) norms. Suitable Bushing CTs shall be provided to meet the system protection requirement. Transformer shall be in accordance to IS: 2026 or equivalent to any other international standard.

5.4.1 TRANSFORMERS SPECIFICATIONS:

(a.)	System voltage	11 kV
(b.)	Cooling	ONAN
(c.)	Type	Two or Three winding
(d.)	Service	Outdoor
(e.)	Duty	Continuous
(f.)	Overload capacity	As per IS: 6600 and specified elsewhere in the specification.
(g.)	Permissible Temperature rise over an ambient temp. of 50 deg. C	
(i.)	Winding (by resistance method)	55 deg. C
(ii.)	Top oil (by thermometer)	50 deg. C
(h.)	Impedance at 75 deg.C	As per IS 2026
(i.)	Noise Level	As per NEMA TR- 1
(j.)	System fault level for 12 kV or Trans. fed from 11 KV side	40 kA

Winding

S.no.		**HV**
(i.)	Highest System Voltage(kV)	12
(ii.)	Lightning impulse withstand voltage, kVp	75
(iii.)	One min power frequency withstand voltage, kVrms	28
(iv.)	Insulation	Uniform

Bushing Parameters

	Parameters	**11 KV**
a.	Rated Voltage(kV)	11KV
b.	Lightning impulse withstand voltage, kVp	75
c.	One min power frequency withstand voltage , kV (rms)	28

d.	Minimum total creepage distances (mm)	25mm/ kV x Rated Voltage of Bushing.
e.	Mounting	Tank/ Transformer body

5.4.2 Construction

The features & construction details of each transformer shall be in accordance with the requirement stated hereunder.

5.4.2.1 Tank and Tank Accessories

Tank shall be of welded construction & fabricated from tested quality low carbon steel of adequate thickness. The welding procedure specification (WPS), procedure qualification record (PQR), shop welding schedule, welder's qualification shall be subject to Employer's approval. After completion of welding, all joints shall be subjected to visual examination. In case of doubt particular weld shall be checked by D.P.Test. However weld joints of load bearing member shall be left unpainted till carrying out of jacking test followed by DP Test during final inspection of transformer. Details of acceptance norms of welding shall be submitted for Employer's approval which shall include permissible undercut, overlap, surface crack, porosity, out of alignment of plate surface in butt joints, maximum gap due to incorrect fit up of fillet joint etc.
Each tank shall be provided with :
(i.)Lifting lug suitable for lifting the equipment complete with oil.

(ii.)A minimum of four jacking pads in accessible position to enable the transformer complete with oil to be raised or lowered using hydraulic or mechanical screw jacks.

(iii.)Suitable haulage holes shall be provided for transformer wheeling in all four directions.

For all transformers, suitable bi-directional skids with pre-drilled holes shall be provided integral with the tank body for fixing the transformer tank on foundation. These skids shall be such that the bottom of the tank body is at a sufficient height above foundation for cleaning purposes.

The transformers (except transformers upto and including 2 MVA) are to be provided with four no. of bi - directional flat rollers of detachable type & shall be mounted on wheels on foundation. Suitable locking arrangement shall be provided for the wheels to prevent accidental movement of transformer.

At least two adequately sized inspection openings one at each end of the tank shall be provided for easy access to bushing & earth connections. The inspection covers shall not weight more than 25 Kg. Handles shall be provided on the inspection cover to facilitate lifting.

All bolted connections shall be fitted with weather proof, hot oil resistant, rubberized cork gasket in between for complete oil tightness. If gasket is compressible, metallic stops shall be provided to prevent over compression.

The tank shall be designed in such a way that it can be mounted on the plinth directly.

Wherever possible the transformer tank & its accessories shall be designed without pockets wherein gas may collect. Where pockets cannot be avoided, pipes shall be provided to vent the gas into the main expansion pipe.

The main tank body shall be capable of withstanding full vacuum.

5.4.2.2 Core

The core shall be constructed from cold rolled, super grain oriented (CRGO), silicon steel laminations.

The core isolation level shall be 2 kV (rms.) for 1 minute in air.

Adequate lifting lugs will be provided to enable the core & windings to be lifted.

5.4.2.3 Windings

The contractor shall ensure that windings of all transformers are made in dust proof & conditioned atmosphere. The Contractor shall furnish details of the facilities available at his works along with the bid.
The conductors shall be of electrolytic grade copper free from scales & burrs.

All windings of the transformers having voltage less than 66 kV shall be fully insulated.

Tapping shall be so arranged as to preserve the magnetic balance of the transformer at all voltage ratio.

5.4.2.4 Insulating Oil

No inhibitors shall be used in the transformer oil. The oil supplied with transformers shall be new and previously unused and conform to IS: 355.

5.4.3 Transformer Foundation

Power Transformer shall be placed on gravel filled foundation if placed on ground/ raised foundation. In this case gravel filled chamber shall be connected through RCC pipe to an oil chamber

5.4.4 Terminal Arrangements

5.4.4.1 Bushings

a. The electrical & mechanical characteristics of bushings shall be in accordance with IS: 2099, IS: 3347 & IS: 12676.

b. Bushings for 52 kV & above shall be of the oil filled condenser type & shall be of draw lead/ rod type to facilitate removal. Bushings of rating below 52 kV shall be solid porcelain or oil communicating type.

c. Condenser type bushings shall be provided with :

1.Oil level gauge,

2.Oil filling plug & drain valve (if not hermetically sealed)

3.Tap for capacitance & tan delta test.

d. Clamps & fittings shall be of hot dip galvanized steel.

e. Bushing & fittings shall be provided with vent pipes that shall be connected to route any gas collection through the Buchholz relay.

f. No arcing horns shall be provided on the bushings.

g. Wherever cable termination is specified, bushing terminals shall be provided with suitable terminal connectors of approved type and size for cable termination.

h. Where current transformers are specified, the bushings shall be removable without disturbing the current transformer.

5.4.4.2 Cable boxes & disconnecting chamber

a. Cable boxes shall be of phase segregated air insulated type & shall be of sufficient size to accommodate Employer's cable & termination. Phase segregation shall be achieved by insulating barriers.

b. Cable boxes shall have bus bars/ terminal connectors of adequate size & bolt holes to receive cable lugs.

c. A suitable removable gland plate of non-magnetic material drilled as per the Employer's instruction shall also be provided in the cable box.

d. The support from base for the cable box shall be of galvanized iron.

e. The contractor shall provide earthing terminals on the cable box.

f. Cable boxes shall be designed such that it shall be possible to move away the transformer without disturbing the cable terminations, leaving the cable box on external supports.

g. Cable boxes shall have removable top cover & ample clearance shall be provided to enable either transformer or each cable to be subjected separately to high voltage test.

5.4.4.3 Bushing Current Transformer

a. Current transformer shall comply with IS: 2705.

b. It shall be possible to remove turret mounted current transformers from the transformer tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents & local heat generated in the turret.

c. All secondary leads shall be brought to a weatherproof terminal box near each bushing. These terminals shall be wired out to transformer marshalling box using separate cables for each core.

5.4.4.4 Terminal Marking

The terminal marking & their physical position shall be as per IS: 2026 unless specified otherwise.

5.4.4.5 Marshalling Box (M. BOX) Unit

(a.)Each transformer shall be provided with one Marshalling Box housing all the cooler control, OTI & WTI etc.

(b.)The sheet steel used for all the cabinet boxes shall be at least 2.5 mm thick.
The gasket used shall be of neoprene rubber. A space heater & cubicle lighting with on–off switch shall be provided in each cabinet. A circuit breaker/ contactor with thermal overload device for controlling the AC auxiliary supply shall be provided.
(c.)Terminal Blocks

(1.)The terminal blocks to be provided shall be fully enclosed with removable covers & made of molded, non-inflammable plastic material with blocks & barriers molded integrally. The terminal blocks shall be of 650V grade & have 10 A continuous rating. Terminal blocks for current transformer secondary leads shall be provided with test links & isolating facilities. Also current transformer secondary leads shall be provided with short circuiting & earthing facilities. At least 20% spare terminals shall be provided on each panel & these spare terminals shall be uniformly distributed on all terminal blocks.

(2.)Terminal blocks shall be suitable for connecting the following conductors on each side :

(i.)Current transformer circuits – minimum of two No. of 2.5 sq. mm copper wires each side

(ii.)Other circuits— minimum of one No. of 2.5 sq. mm copper wire each side

(d.)The temperature indicators shall be so mounted that the dials are not more than 1500 mm from ground level. Glazed door of suitable size shall be provided for convenience of reading.

(e.)All incoming cables shall enter the marshalling box from the bottom. A removable undrilled gland plate shall be provided at the bottom of the box for accommodating glands for Employer's incoming and outgoing cables, which shall not be less than 450 mm from finished floor level.

(f.)All devices and terminal blocks inside the marshalling box shall be clearly identified by symbols corresponding to those used on applicable schematic or wiring diagram.

(g.)It shall be located in such a way that, the same shall not face towards the transformer.

(h.)The gland plate shall be made into two detachable halves, for facilitating the termination of Employer's cable and Contractor's cables separately. The gland plate and the associated compartment shall be sealed in a suitable manner to prevent the ingress to moisture, rodents, insects etc.

(i.)One dummy terminal block in between each trip wire terminal shall be provided.

(j.)Wiring Scheme shall be engraved in a plate and the same shall be fixed inside the Marshalling Box door.

5.4.4.6 Control Wiring & Cabling

Supply, laying & termination of all cables & accessories required of proper termination from the M. Box so as to make equipment complete & functional shall be in scope of supplier. The cable between the M. Box & transformer shall be laid by the supplier through GI conduits/ pipes. Cable box/ sealing end shall be suitable for following types of cables:

(i.)	LV Voltage	1100 V grade PVC Insulated aluminum conductor cable with armor.
(ii.)	Control	1100 V grade PVC Insulated 2.5 sq mm stranded copper conductor with armor.

5.4.5 Cooling Equipment

The radiators shall be detachable type, mounted on the tank. Each radiator shall be provided with the following:

(a.) A drain plug at the bottom.
(b.) An air release plug at the top.
(c.) Shut off valve at each point of connection to the tank. The location and configuration of radiators shall be subject to Employer's approval.

5.4.6 TAP CHANGER DEVICE

Off Circuit Tap change Switch

a. The tap change switch shall be three phase, hand operated for simultaneous switching of similar taps on the three phases by operating on external hand wheel.

b. The tap changing shall be possible without disturbing the transformer in any way except de-energising.

c. Arrangement shall be made for securing and pad-locking the tap changer in any of the working positions, and it shall not be possible for setting or padlocking it in any intermediate position. An indicating device shall be provided to show the tap in use.

d. The Cranking device for manual operation of the off circuit tap changing gear shall be removable and suitable for operation by a man standing on ground level. The mechanism shall be complete with the following:-

1. Mechanical tap position indicator which shall be clearly visible from near the transformer.

2. Mechanical stops to prevent over cranking of the mechanism beyond the extreme tap positions.

3. The manual operating mechanism shall be labeled to show direction of operation for raising the secondary voltage and vice versa.

4. A warning plate indicating "The switch shall be operated only when the transformer has been de-energised" shall be fitted.

5.4.7 Valves

a. All valves upto and including 50 mm shall be of gun metal or of cast steel. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counter clockwise when facing the hand wheel.

b. Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.

c. Each valve shall be provided with the indicator to show clearly the position of the valve.

d. Gland packing/ gasket material shall be of teflon rope/ nitrile rubber. In case of gate/ globe valves, gland packing preferably of teflon rope shall be used to prevent oil seepage through the gland.

e. After testing, inside surface of all cast iron valves coming in contact with oil shall be applied with one coat of oil resisting paint/ varnish with two coats of red oxide zinc chromate primer followed by two coats of fully glossy finishing paint conforming to IS:2932 and of a shade (Preferably red or yellow) distinct and different from that of main tank surface. Outside surface except gasket setting surface of butterfly valves shall be painted with two coats of red oxide zinc chromate conforming to IS: 2074 followed by two coats of fully glossy finishing paint.

f. All hardware used shall be cadmium plated/ electro galvanised.
g. Sampling & drain valves should have zero leakage rate.

5.4.8 Bolts & Nuts

All bolts & nuts exposed to weather shall be hot dip galvanised steel/ cadmium plated steel

5.4.9 Gasket

The gaskets shall not deteriorate during the life of transformer if not opened for maintenance at site. Supplier shall also recommend quality & make of gaskets to be used for replacement during maintenance if required. All joints flanged or welded associated with oil shall be such that no oil leakage or sweating occurs during the life of transformer. The quality of these joints is considered established, only if the joints do not exhibit any oil leakage or sweating for a continuous period of at least 3 months during the guarantee period. In case any sweating/ leakage is observed, contractor shall rectify the same & establish for a further period of 3 months of the same. If it is not established during the guaranteed period, the guaranteed period shall be extended until the performance is established.

5.4.10 Fittings

The following fittings shall be provided with each transformer covered in this specification:

a. Conservator for main tank with oil filling hole and cap, isolating valves, drain valve, magnetic oil level gauge with low level alarm contacts and dehydrating silicagel breather. Breather for conservators shall be mounted not more than 1400 mm above rail top.

b. Oil preservation system: - as specified elsewhere.

c. Minimum two Nos. of spring operated pressure relief devices with alarm/ trip contacts for transformer of 2 MVA & above rating. Discharge of PRD shall be properly taken through pipes & directed away from the transformer/ other equipment.

d. Buchholz relay double float type with isolating valves on both sides, bleeding pipe with Gas collecting device at the end to collect gases and alarm and trip contacts. Control cable termination at Buchhloz relay shall be properly sealed to prevent water entry.

e. Air release plug.

f. Inspection openings and covers.

g. Bushing with metal parts and gaskets to suit the termination arrangement.

h. Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs.

i. Protected type Mercury or alcohol in glass thermometer.

j. Bottom and top filter valves with threaded male adapters, bottom Sampling valve & drain valve.

k. Rating and diagram plates on transformers (English & Hindi) and auxiliary apparatus.

l. Radiator as specified.

m. Prismatic/ toughened glass oil gauge for transformers.

n. 150 mm dial type oil temp indicator with alarm and trip contacts, maximum reading pointer & resetting device. Accuracy class shall be ± 1.5 % or better.

o. 150-mm dial type Winding temp indicator with alarm and trip contacts, maximum reading pointer & resetting device. Accuracy class shall be ± 1.5 % or better.

p. Flanged bi-directional wheels.

q. Marshalling Box.

r. Off load tap changing gear

s. Cooling equipment.

t. Bushing current transformers.

u. Insulating oil.

v. Drain valves/ plugs shall be provided in order that each section of pipe work can be drained independently. Sludge valve at bottom most point of tank to be provided for easy flush out/ removal of sludge during maintenance.

w. Terminal marking plates.

x. Valves schedule plates.

y. Two (2) earthing terminals on all the equipment mounted separately suitable for connection to suitable GI flat along with 2 Nos. tapped holes. M10 bolts etc.

z. Rain hoods to be provided on Buchholz, MOG & PRD. Entry points of wires shall be suitably sealed.

The fittings listed above are only indicative and other fittings, which generally are required for satisfactory operation of the transformer, are deemed to be included.

5.4.11 Performance

a)The maximum flux density in any part of the core & yoke at the rated MVA, voltage & frequency shall be such that under 110% continuous voltage condition it does not exceed 1.9 Tesla.

b)The transformer & all its accessories including CT's etc, shall be designed to withstand without injury the thermal & mechanical effects of any external short circuit to earth & of short circuits at the terminal of any winding for a period of 2 sec. Contractor shall submit the short circuit withstand calculations.

c) Transformers shall withstand, without injurious heating, combined voltage & frequency fluctuations, which produce the following over fluxing condition.

1)	110% - continuous
	125% - for one minute
	140% - for five seconds
2)	Contractor shall indicate 150% and 170% over voltage withstand time.
3)	Over fluxing characteristics up to 170% shall be submitted.

d) The transformers shall be capable of being operated continuously without danger on any tapping at the rated MVA with voltage variation of ±10% corresponding to the voltage of tapping.

e) The transformers shall be capable of being loaded in accordance with IS: 6600/ IEC: 60076-7 up to load of 150 %. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.

5.4.12 Tests and Inspection

The Type Test & Routine test of the transformer shall be carried out in accordance with IS: 2026 .In addition to this tank Vacuum test and tank pressure test shall also be carried out as a type test in line with CBIP norms. Oil leakage test shall also be performed as routine test as per the clause no. (c) below.

In case the Contractor has conducted such specified type test(s) within last ten years as on the date of bid opening, he may submit the type test reports to the owner for waiver of conductance of such type test(s). These reports should be for the tests conducted on the equipment similar to those

proposed to be supplied under this contract and 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 ten 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 to the Employer and submit the reports for approval.

a. Vacuum Test

Each type of 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/ sq. m 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)
Up to and including 750	5
751 to 1250	6.5
1251 to 1750	8
1751 to 2000	9.5
2001 to 2250	11
2251 to 2500	12.5
2501 to 3000	16
Above 3000	19

b. Tank pressure Test

Transformer tank of each type shall be subjected to a pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 KN/ sq. m whichever is lower, measured at the base of the tank & 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.

c. Oil leakage test on assembled transformer

All tank & oil filled compartment shall be tested for oil tightness by being completely filled with oil of viscosity not greater than that of specified oil at the ambient temperature & applying pressure equal to the normal pressure plus 35 KN/ sq. m measured at the base of the tank. The pressure shall be maintained for a period of not less than 24 hours during which time no sweating shall occur.

5.5 SWITCHGEAR EQUIPMENTS:

One 11 kV Integrated HT switchgear panel at Pathermuda site (02 MWp) shall be provided. The no. of breaker panels (VCB type) shall be 09 no. viz. one no. bus coupler, two no. incomers from SPV plant, two no. feeders to 11 kV miscellaneous switchgear, two no. feeders to AWRS transformer, two no. spare panels. Bus PT and line PT requirements shall also be taken into account by the contractor

in addition to the above mentioned panels.

One 11 kV Integrated HT switchgear panel at PTS stage-II site (08 MWp) shall be provided. The no. of breaker panels (VCB type) shall be 09 no. viz. one no. bus coupler, two no. incomers from SPV plant, two no. feeders to 11 kV colony feeders, four no. spare panels. Bus PT and line PT requirements shall also be taken into account by the contractor in addition to the above mentioned panels.

The switchgear will contain all equipments viz. Circuit breakers, CTs, PTs, relays and associated equipments.

5.5.1 Codes and Standards:

All standards, specification and codes of practices referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS Codes, Standards etc.) referred to herein, the former shall prevail. All work shall be carried out as per the following standards and codes

a)	IS: 996	Single phase small AC and universal electrical motors.
b)	IS:1248	Direct Acting indicating analogue electrical measuring instruments and Accessories.
c)	IS: 13947	Degree of protection provided by enclosures for low voltage switchgear and control gear.
d)	IS: 2544	Porcelain post insulators for systems with nominal voltages greater than 1000 Volts.
e)	IS: 2705	Current transformers.
f)	IS: 3156	Voltage Transformers
g)	IS: 6005	Code of practice for phospating of iron and steel.
h)	IS: 5082	Specification for wrought aluminum and aluminum alloy bars, rods, tubes and selections for electrical purposes.
i)	IEC: 61850	Communication Standard for Numerical relays
j)	IEC: 61131-3	Automation Standard for Numerical relays
k)	IS: 9046	AC contactors for voltages above 1000 volts and up to and including 11000 Volts.
l)	IS: 13703	Low voltage fuses
m)	IS: 9385	HV fuses
n)	IS: 9431	Specification for indoor post insulators of organic material for system with nominal voltages greater than

		1000 volts up to and including 300 kV
o)	IS: 9921	A.C. disconnectors (isolators) and Earthing switches for voltages above 1000 V
p)	IS: 11353	Guide for uniform system of marking and identification of conductors and apparatus terminals.
q)	IS: 13118	Specification for high voltage AC circuit breakers.
r)	IEC: 60099-4	Metal oxide surge arrestor without gap for AC system
s)	IS/ IEC: 62271-100	High voltage alternating current circuit breakers.
t)	IS/ IEC: 62271-200	High voltage metal enclosed switchgear and control gear.
u)	IEC: 60947-7-1	Terminal blocks for copper conductors
v)	IS :513 (2008)	Cold Rolled Low Carbon Steel Sheets and Strips

a) SYSTEM PARAMETERS		
1	Nominal System voltage	11 kV
2	Highest System voltage	12 kV
3	Rated Frequency	50 Hz
4	Number of phases/ poles	Three
5	System neutral earthing	Earthed through Resistance to limit fault current to 300A
6	One minute power frequency withstand voltage	
	- for Type tests	28 kV
	- for Routine tests	28 kV
7	1.2/ 50 microsecond	75 kV (peak)
8	Maximum system fault level including	40 kA (rms) for one (1) sec

	initial motor contribution	
9	Short time rating for bus bars, ckt. breakers, current transformers and swgr. Assembly.	40 kA (rms) for one (1) sec.
10	Dynamic withstand rating	100 kA (peak)
11	IAS Rating	40 KA 0.2 sec
12	Control supply voltage	
	- Trip and closing coils	240V DC/ 120V DC
	- Spring charging motor	240V DC/ 120V DC
	- Space heaters	240 V AC single phase with neutral solidly earthed
13	Maximum ambient air temperature	50 deg. C

b)SWGR. CUBICLE CONSTRUCTIONAL REQUIREMENTS

1.	Color finish	
	Exterior	RAL9002 (Main body) RAL 5012 (Extreme end covers)
2.	Cable entry	
	a) Power Cables	
	b) Control Cables	
3.	Bus duct entry	Top
4.	Employer's Earthing conductor	Galvanized steel strip

5.5.2 11 KV CIRCUIT BREAKER:

Circuit breakers shall be Circuit Breaker SF6 or Vacuum, Free standing, Floor mounted, metal

clad, fully compartmentalized, restrike free, trip free, stored energy operated and with electrical anti-pumping features. They shall comprise of three separate, identical single pole interrupting units, operated through a common shaft by a sturdy operating mechanism. DC battery bank required for the breaker shall be in the scope of Contractor.

VRLA type of battery shall not be acceptable.

FCBC (Float cum Boost Charger)

Under normal conditions, the battery shall be on Float charger. The charger shall be connected to a distribution board and it shall meet the requirements of DC load (coils of VCB motors, auxillary and numerical relays, Remote annunciation Panel, indicating lamps etc.). Capacity of the charger shall be worked out in detail depending on the DC load and the duty cycle. Load regulation of FCBC shall be 1% from full load to no-load. Charger rectifier shall be MOSFET/IGBT/thyristor. Blocking diode in the path of battery to charger shall be provided. Suitably rated MCBs shall be provided at input and output.

All circuit breaker modules shall have the following accessories:

- Current/ Voltage transformers as per requirement
- Relays as per relevant clauses/ single line diagrams
- Spring charging motor, with its protection and control
- Auxiliary contacts.
- Terminal blocks

CONSTRUCTIONAL REQUIREMENT

a) During closing, main poles shall not rebound objectionably and mechanism shall not require adjustments. Necessary dampers shall be provided to withstand the impact at the end of opening stroke. Slow closing facility shall preferably be provided for checking and adjustment of arc chutes and poles when the breaker is completely withdrawn and isolated.

b) Plug and socket isolating Contacts for main power circuit shall be silver plated, of self-aligning type, of robust design and capable of withstanding the specified short circuit currents. They shall preferably be shrouded with an insulating material. Plug and socket contacts for auxiliary circuits shall also be silver plated, sturdy and of self-aligning type having a high degree of reliability. Thickness of silver plating shall not be less than 10 microns.

c) All working part of the mechanism shall be of corrosion resisting material.
Bearings which require greasing shall be equipped with pressure type grease fittings. Bearing pins, bolts, nuts and other parts shall be adequately secured and locked to prevent loosening or change in adjustment due to repeated operation of the breaker and the mechanism.

d) The operating mechanism shall be such that failure of any auxiliary spring shall not prevent tripping and shall not lead to closing or tripping of circuit breaker. Failure of any auxiliary spring shall also not cause damage to the circuit breaker or endanger the operator.

e) Mechanical indicators shall be provided on the breaker trucks to indicate OPEN/ CLOSED conditions of the circuit breaker, and CHARGED/ DISCHARGED conditions of the closing spring. An operation counter shall also be provided. These shall be visible without opening the breaker compartment door.

f) The closing coil and spring charging motor shall operate satisfactorily at all values of control supply voltage between 187V-242V DC/ 93.5V-121V DC. The shunt trip coil shall operate satisfactorily under all operating conditions of the circuit breaker up to its rated short circuit breaking current at all values of control supply voltage between 154V-242V DC/ 77V-121V DC. The trip coil shall be so designed that it does not get energized when its healthiness is monitored by two indicating lamps (Red) and one trip coil supervision relay.

g) The time taken for charging of closing spring shall not exceed 30 seconds.
The spring charging shall take place automatically preferably after a closing operation. Breaker operation shall be independent of the spring charging motor which shall only charge the closing spring. Opening spring shall get charged automatically during closing operation. As long as power supply is available to the charging motor a continuous sequence of closing and opening operations shall be possible. One open-close- open operation of the circuit breaker shall be possible after failure of power supply to the motor. Spring charging motors shall be capable of starting and charging the closing spring twice in quick succession without exceeding acceptable winding temperature when the control supply voltage is anywhere between 187V- 242V DC/ 93.5V-121V DC. The initial temperature shall be as prevalent in the switchgear panel during full load operation with 50 deg. C ambient air temperature. The motor shall be provided with short circuit protection.

h)Motor windings shall be provided with class E insulation or better. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in a hot, humid and tropical climate.

i)Circuit breaker shall be provided with inter pole barriers of insulating materials. The use of inflammable materials like Hylam shall not be acceptable.

OPERATIONAL REQUIREMENT:

a) Spring return to neutral type control switch (with NAC/ NAT position)

b)Stay - put type selector switches.

c) Thermostatically controlled space heater with switch, illumination and power plug point.

d)All meters/ instruments shall be flush mounted on front panel, at least 96 sq.mm size with 90 deg. scales and accuracy class of 2.0 or better. All feeders shall have an ammeter and ammeter selector switch

The circuit breaker shall meet the following requirements

a) The breaker shall be controlled locally and remotely as required. Facilities shall be provided for mechanical tripping of breaker and manual charging of closing spring to cater to emergency condition.

b) Switching over voltage (unipolar) shall not exceed 2.5 PU of nominal line to neutral voltage, evaluated as per IEEE envelope.

c) Supervision relays provided for trip coil monitoring.

d)Suitable mechanical inter lock shall be provided to prevent inadvertent earthing of any live

part.

e)Castle key interlocks shall be provided to prevent opening of cable compartment door when breaker is closed and bus bar compartment when any of the incomers to bus are closed.

f) Testing of circuit breaker shall be possible in isolated position by keeping the control plug connected

.

g) Only motor wound closing spring charging arrangement is acceptable.

h)Each breaker truck shall have Service - Isolated - Withdrawn Position.

i) Service & test position indication shall be provided on all panels through additional lamps.

Salient Feature of Circuit Breaker

1.	The circuit breakers current rating shall be at an ambient of 50 deg. C and the load requirements	
2.	Short circuit breaker	11 kV
	a) A.C. component	40 kA
	b) D.C. component	As per IS: 13118 or IEC-62271
3.	Short Circuit making current	10 0
4.	Operating Duty	B-3 Min-MB-3 Min-MB
5.	Total break time	Not more than 4 cycles
6.	Total make time	Not more than 5 cycles
7.	Operating Mechanism	Motor wound spring charged stored energy type as per IEC-62271

5.5.3 Instrument Transformer

(a.)All current and voltage transformers shall be completely encapsulated cast resin insulated type, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure, when the switchboard is operating at its rated load and the outside ambient temperature is 50 deg. C. The class of insulation shall be E or better.

(b.)All instrument transformers shall withstand the power frequency and impulse test voltage specified for the switchgear assembly. The current transformer shall further have the dynamic and short time ratings at least equal to those specified for the associated switchgear and shall safely withstand the thermal and mechanical stress produced by maximum fault currents specified when mounted inside the switchgear for circuit breaker modules. However, current transformer mounted in fuse backed contactor module shall have the dynamic and short time rating compatible with the let through current of the fuses.

(c.)The parameters of instrument transformers specified in this specification are tentative and shall be finalised by the Employer in due course duly considering the actual burden of various relays and other devices finally selected. In case the Contractor finds that the specified ratings are not adequate for the relays and other devices offered by him, he shall offer instrument transformer of adequate ratings and shall bring out this fact clearly in his bid.

(d.)All instrument transformers shall have clear indelible polarity markings. All secondary terminals shall be wired to separate terminals on an accessible terminal block.

(e.)Current transformers may be multi or single core and shall be located in the cable termination compartment. All voltage transformers shall be single phase type. The bus VTs shall be housed in a separate panel on a truck so as to be fully withdrawable.

(f.)Core balance CTs (CBCT) shall be provided on outgoing motor and transformer feeders having CT ratio more than 50/ 1A. These CBCTs shall be mounted inside the switchgear panel. The window size of CBCT's shall be based on the overall diameter of the cables, to be finalised during detailed engineering. The CBCT shall be of circular window type.

(g.)All voltage transformers shall have suitable HRC current limiting fuses on both primary and secondary sides. Primary fuses shall be mounted on the withdrawable portion. Replacement of the primary fuses shall be possible with VT truck in ISOLATED position. The secondary fuses shall be mounted on the fixed portion and the fuse replacement shall be possible without drawing out the VT truck from Service position.

a) Current Transformer	
Class of Insulation	Class E or better
Rated output of each	Adequate for the relays and devices connected, but not less than five (5) VA.
Accuracy class : Protection & Measurement	Class PS for differential & REF and core balance CTs; 5P20 for other protection CTs. Required Accuracy for metering is 0.2S for Station & Unit Incomers
Minimum primary earth fault current to be detected by core balance current Transformer	3 Amperes

b) Voltage Transformer		
1.	Rated Voltage Factor	1.2 continuous for all VTs, and 1.9 for 30 seconds for star connected VTs.
2.	Class of Insulation	Class E or better
3.	Other Parameters	Bus PT – 0.5 Class VA req. adequate for application. Line PT – 0.5 Class for sync./3P for door interlocks, VA req. adequate for application.

4.	Per phase VT Ratio	11/√3 KV/ 110/√3 V

5.5.4 Surge Arrestor

The surge arrestors shall be mounted within the switchgear cubicle between line and earth, preferably in the cable compartment. Surge arrestor selected shall be suitable for non-effectively earthed system and rating shall be in such a way that the value of steep fronted switching over voltage generated at the switchgear terminals shall be limited to the requirements of switchgear.

5.5.5 Type Tests

The contractor shall carry out the following type tests on the equipment to be supplied under this contract. The Contractor shall indicate the charges for each of these type tests separately (if required and applicable only) as listed below and the same shall be considered for the evaluation of the bids. The type tests charges shall be paid only for the test(s) actually conducted successfully under this contract and upon certification by the BHEL/NTPC engineer.

a) The following type tests shall be carried out on circuit breaker/ circuit breaker panels, of each voltage class and current rating.

1) Short circuit duty test on circuit breaker, mounted inside the panel offered along with CTs, bushing and separators.

2) Short time withstand test on circuit breaker, mounted inside panel offered together with CTs, bushings and separators.

3) Power frequency withstand test on breaker mounted in side panel.

4) Lightning impulse withstand test on breaker mounted in side panel

5) 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 centre.
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

6) Internal Arc Test as per IEC 62271-200

7) Measurement of resistance of main circuit.

8) Mechanical operation test.

9) Short Circuit withstand test of earthing device (Truck/switch).

The type tests shall be carried out in presence of the BHEL/NTPC representative, for which minimum 15 days notice shall be given by the contractor. The contractor shall obtain the BHEL/NTPC approval for the type test procedure before conducting the type test. The type test procedure shall clearly specify the test set–up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type

test(s) to be carried out.

In case the contractor has conducted such specified type test(s) within last ten years as on the date of bid opening, he may submit during detailed engineering the type test reports to the BHEL/NTPC for waival of conductance of such type test(s). These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client. BHEL/NTPC reserves the right to waive conducting of any or all the specified type test(s) under this contract. In case type tests are waived, the type test charges shall not be payable to the contractor

The type test reports once approved for any projects shall be treated as reference. For subsequent projects of NTPC, an endorsement sheet will be furnished by the manufacturer confirming similarity and "No design Change". Minor changes if any shall be highlighted on the endorsement sheet.

Two (2) protected soft copies on CD-ROM of the approved test results shall be furnished with the equipment. These shall include complete reports and results of the routine tests and type tests (if the latter is carried out) on equipment. If the type tests are not conducted, the CDs shall contain copies of the results of type tests carried out on identical equipment earlier.

Testing to observe compliance to degree of protection, shall be checked for each switch board enclosure and busbar chambers during routine inspection shall be as under.

(a.)IP -4X : It shall not be possible to insert a one (1) mm. dia steel wire into the enclosure from any direction, without using force.

(b.)IP-5X : It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.

5.5.6 Routine Tests

All acceptance and routine tests as per the specification and relevant standards IEC 62271-200 & IEC 62271-100 shall be carried out. Charges for these shall be deemed to be included in the equipment price.

An indicative lists of tests/ checks is mentioned as QA chapter on HT switchgear. However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

Commissioning Checks/ Tests

After installation of panels, power and Control wiring and connections, Contractor shall perform commissioning checks as listed below to verify proper operation of switchgear/ panels and correctness of all equipment in all respects.

In addition the Contractor shall carry out all other checks and tests recommended by the manufacturers.

General

a.Check name plate details according to specification.
b.Check for physical damage
c.Check tightness of all bolts, clamps and connecting terminals
d.Check earth connections.
e.Check cleanliness of insulators and bushings
f.Check heaters are provided
g.H.V. test on complete switchboard with CT & breaker/ contactor in position.
h.Check all moving parts are properly lubricated.
i.Check for alignment of busbars with the insulators to ensure alignment and fitness of insulators.
j.Check for interchange ability of breakers/ contactors.
k.Check continuity and IR value of space heater.
l.Check earth continuity for the complete switchgear board.

Circuit Breaker/ Contactors

(a)Check alignment of trucks for free movement.

(b)Check correct operation of shutters.

(c)Check slow closing operation (if provided)

(d)Check control wiring for correctness of connections, continuity and IR values.

(e)Manual operation of breakers completely assembled.

(f)Power closing/ opening operation, manually and electrically at extreme condition of control supply voltage.

(g)Closing and tripping time.

(h)Trip free and anti-pumping operation.

(i)IR values, resistance and minimum pick up voltage of coils.

(j)Simultaneous closing of all the three phases.

(k)Check electrical and mechanical interlocks provided.

(l) Checks on spring charging motor, correct operation of limit switches and time of charging

(m)All functional checks.

Current Transformers

(a)Megger between windings and winding terminals to body.
(b)Polarity tests.
(c)Ratio identification checking of all ratios on all cores by primary injection of current.
(d)Magnetisation characteristics & secondary winding resistance.
(e)Spare CT cores, if any to be shorted and earthed.

Voltage Transformers

(a)Insulation resistance test.
(b)Ratio test on all cores.
(c)Polarity test.
(d)Line connections as per connection diagram.

Cubicle Wiring

(a)Check all switch developments.

(b)It should be made sure that the wiring is as per relevant drawings. All interconnections between panels shall similarly be checked.

(c)All the wires shall be meggered to earth.

(d)Functional checking of all control circuit e.g. closing, tripping interlock, supervision and alarm circuit including proper functioning of component/ equipment.

(e)Check terminations and connections.

(f)Wire ducting.

(g)Gap sealing and cable bunching.

5.6 11 KV HT CABLES

CODES AND STANDARDS

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS : codes, standards, etc.) referred to herein, the former shall prevail. All the cables shall conform to the requirements of the following standards and codes:

IS:7098 (Part - II)	Specification for Cross linked polyethylene insulated PVC sheathed cables. Part-II: For working voltages from 3.3 KV upto and including 33 KV.
IS : 3975	Low Carbon Galvanized steel wires, formed wires and tapes for armouring of cables.
IS : 4905	Methods for random sampling.
IS : 5831	PVC insulation and sheath of electrical cables.
IS : 8130	Conductors for insulated electrical cables and flexible cords.
IS : 10418	Specification for drums for electric cables.
IS : 10810	Methods of tests for cables.
ASTM-D -2843	Standard test method for density of smoke from the burning or decomposition of plastics.
IEC-754 (Part-I)	Tests on gases evolved during combustion of electric cables.

IEC-332	Tests on electric cables under fire conditions. Part-3: Tests on bunched wires or cables (Category-B).

TECHNICAL REQUIREMENTS

The cables shall be suitable for laying on racks, in ducts, trenches, trestles, conduits and under ground (buried) installation with chances of flooding by water

All cables including EPR cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses developed under steady state and transient operating conditions as specified elsewhere in this specification.

Aluminium conductor used in power cables shall have tensile strength of more than 100 N/ sq.mm. Conductors shall be multi stranded.

XLPE insulation shall be suitable for continuous conductor temperature of 90 deg. C and short circuit conductor temperature of 250 deg C.

The cable cores shall be laid up with fillers between the cores wherever necessary. It shall not stick to insulation and inner sheath. All the cables, other than single core unarmoured cables, shall have distinct extruded PVC inner sheath of black colour as per IS: 5831.

For single core armoured cables, armouring shall be of aluminium wires. For multicore armoured cables armouring shall be of galvanised steel as follows : -

Calculated nominal dia of under armour		Size and Type of armour
i)	Upto 13 mm	1.4mm dia GS wire
ii)	Above 13 & upto 25mm	0.8 mm thick GS formed wire/ 1.6 mm dia GS wire
iii)	Above 25 & upto 40 mm	0.8mm thick GS formed wire/ 2.0mm dia GS wire
iv)	Above 40 & upto 55mm	1.4 mm thick GS formed wire/ 2.5mm dia GS wire
v)	Above 55 & upto 70mm	1.4 mm thick GS formed wire/ 3.15mm dia GS wire
vi)	Above 70mm	1.4 mm thick GS formed wire/ 4.0 mm dia GS wire

The aluminium used for armouring shall be of H4 grade as per IS: 8130 with maximum resistivity of 0.028264 ohm-sq.mm/ mtr at 20 deg.C. The types and sizes of aluminium armouring shall be same as mentioned for galvanised steel at 2.06.00 above.

The gap between armour wires/ formed wires shall not exceed one armour wire/ formed wire space and there shall be no cross over/ over-riding of armour wires/ formed wires. The minimum area of coverage of armouring shall be 90%. The breaking load of armour joint shall not be less than 95% of that of armour wire/ formed wire. Zinc rich paint shall be applied on armour joint surface of GS wires/ formed wires.

Distinct extruded PVC inner sheath of black colour as per IS:5831 shall be provided for the cables as follows:

a).For all multicore cables.

b).For single core armoured cables, where armouring is not being used as metallic screen.

Outer sheath shall be of PVC black in colour. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS properties.

(a.)Oxygen index of min. 29 (Test method as per IS 10810 Part-58)
(b.)Acid gas emission of max. 20% as per IEC-754 (Part-I)
(c.)Smoke density rating shall not be more than 60% during Smoke Density Test as per ASTMD-2843.

Cores of three core cables shall be identified by colouring of insulation or by providing coloured tapes helically over the cores, with Red, Yellow & Blue colours.

In addition to manufacturer's identification on cables as per IS, following marking shall also be provided over outer sheath :

(d.)Cable size and voltage grade - To be embossed

(e.)Word 'FRLS' at every 5 metre - To be embossed

(f.)Screen Fault current _ _ _KA for _ _ _ Sec. (Value of current & time shall be indicated)

(g.)Sequential marking of length of the cable in metres at every one metre - To be embossed/ printed
The embossing/ printing shall be progressive, automatic, in line and marking shall be legible and indelible. For EPR cables identification shall be printed on outer sheath

All cables shall meet the fire resistance requirement as per Category-B of IEC -332 Part - 3

Allowable tolerances on the overall diameter of the cables shall be +\-2 mm maximum.
In plant repairs to the cables shall not be accepted. Pimples, fish eye, blow holes etc. are not acceptable.

The cross-sectional area of the metallic screen strip/ tape/ wires shall be considered in sizing calculations.
The eccentricity shall be calculated as

$$\frac{t_{max} - t_{min}}{t_{max}} \times 100$$

and the ovality shall be calculated as

$$\frac{d_{max} - d_{min}}{d_{max}} \times 100$$

Where tmax/ tmin is the maximum/ minimum thickness of insulation and dmax/ dmin is the maximum/ minimum diameter of the core.

The eccentricity of the core shall not exceed 10% and ovality not to exceed 2% .

Cable selection & sizing

HT cables shall be sized based on the following considerations:

a) Rated current of the equipment

b) The voltage drop in the cable, during motor starting condition, shall be limited to 10% and during full load running condition, shall be limited to 3% of the rated voltage

c) Short circuit withstand capability

De-rating Factors

De-rating factors for various conditions of installations including the following shall be considered while selecting the cable sizes:

a) Variation in ambient temperature for cables laid in air
b) Grouping of cables
c) Variation in ground temperature and soil resistivity for buried cables.

Cable lengths shall be considered in such a way that straight through cable joints is avoided.

Cables shall be armoured type if laid in switchyard area or directly buried.

CONSTRUCTIONAL FEATURES

Cables shall conform to IS-7098 Part-II. These cables shall be multi-stranded, compacted circular aluminium conductor, XLPE-insulated, metallic screened, PVC outer sheathed. The conductor screen and insulation screen shall both be of extruded semiconducting compound and shall be applied along with the XLPE insulation in a single operation of triple extrusion process so as to obtain continuously smooth interfaces. Method of curing shall be "dry curing/ gas curing/ steam curing ". The metallic screen for each core shall be capable of carrying the system earth fault current and shall consist of copper wires or tape with minimum overlap of 20%. However, for single core armoured cables, the armouring shall constitute the metallic part of the screening.

Trailing cables shall have tinned copper (class 5) conductor, insulated with heat resistant elastomeric compound based on Ethylene Propyline Rubber (EPR) suitable for withstanding 90 deg.C continuous conductor temperature and 250deg C during short circuit, inner-sheathed with heat resistant elastomeric compound, nylon cord reinforced, outer-sheathed with heat resistant, oil resistant and flame retardant heavy duty elastomeric compound conforming to IS 9968.

TYPE, ROUTINE AND ACCEPTANCE TESTS

a) The contractor shall carry out the type tests as listed in this specification on the equipment to be supplied under this contract. The Contractor shall indicate the charges for each of these type tests as listed below (if required & applicable only) and the same shall be considered for the evaluation of the bids.

b) The type tests shall be carried out in presence of the BHEL/NTPC representative, for which minimum 15 days notice shall be given by the contractor. The contractor shall obtain the BHEL/NTPC approval for the type test procedure before conducting the type test. The type test procedure shall clearly specify the test set–up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.

c) In case the contractor has conducted such specified type test(s) within last ten years as on the date of bid opening, he may submit during detailed engineering the type test reports to BHEL/NTPC for waival of conductance of such type test(s). These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client. BHEL/NTPC reserves the right to waive conducting of any or all the specified type test(s) under this contract. In case type tests are waived, the type test charges shall not be payable to the contractor.

d) All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.
e) The type test reports once approved for any projects shall be treated as reference. For subsequent projects of NTPC, an endorsement sheet will be furnished by the manufacturer confirming similarity and "No design Change". Minor changes if any shall be highlighted on the endorsement sheet.

All types and sizes of cables being supplied shall be subjected to type tests, routine tests and acceptance tests as specified below and according to relevant standards.

The following type tests shall be carried out on one size each of 11/ 11KV cables. Size shall be decided by the employer during detailed engineering.

S. No.	**Type Test**	**Remarks**
	For Conductor	
1.	Resistance test	
	For Armor Wires/ Formed Wires	
2.	Measurement of Dimensions	
3.	Tensile test	
4.	Elongation Test	
5.	Torsion test	For round wires only
6.	Wrapping test	
7.	Resistance test	
8 (a)	Mass of zinc coating test	For GS Formed wires/ wires only

8 (b)	Uniformity of zinc coating	For GS Formed wires/ wires only
For PVC/ XLPE insulation & PVC Sheath		
9.	Test of thickness	
10.	Tensile strength elongation tests before ageing and after ageing	
11.	Ageing in air oven	
12.	Loss of mass test	For PVC outer sheath only
13.	Hot deformation test	For PVC outer sheath only
14.	Heat shock test	For PVC outer sheath only
15.	Shrinkage test	
16.	Thermal stability test	For PVC outer sheath only
17.	Hot set test	For XLPE insulation only
18.	Water absorption test	For XLPE insulation only
19.	Oxygen index test	For PVC outer sheath only
20.	Smoke density test	For PVC outer sheath only
21.	Acid gas generation test	For PVC outer sheath only
22.	Flammability test as per IEC – 332 – Part -3 (Category – B)	For completed cable only

The following type tests shall be carried out on each type (voltage grade) & size of the cable:

S. No.	Type test for all cables
1.	Insulation resistance test (Volume Resistivity method)
2.	High voltage test
For cables of 11/11 KV Grade only	
3.	Partial Discharge test
4.	Bending test

5.	Dielectric power factor test
	a) As a function of voltage
	b) As a function of temperature
6.	Heating cycle test
7.	Impulse withstand test

Indicative list of tests/ checks, Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of H.T. Cables enclosed.

5.7 Protections, Control and Metering

5.7.1 General System Description

It is intended to automate the Switchgears specified in the scope of supply and use Communicable Numerical relays for Protection, Control, Metering and Status Monitoring. All the feeders shall have provision to be remote controlled from the CMCS. Remote Annunciation Panel (RAP) shall be provided in CMCS (adjacent to SCADA) for controlling all the HT breakers in the plant. RAP shall also give the annunciations of all the relays and breaker status.

5.7.2 System Architecture and Requirements

The Contractor's scope of work shall include the supply, delivery, installation, testing and commissioning of the following:

a)Communicable Numerical Relays
b)Communication network
c)Any other equipment required to the intended specification

The integration of the complete automation system (including all status, analogue indications, alarms and controls) to enable the operator to monitor the complete plant auxiliaries from CMCS.

The point-to-point testing of all signals for the Switchgear network at the plant and protection equipment end and the terminal end shall be the responsibility of the Contractor. The Contractor shall provide full details of the offered system Architecture with the Bid.

The System architecture shall be flexible to allow future extensions.

Each component / module of the system including all the communication links, shall be provided with built-in supervision and self-diagnostic features and any failures shall be alarmed to the operator.

The offered equipment shall be of state of art technology and hardware shall be of proven field track record. Contractor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply. Contractor shall give a notice for at

least one year to the user of equipment before phasing out the product / spares to enable user for the placement of order for spares and services.

5.7.3 Numerical relays

General requirements

a) All numerical relays, auxiliary relays and devices shall be of types, proven for the application; satisfying requirements specified elsewhere and shall be subject to Employer's approval. Numerical Relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity to the satisfaction of the Employer.

b) All relays and timers shall be rated for control supply voltage as mentioned elsewhere under parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Making, carrying and breaking current ratings of their contacts shall be adequate for the circuits in which they are used. Interrogation voltage for the binary inputs shall be suitably selected to ensure avoidance of mal operation due to stray voltages.

c)The protective relays shall have at least 10 Nos potential free contacts (Programmable). Auxiliary relays shall have contacts as required. Relay output contacts shall be suitable for directly wiring in the breaker closing and trip circuit operating from 240 V DC/120V DC control voltage.

d) Failure of a control or auxiliary supply and deenergisation of a relay shall not initiate any circuit breaker /contactor operation. All relays shall withstand a minimum test voltage of 2 kV AC rms for one minute.

e)All the numerical relays shall have communications on two ports, local front port communication to laptop and a second port on IEC 61850 to communicate with the data concentrator through LAN.

f) All Numerical relays shall have features for electrical measurement including voltage, current, power (active/reactive) and energy parameters.

g) Mapping details of all the details shall be submitted in IEC format.

h) Relays shall have separate output for individual functionality and the master trip shall be software configurable in case of multi output relays. Relays shall have event recording feature, recording of abnormalities and operating parameters with time stamping.

i) Preferably comprehensive single numerical relay shall have provision of both current and voltage inputs. Relays used in incomers, tie and bus couplers shall have provision of two sets of voltage signal inputs for the purpose of synchronization.

j) All CT & PT terminals shall be provided as fixed type terminals on the relay to avoid any hazard due to loose connection leading to CT opening or any other loose connection. In no circumstances Plug In type connectors shall be used for CT / PT connections. Vendor to ensure the same for all protective relay models offered.

k) All numerical relay shall have key pad / keys to allow relay setting from relay front. All hand reset relays shall have reset button on the relay front. Relay to be self or hand reset shall be software

selectable. Manual resetting shall be possible from remote.

l) Relays shall have suitable output contact for breaker failure protection.

m) Relays shall have self diagnostic feature with self check for power failure, programmable routines, memory and main CPU failures.

n)Relays shall have at least two sets or groups of two different sets of adaptable settings. Relays shall have multiple IEC/ ANSI programmable characteristics.
o)Design of the relay must be immune to any kind of electromagnetic interference. Vendor to submit all related type test reports for the offered model along with the offer.

5.7.4 Transformer Feeder Protections

The Transformer protection relay shall be suitable for providing the following protections

a. Three Phase Over current and Earth Fault protection (50 & 50 N1/ 50 N2)

The relay shall have over current and earth fault protection. The over current element should have the minimum setting adjustable between 250-2000% of CT secondary rated current. The instantaneous stage also should have cold load pick up (doubling) feature to allow the lesser short circuit setting for better insulation life of transformer while ensuring that relay does not mal operate during energizing of transformer. For definite time delayed over current characteristic the pickup setting should have range of minimum 150% to 600 % with time delay of 0.3 sec to 3.0 sec. The second stage of protection shall be with instantaneous operation.

The earth fault element should be suitable for both residually connected CT input as well as CBCT input. With CBCT the relay shall be suitable for detection of earth fault currents in the range of 10 mA secondary.

b. Restricted Earth Fault protection (64 R)

Restricted earth fault protection (64R) connected between CT's of LT incomer and neutral of transformer. The protection should be provided with high stability circulating current relays having pick up setting range of 10 to 40 % of CT secondary. Necessary stabilizing resistors if required shall be provided.

c. Stand by earth fault protection (51 N)

The stand by earth fault protection should be of definite time delay type provided having a pick up setting range of 10% to 40% with a timer delay of 0.3 sec to 3 sec.

5.7.5 Protections for Incomers, Bus couplers and Tie feeders

The Incomer, Bus Coupler & Tie feeder protection relay shall be suitable for providing the following protections

1. The relay shall have over current and earth fault protection. The over current element should have the minimum setting adjustable between 250-2000% of CT secondary rated current. The earth fault element should be suitable for residually connected CT input. The relay shall be suitable for

detection of earth fault currents in the range of 5% to 10%. The relay should have built in Lockout feature.
2. Synchronizing check feature as a part of manual live change over and dead bus closing feature for dead bus closing shall be provided.

3. Bus no volt signal shall be configured in the relay for employer's use.

5.8 EARTHING

Earthing system shall be in strict accordance with IS:3043 and Indian Electricity Rules/ Acts. Earthing system network/ earth mat shall be interconnected mesh of mild steel rods buried in ground in the plant. All off-site areas shall be interconnected together by minimum two parallel conductors. The Contractor shall furnish the detailed design and calculations for Employer's approval. Contractor shall obtain all necessary statutory approvals for the system.

The earth conductors shall be free from pitting, laminations, rust, scale and other electrical, mechanical defects.

The material of the earthing conductors shall be as follows

1	Conductors above ground level and in built up trenches.	Galvanized steel
2	Conductors buried in earth	Mild steel
3	Earth electrodes	Mild steel rod

The sizes of earthing conductors for various electrical equipments shall be as below:

	Equipment	Earthing Conductor Buried in Earth	Earthing Conductor above ground level & in built-up trenche
1	Main earth grid	40 mm dia. MS rod	65 x 8mm GS flat
2	11kV switchgear equipment and 415V switchgear	--------	65 x 8mm GS flat
3	415 V MCC/ Distribution boards/ Transformers	--------	50 x 6mm GS flat
4	Fractional Horse power motor	--------	8 SWG GS wire
5	1KW to 25 KW	--------	25 x 3mm GS flat
6	Columns, structures, cable		50 x 6mm GS flat

	trays and bus ducts enclosures	--------	

Metallic frame of all electrical equipment shall be earthed by two separate and distinct connections to earthing system, each of 100% capacity, Crane rails, tracks, metal pipes and conduits shall also be effectively earthed at two points. Steel RCC columns, metallic stairs, and rails etc. of the building housing electrical equipment shall be connected to the nearby earthing grid conductor by one earthing ensured by bonding the different sections of hand rails and metallic stairs. Metallic sheaths/ screens, and armour of multi-core cables shall be earthed at both ends. Metallic Sheaths and armour of single core cables shall be earthed at switchgear end only unless otherwise approved. Every alternate post of the switchyard fence shall be connected to earthing grid by one GS flat and gates by flexible lead to the earthed post. Railway tracks within the plant area shall be bonded across fish plates and connected to earthing grid at several locations. Portable tools, appliances and welding equipment shall be earthed by flexible insulated cable

Each continuous laid lengths of cable tray shall be earthed at minimum two places by G.S. flats to earthing system, the distance between earthing points shall not exceed 30 meter. Wherever earth mat is not available, necessary connections shall be done by driving an earth electrode in the ground Neutral connections and metallic conduits/ pipes shall not be used for the equipment earthing. Lightning protection system down conductors shall not be connected to other earthing conductors above the ground level.

Connections between earth leads and equipment shall normally be of bolted type. Contact surfaces shall be thoroughly cleaned before connections. Equipment bolted connections after being tested and checked shall be painted with anti-corrosive paint/ compound.

Suitable earth risers as approved shall be provided above finished floor/ ground level, if the equipment is not available at the time of laying of main earth conductor.

Connections between equipment earthing leads and between main earthing conductors shall be of welded type. For rust protection the welds should be treated with red lead compound and afterwards thickly coated with bitumen compound. All welded connections shall be made by electric arc welding.

Resistance of the joint shall not be more than the resistance of the equivalent length of conductors.

Earthing conductors buried in ground shall be laid minimum 600 mm below grade level unless otherwise indicated in the drawing. Back filling material to be placed over buried conductors shall be free from stones and harmful mixtures. Back filling shall be placed in layers of 150 mm.

Earthing conductors embedded in the concrete floor of the building shall have approximately 50 mm concrete cover.

A minimum earth coverage of 300 mm shall be provided between earth conductor and the bottom of trench/ foundation/ underground pipes at crossings. Earthing conductors crossings the road can be installed in pipes. Wherever earthing conductor crosses or runs at less than 300 mm distance along metallic structures such as gas, water, steam pipe lines, steel reinforcement in concrete, it shall be bonded to the same.
Earthing conductors along their run on columns, walls, etc. shall be supported by suitable welding/ cleating at interval of 1000mm and 750mm respectively.

Earth pit shall be constructed as per IS:3043. Electrodes shall be embedded below permanent moisture level. Minimum spacing between electrodes shall be 600mm. Earth pits shall be treated with salt and charcoal if average resistance of soil is more than 20 ohm meter.

On completion of installation continuity of earth conductors and efficiency of all bonds and joints shall be checked. Earth resistance at earth terminations shall be measured and recorded. All equipment required for testing shall be furnished by contractor.

Earthing conductor shall be buried at least 2000mm outside the fence of electrical installations. Every alternate post of the fences and all gates shall be connected to earthing grid by one lead.

Other Requirements of Earthing System:

Standard/ Code	IEEE 80, IS 3043
System Fault Level	As per system requirement
Soil resistivity	Actual as per site conditions
Min. Steel corrosion	0.12mm/ year
Depth of burial of main earth conductor	600mm below grade level; where it crosses trenches, pipes, ducts, tunnels, rail tracks, etc., it shall be at least 300mm below them.
Conductor joints	By electric arc welding, with resistance of joint not more than that of the conductor.

Welds to be treated with red lead for rust protection and then coated with bitumen compound for corrosion protection.

Surface resistivity - Gravel 3000 ohm-meter
- Concrete 500 ohm-meter

5.9 MISCELLANEOUS ELECTRICAL WORKS AND EQUIPMENTS

5.9.1 Cable Gland

The cable ends shall be terminated with adequate size metallic double compression cable glands. Cable glands shall be of robust construction capable of clamping cable and cable armour (for armoured cables) firmly without injury to insulation. The glands shall be earthed at two locations. Suitable lock type crimping lugs shall be used for cable end terminations. Where cables are raising from ground, suitable PVC pipe guarding shall be provided for cable raising with sealing of the guarding PVC pipe including a suitable clamp.

5.9.2 Cable lugs/ ferrules

Cable lugs/ ferrules for power cables shall be tinned copper solderless crimping type suitable for aluminium compacted conductor cables. Cable lugs and ferrules for control cables shall be tinned

copper type. The cable lugs for control cables shall be provided with insulating sleeve and shall suit the type of terminals provided on the equipments. Cable lugs and ferrule shall conform to relevant standard.

5.9.3 Cable Drums

(a)Cables shall be supplied in non returnable wooden or steel drums of heavy construction. The surface of the drum and the outer most cable layer shall be covered with water proof cover. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/ rubber caps secured by 'U' nails so as to eliminate ingress of water during transportation, storage and erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS: 10418.

(b)Each drum shall carry manufacturer's name, purchaser's name, address and contract number, item number and type, size and length of cable and net gross weight stenciled on both sides of the drum. A tag containing same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

(c)The standard drum length for power cables shall not be less than 500 meters. The length per drum shall be subjected to a maximum tolerance of +/- 5% of the standard drum length. The Employer shall have the option of rejecting cable drum with shorter lengths. For each size, the variance of total quantity, adding all the supplied drum lengths, from the ordered quantity, shall not exceed +/ -2%.

5.9.4 Trefoil clamps

Trefoil clamps for single core cables shall be pressure die cast aluminium or fibre glass or nylon and shall include necessary fixing accessories like G.I. nuts, bolts, washers, etc. Trefoil clamps shall have adequate mechanical strength to withstand the forces generated by the peak value of maximum system short circuit current.

5.9.5 Cable Clamps & Straps

The cable clamps required to clamp multicore cables on vertical run shall be made up of Aluminum strip of 25x3 mm size. For clamping the multicore cables, self- locking, de-interlocking type nylon clamps/ straps shall be used. The clamps/ straps shall have sufficient strength and shall not get affected by direct exposure to sun rays and outdoor environment.

5.9.6 Receptacles

Receptacles boxes shall be fabricated out of MS sheet of 2mm thickness and hot dipped gavanised or of die-cast aluminium alloy of thickness not less than 2.5 mm. The boxes shall be provided with two nos. earthing terminals, gasket to achieve IP55 degree of protection, terminal blocks for loop-in loop-out for cable of specified sizes, mounting brackets suitable for surface mounting on wall/ column/ structure, gland plate etc. The ON-OFF switch shall be rotary type heavy duty, double break,AC23 category, suitable for AC supply. Plug and Socket shall be shrouded Die-cast aluminium. Socket shall be provided with lid safety cover. Robust mechanical interlock shall be provided such that the switch can be put ON only when the plug is fully engaged and plug can be withdrawn only when the switch is in OFF position. Also cover can be opened only when the switch is in OFF position. Wiring shall be carried out with 1100 V grade PVC insulated stranded aluminium/ copper wire of

adequate size. The Terminal blocks shall be of 1100 V grade. The Terminal blocks shall be of 1100 V grade made up of unbreakable polymide 6.6 grade with adequate current rating and size. The welding receptacles shall be provided with inbuilt ELCB rated for suitable mA sensitivity.

5.9.7 Trenches

Cable trench shall be of RCC type of inner size 700 mm width and 400 mm depth and outer size 900 mm width and 600 mm depth including RCC slab of 100 mm thickness at top. One no. spare core is to be laid for each double circuit of 3 phase. Sand filling to be done in the trench after cable laying. Trefoil clamp is to be provided for each circuit. Total trench work length anticipated is 3.0 km approximately. Flooring of built up trenches shall be sloped for effective drainage with sump pits and sump pumps. No subzero level cable vault/trenches shall be provided below control building/switchgear rooms in plant.

General

The cable slits to be used for motor/ equipment power/ control supply shall be sand filled & covered with PCC after cabling.

Sizing criteria, derating factors for the cables shall be met as per respective chapters. However for the power cables, the minimum conductor size shall be 6 sq.mm. for aluminium conductor and 2.5 sq.mm. for copper conductor cable.

Conscious exceptions to the above guidelines may be accepted under special conditions but suitable measures should be taken at such location to:

•Meet all safety requirements

•Safeguard against fire hazards, mechanical damage, flooding of water, oil accumulation, electrical faults/ interferences, etc

5.9.8 Cable trays, Fittings & Accessories

Cable trays shall be ladder/ perforated type as specified complete with matching fittings (like brackets, elbows, bends, reducers, tees, crosses, etc.) accessories (like side coupler plates, etc. and hardware (like bolts, nuts, washers, G.I. strap, hook etc.) as required. Cable tray shall be ladder type for power & control cables and perforated for instrumentation cables.

Cable trays, fittings and accessories shall be fabricated out of rolled mild steel sheets free from flaws such as laminations, rolling marks, pitting etc. These (including hardware) shall be hot dip galvanized as per relevant IS.

Cable trays shall have standard width of 150 mm, 300 mm & 600 mm and standard lengths of 2.5 metre. Thickness of mild steel sheets used for fabrication of cable trays and fittings shall be 2 mm. The thickness of side coupler plates shall be 3 mm.

Cable troughs shall be required for branching out few cables from main cable route. These shall be U-shaped, fabricated of mild steel sheets of thickness 2 mm and shall be hot dip galvanised as per relevant IS. Troughs shall be standard width of 50 mm & 75 mm with depth of 25 mm

Support System for Cable Trays

Cable tray support system shall be pre-fabricated similar or equivalent to "Unistrut make".

Support system for cable trays shall essentially comprise of the two components i.e. main support channel and cantilever arms. The main support channel shall be of two types : (i) C1:- having provision of supporting cable trays on one side and (ii) C2:- having provision of supporting cable trays on both sides. The support system shall be the type described hereunder

a. Cable supporting steel work for cable racks/ cables shall comprise of various channel sections, cantilever arms, various brackets, clamps, floor plates, all hardware such as lock washers, hexagon nuts, hexagon head bolt, support hooks, stud nuts, hexagon head screw, channel nut, channel nut with springs, fixing studs, etc.

b. The system shall be designed such that it allows easy assembly at site by using bolting. All cable supporting steel work, hardware fittings and accessories shall be prefabricated factory galvanised.

c. The main support and cantilever arms shall be fixed at site using necessary brackets, clamps, fittings, bolts, nuts and other hardware etc. to form various arrangements required to support the cable trays. Welding of the components shall not be allowed. However, welding of the bracket (to which the main support channel is bolted) to the overhead beams, structural steel, insert plates or reinforcement bars will be permitted. Any cutting or welding of the galvansied surface shall be brushed and red lead primer, oil primer & aluminium paint shall be applied.
d. All steel components, accessories, fittings and hardware shall be hot dip galvanised after completing welding, cutting, drill ing and other machining operation.

e. The main support channel and cantilever arms shall be fabricated out of 2.5mm thick rolled steel sheet conforming to IS.

f. Cantilever arms of 320 mm, 620mm and 750 mm in length are required, and shall be suitable for assembling the complete arm assembly on to component constructed of standard channel section. The back plate shall allow sufficient clearance for fixing bolt to be tightened with tray in position.

g. Support system shall be able to withstand

- weight of the cable trays
- weight of the cables (75 Kg/ Metre run of each cable tray)
- Concentrated load of 75 Kg between every support span.
- Factor of safety of minimum 1.5 shall be considered.

Nevertheless, the support system shall be designed by the Contractor to fully meet the requirements of type tests as specified. In case the system fails in the tests, the components design modification shall be done by the Contractor without any additional cost to the Employer. The Contractor shall submit the detailed drawings of the system offered by him.

Provision is to be made for two no. road crossing of 10 meter width each. Road crossing to be

done with underground laying of hume pipes with PCC encasing. The work anticipated is 2.5 km approximately of cable trestle. Cable trestle is to be made cantilever type with cable tray.

5.9.9 Pipes, Fittings & Accessories

Pipes offered shall be complete with fittings and accessories (like tees, elbows, bends, check nuts, bushings, reducers, enlargers, coupling caps, nipples etc.) The size of the pipe shall be selected on the basis of maximum 40% fill criteria

GI Pipes shall be of medium duty as per IS:1239

Duct banks shall be High Density PE pipes encased in PCC (10% spare of each size, subject to minimum one) with suitable water-proof manholes.

Hume pipes shall be NP3 type as per IS 458.

6.0 CIVIL WORK

6.1 FENCING

The complete plant boundary covering module yard, control room, switchgear room and 11 kV switchyard, security cabin etc. shall be fenced with combination of metallic chain link and barbed wire. Height of fencing shall be at least 2m above the toe-wall. MS angle posts shall conform to "IS 226-1969 and IS 800-1984". Metallic chain link fencing shall be provided upto 1.6 m above toe-wall with pole spacing of 2.50 m between adjacent posts. The mesh size of chain link fencing shall be 50X50 mm of 8 gauge GI wire. The balance 0.4 m shall comprise of fencing of barbed wire on half Y steel post. The barbed wire shall confirm to conforming to IS: 278. The spacing between barbed wires shall be maximum 12.5cm center to center. Gates with roller blades shall be provided. Fencing along with gate shall be earthed at two points through separate earth electrodes. All nuts, bolts, fastners clamps, clips etc. shall be galvanized.

Toe walls either of brick masonry with bricks of minimum 50kg./ sq.cm. crushing strength or of hollow concrete block masonry shall be provided between the fence posts all along the run of the fence with suitable foundation. Toe wall shall be minimum 200mm above the formation level with 50mm thick P.C.C. coping (1:2:4) and shall extend minimum 300mm below the formation level. Toe wall shall be plastered with cement sand mortar (1:6) on both sides and shall be painted with two coats of textured cement point (Sandtax Matt or equivalent) of approved colour and shade. Toe wall shall be provided with weep holes at appropriate spacing.

6.2 PLANNING AND DESIGNING

The contractor has to plan and design the pre-fab inverter room foundations each of approx. 30 sq m area or standard RCC framed structure as per similar dimensions with cable trench arrangement (subject to NTPC approval), plant building (CMCS) of RCC construction of minimum 225 sq. m and 100 sq. m area for 8 MW and 2 MW respectively, HT panel foundation and CSS or conventional switchyard foundations as per the topographical survey and soil test reports. The contractor shall develop general layout drawing of plant array field, internal roads and pathways, drainage system, approach roads (ensuring no water logging in the plant premises) along with sanitary plumbing layout etc. All designs & drawings have to be developed based on specifications given in the tender, soil report and relevant IS unless otherwise specified. All details related to internal electrification, water supply and sewerage system should be clearly shown in the drawing.

6.3 INSTRUCTIONS TO CONTRACTOR

1. Optimization of land utilization with appropriate Array layout for maximum power packaging. For the PV array field, contractor shall furnish shadow factor analysis and shading diagram by employing applicable software and the details shall be incorporated in the PV array drawing.
2. Module cleaning system for periodic cleaning of modules with water points for every row, valves, hose pipes and nozzles as required.
3. All design should be done for optimal usage of space material, and labor without compromising the effect of shadow, cooling, ventilation, accessibility, losses during electrical connections etc.
4. The contractor shall submit preliminary drawings for approval and based on recommendations, in any, the contractor must submit final drawings for formal approval. Only approved drawings shall be used to proceed with construction works.
5. Buildings shall comply with National Building Code and/or other relevant international standards.

OR

Pre-Fab Inverter room (Numbers depending on the plant layout) with civil foundation and platform is also accepted subject to approval of BHEL/NTPC. Pre fab rooms designed shall take care of the Temperature within Inverter room under the conditions when ambient temperature is 50 deg C.

Pre- Fab or Civil constructed Inverter room shall take into consideration. HVAC details and the required ducting from each inverter shall be provided for proper extraction of Hot air from each Inverter so as to maintain the inverter temperature at its specified operating temperature. Based on HVAC calculations, If required contractor has to provide exhaust fans within each inverter room.

The inverter room shall be complete in all respect viz

(a). Trenches for DC and AC cables (3 tier arrangement with cable tray) and the required chequred plates to cover the open trenches within the inverter rooms.

(b). Electrical wiring and light fittings with Fans. Light fittings shall be decided based on the Lux calculation to be furnished by the contractor and approved by BHEL/NTPC.

(c.) Fire alarm and Fire protection system in each inverter room shall be provided as per the IS.

(d). Fire fighting equipment in each inverter room shall also be provided as per the IS.

(e). Each Inverter room shall have the required space and furniture accessories to place the data communication system including operator chair, which is primarily (Such as PLC) which is primarily meant to collect the Inverters data, LT breaker data , HT switchboard data (Including Auxiliary and Numerical relays), Transformer data, String Monitoring system data, weather station data and any other data from the solar quadrant. Interfacing and Interconnecting to communication system within Inverter room to obtain the data mentioned as above shall be in the scope of contractor.

(f). Signal cabling laying (paired screen cables, CAT 5 E Cables etc.) from each Inverter room to Control Monitoring and Control Station (CMCS) is in the scope of contractor.

(g). Cable trench work and DC power cable laying in the PV array field to respective inverter rooms.

(h). Interconnection of Inverter output cable to Transformer located in CSS (if employed otherwise open switch yard) via LT Breaker through cable trays.

(i). 11 kV Cable laying and termination from HT side of the transformer to HT panel located in CSS/ open switch yard.

(j). 11 kV Cable laying and termination from each HT panel located in respective CSS to Plant HT panel and/or Integrated HT panel. (Refer SLD attached).

(k). Supply and Laying of 7 runs (for each site) of 11 kV Al XLPE 300 sq mm armored cable from Integrated HT panels to AWRS transformer through cable trestle with a new cable tray with trefoils (in case of 2 MW) and to PTS ATM counter through RCC cable trench with trefoils (in case of 8 MW).

(l). Supply of Earthing material and earthing of solar array field (Supports structures, LA's, Outdoor panels etc,), Switchyard, LA's, CSS components. Pre-Fab room, CSS enclosure, inverter room equipment and switchyard equipment is in the scope of contractor. Design and construction of earth mat at solar power plant is in the scope of the contractor. Design of earth mat for switch yard shall be

got approved from BHEL/NTPC before commencement of works. Complete switch yard engineering layout shall be furnished for the approval.

6. Land development including Levelling and Grading as per design formation level shall be done prior to commencement of any construction work.
7. The contractor shall submit complete drawings fulfilling all requirements for acceptance and approval by BHEL. Final design and drawings are to be prepared for construction as per instruction based on the approved drawings.

6.4 SITE DEVELOPMENT

Before commencement of work including filling of the project site, the contractor must visit the site to assess the actual condition and situation of the land.
Landscaping and leveling works on the entire area of the plant premises shall be done as per drawing developed by the contractor (and as per approval). All proper attention must be given to the drainage, water runoff and general slope of the plant area.

6.5 APPROACH ROAD AND PATHWAYS:

Pathways shall be leveled and compacted. Brick should be class II or better class (Fly-ash bricks produced by NTPC can also be employed provided it is readily available during the construction). The width of the internal pathways shall be 1.25 m minimum and shall be provided between each row. Peripheral pathways other than approach road shall be of 2.5m width and designed to facilitate movements to carry out daily maintenance. Approach road from nearest main road to control room shall be flexible type Bituminous of width at least 3.75 m with one meter shoulder each side as per IRC.

6.6 CONTROL MONITORING AND CONTROL STATIONS (CMCS)

For the operation & maintenance of SPV Plant the central CMCS has been proposed at both sites. It shall have

1. Air conditioned SCADA room
2. Store Room
3. Lobby
4. Pantry
5. Toilet and Urinal
6. Office room
7. Battery room

For ease of maintenance and layout point of view, CMCS will be located at both sites.

The area requirement of CMCS shall be as below:

Capacity	Minimum total Built up area of CMCS

08 MW	225 sq. m
02 MW	100 sq. m

The Contractor to submit the drawing of CMCS to the owner for approval.
Note: The total area of CMCS (8 + 2 MW) remaining same, individual block areas of CMCS may vary as per the detailed design.

6.7 SECURITY CHECK POST WITH TOILET CUM URINAL

Security cabin shall be of Pre-Fab type or RCC type subject to NTPC approval. Dimensions of security cabin shall be 3m x 3m. In addition to this, W/C shall be provided attached to the security cabin. All the necessary plumbing and sanitary lines shall be drawn. Necessary electrical connections for lighting and exhaust fan in W/C shall be provided.

GENERAL SPECIFICATION:

All building shall be designed to meet national building code requirement.
i) RCC Works

All RCC works shall be of designed mix as required grade as per IS 456- 2000 and shall be produced using weigh batchers. Design mix for the required grade shall be carried out by reputed third party agency acceptable to NTPC. The materials used viz. Cement reinforcement, steel etc. shall be as per relevant IS standards. In addition IS: 2502 Code of Practice for Bending and Fixing of Bars for concrete reinforcement must be complied. Reinforcement shall be high strength TMT Fe 415 or Fe 500 conforming to "IS: 1786-1985".
Concrete for all RCC works shall be machine mixed. For this purpose, contractor shall deploy **mini batching plant having digitized recording system**, which shall be calibrated with NABL/NPL traceable weights. The batching plant shall have the facility of obtaining the digitized output giving details of the various constituents (cement, aggregate, water, admixtures, fly ash etc.) in each batch of concrete being produced. Samples of concrete making materials and concrete shall be tested as per the provisions of technical specifications and field quality plan.

ii) Masonry work

All brick works shall be using at least II class bricks of approved quality as per IS 2212 and IS: 3495. The cement mortar for brick masonry shall be in the ratio 1 cement and 5 sand (by weight). The cement mortar shall be machine mixed. Bricks required for masonry work shall be thoroughly soaked in clean water tank for approximately two hours. Brick shall be laid in English bond style. Green masonry work shall be protected from rain. Masonry work shall be kept moist on all the faces for a period of seven days.

iii) Doors & Windows :

Doors, windows and ventilators of air-conditioned areas, office rooms, entrance lobby of all buildings (where ever provided), and all windows and ventilators of main plant and service building shall have, electro colour dyed (anodised with 15 micron coating thickness) aluminium framework with glazing. Each window of SCADA room and office room will have Venetian blinds. All doors of toilet areas shall be of steel framed solid core flush shutter. All other buildings doors, windows, ventilators (unless otherwise specified) shall be of steel.

In case of steel, the doors shall be fabricated from 1.6 mm thick MS sheets and shall meet the general requirements of IS: 4351. Steel windows and ventilators shall be as per IS:1361 and IS:1038. The structural steel shall conform to IS: 7452 and IS: 2062. All windows and ventilators on ground floor of all buildings shall be provided with suitable grill.

Minimum size of door provided shall be 2.1 m high and 1.2 m wide. However for toilets minimum width shall be 0.75 m and office areas minimum width shall be 1.20m.

The main entrance shall be double leaf door. The holdfasts shall be made from steel flats (50 mm and 5 mm thick). The fixtures, fastenings and door latch are to be made with same materials.

All steel windows shall be metal steel framed and manufactured from low carbon, hot-rolled Z-bar steel sections, and 25 mm wide and of minimum thickness 3 mm, drilled and tapped for hardware. The top of frames shall be provided with rain lip.

Each window unit shall have a solid bronze polished, cam locking handle and strike. All steel windows shall be suitably painted after fabrication in accordance with the relevant Indian Standard(s).

Fixing of metalled doors and windows shall be done in accordance to IS:1081 and IS 7452.

Doors and windows on external walls of the buildings (other than areas provided, with insulated metal claddings) shall be provided with RCC sunshade over the openings with 300 mm projection on either side of the openings. Projection of sunshade from the wall shall be minimum 450 mm over window openings and 750 mm over door openings except for main entrance door to the control room where the projection shall be 1500mm.

iv) Glazing

All accessible ventilators and windows of all buildings shall be provided with min. 4mm thick float glass, plain or tinted for preventing solar radiations, unless otherwise specified.
For single glazed aluminium partitions and doors, float glass of 8mm or 10 mm thickness shall be used. All glazing work shall conform to IS:1083 and IS:3548.

6 mm reflective toughened glass, with following minimum technical characteristics: Solar factor 45% or less, U-value less than 5.7 W/ SQMK, VLT min 35%: The glass to be used should be from the manufacturers of glass like Glavebel (Belgium), Saint Gobain (France) or Fort (USA) Or equivalent. The glass should be free from distortion and thermal stress

v) Plastering:

All external surfaces shall have 18 mm cement plaster in two coats, under layer 12 mm thick cement plaster 1:5 and finished with a top layer 6 mm thick cement plaster 1:6 (DSR 13.19) with water proofing compound. White cement primer shall be used as per manufacturer's recommendation.

At least one coat of plaster shall be applied to interior walls by hand or mechanically, to a total thickness of 12 mm using 1:6, 1 cement and 6 sand. Plastering shall comply to IS: 1542, IS:1661, IS:1630. Oil bound washable distemper on smooth surface applied with 2 mm thick Plaster of Paris

putty for control room.

Plaster of Paris (Gypsum Anhydrous) conforming to IS:2547 shall be used for plaster of Paris punning.

vi) Flooring:

The Cement shall be ordinary Portland cement as per IS:269. Flooring for all air conditioned areas, corridor and offices area shall be provided with vitrified ceramic tiles of size 600X 600 mm and min 9 mm thickness, laid with 3 mm ground joints as per approved pattern, painted nearly with 3X4 mm stainless epoxy grout or equivalent. Flooring for stores, security cabin shall be of cement concrete flooring as per IS 2571-1970.

Heavy duty (Grade V) dust pressed non-skid type ceramic tiles (300X 300 mm) as per IS 13755, shall be provided for flooring of toilets and pantries.

For pantry slab and control room floor mirror polished (6 layers of polish) Granite stone (slab) of minimum thickness of 18 mm shall be used.

vii) Roofing

Roof of the C.R. Building shall consist of Cast-in-situ RCC slab treated with a water proofing system which shall be an integral cement based treatment conforming to CPWD specification (item no. 25.8 of DSR 1997). The roof of the building shall be water proof with tarfelt 5 layer over screeding. The roof shall be designed for minimum superimposed load to 150 kg/ m2.

For efficient disposal of rainwater, the run off gradient for the roof shall not be less than 1:100 and the roof shall be provided with RCC water gutter, wherever required. Gutter shall be made water tight using suitable water tight treatment. This gradient can be provided either in structure or subsequently by screed concrete 1:2:4 (using 12.5 mm coarse aggregate) and/ or cement mortar (1:4). However, minimum 25 mm thick cement mortar (1:4) shall be provided on top to achieve smooth surface.

viii) Painting of Walls & Ceilings

The paint shall be anti-fungal quality of reputed brand suitable for masonry surfaces for high rainfall zone. All painting on masonry or concrete surface shall preferably be applied by roller. If applied by brush then same shall be finished off with roller. For painting on concrete, masonry and plastered surface IS:2395 shall be followed. All paints shall be of approved make including chemical resistant paint. Minimum 2 finishing coats of paint shall be applied over a coat of primer.

For painting on steel work and ferrous metals, BS: 5493 and IS:1477 shall be followed. The type of surface preparation, thickness and type of primer, intermediate and finishing paint shall be according to the painting system adopted.

The cement paint as per as per IS: 5410 shall be of approved brand and manufacturer. Ceiling of all rooms except Battery room shall be white washed. The ceiling of Battery room (if provided) shall be acid resistant paint.

ix) Plinth Protection

Plinth protection shall be provided around all the buildings with Brickbats and PCC 1:2:4 & smoothly finish of top surface.

x) Water supply

GI pipes of Medium quality conforming to IS 1239 (Part I-1990) and IS 1795- 1982 (reaffirmed 1990) for Mild Steel pipes shall be used for all water supply and plumbing works.

The Sintex or equivalent make PVC storage water storage tank conforming to IS:12701 shall be provided over the roof of the control room with adequate capacity for 10 no. person and 24 hr requirement, complete with all fitting including float valve, stop cock etc. The capacity of the tank shall be minimum 500 litres.

xi) Plumbing and Sanitary

Each toilet shall have the following minimum fittings.

(a) WC (Western type) 390 mm high with toilet paper roll holder and all fittings or WC (Indian Type) with all fittings (both types of WCs shall be provided at alternate locations).
(b) Urinal (430 x 260 x 350 mm size) with all fittings.
(c) Wash basin (550 x 400 mm) with all fittings.
(d) Bathroom mirror (600 x 450 x 6 mm thick) hard board backing.
(e) CP brass towel rail (600 x 20 mm) with C.P. brass brackets.
(f) Soap holder and liquid soap dispenser.

All fittings, fastener, grating shall be chromium plated. Necessary plumbing lines shall be provided for office cum control room building and Security cabin.

The floor finish for washroom, pantry and toilet shall be vitrified ceramic anti- slip tiles and Dado glaze ceramic tiles upto 2.1m shall be used. The normal size of Ceramic tiles shall be 300 mm X 300 mm X 9 mm and shall comply IS: 15622.

The Contractor shall design & provide below ground one septic tank and two soak pits and assuming that a total of 10 no. persons shall be working for O&M in combined three shift. The discharge water has to be connected to soak pit or proper discharge drain as per applicable pollution norms. The package type sewage treatment plant may be used, if required. The discharge water from the toilet is not to be put in the normal drain.

The pantry shall consist of one number stainless steel pantry sink, as per IS :13983, of size 610 x 510 mm, bowl depth 200 mm with drain board of at least 450 mm length with trap, with inlet and outlet connections and GI concealed water supply pipe of minimum 12 mm dia of medium class, sanitary pipe of minimum 75 mm diameter, floor trap with Stainless Steel grating, inlet and outlet connections for supply and drainage, with all bends, tees, junctions, sockets, etc., as are necessary for the commissioning and efficient functioning of the pantry (all sanitary fittings shall be heavy duty chrome plated brass, unless specified otherwise)

xii) Electrification of Building

Electrification of building shall be carried out as per IS 732-1989, IS 4648: 1968 and other relevant standards.

xiii) Stairs:
Contractor to provide service ladder made up of aluminum with load bearing capacity of at least 150 kg to access the roof for maintenance of communication equipment and water tank.

xiv) False Ceiling:
The control room shall be provided with false ceiling of 15 mm thick mineral fibre board, in tile form of size 600mm x 600mm, along with galvanised light gauge rolled form supporting system in double web construction pre painted with steel capping, of approved shade and colour, to give grid of maximum size of 1200x600 mm as per manufacturers details including supporting grid system, expansion fasteners for suspension arrangement from RCC, providing openings for AC ducts(if required), return air grills(if required), light fixtures, etc., all complete.

xv) Lighting

The lighting design of the buildings shall be carried out as per IS 3646-1992. The average illumination level of control room shall be 300 Lux with Mirror optics with anti-glare type or Decorative Mirror optics type of fixture. The building shall be provided with adequate light fittings, 5A/ 15A 1 phase sockets, fans etc. controlled by required ratings of MCBs and MCB DBs. All MCBs/ Isolators shall be mounted inside the panel and a bakelite/ fibre glass sheet shall be provided inside such that operating knobs project out of it for safe operation against accidental contact. Operating handle of incoming MCCB/ isolator shall project out of door. Wiring inside the panel shall be carried out with 1100V grade PVC insulated stranded copper conductors of adequate size.

All buildings and roads are to be provided with lighting system and light fittings. The provision of power supply system with switch and sockets is to be provided along the roads for maintenance work, if so required.

6.8 SPECIFICATION OF INVERTER ROOM

Inverters shall be housed in **Pre-fab inverter rooms or standard RCC framed structures of same dimensions with cable trench arrangement located in the PV array field (The use of pre-fab inverter rooms is subject to approval by NTPC).** The building shall be constructed as per National Building Code.
The foundation platform for the pre-fab structure shall be constructed with RCC and masonry works as per required dimensions. The Floor Finish Level of the inverter room shall be min. 450mm above surrounding Ground Level.
Cable trenches with GI cable trays shall be provided. Bottom of the trench shall be minimum 100mm above surrounding ground level.
Cladding system should be a weather tight building envelope, suitable for complete life of solar plant.
The layout of Inverter room shall be designed so as to divert the heat generated from each inverter outside the room. The inverter room shall be designed for a life of 25 years. The successful contractor shall have to get the structural design done as per the prevailing IS codes.
The structural design of inverter room of each identical type shall have to be proof checked by any IIT / NIT. The structure design shall have to be got approved from BHEL/NTPC, before actual start of the work.
i. Structure:
The steel structure of the Shelter shall be designed for loads and load combination as per Indian Standards (latest revisions) such as IS: 875, IS:1893, IS:800, IS:456 etc The steel shall be hot-dipped

galvanized with a minimum Z180 coating for load bearing applications and Z120 for non-load bearing applications.
Alternately, the steel hot-dipped in Alum/Zinc (with 55% Aluminium and 45% Zinc) can be also used. The applicable codes are ASTM A653 for galvanized and ASTM A792 for Galvalume/Zincalume.

ii. Fasteners:

Steel bolts, nuts and washers complying with AS 1112:2000. Self-drilling screws complying with AS 3566.1 and AS 3566.2 shall be used.

iii. Roof:

The roofing shall be double skin trapezoidal profile sheet of pre-painted 0.45 mm BMT (Base Metal Thickness) Hi Tensile Zincalume/Galvalume 0.5 TCT, confirming to IS:513 and ASTM A792M/AS1397. Stiffening ribs / subtle fluting for effective water shedding and special male/ female ends with full return legs on side laps for purlin support and anti-capillary flute in side lap shall be provided.
Both upper and lower sheets shall be separated through spacers and fastened through zinc /zinc-tin coated self-drilling screws. The fastener size shall be calculated as per the design or manufacturers recommendations.
Both sheets shall be sandwiched with an under insulation of 50mm thick glass wool of density 50 kg/m3 with aluminum foil backing and complete with gutters and down take pipes. Along with Flashing & Top cap of required size and color complete with all necessary hardware complete. Roof shall be projected at least 600 mm from the wall.

iv. Doors Frames

Door frames shall be of T-iron frame of mild steel Tee-sections as per DSR- 2007 item no 10.13. All doors shall be provided necessary fittings like hinges, handles, mortice locks, tower bolts, stopper, hydraulic door closer, magic eye (for main doors) etc of CP brass complete as detailed in tender drawing or submitted by contractor in shop drawing and approved by BHEL.
Black powder coated aluminium doors shall be with extruded built up standard tubular sections, appropriate Z sections and other sections of approved make conforming to IS: 733 and IS:1285, fixed to Pre-engineered structure including necessary filling up of gaps at junctions with required PVC/neoprene felt etc. including hinges / pivots and double action hydraulic floor spring of approved brand and manufacture IS:6315 marked, lock, handle and all necessary fittings.
The door entrance shall include Mild Steel single leaf door. The structural steel shall conform to IS: 7452 and IS: 2062. The holdfasts shall be made from steel flats (50 mm and 5 mm thick). The fixtures, fastenings and door latch are to be made with same materials.

v. Windows Frame:

Aluminium black powder coated section, frame shall be of 92x31 mm, minimum 16G thick as per approved design

vi. Ventilators

Aluminum black powder coated frame of minimum size 62x25 mm and 16G thick as per approved design. Suitable sunshades made out of approved colour sheet reinforced with Aluminium angle frame of minimum 35x35x4 mm size with soffit of same material will be provided to all external windows and door. The minimum projection for the sunshades will be 450 mm and 300mm wider than the width of the opening

vii. Plinth Protection:

750 wide plinth protection 50 mm thick of cement concrete 1:3:6 (1cement : 3 coarse sand : 6 graded stone aggregate 20 mm nominal size) over 75 mm bed of dry brick ballast 40 mm nominal size well rammed and consolidated and grouted with fine sand including finishing the top smooth, shall be provided around the Pre-Engineered Structure.

viii. Floor Finish

Flooring, including preparation of surface, cleaning etc shall be of cement concrete flooring as per IS 2571-1970 with ironite hardener. The inverter room floor shall be at least 450 mm above the ground level.

IX. Wall Cladding:

The walls shall be of double skinned trapezoidal profile sheet of pre-painted 0.45 mm BMT (Base Metal Thickness) Hi Tensile Zincalume/Galvalume 0.5 TCT, confirming to IS:513 and ASTM A792M/AS1397. The profile shall be trapezoidal.

Both the walls should be separated by spacers system made up of cold formed steel bars and fastened through zinc /zinc-tin coated self-drilling screws.

X. Wall Insulation:

All voids of external and internal metalled walls shall be filled with 50 mm thick Mineral glass Wool/rockwool insulation of density 50 kg/m3 covered with high strength meshless Aluminium foil with proper supports etc as approved.

XI. Painting

The exterior sheet (roof as well as wall) shall have total paint thickness of 25 micrometre comprising of 20 micrometre exterior coat of Super Durable Polyester (XRW) and 5 micrometer primers coats.

Other faces of sheets shall be painted with 10 micron polyester over 5 micrometre primer coats. The colour shade shall be subject to BHEL-BHEL/NTPC approval

XII. Lighting:

The inverter room shall be provided with electric light to achieve average illumination level of 75 Lux. However room should be designed to utilised maximum natural light during the day.

6.9 WATER WASHING ARRANGEMENT FOR MODULE CLEANING

Contractor shall provide permanent arrangement for module washing in the SPV Plant. This shall include installing tube well with pump and motor and laying network of GI pipe in each row of SPV panels. Opening from the GI pipe with manual isolating valves with nozzles should be provided at regular interval in each row of SPV panels. Contractor shall provide the single line diagram of water washing arrangement with location of pump to BHEL for approval.

Contractor shall make arrangement for water storage in the form of underground sumps or over-head tanks as required for module washing system as well as fire fighting facility.

6.10 DEWATERING/ SUMP PUMP AND DRAINAGE SYSTEM

Suitable water drainage system for module washing, rainy/ storm water along with sump pump(s) etc. (if required) is to be designed and constructed by the Contractor after approval of respective drawings and connection to discharge system as per applicable pollution norms and site requirement.

Brick or stone masonry shall be acceptable. Drainage philosophy based on site area levels and invert levels of drains shall be developed and document/drawings shall be submitted.

6.11 WATER STORAGE TANK

In addition to the tank provided for control room building etc, PVC water storage tank(s) of Sintex or equivalent make conforming to IS: 12701 of total capacity of minimum 10,000 litres (at each site) shall be provided with inlet & outlet valves, suitable pressure pumps (if required) & pipelines etc. for module washing and service water in building. The cumulative capacity for both sites will not be less than 20,000 litres. The tanks will be provided in two or more no., at each site of high impact strength and toughness, whether underground or on ground of reputed brand/ make & good quality so that at least one no. is available during cleaning/ maintenance.

6.12 AUXILIARY POWER REQUIREMENT

Permanent arrangement of auxiliary power supply will be in the scope of the Contractor. Contractor shall install compatible inverter and/ or transformer for auxiliary power requirements of lighting, water pump(s), Electronics equipments, switchgear panels etc. Lighting, electronic equipments and switchgear panels must have standby power source from DCDB fed source. Energy meter at each site shall also be provided in addition to the meters specified.

The complete scheme is to be designed and developed by the Contractor after approval of scheme from owner

6.13 PROJECT NAME BOARD

Display board at the entrance of the plant shall be provided at each site of size approx. 5ft. x 3ft with text as will be provided by owner. The board shall be of metallic sheet with iron stand pipes and painted to give a pleasant look.

6.14 FIELD QUALITY PLAN:

Approved FQP for civil works shall be strictly followed at site during the works. A reference copy attached as per Exhibit - 10. Details may change as per the requirements.

7.0 GENERAL REQUIREMENTS

7.1 SUBMISSION OF ENGINEERING DATA & DRAWINGS

The contractor shall submit the following Engineering drawings, data, design and engineering information (not limited to the list given below) in both soft copy (CD) and hard copy to NTPC and BHEL along with a "Master Drawing List (MDL)". Along with the LOA/PO, BHEL shall furnish the MDL along with the schedule for each drawing to the successful bidder. Contractor shall ensure compliance to this schedule.

1. SPV array and cable layout.
2. Module foundation
3. Main & service road with general drainage
4. Inverter room layout, CSS/conventional switchyards and CMCS building layout
5. 11 kV Switchyard
6. Power Evacuation system
7. Earthing
8. Lighting, water supply and drainage
9. Constructional details (Civil and Structural drawings) for Inverter room, CSS/conventional switchyards, CMCS building and the like.

Any other Engineering drawings, data, design and engineering information (whether specifically mentioned in the document or not) require to fulfill the stated scope of work shall be deemed to be included.

7.2 Fire protection & Fire fighting system

The SPV plant shall be equipped with suitable fire protection & fire fighting systems (at each site) for protection of entire equipment including switchyard & control room as per CEIG requirements. Contractor shall comply with recommendation of Tariff Advisory Committee to incurring minimal premium for insurance. The installation shall meet all applicable statutory requirements, safety regulations in terms of fire protection.

Contractor to provide following number of portable fire extinguisher

	DCP Type (ABC type) (10 Kg. Cap)	CO2 Type Hand 9 kg	Foam Type Hand 9 kg	Hand Portable pressurized Water C02
CMCS	1		1	1
Inverter Rooms	1	1	1	1
CSS and/or Switch yard area	2	1	1	1

Contractor to provide intelligent microprocessor based main fire alarm panel of modular construction complete with central processing unit, input and output modules, power supply module, supervision control and isolator modules with 10% spare provisions.

Fire detection alarm system shall include alarm initiating devices e.g. multisensor type smoke detectors and alarm notification Appliances (Audio device).

Multisensor type smoke detectors shall be provided for below false ceiling areas of control room and ACDB and/ or inverter room. One (01) sensor shall be provided for each 25 sqm of area.

Fire Alarm Control Panel Indication

(a)Alarm conditions shall be immediately displayed on the control panel. Alarm LED shall flash on the control panel until the alarm has been acknowledged. Once acknowledged the LED shall remain lit. A subsequent alarm received from another zone after acknowledgement shall illuminate the alarm LED and the panel display shall show the new alarm information.

(b)During an alarm condition, an alarm tone shall sound within the control panel until the alarm is acknowledged.

(c)If the audible alarm signals are silenced for any reason, they shall automatically resound if another zone is activated.

(d)All alarm signals shall be automatically "locked in" at the control panel until the operated device is returned to its normal condition and the control panel is manually reset.

7.3 MANDATORY SPARES & CONSUMABLES

Mandatory spares attached as per exhibit are those which are considered essential. Vendor shall furnish the itemized and total price for spares. All mandatory spares shall be delivered at site.
Contractor shall maintain the mandatory spares, consumables & various components of SPV plant for smooth running during O&M period. Contractor shall also replenish the consumed mandatory spares during the O&M period to maintain the stock as mentioned in Bid Proposal Sheet. The contractor shall also mention the source of supply.

7.4 TRIAL RUN

SPV Plant site shall be deemed to be successfully erected & commissioned after submission of relevant commissioning certificate from BHEL/NTPC.
During the trial operation, SPV plant shall perform trouble-free operation for cumulative 72 hours during which functionality of all plant components shall be demonstrated and the system shall be in Generating mode.

7.5 WARRANTY

The successful contractor shall provide a warranty covering all including mechanical structure, electrical works including PCU/inverters/maximum power point tracker unit/distribution boards/digital meters/switchgear and overall workmanship of the solar power plants/system against any manufacturing/design/installation defects for a period of five (5) years.
The warranty period shall commence from the date of successful completion of trial run as per clause No 7.4

7.6 INSURANCE

Contractor shall organize insurance for all the materials supplied by him. The insurance shall be

arranged for the materials supplied by the successful bidder for

a) The goods in transit
b) Storage, erection and commissioning

7.7 TAKING OVER

Upon successful completion of all the facilities pertaining to the scope of work**,** contractor shall approach the owner in writing for "final take over" of the plant. On receipt of such request, owner shall issue to the contractor a taking over certificate as a proof of the final acceptance of the system. Such certificate shall not relieve the Contractor of any of his obligations which otherwise survive, by the terms and conditions of the Contract after issuance of such certificate.

8.0 SPECIFICATION FOR OPERATION AND MAINTENANCE CONTRACT

The successful Contractor shall provide Operation and maintenance of SPV Plant along with grid connecting system for a period of one year form date of completion of trial run. During O&M period, BHEL/NTPC personnel shall have unrestricted entry to the Solar plant and Control Room any time. BHEL/NTPC may suitable depute its personals to associate with O&M activities. Contractor shall assist them in developing expertise through their day to day O&M activities. All records of maintenance must be maintained by the contractor which can be accessed by BHEL/NTPC on demand. These readings are to be handed over to BHEL/NTPC after the O&M period of contract. After O&M period, BHEL/NTPC may at its discretion decide to extend the existing O&M contract on mutually acceptable terms & conditions or undertake the O&M of the SPV Plant on its own.

The Contractor shall be responsible for supply of all spare parts, repairs/ replacement of any defective equipment(s) including civil works at his own cost as required from time to time during the O&M period.

The contractor shall be responsible for all the required activities for the successful running, optimum energy generation etc.

(a) Deputation of O&M, engineering and supporting personal.
(b) Ensure, successful running of SPV Plant for optimum energy generation.
(c) Safety and protection of the plant by deputing sufficient security personals
(d) Monitoring, controlling, troubleshooting, maintaining of records, registers.
(e) Supply of all spares, consumables and fixing / application of the same.
(f) Cleaning of the plant including array yard on regular basis and as and when required.
(g) Normal and preventive maintenance of the plant such as cleaning of module surface, tightening of all electrical connections, line accessories, transformers and associated switchgear on the HT side.
(h) Conducting periodical checking, testing, over hauling and preventive action.
(i) Submission of periodical reports to the owner on the energy generation & operating conditions of the SPV plant.
(j) BHEL/NTPC shall take only Fire & Allied Peril insurance during O&M period. All other type of insurance during O&M period shall be taken by the contractor.
(k) Daily work of the operators involves logging the voltage, current, power factor, power and energy output of the SPV plant, temperature, logging down individual array output data once a day
(l) The operator shall record monthly energy output of each array and transformer and reports shall be prepared on performance of SPV plant.
(m) The contractor shall at his own expense provide all amenities to his workmen as per applicable laws and rules.
(n) The Contractor shall ensure that all safety measures are taken at the site to avoid accidents to his employees or his Co-contractor's employees

(o) The Contractor shall immediately report the accidents, if any, to the Engineer In charge & to all the concerned authorities as per prevailing laws of the state.
(p) The Contractor shall comply with the provision of all relevant Acts of Central or State Governments including payment of Wages Act 1936, Minimum Wages Act 1948, Employer's Liability Act 1938, Workmen's Compensation Act 1923, Industrial Dispute Act 1947, Maturity Benefit Act 1961, Employees State Insurance Act 1948, Contract Labor (Regulations & Abolishment) Act 1970 or any modification thereof or any other law relating whereto and rules made there under from time to time.
(q) In order to ensure longevity, safety of the core equipment and optimum performance of the system the contractor should use only genuine spares of high quality standards.
(r) BHEL/NTPC may suitably depute its personals to associate with O&M activities. The contractor shall assist them in developing expertise through their day to day O&M activities. All records of maintenance and meter readings must be maintained by the contractor for use of BHEL/NTPC.
(s) Charges for Water, Electricity and data communication etc during O&M period shall be borne by the Contractor.

9.0 PERFORMANCE GUARANTEE (PG) TEST

This test shall be binding on both the parties of the Contract to determine compliance of the equipment with the functional guarantee (Excluding PV modules- BHEL supply). Any special equipment, instrumentation tools and tackles required for the successful completion of the Performance Guarantee Test shall be provided by the Contractor free of cost. The accuracy class of the instrumentation shall be as per the relevant clause of documents. The procedure for PG demonstration test shall be as follow:

1. A calibrated pyranometer shall be installed by the Contractor at the location mutually agreed by Contractor and BHEL/NTPC. The test report for the calibration shall be submitted by the Contractor for approval by BHEL/NTPC. The output of this pyranometer for three months of the PG test shall be made available at SCADA and shall be called "Measured average global solar radiation".
2. Actual energy exported from the plant supplied by the Contractor shall be noted for three consecutive months. For this purpose, the net energy exported at the 11 kV outgoing feeder(s) shall be taken into account.
3. This measured value of energy at step-2 shall be compared with "Base Generation" for the PG test – 14.10 Million units at 11 kV level.
4. "Base Generation" for a month is the quoted generation by BHEL to NTPC (14.10 MU). BHEL shall furnish the detailed procedure of PG test during detailed engineering to the successful bidder.

Following factors shall be considered for computing the "Base Generation"

a) Effect due to variation of meteorological parameters e.g. ambient temperature, wind speed, humidity etc shall not be considered.

b) Generation loss due to grid outage(or power evacuation system which is not in the scope of the Contractor): The measured global solar radiation of the period of the outage of the power evacuation system shall be excluded to calculate average global solar radiation for the period of PG test. However, if the grid outage or power evacuation system exceeds 07 days, then the PG test may be extended for that outage period at the discretion of owner. **In order to facilitate this SCADA shall log the Grid loss hours and corresponding solar energy (Wh) for computation of energy generation lost due to Grid loss hours. It is essential that the SCADA software must have built-in algorithm to convert solar radiation obtained from pyranometer in Watt/m2 to WattHour.**

Note: Contractor shall coordinate with BHEL team at site during PG test to conduct the complete procedure.

10.0 QUALITY ASSURANCE CHAPTERS

Following QA chapters are attached

a. 11 KV Switchyard equipment

b. Cabling & earthing, Lightning Protection

c. Pyranometer, anemometer, thermometers

d. LT Switchgear

e. LT Bus Duct

f. Power Conditioning Unit

g. SCADA

h. Power Transformers

i. LT Control cable

j. LT power cable

k. HT Cables

l. Civil Work

a. 11 kV Switchyard Equipments

Attributes / Characteristics Items/Components Sub Systems	Make, model, Type & Rating, Test Certificate	Routine & Acceptance Test as per IS / IEC	Functional requirement s as per NTPC Specificatio n
Circuit Breaker (IEC:62271-100)	Y	Y	Y
Interrupter & hollow insulator (IEC:233/ IS:5284)	Y	Y	Y
Isolator (IEC:62271-102)	Y	Y	Y
Current Transformer (IEC:60044)	Y	Y	Y
Voltage Transformer (IEC:)	Y	Y	Y
Bus Post Insulator (IEC:168 / 273 / IS:2544)	Y	Y	Y
Disc,Pin & String Insualtor (IEC:383 / IS:731)	Y	Y	Y
Surge Arrestor (IEC:99-4)	Y	Y	Y
Hardware fittings for Insulator (IS:2486 / BS:3288)	Y	Y	Y
Spacer Clamps & Connector (IS:10162 / 5561)	Y	Y	Y
Aluminium Tube (IS:5082 / 2673 / 2678)	Y	Y	Y
Conductor (IS:398)	Y	Y	Y
Galvanised Steel Structures (IS:2062/2629/4759/6745)	Y	Y	Y
Vibration Damper (IS:9708)	Y	Y	Y
Sag Compensating Spring DIN:2089/2096 IS:3195 / 7906	Y	Y	Y
Control & Relay Panel	Y	Y	Y
Leakage Current Analyser	Y	Y	Y
Protection Relays	Y	Y	Y
Tariff Metering System as per IEC 62052-11 & 62053-22 & IS 14697)	Y	Y	Y
Synchronising Trolly	Y	Y	Y
Relay Test Kit	Y	Y	Y
Surge Monitor	Y	Y	Y

Notes : 1) This is an indicative list of test/checks. The manufacture is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents during QP finalisation for all items.

2) All major Bought Out Items will be subject to NTPC approval.

b. CABLING, EARTHING, LIGHTNING PROTECTION

ATTRIBUTES / CHARACTERISTICS ITEMS/COMPONENTS / SUB SYSTEMS	Dimension	Paint shade, paint thickness, adhesion	Pre-treatment of sheet	IP protection	Proof load*	Surface finish	Deflection test*	HV & IR	Galvanise Test (If Applicable)	Functional	Bought out items/Bill of material	Routine tests as per relevant standard & specification	Acceptance tests as per relevant standard & specification	Constructional feature as per NTPC Specification
Wall Mounted-Lighting Panel (IS-513, IS:5, IS:2629, 2633, 6745)	Y	Y	Y	Y		Y		Y	Y	Y	Y	Y	Y	Y
Switch box/junction box/ Receptacles Panel (IS-513, IS:5, IS:2629, 2633, 6745)	Y	Y	Y	Y		Y		Y	Y	Y	Y	Y	Y	Y
Cable glands(BS-6121)	Y											Y		
Cable lug(IS-8309)	Y											Y		
Lighting wire(IS-694)	Y											Y		
Flexible conduits	Y											Y		Y
Conduits(Galvanise & Epoxy) IS-9537 & IS-2629,2633 ,6745	Y		Y								Y	Y		Y
RCC Hume Pipe (IS-458)												Y		
Cable termination & straight through joint (VDE-0278)	Y											Y		Y
Cable Trays, Flexible supports system & accessories IS-513, 2629,2633,6745	Y		Y		Y	Y	Y	Y	Y	Y		Y	Y	Y
Trefoil clamp	Y													Y
GI flats for earthing & lighting protection (IS 2062, 2629, 6745,2633)	Y		Y						Y			Y		Y
GI wire (IS-280)	Y											Y		
Fire Sealing System (BS – 476)												Y	Y	Y

Note:

1. This is an indicative list of tests /checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2.* Deflection Test on cable trays and Proof Load test on cable trays support system will be as per details given in the NTPC technical specification & approved MQP. The above acceptance tests shall be done only on one sample from each size of offered lot.
3. Make of all items will be subject to NTPC approval.

c. Pyranometer, anemometer, thermometers:

Routine test reports as per relevant standard

Calibration tests reports as per standard

Test report (TR): Should be supplied with the unit after all tests. The TR shall include detailed description of all parameters tested qualified and warranted.

d. LT SWITCHGEAR

(MCC, PCC, ACDB, DCDB, FUSE BOARDS, LOCAL PUSH BUTTON STATION, LOCAL MOTOR STARTERS)

ATTRIBUTES / CHARACTERIS-TICS **ITEMS/ COMPONENTS/ SUB SYSTEM ASSEMBLIY**	Make, Model, Type, Rating & TC	Dimensions & Finish	Electrical properties	Mechanical Properties	Chemical properties	Functional & Operational Features as per NTPC Spec.	Item to conform to relevant standards	Pretreatment as per IS 6005	Paint Shade, Adhesion, Thickness & Finish	Functional Checks	Milli-volt drop Test	IR – HV – IR Test	Degree of Protection Routine test as per NTPC spec	All Routine tests as per NTPC spec. & relevant std.
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	Y	Y	Y	Y			Y							
Air Circuit Breaker (IEC: 60947)	Y	Y				Y	Y			Y	Y			Y
Energy Meters (IS : 13010, 13779)	Y	Y				Y	Y			Y				Y
Power & Aux. Contactors (IEC : 60947)	Y	Y				Y	Y			Y				
Protection & Aux. Relays	Y	Y				Y	Y			Y				Y
Control & Selector Switches (IEC : 60947)	Y	Y				Y	Y			Y				
CT's & PT's (IS 2705 / 3156)	Y	Y					Y							Y
MCCB (IEC : 60947)	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 (IEC : 60947)	Y	Y				Y	Y			Y				
Control Terminal Blocks	Y	Y				Y	Y							

LT SWITCHGEAR

(MCC, PCC, ACDB, DCDB, FUSE BOARDS, LOCAL PUSH BUTTON STATION, LOCAL MOTOR STARTERS)

ATTRIBUTES / CHARACTERI S- TICS **ITEMS/ COMPONENT S/ SUB SYSTEM ASSEMBLIY**	Make, Model, Type, Rating & TC	Dimensions & Finish	Electrical properties	Mechanical Properties	Chemical properties	Functional & Operational Features as per NTPC Spec.	Item to conform to relevant Standards	Pretreatment as per IS 6005	Paint Shade, Adhesion, Thickness &	Functional Checks	Milli-volt drop Test	IR – HV – IR Test	Degree of Protection Routine test as per NTPC spec	All Routine tests as per NTPC spec. & relevant std.
Fuse (IS 13703)	Y	Y				Y	Y							
Control Transformer (IS : 12021)	Y	Y				Y	Y			Y				Y
Push Buttons (IS : 4794)	Y	Y				Y	Y			Y				
Transducer (IEC : 60688)	Y	Y				Y	Y			Y				Y
MCB (IS : 8828)	Y	Y				Y	Y			Y				
Breaker Handling Trolley	Y	Y				Y			Y	Y				Y
Synthetic Rubber Gasket	Y	Y		Y	Y		Y							
LT SWITCHGEAR (IS : 8623)	Y	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes:

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. Makes of all major Bought Out Items will be subject to NTPC approval.

e. LT BUSDUCT

ATTRIBUTES , CHARACTERISTICS ITEM, COMPONENTS, SUB SYSTEM ASSEMBLY	Dimension & Surface Finish	Make, Type, Rating & TC	Electrical Properties	Mechanical Properties	Chemical Properties	Item to conform to relevant IS	WPS Approval, Welder Qualification	Weld Quality Check (DP test & x-ray Test)	Paint Shade, Thickness, Adhesion & Finish	Tightness by Torque measurement	Electrical Clearances	Galvanizing Test as per IS 2629/ 2633/ 4759	IR – HV – IR Test	Phase Sequence Check	Degree of Protection routine test as per NTPC spec.
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	Y	Y		Y	Y										
Rubber Bellows (IS : 3400)	Y	Y		Y	Y										
Support Insulator	Y	Y	Y	Y											
Galvanized Structure & GI Earthing Flat (IS : 2629 / 2633 / 4749)	Y	Y				Y						Y			
Space Heater & Thermostat		Y	Y										Y		
LT Busduct (IS : 8623 PART 2)	Y	Y				Y	Y	Y	Y	Y	Y		Y	Y	Y

Notes:

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. Makes of all major Bought Out Items will be subject to NTPC approval.

f. PCU quality plan:

A) Bought out components & raw material checks, as per internal standards of the manufacturer

B) in-process checks, as per internal standards of the manufacturer

C) Routine tests as per following on the assembled PCU:

1) Function Test to demonstrate operation of its control system and the ability to be automatically synchronized and connected in parallel with a utility service, prior to its shipment.

2) Operation of all controls, protective and instrumentation (metering) circuits demonstrated by direct test if feasible or by simulation

3) Functional check on protection circuits for faults and isolation protection for utility service interface including calibration

4) Function testing of operation of start up , disconnect and shutdown controls including, stable operation of the PCU and response to control signals

5) Test to measure maximum power point tracking (MPPT) performance under varying outdoor conditions using a PV array / PV array simulator.

D) Following sample tests will be carried out on PCU:

Sample testing to include measurement of phase currents, efficiencies, harmonic content and power factor at 25, 50, 75 and 100% of the rated nominal power.

Test report (TR): Should be supplied with the unit after all tests as per approved quality plan. The TR shall include detailed description of all parameters tested qualified and warranted.

g. SCADA System

TESTS / ITEMS	Visual ®	GA, BOM ,Lay Out of components ®	Dimensions ®	Paint Shade/ Thickness/Adhesion	Component Rating/ Make / Type ®	Wiring ®	IR & HV ®	Review of TC for instruments/ Devices/ Recorders, Indicators/ Mosaic Items/	Accessibility of TBS/ Devices ®	Illumination ®	Functional Check for Control Element , Annunciation ®	Mimic ®	Test as per Std ® & (A)
1. SCADA Panel	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Note: **1) Detailed procedure of Environmental Stress Screening test shall be as per Quality Assurance Programme in General Technical Conditions**

2) This is an indicative list of test/ checks. The manufacturer is to furnish a detailed quality plan indicating the Practice and Procedure alongwith relevant supporting documents.

Y - Test Applicable , ® - Routine Test (A) - Acceptance Test

h. POWER TRANSFORMER

Attributes / Characteristics / Items/Components Sub Systems	Visual & Dimensional Checks	Mechanical properties	Electrical strength	Thermal properties	Chemical Composition	Compatibility with oil	NDT / DPT / MPI / UT	Ageing Test.	Voltage Ratio, Vector Group & Polarity, Magnetic	Make / Type / Rating / Model / TC / General Physical Inspection.	WPS & PQR	Routine Test as per relevant test	Routine Test
Tank, H.V. & L.V. Cable Box / Flange throat	Y	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 & Built Core	Y	Y	Y		Y	Y							
Bushing / Insulator (IS:2544 / 5621)	Y	Y								Y		Y	
Gasket	Y				Y	Y		Y				Y	
Transformer Oil												Y	
OLTC / Off-Circuit Tap Changer	Y									Y			Y
Core Coil Assembly & Pre-tanking	Y								Y				
Marshalling Box	Y	Y					Y					Y	
WTI, OTI, MOG, PRD, Breather, Terminal Connector, Bucholz Relay, Globe & Gate Valve,	Y									Y			
Welding (ASME Sect-IX)	Y										Y		
Complete Transformer (IS:2026/ IEC-60076)	Y												Y

Note: 1) This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

2) All major Bought out Items will be subject to NTPC approval.

i. **LT CONTROL CABLES** **1 Of 3**

(1.1 KV PVC Cables)

Attributes / Characteristics Item / Components / Sub System Assembly	Make, Rating, Type & TC	Dimension/surface finish	Mechanical Properties	Chemical Composition	Electrical Properties	Spark Test	Lay length / Sequence	Armour coverage, Cross over, looseness, Gap between two armour wire/strip	Sequential marking/surface finish /cable length	Tensile strength, elongation before & after ageing of insulation & outer sheath	Thermal Stability of insulation and outer sheath *	Anti ternite treatment on wooden drums	Constructional / requirement as per NTPC Spec.	Routine and acceptance test as per Relevant Standard and NTPC specification	FRLS Test
Copper Conductor (IS-8130)	Y	Y	Y	Y	Y										
PVC Compound (IS-5831)	Y		Y		Y					Y					
XLPE Compound(IS-7098 Part-I)	Y		Y		Y					Y					
FRLS PVC Compound(IS-5831) ASTM-D-2843/ IS 10810 (Part-58) IEC-60754 Part-I	Y		Y							Y					
Armour wire/strip (IS-3975)	Y	Y	Y												
Insulated Core		Y				Y					Y				
Laid up core		Y					Y								
PVC Inner sheath		Y													
Armouring		Y						Y							
Outer sheath		Y							Y	Y	Y				Y
Finish cable (IS-1554 & 7098 – Part-1) ASTM-D-2843/ IS 10810 (Part- - 58) IEC-60754 Part-I Swedish Chimney SS 4241475 for (F3 category) Flammability test IEC-60332 Part –3 Cat-B	Y	Y						Y	Y	Y	Y		Y	Y	Y
Wooden drum (IS-10418) / Steel drum		Y										Y			

Note: This is an indicative list of test/checks. The manufacturer is to furnish a detailed quality plan indicating the practice and procedure along with relevant supporting documents.

(1) Drum number (2) IS 1554 (3)Cable size, Voltage grade , Words " FRLS" & Screen Fault Current & duration at every 5 meter is to be embossed. Embossing shall be automatic, in line & marking shall be legible & indelible. (4) Sequential marking of length of cable in meter at every one meter is to be embossed / printed. Embossing / printing shall be progressive, automatic, in line & marking shall be legible & indelible

LT Control Cables 2 Of 3
(1.1 KV PVC Cables)

	ROUTINE TESTS **Routine tests shall be carried out on each drum of finished cables for all types & sizes.** **Following shall constitute routine tests:**	
1)	Conductor Resistance test	
2)	High voltage test at room temperature	
	ACCEPTANCE TESTS	
	Following Acceptance tests shall be carried out for each type and size of the cables on the cable drums selected at random as per sampling plan mentioned in IS: 1554 Part 1	
A)	**For Conductor**	
1)	Annealing test	For copper conductor only
2)	Resistance test	
B)	**For Armour Wires / Formed Wires (If applicable**)	
1)	Measurement of Dimensions	
2)	Tensile Tests	
3)	Elongation Test	
4)	Torsion Test	For Round wires only
5)	Wrapping Test	
6)	Resistance Test	
7)	Mass of Zinc coating test	For G S wires / Formed wires only
8)	Uniformity of Zinc coating	For G S wires / Formed wires only
9)	Adhesion test	For G S wires / Formed wires only
10)	Freedom from defects	
C)	**For PVC / PVC Sheath**	
1)	Test for thickness	
2)	Tensile strength & Elongation before ageing	
D)	**For completed cables**	
1)	Insulation resistance test (Volume resistivity method)	
2)	High voltage test at room temperature	
E)	**Following tests shall be carried out and only one sample shall be taken from each offered lot of all sizes for these tests:-**	
1)	Thermal stability test **on PVC insulation and outer sheath**	
2)	Oxygen index test **on outer sheath**	
3)	Smoke density rating test **on outer sheath as per ASTM –D 2843**	
4)	Acid gas generation test **on outer sheath as per IEC –60 754 (Part 1)**	

	LT Control Cables 3 Of 3 **(1.1 KV PVC Cables)**
F)	**Ageing test on PVC insulation and PVC outer sheath as per following**
	In case of regular manufacturers:- Samples as per relevant IS from every size per type of cable in the offered lot shall be testedfor tensile strength & elongation (before ageing). The values will be compared with corresponding values mentioned in the type test report accepted by NTPC. In case values of tensile strength & elongation (before ageing) are within + /- 15% of the type test reports then 1 sample per type of cable of offered lot will be put on accelerated ageing test. The accelerated ageing test procedure: sample to be put in air oven at temperature of 130^c +/- 2^c for 5 hours, tensile strength & elongation acceptance norms as per relevant IS.
	In case of new manufacturers / suppliers (supplying first time to NTPC through corporate contract):- Samples as per relevant IS from every size per type of cable in the offered lot shall be tested for tensile strength & elongation (before ageing). The values will be compared with corresponding values mentioned in the type test report accepted by NTPC. In case values of tensile strength & elongation (before ageing) are not within + /- 15% of the type test reports then sample from that particular cable size will be put on ageing test as per relevant IS. However not withstanding above condition, 1 sample per cable type of offered lot will be put on ageing test as per relevant IS.
G)	**Flammability test as per IEC 60332 - Part- 3 (Category- B) on completed cable as per following sampling plan.**
	The test shall be carried out on every size & type of control cable offered for inspection as an acceptance test. This test will be carried out using composite sampling i.e. irrespective of sizes of cables of a particular type, may be tested together as per calculations in line with the IEC (all sizes will be covered)
I)	**Following tests shall be carried on one length of each size of offered lot:**
	Surface finish, length measurement, sequence of cores, armour coverage, Gap between two consecutive armour wires / formed wires

j. LT Power Cables 1 Of 3

1.1 KV PVC & XLPE Cables

Attributes / Characteristics Item / Components / Sub System Assembly	Make, Rating, Type & TC	Dimension/surface finish	Mechanical Properties	Chemical Composition	Electrical Properties	Spark Test	Hot set test (XLPE)	Lay length / Sequence	Armour coverage, Cross over, looseness, Gap between two armour wire/strip	Sequential marking/surface finish /cable length	Tensile strength, elongation before & after ageing of insulation & outer sheath	Thermal Stability of insulation and outer sheath *	Anti ternite treatment on wooden drums	Constructional / requirement as per NTPC Spec.	Routine and acceptance test as per Relevant Standard and NTPC specification	FRLS Test
Aluminum (IS-8130)	Y	Y	Y	Y	Y											
PVC Compound (IS-5831)	Y		Y		Y						Y					
XLPE Compound(IS-7098 Part-I)	Y		Y		Y		Y				Y					
FRLS PVC Compound(IS-5831) ASTM-D-2843/ IS 10810 (Part-58) IEC-60754 Part-I	Y		Y								Y					
Armour wire/strip (IS-3975)	Y	Y	Y													
Insulated Core		Y				Y	Y					Y				
Laid up core		Y						Y								
PVC Inner sheath		Y														
Armouring		Y							Y							
Outer sheath		Y								Y	Y	Y				Y
Finish cable (IS-1554 & 7098 – Part-1) ASTM-D-2843/ IS 10810 (Part- - 58) IEC-60754 Part-I Swedish Chimney SS 4241475 for (F3 category) Flammability test IEC-60332 Part –3 Cat-B	Y	Y							Y	Y	Y	Y		Y	Y	Y
Wooden drum (IS-10418) / Steel drum		Y											Y			

Note: 1. This is an indicative list of test/checks. The manufacturer is to furnish a detailed quality plan indicating the practice and procedure along with relevant supporting documents.

2. Not applicable for XLPE insulation

(1) Drum number (2) IS 7098-Part II (3)Cable size, Voltage grade , Words " FRLS" & Screen Fault Current & duration at every 5 meter is to be embossed. Embossing shall be automatic, in line & marking shall be legible & indelible. (4) Sequential marking of length of cable in meter at every one meter is to be embossed / printed. Embossing / printing shall be progressive, automatic, in line & marking shall be legible & indelible

	ROUTINE TESTS **Routine tests shall be carried out on each drum of finished cables for all types & sizes.** **Following shall constitute routine tests:**
1)	Conductor Resistance test
2)	High voltage test at room temperature

	ACCEPTANCE TESTS	
	Following Acceptance tests shall be carried out for each type and size of the cables on the cable drums selected at random as per sampling plan mentioned in IS: 1554 Part 1 & IS 7098 Part-I	
A)	**For Conductor**	
1)	Annealing test	For copper conductor only
2)	Tensile test	For aluminium conductor only
3)	Wrapping test	For aluminium conductor only
4)	Resistance test	
B)	**For Armour Wires / Formed Wires (If applicable)**	
1)	Measurement of Dimensions	
2)	Tensile Tests	
3)	Elongation Test	
4)	Torsion Test	For Round wires only
5)	Wrapping Test	
6)	Resistance Test	
7)	Mass of Zinc coating test	For G S wires / Formed wires only
8)	Uniformity of Zinc coating	For G S wires / Formed wires only
9)	Adhesion test	For G S wires / Formed wires only
10)	Freedom from defects	
C)	**For PVC / XLPE insulation & PVC Sheath**	
1)	Test for thickness	
2)	Hot set test	For XLPE insulation only
3)	Tensile strength & Elongation before ageing	
D)	**For completed cables**	
1)	Insulation resistance test (Volume resistivity method)	
2)	High voltage test at room temperature	

1.1 KV PVC & XLPE Cables

E)	**Following tests shall be carried out and only one sample shall be taken from each offered lot of all sizes for these tests:-**
1)	Thermal stability test **on PVC insulation and outer sheath**
2)	Oxygen index test **on outer sheath**
3)	Smoke density rating test **on outer sheath as per ASTM –D 2843**
4)	Acid gas generation test **on outer sheath as per IEC –60 754 (Part 1)**
F)	**Ageing test on PVC insulation and PVC outer sheath as per following**
	In case of regular manufacturers:- Samples as per relevant IS from every size per type of cable in the offered lot shall be tested for tensile strength & elongation (before ageing). The values will be compared with corresponding values mentioned in the type test report accepted by NTPC. In case values of tensile strength & elongation (before ageing) are within + /- 15% of the type test reports then 1 sample per type of cable of offered lot will be put on accelerated ageing test. The accelerated ageing test procedure: sample to be put in air oven at temperature of 130^c +/- 2^c for 5 hours, tensile strength & elongation acceptance norms as per relevant IS. However in case the tensile strength and elongation values are not within +/- 15% of type test values then ageing test will be carried out on that particular size of cable of offered lot as per relevant IS.
	In case of new manufacturers / suppliers (supplying first time to NTPC through corporate contract):- Samples as per relevant IS from every size per type of cable in the offered lot shall be tested for tensile strength & elongation (before ageing). The values will be compared with corresponding values mentioned in the type test report accepted by NTPC. In case values of tensile strength & elongation (before ageing) are not within + /- 15% of the type test reports then sample from that particular cable size will be put on ageing test as per relevant IS. However not withstanding above condition, 1 sample per cable type of offered lot will be put on ageing test as per relevant IS.
G)	**Flammability test as per IEC 60332 - Part- 3 (Category- B) on completed cable as per following sampling plan.**
	The test shall be carried out on every size & type of control cable offered for inspection as an acceptance test. This test will be carried out using composite sampling i.e. irrespective of sizes of cables of a particular type, may be tested together as per calculations in line with the IEC (all sizes will be covered)
I)	**Following tests shall be carried on one length of each size of offered lot:**
	Surface finish, length measurement, sequence of cores, armour coverage, Gap between two consecutive armour wires / formed wires

k. HT Power Cables 1 Of 3

Attributes / Characteristics Item / Components / Sub System Assembly	Make, Type, Rating & T.C	Dimension/surface finish	Mechanial properties	Chemical Composition	Spark Test(as applicable)	Curing Properties	Electrical properties	Hot Set Test/ Eccentricity & Ovality	Lay length & Sequence	Armour coverage, cross over, looseness, gap between two wire	Sequential marking/surface finish/ cable length	T.S & elongation before & after ageing on outer sheath & insulation	Thermal seability on outer sheath	Metallic (Cu) Screening (If applicable)	Anti termite coating on wooden drums	Constructional requirements feature as per NTPC specification	Routine & Acceptance Test as per relevant standard & NTPC	FRLS Test
Aluminium (IS-8130)	Y	Y	Y	Y			Y											
Semiconducting Compound	Y		Y			Y	Y											
XLPE Compound (IS-7098 Part-II)	Y		Y			Y	Y					Y						
FRLS PVC Compound (IS-5831, ASTM-D2843, IS10810(Part 58) ,IEC-60754 Part-1)	Y		Y									Y	Y					Y
Triple Extrusion & 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			Y		Y
Power Cable (Finished) (IS : 7098 Part II, IEC : 60332 (Part 3 Cat. B), IS-5831, ASTM-D2843, IS10810(Part 58) , IEC-	Y								Y	Y	Y	Y	Y			Y	Y	Y
Wooden drum(IS-10418) /Steel Drum		Y													Y			

Notes:

3. **This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.**
4. **Make of all major Bought Out Items will be subject to NTPC approval.**
5. **(1) Drum number (2) IS 7098-Part II (3)Cable size, Voltage grade , Words " FRLS" & Screen Fault Current & duration at every 5 meter is to be embossed. Embossing shall be automatic, in line & marking shall be legible & indelible. (4) Sequential marking of length of cable in meter at every one meter is to be embossed / printed. Embossing / printing shall be progressive, automatic, in line & marking shall be legible & indelible**

ROUTINE TESTS

Routine tests shall be carried out on each drum of finished cables for all types & sizes. Following shall constitute routine tests:

1)	Conductor Resistance test
2)	High voltage test
3)	Partial discharge test **(for Screened cables only)**

ACCEPTANCE TESTS

Following Acceptance tests shall be carried out for each type and size of the cables on the cable drums selected at random as per sampling plan mentioned in IS: 7098 Part 1I

A)	**For Conductor**	
1)	Tensile Test	
2)	Wrapping Test	
3)	Resistance test	
B)	**For Armour Wires / Formed Wires (If applicable**)	
1)	Measurement of Dimensions	
2)	Tensile Tests	
3)	Elongation Test	
4)	Torsion Test	For Round wires only
5)	Wrapping Test	
6)	Resistance Test	
7)	Mass of Zinc coating test	For G S wires / Formed wires only
8)	Uniformity of Zinc coating	For G S wires / Formed wires only
9)	Adhesion test	For G S wires / Formed wires only
10)	Freedom from defects	
C)	**For XLPE insulation & PVC Sheath**	
1)	Test for thickness	
2)	Tensile strength & Elongation before ageing	
3)	**Hot set test**	**(For XLPE insulation)**
D)	**For completed cables**	
1)	Insulation resistance test (Volume resistivity method)	
2)	High voltage test	
3	Partial discharge test **(for Screened cables only**)	

E) **Following tests shall be carried out and only one sample shall be taken from each offered lot of all sizes for these tests:-**

1) Thermal stability test **on PVC insulation and outer sheath**
2) Oxygen index test **on outer sheath**
3) Smoke density rating test **on outer sheath as per ASTM –D 2843**
4) Acid gas generation test **on outer sheath as per IEC –60 754 (Part 1)**

F) **Ageing test on XLPE insulation and PVC outer sheath as per following: In case of regular manufacturers:-**

Samples as per relevant IS from every size per type of cable in the offered lot shall be tested for tensile strength & elongation (before ageing). The values will be compared with corresponding values mentioned in the type test report accepted by NTPC. In case values of tensile strength & elongation (before ageing) are within + /-
15% of the type test reports then 1 sample per type of cable of offered lot will be put on accelerated ageing test. The accelerated ageing test procedure: sample to be put in air oven at temperature of 130^c +/- 2^c for 5 hours, tensile strength & elongation acceptance norms as per relevant IS. However in case the tensile strength and elongation values are not within +/- 15% of type test values then ageing test will be carried out on that particular size of cable of offered lot as per relevant IS.

In case of new manufacturers / suppliers (supplying first time to NTPC through corporate contract):-

Samples as per relevant IS from every size per type of cable in the offered lot shall be tested for tensile strength & elongation (before ageing). The values will be compared with corresponding values mentioned in the type test report accepted by NTPC. In case values of tensile strength & elongation (before ageing) are not within
+ /- 15% of the type test reports then sample from that particular cable size will be put on ageing test as per relevant IS. However not withstanding above condition, 1 sample per cable type of offered lot will be put on ageing test as per relevant IS.

G) **Flammability test as per IEC 60332 – Part – 3 (Category – B) on completed cable as per following sampling plan.**

The test shall be carried out on 1 sample per type of cable offered irrespective of sizes offered as an acceptance test.

H) **Following tests shall be carried on one length of each size of offered lot:**

1) Surface finish, length measurement, sequence of cores, armour coverage, Gap between two consecutive armour wires / formed wires

2) Measurement of Eccentricity & Ovality

l. Civil Works

QUALITY ASSURANCE AND INSPECTION FOR CIVIL WORKS

INTRODUCTION

This part of the specification covers the sampling, testing and quality assurance requirement (including construction tolerances and acceptance criteria) for all civil and structural works covered in this specification.

This part of the technical specification shall be read in conjunction with other parts of the technical specifications, general technical requirements & erection conditions of the contract which covers common QA requirements. Wherever IS code or standards have been referred they shall be the latest revisions.

The rate for respective items of work or price shall include the cost for all works, activities, equipment, instrument, personnel, material etc. whatsoever associated to comply with sampling, testing and quality assurance requirement including construction tolerances and acceptance criteria and as specified in subsequent clauses of this part of the technical specifications. The QA and QC activities in all respects as specified in the technical specifications/ drawings / data sheets / quality plans / contract documents shall be carried out at no extra cost to the owner.

The contractor shall prepare detailed construction and erection methodology scheme which shall be compatible to the requirements of the desired progress of work execution, quality measures, prior approvals if any and the same shall be got approved by the Engineer. If required, work methodology may be revised/ reviewed at every stage of execution of work at site, to suit the site conditions by the contractor at no extra cost to the owner.

QA AND QC MANPOWER

The contractor shall nominate one overall QA coordinator for the contract detailing the name, designation, contact details and address at the time of post bid discussions. All correspondence related to Quality Assurance shall be addressed by the contractor's QA coordinator to BHEL and BHEL/NTPC. BHEL and BHEL/NTPC shall address all correspondence related to Quality issues to the contractor's QA coordinator. The contractor's QA coordinator shall be responsible for co-ordination of Quality activities between various divisions of the contractor and their sub-Contractors on one hand & with BHEL and BHEL/NTPC on the other hand.

The contractor shall appoint a dedicated, experienced and competent QA&QC in-charge at site, preferably directly reporting to the Project Manager, supported as necessary by experienced personnel, to ensure the effective implementation of the approved QAP. The contractor shall finalize and submit a deployment schedule of QA&QC personnel along with their details to BHEL and BHEL/NTPC for approval/ acceptance and further shall ensure their availability well before the start of the concern activity.

Contractor shall furnish the QA & QC manpower deployment schedule based on the quantum of work. It is essential to post qualified QA & QC man power at site so as to strictly monitor quality of works and also arrange for compliance.

SAMPLING AND TESTING OF CONSTRUCTION MATERIALS

The method of sampling for testing of construction materials and work / job samples shall be as per the relevant IS / standards / codes and in line with the requirements of the technical specifications /

quality plans. All samples shall be jointly drawn, signed and sealed wherever required, by the contractor and the engineer or his authorized representative.

The contractor shall carry out testing in accordance with the relevant IS / standards / codes and in line with the requirements of the technical specifications / quality plans. Where no specific testing procedure is mentioned, the tests shall be carried out as per the best prevalent engineering practices and to the directions of the Engineer. All testing shall be done in the presence of the engineer or his authorized representative in a NABL accredited / Govt. Laboratory acceptable to BHEL and BHEL/NTPC. This includes all IITs, NCB, CSMRS, reputed government / autonomous laboratories / organizations, NITs and other reputed testing laboratories. The test samples for such test shall be jointly selected and sealed by the engineer and thereafter these shall be sent to the concerned laboratory through the covering letter signed by BHEL and BHEL/NTPC engineer. The test report along with the recommendations shall be obtained from the laboratories without delay and submitted to BHEL and BHEL/NTPC.

Third Party Laboratory Testing: In case material test certificate are furnished for bought out items for civil works, these will be clearly correlated and be traceable with the batch no. and consignment note/ challans. Samples of bought out items shall be tested at third party lab if required by BHEL and/or NTPC. If contractors proposes to carry out testing of bought out items/ materials as per above, the same shall be done through the third party independent labs or any other lab acceptable to BHEL and NTPC.
Contractor shall carry out concrete mix design, test on aggregates, cement, admixtures, fly ash at BHEL/NTPC accepted laboratories as mentioned in the technical specification.
Sampling for testing building materials, all ingredients i.e. cement, coarse and fine aggregates, fly ash, water including admixtures required for concreting and other construction work shall be done for conducting tests as mentioned above.
Sampling shall be done jointly with FQA engineers of BHEL and NTPC. These shall be sealed and sent to the testing agency/laboratory,
Contractor shall submit all test reports along with their recommendations pertaining to mix design and suitability of use of building material, as mentioned above for BHEL and NTPC approval.

PURCHASE AND SERVICE
Structural steel supply in the scope of the contractor shall be procured from main steel producers like SAIL, TISCO, IISCO, RINL, Essar Steel, Ispat Industries, JSW Steel, Lloyds Steel, Jindal Steel & Power. In case of non-availability of some of the sections with main steel producers the contractor may propose to procure the sections from the re-rollers of the main steel producers, the name of such re-rollers will have to be cleared by corporate quality assurance of BHEL and BHEL/NTPC for which details such as BIS approval, main steel producer's approval, past experience for production of sections of specified material, details of machines plants testing facilities etc., Confirmation that the process control and manufacturing of steel sections by re-rollers shall be same as that of main steel producers, that billets for re-rolling will be sourced from main steel producers only shall be furnished with regards to re-roller.

Even after clearance of re-rollers, induction of billets with identified and correlated Mill test certificates (TC's) in the process of re-rolling, sampling of steel, quality checks thereof and stamping of final product for further identification and correlation with TC's prior to dispatch shall be the responsibility of the contractor and these shall be performed in presence of the authorized representative of the main Contractor.

Reinforcement steel supply in the scope of the contractor shall be procured from main steel producers like SAIL, TISCO, IISCO, RINL, Essar Steel, Ispat Industries, JSW Steel, Lloyds Steel, Jindal

Steel & Power, Jai Balaji Industries Ltd, Durgapur (for 8-40mm reinforcement steel) and mill test certificates (TC) is to be obtained and submitted to BHEL and BHEL/NTPC for co-relation. In case any size /diameter specified is not available with main steel producers and are proposed to be supplied from the conversion agent of the main steel producer the name of such conversion agent/ re-roller shall have to be approved by BHEL and BHEL/NTPC for which details such as BIS approval, Main steel producer's approval, Past experience for production of sections of specified material, details of machines, plants testing facilities etc., and confirmation that the process control and manufacturing of steel sections by re-rollers is the same as that of main steel producers, that billets for re-rolling are sourced from main steel producers only shall be furnished with regards to re-roller.

FIELD AND MANUFACTURING QUALITY PLAN

Well before the start of the work, the contractor shall prepare and submit the Field Quality Plans (FQP) on the format No. QS-01-QAI-P-09/F2-R1, and obtain approval of BHEL and BHEL/NTPC, which shall detail out for all the works, equipments, services, quality practices and procedures etc in line with the requirement of the technical specifications to be followed by the contractor at site. This FQP shall cover for all the items / activities covered in the contract / schedule of items required, right from material procurement to completion of the work at site. An Indicative Field Quality Plan for civil works is enclosed as exhibit for both civil works and also for structural steel works.

Contractor shall submit and finalize FQP in given BHEL/NTPC-format in line with the FQP enclosed at technical specification covering all the items indicating all the test including frequency of the tests **within 2 week from the date of PO.**

FQPs shall detail out all the quality procedures, practices and checks to be followed at the site right from the receipt of material to erection/construction stage of concern activity. Details of storage and preservation procedures/ fabrication/ erection/ installation/ construction/ finishing/ monitoring, field tests, acceptance tests procedures etc. shall be furnished in FQP for civil works and structural steel works in line with the technical specifications.

In the approved FQP and MQP, BHEL shall identify Customer Hold Points (CHP) beyond which work shall not proceed without the consent of BHEL in writing. No materials shall be dispatched from the Manufacturer's works before the is accepted subsequent to final inspection including verification of records of all previous tests and is authorized for dispatch by issue of Material Clearance/CHP.

LABORATORY AND FIELD TEST

Based on finalised work schedule and item wise quantum of work, and in line with the approved FQP, they shall submit a schedule of tests required to be conducted weekly and shall accordingly deploy the manpower, equipment and field laboratory facilities.

QA & QC LABORATORY SET-UP

Contractor shall set-up QA&QC laboratory at site, in line with the technical specification requirements and them functional. Contractor shall deploy the minimum no. of laboratory equipments required for Field QA&QC laboratory. An indicative list is given below. The required no. of sets of laboratory equipments and QA&QC manpower shall be deployed **at least 15 days prior** to start of the concern test/activity at site. Contractor shall undertake joint sampling of material with BHEL and BHEL/NTPC site FQAs for the tests proposed to be conducted at third party laboratory well in advance to ensure availability of test results/report well before the start of concern activity/work.

S.No.	EQUIPMENT	APPROXIMATE Nos.
1	Cube moulds for cement testing	12
2	Sieve shaker	1
3	Sieves for sand, coarse and fine aggregate	1 set for each

4	Sieves for coarse aggregates	1 set
5	Slump testing equipment	6 sets
6	Oven	5
7	Physical balance	1
8	Thermometer	4
9	Burret	2
10	Measuring cylinder	9
11	Measuring flask	3
12	Compression testing machine	1 set
13	Cube moulds for concrete	18
14	Mechanical weighing machine	1(100kg capacity)
15	Drum type concrete mixer (for trial mixes)	1

NOTE:

1. The equipments listed above are indicative and required to be mobilised as minimum requirement. Additional equipment, if any, required for successful completion of work shall be provided/ arranged by the contractor.
2. All test reports/ inspection reports have to be computerized and maintained on LAN with an access to the owner.
3. Based on the schedule, QA&QC work plan shall be finalized by the contractor and the same shall be submitted to the engineer-in-charge for acceptance/ approval. The finalized work plan shall be maintained on the computer to be accessed by the owner for database and day to day monitoring.

OTHER:

Contractor shall deploy mini batching plant having digitized recording system, which shall be calibrated with NABL/NPL traceable weights. The batching plant shall have the facility of obtaining the digitized output giving details of the various constituents (cement, aggregate, water, admixtures, fly ash etc.) in each batch of concrete being produced. Samples of concrete making materials and concrete shall be tested as per the provisions of technical specifications and field quality plan.

GENERAL QA REQUIREMENTS

The contractor shall ensure that the works, BOIs and services under the scope of contract whether manufactured or performed within contractor's works or at his sub-contractor's premises or at the BHEL/NTPC's site or at any other place of work are in accordance with the BHEL technical specification, applicable standards / codes, approved drawings / data sheets / quality plans and BOQ. All the works, BOIs and services shall be carried out as per the best prevalent engineering practices and to the directions of the Engineer.

Part-B
LIST OF EXHIBITS

Exhibits not shown here. Attached as per Annexure

PART- C

GENERAL TECHNICAL REQUIREMENTS

TABLE OF CONTENTS PART - C

GENERAL TECHNICAL REQUIREMENTS

1.0 INTRODUCTION

This part covers technical requirements which will form an integral part of the Contract. The following provisions shall supplement all the detailed technical requirements brought out in the Technical Specifications.

2.0 BRAND NAME

Whenever a material or article is specified or described by the name of a particular brand, manufacturer or Contractor, the specific item mentioned shall be understood to be indicative of the function and quality desired, and not restrictive; other manufacturer's products may be considered provided sufficient information is furnished to enable the Employer to determine that the products proposed are equivalent to those named.

3.0 BASE OFFER & ALTERNATE PROPOSALS

The Contractor's proposal shall be based upon the use of equipment and material complying fully with the requirements specified herein. It is recognized that the Contractor may have standardized on the use of certain components, materials, processes or procedures different than those specified herein. Alternate proposals offering similar equipment based on the manufacturer's standard practice may also be considered, provided the base offer is in line with technical specifications and such proposals meet the specified design standards and performance requirement and are acceptable to the Employer. Sufficient amount of information for justifying such proposals shall be furnished to Employer along with the bid to enable the Employer to determine the acceptability of these proposals.

4.0 COMPLETENESS OF FACILITIES

4.1 Contractors may note that this is a contract inclusive of the scope as indicated elsewhere in the specification. Each of the plant shall be engineered and designed in accordance with the specification requirement. All engineering and associated services are required to ensure that a completely engineered plant is provided.

4.2 All equipment furnished and works done by the Contractor shall be complete in every respect, with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or those needed for erection, completion and safe operation & maintenance of the equipment and for the safety of the operating personnel, as required by applicable codes, though they may not have been specifically detailed in the respective specifications, unless included in the list of exclusions.

All similar standard components/ parts of similar standard equipment provided shall be interchangeable with one another.

5.0 CODES & STANDARDS

5.1 In addition to the codes and standards specifically mentioned in the relevant technical specifications for the equipment / plant / system, all equipment parts, systems and works covered under this specification shall comply with all currently applicable statutory regulations and safety codes of the Republic of India as well as of the locality where they will be installed, including the following:

(a.) Bureau of Indian Standards (BIS)
(b.) Indian electricity act
(c.) Indian electricity rules
(d.) Indian Explosives Act
(e.) Indian Factories Act and State Factories Act
(f.) Indian Boiler Regulations (IBR)
(g.) Regulations of the Central Pollution Control Board, India
(h.) Regulations of the Ministry of Environment & Forest (MoEF), Government of India
(i.) Pollution Control Regulations of Department of Environment, Government of India

(j.) State Pollution Control Board.
(k.) Rules for Electrical installation by Tariff Advisory Committee (TAC).
(l.) Any other statutory codes / standards / regulations, as may be applicable.

5.2 Unless covered otherwise by Indian codes & standards and in case nothing to the contrary is specifically mentioned elsewhere in the specifications, the latest editions (as applicable as on date of bid opening), of the codes and standards given below shall also apply:
(a.) Japanese Industrial Standards (JIS)
(b.) American National Standards Institute (ANSI)
(c.) American Society of Testing and Materials (ASTM)
(d.) American Society of Mechanical Engineers (ASME)
(e.) American Petroleum Institute (API)
(f.) Standards of the Hydraulic Institute, U.S.A.
(g.) International Organization for Standardization (ISO)
(h.) Tubular Exchanger Manufacturer's Association (TEMA)
(i.) American Welding Society (AWS)
(j.) National Electrical Manufacturers Association (NEMA)
(k.) National Fire Protection Association (NFPA)
(l.) International Electro-Technical Commission (IEC)
(m.) Expansion Joint Manufacturers Association (EJMA)
(n.) Heat Exchange Institute (HEI)

5.3 Other International/ National standards such as DIN, VDI, BS, GOST etc. shall also be accepted for only material codes and manufacturing standards, subject to the Employer's approval, for which the Contractor shall furnish, along with the offer, adequate information to justify that these standards are equivalent or superior to the standards mentioned above. In all such cases the Contractor shall furnish specifically the variations and deviations from the standards mentioned elsewhere in the specification together with the complete word to word translation of the standard that is normally not published in English.

5.4 As regards highly standardized equipment such as Steam Turbine and Generator, National /International standards such as JIS, DIN, VDI, ISO, SEL, SEW, VDE, IEC & VGB shall also be considered as far as applicable for Design, Manufacturing and Testing of the respective equipment. In addition, these standards shall be referred for the design of machine foundations, wherever specifically mentioned in the specifications. However, for those of the above equipment not covered by these National / International standards, established and proven standards of manufacturers shall also be considered.

5.5 In the event of any conflict between the codes and standards referred to in the above clauses and the requirement of this specification, the requirement of Technical Specification shall govern.

5.6 Two (2) English language copies of all-national and international codes and/or standards which are not available with NTPC and same is used in the design of the plant, equipment, civil and structural works shall be provided by the Contractor to the Employer within two calendar months from the date of the Notification of Award.

5.7 In case of any change in codes, standards & regulations between the date of bid opening and the date when Contractors proceed with fabrication, the Employer shall have the option to incorporate the changed requirements or to retain the original standard. It shall be the responsibility of the Contractor to bring to the notice of the Employer such changes and advise Employer of the resulting effect.

6.0 EQUIPMENT FUNCTIONAL GUARANTEE

The functional guarantees of the equipment under the scope of the Contract is given elsewhere in the technical specification.

7.0 DESIGN OF FACILITIES/ MAINTENANCE & AVAILABILITY CONSIDERATIONS

7.1 Design of Facilities

All the design procedures, systems and components proposed shall have already been adequately developed and shall have demonstrated good reliability under similar conditions elsewhere.

The Contractor shall be responsible for the selection and design of appropriate equipment to provide the best coordinated performance of the entire system. The basic requirements are detailed out in various clauses of the Technical Specifications. The design of various components, assemblies and subassemblies shall be done so that it facilitates easy field assembly and dismantling. All the rotating components shall be so selected that the natural frequency of the complete unit is not critical or close to the operating range of the unit.

7.2 Maintenance and Availability Considerations

Equipment/facilities offered shall be designed for high availability, low maintenance and ease of maintenance. The Contractor shall specifically state the design features incorporated to achieve high degree of reliability/ availability and ease of maintenance. The Contractor shall also furnish details of availability records in the reference plants stated in his experience list.

Contractor shall state in his offer the various maintenance intervals, spare parts and man-hour requirement during such operation. The intervals for each type of maintenance namely the minor and major overhauls shall be specified in terms of fired hours, clearly defining the spare parts and man- hour requirement for each stage.

Lifting devices i.e. hoists and chain pulley jacks, etc. shall be provided by the contractor for handling of any equipment or any of its part having weight in excess of 500 kgs during erection and maintenance activities.

Lifting devices like lifting tackles, slings, etc. to be connected to hook of the hoist / crane shall be provided by the contractor for lifting the equipment and accessories covered under the specification.

8.0 DOCUMENTS, DATA AND DRAWINGS TO BE FURNISHED BY CONTRACTOR

8.1 Contractors may note that this is a contract inclusive of the scope as indicated elsewhere in the specification. Each of the plant and equipment shall be fully integrated, engineered and designed to perform in accordance with the technical specification. All engineering and technical services required ensuring a completely engineered plant shall be provided in respect of mechanical, electrical, control & instrumentation, civil & structural works as per the scope.

8.2 The Contractor shall furnish engineering data/drgs. for entire equipment covered under this specification in accordance with the schedule of information as specified in Technical Specification and Data sheets.. This documentation shall include but not be limited to the following:

8.2.1 INSTRUCTION MANUALS

The Contractor shall submit to the Employer, draft Instruction Manuals for all the equipment covered under the Contract by the end of one year from the date of his acceptance of the Letter of Award. The Instruction manuals shall contain full details required for erection, commissioning, operation and maintenance of each equipment. The manual shall be specifically compiled for this project. After finalization and approval of the Employer the Instruction Manuals shall be submitted. The Contract shall not be considered to be completed for purposes of taking over until the final Instructions manuals have been supplied to the Employer. The Instruction Manuals shall comprise of the following.

(a.) Erection & Commissioning Manuals/Checklists

The erection & Commissioning Manuals/Checklists shall be submitted at least three (3) months prior to the commencement of erection activities of particular equipment/system. The erection manual should contain the following as a minimum.

a) Erection strategy.

b) Sequence of erection.

c) Erection instructions.

d) Critical checks and permissible deviation/tolerances.
e) List of tool, tackles, heavy equipment like cranes, dozers, etc.
f) Bill of Materials
g) Procedure for erection.
h) General safety procedures to followed during erection/installation.
i) Procedure for initial checking after erection.
j) Procedure for testing and acceptance norms.
k) Procedure / Check list for pre-commissioning activities.
l) Procedure / Check list for commissioning of the system.
m) Safety precautions to be followed in electrical supply distribution during erection

(b.) Operation & Maintenance Manuals

i) The operating and maintenance instructions together with drawings (other than shop drawings) of the equipment, as completed, shall be in sufficient detail to enable the Employer to operate, maintain, dismantle, reassemble and adjust all parts of the equipment. They shall give a step by step procedure for all operations likely to be carried out during the life of the plant / equipment including, operation, maintenance, dismantling and repair including periodical activities such as chemical cleaning of the generator. Each manual shall also include a complete set of drawings together with performance/rating curves of the equipment and test certificates wherever applicable. The contract shall not be considered to be completed for purposes for taking over until these manuals have been supplied to the Employer.
ii) If after the commissioning and initial operation of the plant, the manuals require any modification / additions / changes, the same shall be incorporated and the updated final instruction manuals shall be submitted to the Employer for records.
iii) A separate section of the manual shall be for each size/ type of equipment and shall contain a detailed description of construction and operation, together with all relevant pamphlets and drawings.
iv) The manuals shall include the following:

a) List of spare parts along with their drawing and catalogues and procedure for ordering spares.
b) Lubrication Schedule including charts showing lubrication checking, testing and replacement procedure to be carried daily, weekly, monthly & at longer intervals to ensure trouble free operation.
c) Where applicable, fault location charts shall be included to facilitate finding the cause of maloperation or break down.

v) Detailed specifications for all the consumables including lubricant oils, greases, and chemicals etc. system/equipment/assembly/subassembly - wise required for the complete plant.
vi)On completion of erection, a complete list of bearings / equipment giving their location, and identification marks etc. shall also be furnished to the Employer indicating lubrication method for each type/category of bearing.

8.2.2 Project Completion Report

The Contractor shall submit a Project Completion Report at the time of handing over the plant. After final acceptance of individual equipment /system by BHEL the Contractor will update all original drawings and documents for the equipment/ system to "as built" conditions and submit.

8.3 ENGINEERING INFORMATION SUBMISSION SCHEDULE

Prior to the award of Contract, a Detailed Engineering Information Submission Schedule shall be tied up with the Employer. For this, the Contractor shall furnish a detailed list of engineering information along with the proposed submission schedule. This list would be a comprehensive one including all engineering data / drawings / information for all bought out items and manufactured items. The information shall be categorised into the following parts.
(a.) Information that shall be submitted for the approval of the Employer before proceeding further, and
(b.) Information that would be submitted for Employer's information only.
The Engineering Information Schedule shall be updated month-wise.

The schedule should allow adequate time for proper review and incorporation of changes/ modifications, if any, to meet the contract without affecting the equipment delivery schedule and overall project schedule. The early submission of drawings and data is as important as the manufacture and delivery of equipment and hardware and this shall be duly considered while determining the overall performance and progress.

8.4 ENGINEERING PROGRESS AND EXCEPTION REPORT

8.4.1 Report giving the status of each engineering information including

(a.) A list of drawings/engineering information which remains unapproved for more than four (4) weeks after the date of first submission

(b.) Drawings which were not submitted as per agreed schedule.

8.4.2 The draft format for this report shall be furnished to the Employer within four (4) weeks of the award of the contract, which shall then be discussed and finalised with the Employer.

8.5 TECHNICAL CO-ORDINATION MEETING

The Contractor shall organize and attend at least one monthly progress Meetings with the Employer/Employer's representatives during the period of Contract at mutually agreed venues for review of progress & resolving technical clarifications, if any. The Contractor shall attend such meetings at his own cost and fully co-operate with such persons and agencies involved during the discussions.

The Contractor shall ensure availability of the concerned experts / consultants/ personnel who are empowered to take necessary decisions during these meetings. The Contractor shall be equipped with necessary tools and facilities so that, if required, the drawings/documents can be resubmitted after incorporating necessary changes and approved during the meeting itself.

The Contractor shall furnish monthly progress report to the Employer detailing out the progress achieved on all erection activities as compared to the schedules. This shall be supplemented by printed colour photographs and video in VCD/DVD indicating various stages of erection and the progress of the work done at Site. The report shall also indicate the reasons for the variance between the scheduled and actual progress and the action proposed for corrective measures, wherever necessary.

8.6 **DESIGN IMPROVEMENTS**

The Employer or the Contractor may propose changes in the specification of the equipment or quality thereof and if the parties agree upon any such changes the specification shall be modified accordingly.

If any such agreed upon change is such that it affects the price and schedule of completion, the parties shall agree in writing as to the extent of any changing the price and/or schedule of completion before the Contractor proceeds with the change. Following such agreement, the provision thereof, shall be deemed to have been amended accordingly.

8.7 **EQUIPMENT BASES**

A cast iron or welded steel base plate shall be provided for all rotating equipment which is to be installed on a concrete base, unless otherwise specifically agreed to by the Employer. Each base plate which support the unit and its drive assembly, shall be of a neat design with pads for anchoring the units, shall have a raised lip all around, and shall have threaded drain connections.

8.8 **PROTECTIVE GUARDS**

Suitable guards shall be provided for protection of personnel on all exposed rotating and/or moving machine parts. All such guards shall be designed for easy installation and removal for maintenance purpose.

8.9 **LUBRICANTS, SERVO FLUIDS AND CHEMICALS (WHERE EVER APPLICABLE)**

The Contractor’s scope includes all the first fill and one year’s topping, requirements of consumables such as oils, lubricants including grease, servo fluids, gases and essential chemicals etc. Consumption of all these consumables during the initial operation and final filling after the initial operation shall also be included in the scope of the Contractor.

8.9.1 As far as possible lubricants marketed by reputed companies shall be used. The variety of lubricants shall be kept to a minimum possible. Detailed specifications for the lubricating oil, grease, gases, servo fluids, control fluids, chemicals etc. required for the complete plant covered

herein shall be furnished. On completion of erection, a complete list of bearings/ equipment giving their location and identification marks shall be furnished to the Employer alongwith lubrication requirements.

8.9.2 Lubrication Equipment shall be lubricated by systems designed for continuous operation. Lubricant level indicators shall be furnished and marked to indicate proper levels under both standstill and operating conditions.

8.10 **Material of Construction**

All materials used for the construction of the equipment shall be new and shall be in accordance with the requirements of this specification. Materials utilised for various components shall be those which have established themselves for use in such applications.

8.11 **RATING PLATES, NAME PLATES & LABELS**

8.11.1 Each main and auxiliary item of plant including instruments shall have permanently attached to it in a conspicuous position, a rating plate of noncorrosive material upon which shall be engraved manufacturer's name, equipment, type or serial number together with details of the ratings, service conditions under which the item of plant in question has been designed to operate, and such diagram plates as may be required by the Employer.

8.11.2 Such nameplates or labels shall be of white non-hygroscopic material with engraved black lettering or alternately, in the case of indoor circuit breakers, starters, etc. of transparent plastic material with suitably coloured lettering engraved on the back. The name plates shall be suitably fixed on both front and rear sides.

8.11.3 Hanger/ support numbers shall be marked on all pipe supports, anchors, hangers, snubbers and restraint assemblies. Each constant and variable spring support shall also have stamped upon it the designed hot and cold load which it is intended to support. Suitable scale shall also be provided to indicate load on support/hanger.

8.11.4 Nameplates shall be as per best practices of the industry

8.11.5 All such plates, instruction plates, etc. shall be bilingual with Hindi inscription first, followed by English. Alternatively, two separate plates one with Hindi and the other with English inscriptions may be provided.

8.11.6 All segregated phases of conductors or bus ducts, indoor or outdoor, shall be provided with coloured phase plates to clearly identify the phase of the system

8.12 **TOOLS AND TACKLES**

The Contractor shall supply with the equipment one complete set of all special tools and tackles and other instruments required for the erection, assembly, disassembly and proper maintenance of the plant and equipment and systems (including software). These special tools will also include special material handling equipment, jigs and fixtures for maintenance and calibration / readjustment, checking and measurement aids etc. A list of such tools and tackles shall be submitted by the Contractor alongwith the offer.

The price of each tool / tackle shall be deemed to have been included in the total bid price. These tools and tackles shall be separately packed and sent to site. The Contractor shall also ensure that these tools and tackles are not used by him during erection, commissioning and initial tackles. All the tools and tackles shall be of reputed make acceptable to the Employer.

8.13 **Welding**

If the manufacturer has special requirements relating to the welding procedures for welds at the terminals of the equipment to be per formed by others the requirements shall be submitted to the Employer in advance of commencement of erection work.

8.14 **COLOUR CODE FOR ALL EQUIPMENTS/ PIPINGS/ PIPE SERVICES**

All equipment/ piping/ pipe services are to be painted by the Contractor in accordance with Employer's standard colour coding scheme, which will be furnished to the Contractor during detailed engineering stage.

8.15 **PROTECTION AND PRESERVATIVE SHOP COATING**

8.16 **PROTECTION**

All coated surfaces shall be protected against abrasion, impact, discoloration and any other damages. All exposed threaded portions shall be suitably protected with either metallic or a non-metallic protection device. All ends of all valves and pipings and conduit equipment connections shall be properly sealed with suitable devices to protect them from damage. The parts which are likely to get rusted, due to exposure to weather, should also be properly treated and protected in a suitable manner. All primers/paints/coatings shall take into account the hot humid, corrosive & alkaline, subsoil or over ground environment as the case may be.

8.17 **Preservative Shop Coating**

All exposed metallic surfaces subject to corrosion shall be protected by shop application of suitable coatings. All surfaces which will not be easily accessible after the shop assembly, shall be treated beforehand and protected for the life of the equipment. All surfaces shall be thoroughly cleaned of all mill scales, oxides and other coatings and prepared in the shop. The surfaces that are to be finish-painted after installation or require corrosion protection until installation, shall be shop painted with at least two coats of primer.

Transformers and other electrical equipment if included shall be shop finished with one or more coats of primer and two coats of high grade resistance enamel. The finished colours shall be as per manufacturer's standards, to be selected and specified by the Employer at a later date.

Shop primer for all steel surfaces which will be exposed to operating temperature below 95 degrees Celsius shall be selected by the Contractor after obtaining specific approval of the Employer regarding the quality of primer proposed to be applied. Special high temperature primer shall be used on surfaces exposed to temperature higher than 95 degrees Celsius and such primer shall also be subject to the approval of the Employer.

All other steel surfaces which are not to be painted shall be coated with suitable rust preventive compound subject to the approval of the Employer.

All piping shall be cleaned after shop assembly by shot blasting or other means approved by the Employer. Lube oil piping or carbon steel shall be pickled.

Painting for Civil structures shall be done as per relevant part of technical specification.

9.0 QUALITY ASSURANCE PROGRAMME

9.1 The Contractor shall adopt suitable quality assurance programme to ensure that the equipment and services under the scope of contract whether manufactured or performed within the Contractor's works or at his sub-contractor's premises or at the Employer's site or at any other place of work are in accordance with the specifications. Such programmes shall be outlined by the Contractor and shall be finally accepted by the Employer/authorised representative after discussions before the award of the contract. The QA programme shall be generally in line with IS/ISO-9001.A quality assurance programme of the contractor shall generally cover the following:

9.2

(a) His organisation structure for the management and implementation of the proposed quality assurance programme

(b) Quality System Manual

(c) Design Control System

(d) Documentation and Data Control System

(e) Qualification data for Contractor's key personnel.

(f) The procedure for purchase of materials, parts, components and selection of sub-contractor's services including Contractor analysis, source inspection, incoming raw-material inspection, verification of materials purchased etc.

(g) System for shop manufacturing and site erection controls including process, fabrication and assembly.

(h) Control of non-conforming items and system for corrective actions and resolution of deviations.

(i) Inspection and test procedure both for manufacture and field activities.

(j) Control of calibration and testing of measuring testing equipment.

(k) System for Quality Audits.
(l) System for identification and appraisal of inspection status.
(m) System for authorising release of manufactured product to the Employer.
(n) System for handling, storage and delivery.
(o) System for maintenance of records, and
(p) Quality plans for manufacturing and field activities detailing out the specific quality control procedure adopted for controlling the quality characteristics relevant to each item of equipment/component.

9.3 GENERAL REQUIREMENTS - QUALITY ASSURANCE (IF ONLY APPLICABLE)

9.3.1 All materials, components and equipment covered under this specification shall be procured, manufactured, erected, commissioned and tested at all the stages, as per a comprehensive Quality Assurance Programme. An indicative programme of inspection/tests to be carried out by the contractor for some of the major items is given in the respective technical specification. This is, however, not intended to form a comprehensive programme as it is the contractor's responsibility to draw up and implement such programme duly approved by the Employer. The detailed Quality Plans for manufacturing and field activities shall be drawn up by the Contractor and will be submitted to Employer for approval. Schedule of finalisation of such quality plans will be finalised before award on enclosed format No. QS-01-QAI-P-01/F3. Monthly progress reports on MQP/FQP submission/approval shall be furnished on enclosed format No. QS-01-QAI-P-02/F1

9.3.2 Manufacturing Quality Plan will detail out for all the components and equipment, various tests/inspection, to be carried out as per the requirements of this specification and standards mentioned therein and quality practices and procedures followed by Contractor's/ Subcontractor's/ sub-supplier's Quality Control Organisation, the relevant reference documents and standards, acceptance norms, inspection documents raised etc., during all stages of materials procurement, manufacture, assembly and final testing/performance testing. The Quality Plan shall be submitted on electronic media e.g. floppy or E-mail in addition to hard copy, for review and approval. After approval the same shall be submitted in compiled form on CD-ROM.

9.3.3 Field Quality Plans will detail out for all the equipment, the quality practices and procedures etc. to be followed by the Contractor's "Site Quality Control Organisation", during various stages of site activities starting from receipt of materials/equipment at site.

9.3.4 The Contractor shall also furnish copies of the reference documents/plant standards/acceptance norms/tests and inspection procedure etc., as referred in Quality Plans along with Quality Plans. These Quality Plans and reference documents/standards etc. will be subject to Employer's approval without which manufacturer shall not proceed. These approved documents shall form a part of the contract. In these approved Quality Plans, Employer shall identify customer hold points (CHP), i.e. test/checks which shall be carried out in presence of the Employer's Project Manager or his authorised representative and beyond which the work will not proceed without consent of Employer in writing. All deviations to this specification, approved quality plans and applicable standards must be documented and referred to Employer along with technical justification for approval and dispositioning.

9.3.5 No material shall be dispatched from the manufacturer's works before the same is accepted, subsequent to predispatch final inspection including verification of records of all previous tests/inspections by Employer's Project Manager/Authorised representative and duly authorised for dispatch by issuance of Material Despatch Clearance Certificate (MDCC).

9.3.6 All material used for equipment manufacture including casting and forging etc. shall be of tested quality as per relevant codes/standards. Details of results of the tests conducted to determine the mechanical properties; chemical analysis and details of heat treatment procedure recommended and actually followed shall be recorded on certificates and time temperature chart. Tests shall be carried out as per applicable material standards and/or agreed details.

9.3.7 The contractor shall submit to the Employer Field Welding Schedule for field welding activities in the enclosed format No.: QS-01-CQA-W-11/F1. The field welding schedule shall be submitted to the

Employer along with all supporting documents, like welding procedures, heat treatment procedures, NDT procedures etc. at least ninety days before schedule start of erection work at site.

9.3.8 All welding and brazing shall be carried out as per procedure drawn and qualified in accordance with requirements of ASME Section IX/BS-4870 or other International equivalent standard acceptable to the Employer. All welding/brazing procedures shall be submitted to the Employer or its authorised representative for approval prior to carrying out the welding/brazing.

9.3.9 All brazers, welders and welding operators employed on any part of the contract either in Contractor's/ sub-contractor's works or at site or elsewhere shall be qualified as per ASME Section-IX or BS-4871 or other equivalent International Standards acceptable to the Employer.

9.3.10 Welding procedure qualification & Welder qualification test results shall be furnished to the Employer for approval. However, where required by the Employer, tests shall be conducted in presence of Employer/authorised representative.

9.3.11 For all pressure parts and high pressure piping welding, the latest applicable requirements of the IBR (Indian Boiler Regulations) shall also be essentially complied with. Similarly, any other statutory requirements for the equipment/systems shall also be complied with. On all back-gauged welds MPI/LPI shall be carried before seal welding.

9.3.12 Unless otherwise proven and specifically agreed with the Employer, welding of dissimilar materials and high alloy materials shall be carried out at shop only.

9.3.13 No welding shall be carried out on cast iron components for repair.

9.3.14 All the heat treatment results shall be recorded on time temperature charts and verified with recommended regimes.

9.3.15 All non-destructive examination shall be performed in accordance with written procedures as per International Standards, The NDT operator shall be qualified as per SNT-TC-IA (of the American Society of non-destructive examination). NDT shall be recorded in a report, which includes details of methods and equipment used, result/evaluation, job data and identification of personnel employed and details of co-relation of the test report with the job.

All plates of thickness above 40mm & all bar stock/Forging above 40mm dia shall be ultrasonically tested. For pressure parts, plate of thickness equal to or above 25mm shall be ultrasonically tested.

9.3.16 The Contractor shall list out all major items/ equipment/ components to be manufactured in house as well as procured from sub-contractors (BOI).

All the sub-contractor proposed by the Contractor for procurement of major bought out items including castings, forging, semi-finished and finished components/equipment etc., list of which shall be drawn up by the Contractor and finalised with the Employer, shall be subject to Employer's approval on enclosed format No. QS-01-QAI-P-01/F3. The contractor's proposal shall include Contractor's facilities established at the respective works, the process capability, process stabilization, QC systems followed, experience list, etc. along with his own technical evaluation for identified sub-contractors enclosed and shall be submitted to the Employer for approval within the period agreed at the time of pre awards discussion and identified in "DR" category prior to any procurement. Monthly progress reports on sub-contractor detail submission / approval shall be furnished on enclosed on format no. QS- 01-QAI-P-02/F2. Such Contractor approval shall not relieve the contractor from any obligation, duty or responsibility under the contract.

9.3.17 For components/equipment procured by the contractors for the purpose of the contract, after obtaining the written approval of the Employer, the contractor's purchase specifications and inquiries shall call for quality plans to be submitted by the suppliers. The quality plans called for from the sub-contractor shall set out, during the various stages of manufacture and installation, the quality practices and procedures followed by the Contractor's quality control organisation, the relevant reference documents/standards used, acceptance level, inspection of documentation raised, etc. Such quality plans of the successful Contractors shall be finalised with the Employer and such approved Quality Plans shall form a part of the purchase order/contract between the Contractor and sub-contractor. Within three weeks of the release of the purchase orders /contracts for such bought out items /components, a copy of

the same without price details but together with the detailed purchase specifications, quality plans and delivery conditions shall be furnished to the Employer on the monthly basis by the Contractor along with a report of the Purchase Order placed so far for the contract. **

9.3.18 Employer reserves the right to carry out quality audit and quality surveillance of the systems and procedures of the Contractor's or their sub-contractor's quality management and control activities. The contractor shall provide all necessary assistance to enable the Employer carry out such audit and surveillance.

9.3.19 The contractor shall carry out an inspection and testing programme during manufacture in his work and that of his sub-contractor's and at site to ensure the mechanical accuracy of components, compliance with drawings, conformance to functional and performance requirements, identity and acceptability of all materials parts and equipment. Contractor 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.

9.3.20 Quality audit/surveillance/approval of the results of the tests and inspection will not, however, prejudice the right of the Employer to reject he 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 Contractor in ensuring complete conformance of the materials/equipment supplied to relevant specification, standard, data sheets, drawings, etc.

9.3.21 For all spares and replacement items, the quality requirements as agreed for the main equipment supply shall be applicable.

9.3.22 Repair/rectification procedures to be adopted to make the job acceptable shall be subject to the approval of the Employer/ authorised representative.

9.3.23 Burn in and Elevated Temperature Test Requirement for Electronics Solid State Equipment

(a.) All solid state electronic systems/equipment shall be tested as a complete system/equipment with all devices connected for a minimum of 168 hours (7 Days) continuously under energized conditions prior to shipment from manufacturing works, as per the following cycle.

(1.) Elevated Temperature Test Cycle

During the elevated temperature test which shall be for 48 hours of the total 168 hours of testing, the ambient temperature shall be maintained at 50 deg. C. The equipment shall be interconnected with devices which will cause it to repeatedly perform all operations it is expected to perform in actual service with load on various components being equal to those which will be experienced in actual service.

During the elevated temperature test the cubicle doors shall be closed (or shall be in the position same as they are supposed to be in the field) and inside temperature in the zone of highest heat dissipating components/modules shall be monitored. The temperature rise inside the cubicle should not exceed 10 deg. C above the ambient temp. at 50 deg. C.

(b.) Burn in Test Cycle

The 48 hours elevated temperature test shall be followed by 120 hours of burn in test as above except that the temperature shall be reduced to the ambient temperature prevalent at that time.

During the above tests, the process I/O and other load on the system shall be simulated by simulated inputs and in the case of control systems, the process which is to be controlled shall also be simulated. Testing of individual components or modules shall not be acceptable.

In case the Contractor/ sub-contractor is having any alternate established procedure of eliminating infant mortile components, the detail procedures followed by the Contractor/ sub- contractor along with the statistical figures to validate the alternate procedure to be forwarded.

The Contractor/Sub-contractor shall carry out routine test on 100% item at contractor/sub-contractor's works. The quantum of check/test for routine & acceptance test by employer shall be generally as per criteria/sampling plan defined in referred standards. Wherever standards have not been mentioned quantum of check/test for routine / acceptance test shall be as agreed during detailed engineering stage.

9.03.24 QUALITY ASSURANCE AND INSPECTION FOR CIVIL WORKS

INTRODUCTION

This part of the specification covers the sampling, testing and quality assurance requirement (including construction tolerances and acceptance criteria) for all civil and structural works covered in this specification.

This part of the technical specification shall be read in conjunction with other parts of the technical specifications, general technical requirements & erection conditions of the contract which covers common QA requirements. Wherever IS code or standards have been referred they shall be the latest revisions.

The rate for respective items of work or price shall include the cost for all works, activities, equipment, instrument, personnel, material etc. whatsoever associated to comply with sampling, testing and quality assurance requirement including construction tolerances and acceptance criteria and as specified in subsequent clauses of this part of the technical specifications. The QA and QC activities in all respects as specified in the technical specifications/ drawings / data sheets / quality plans / contract documents shall be carried out at no extra cost to the owner.

The contractor shall prepare detailed construction and erection methodology scheme which shall be compatible to the requirements of the desired progress of work execution, quality measures, prior approvals if any and the same shall be got approved by the Engineer. If required, work methodology may be revised/ reviewed at every stage of execution of work at site, to suit the site conditions by the contractor at no extra cost to the owner.

QA AND QC MANPOWER

The contractor shall nominate one overall QA coordinator for the contract detailing the name, designation, contact details and address at the time of post bid discussions. All correspondence related to Quality Assurance shall be addressed by the contractor's QA coordinator to NTPC. NTPC shall address all correspondence related to Quality issues to the contractor's QA coordinator. The contractor's QA coordinator shall be responsible for co-ordination of Quality activities between various divisions of the contractor and their sub-vendors on one hand & with NTPC on the other hand.

The contractor shall appoint a dedicated, experienced and competent QA&QC in- charge at site, preferably directly reporting to the Project Manager, supported as necessary by experienced personnel, to ensure the effective implementation of the approved QAP. The contractor shall finalize and submit a deployment schedule of QA&QC personnel along with their details to NTPC for approval/ acceptance and further shall ensure their availability well before the start of the concern activity.

SAMPLING AND TESTING OF CONSTRUCTION MATERIALS

The method of sampling for testing of construction materials and work / job samples shall be as per the relevant IS / standards / codes and in line with the requirements of the technical specifications / quality plans. All samples shall be jointly drawn, signed and sealed wherever required, by the contractor and the engineer or his authorized representative.

The contractor shall carry out testing in accordance with the relevant IS / standards / codes and in line with the requirements of the technical specifications / quality plans. Where no specific testing

procedure is mentioned, the tests shall be carried out as per the best prevalent engineering practices and to the directions of the Engineer. All testing shall be done in the presence of the engineer or his authorized representative in a NABL accredited / Govt. Laboratory acceptable to NTPC. This includes all IITs, NCB, CSMRS, reputed government / autonomous laboratories / organizations, NITs and other reputed testing laboratories. The test samples for such test shall be jointly selected and sealed by the engineer and thereafter these shall be sent to the concerned laboratory through the covering letter signed by NTPC engineer. The test report along with the recommendations shall be obtained from the laboratories without delay and submitted to NTPC.

PURCHASE AND SERVICE

Structural steel supply if in the scope of the contractor shall be procured from main steel producers like SAIL, TISCO, IISCO, RINL, Essar Steel, Ispat Industries, JSW Steel, Lloyds Steel, Jindal Steel & Power. In case of non-availability of some of the sections with main steel producers the contractor may propose to procure the sections from the re-rollers of the main steel producers, the name of such re-rollers will have to be cleared by corporate quality assurance of NTPC for which details such as BIS approval, main steel producer's approval, past experience for production of sections of specified material, details of machines plants testing facilities etc., Confirmation that the process control and manufacturing of steel sections by re-rollers shall be same as that of main steel producers, that billets for re-rolling will be sourced from main steel producers only shall be furnished with regards to re-roller.

Even after clearance of re-rollers, induction of billets with identified and correlated Mill test certificates (TC's) in the process of re-rolling, sampling of steel, quality checks thereof and stamping of final product for further identification and correlation with TC's prior to dispatch shall be the responsibility of the contractor and these shall be performed in presence of the authorized representative of the main Contractor.

Reinforcement steel supply if in the scope of the contractor shall be procured from main steel producers like SAIL, TISCO, IISCO, RINL, Essar Steel, Ispat Industries, JSW Steel, Lloyds Steel, Jindal Steel & Power, Jai Balaji Industries Ltd, Durgapur (for 8-40mm reinforcement steel) and mill test certificates (TC) is to be obtained and submitted to NTPC for co-relation. In case any size /diameter specified is not available with main steel producers and are proposed to be supplied from the conversion agent of the main steel producer the name of such conversion agent / re- roller shall have to be approved by NTPC for which details such as BIS approval, Main steel producer's approval, Past experience for production of sections of specified material, details of machines, plants testing facilities etc., and confirmation that the process control and manufacturing of steel sections by re-rollers is the same as that of main steel producers, that billets for re-rolling are sourced from main steel producers only shall be furnished with regards to re-roller.

9.04 QA DOCUMENTATION PACKAGE

The Contractor shall be required to submit the QA Documentation in two hard copies and two CD ROMs, as identified in respective quality plan with tick mark.

9.04.01 Each QA Documentation shall have a project specific Cover Sheet bearing name & identification number of equipment and including an index of its contents with page control on each document.

The QA Documentation file shall be progressively completed by the Supplier's sub- supplier to allow regular reviews by all parties during the manufacturing.

The final quality document will be compiled and issued at the final assembly place of equipment before dispatch. However CD-Rom may be issued not later than three weeks.

9.04.02 Typical contents of QA Documentation is as below:-

(a)Quality Plan

(b)Material mill test reports on components as specified by the specification and approved Quality Plans.

(c)Manufacturer / works test reports/results for testing required as per applicable codes and standard referred in the specification and approved Quality Plans.

(d)Non-destructive examination results /reports including radiography interpretation reports. Sketches/drawings used for indicating the method of traceability of the radiographs to the location on the equipment.

(e)Heat Treatment Certificate/Record (Time- temperature Chart)

(f)All the accepted Non-conformance Reports (Major/Minor) / deviation, including complete technical details / repair procedure).

(g)CHP / Inspection reports duly signed by the Inspector of the Employer and Contractor for the agreed Customer Hold Points.

(h)Certificate of Conformance (COC) wherever applicable.

(i)MDCC

9.04.03 Similarly, the contractor shall be required to submit two sets (two hard copies and two CD ROMs), containing QA Documentation pertaining to field activities as per Approved Field Quality Plans and other agreed manuals/ procedures, prior to commissioning of individual system.

9.04.04 Before dispatch / commissioning of any equipment, the Supplier shall make sure that the corresponding quality document or in the case of protracted phased deliveries, the applicable section of the quality document file is completed. The supplier will then notify the Inspector regarding the readiness of the quality document (or applicable section) for review.

(a)If the result of the review carried out by the Inspector is satisfactory, the Inspector shall stamp the quality document (or applicable section) for release.

(b)If the quality document is unsatisfactory, the Supplier shall endeavor to correct the incompleteness, thus allowing to finalize the quality document (or applicable section) by time compatible with the requirements as per contract documents. When it is done, the quality document (or applicable section) is stamped by the Inspector.

(c)If a decision is made dispatch, whereas all outstanding actions cannot be readily cleared for the release of the quality document by that time. The supplier shall immediately, upon shipment of the equipment, send a copy of the quality document Review Status signed by the Supplier Representative to the Inspector and notify of the committed date for the completion of all outstanding actions & submission. The Inspector shall stamp the quality document for applicable section when it is effectively completed. The submission of QA documentation package shall not be later than 3 weeks

after the dispatch of equipment.

9.04.05 TRANSMISSION OF QA DOCUMENTATION

On release of QA Documentation by Inspector, one set of quality document shall be forwarded to Corporate Quality Assurance Department and other set to respective Project Site of Employer.

For the particular case of phased deliveries, the complete quality document to the Employer shall be issued not later than 3 weeks after the date of the last delivery of equipment.

9.05 PROJECT MANAGER'S SUPERVISION

9.05.01 To eliminate delays and avoid disputes and litigation, it is agreed between the parties to the Contract that all matters and questions shall be referred to the Project Manager and without prejudice to the provisions of 'Arbitration' clause in Section GCC of Vol.I, the Contractor shall proceed to comply with the Project Manager's decision.

9.05.02 The work shall be performed under the supervision of the Project Manager. The scope of the duties of the Project Manager pursuant to the Contract, will include but not be limited to the following:

(a)Interpretation of all the terms and conditions of these documents and specifications:
(b)Review and interpretation of all the Contractor's drawing, engineering data, etc:

(c)Witness or his authorised representative to witness tests and trials either at the manufacturer's works or at site, or at any place where work is performed under the contract :

(d)Inspect, accept or reject any equipment, material and work under the contract :

(e)Issue certificate of acceptance and/or progressive payment and final payment certificates

(f)Review and suggest modifications and improvement in completion schedules from time to time, and

(g)Supervise Quality Assurance Programme implementation at all stages of the works.

9.06 INSPECTION, TESTING AND INSPECTION CERTIFICATES

9.06.01 The word 'Inspector' shall mean the Project Manager and/or his authorised representative and/or an outside inspection agency acting on behalf of the Employer to inspect and examine the materials and workmanship of the works during its manufacture or erection.

9.06.02 The Project Manager or his duly authorised representative and/or an outside inspection agency acting on behalf of the Employer shall have access at all reasonable times to inspect and examine the materials and workmanship of the works during its manufacture or erection and if part of the works is being manufactured or assembled on other premises or works, the Contractor shall obtain for the Project Manager and for his duly authorised representative permission to inspect as if the works were manufactured or assembled on the Contractor's own premises or works.

9.06.03 The Contractor shall give the Project Manager/Inspector fifteen (15) days written notice of any material being ready for testing. Such tests shall be to the Contractor's account except for the expenses of the Inspector's. The Project Manager/Inspector, unless the witnessing of the tests is virtually waived and confirmed in writing, will attend such tests within fifteen (15) days of the date on which the equipment is noticed as being ready for test/inspection failing which the contractor may proceed with test which shall be deemed to have been made in the inspector's presence and he shall forthwith forward to the inspector duly certified copies of test reports in two (2) copies.

9.06.04 The Project Manager or Inspector shall within fifteen (15) days from the date of inspection as defined herein give notice in writing to the Contractor, or any objection to any drawings and all or any equipment and workmanship which is in his opinion not in accordance with the contract. The Contractor shall give due consideration to such objections and shall either make modifications that may be necessary to meet the said objections or shall inform in writing to the Project Manager/Inspector giving reasons therein, that no modifications are necessary to comply with the contract.

9.06.05 When the factory tests have been completed at the Contractor's or sub-contractor's works, the Project Manager /Inspector shall issue a certificate to this effect fifteen (15) days after completion of tests but if the tests are not witnessed by the Project Manager /Inspectors, the certificate shall be issued within fifteen (15) days of the receipt of the Contractor's test certificate by the Project Manager /Inspector. Project Manager /Inspector to issue such a certificate shall not prevent the Contractor from proceeding with the works. The completion of these tests or the issue of the certificates shall not bind the Employer to accept the equipment should it, on further tests after erection be found not to comply with the contract.

9.06.06 In all cases where the contract provides for tests whether at the premises or works of the Contractor or any sub-contractor, the Contractor, except where otherwise specified shall provide free of charge such items as labour, material, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Project Manager /Inspector or his authorised representatives to carry out effectively such tests on the equipment in accordance with the Contractor and shall give facilities to the Project Manager/Inspector or to his authorised representative to accomplish testing.

9.06.07 The inspection by Project Manager / Inspector and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed Quality Assurance Programme forming a part of the contract.

9.06.08 To facilitate advance planning of inspection in addition to giving inspection notice as specified at clause no 9.06.03- of this chapter, the Contractor shall furnish quarterly inspection programme indicating schedule dates of inspection at Customer Hold Point and final inspection stages. Updated quarterly inspection plans will be made for each three consecutive months and shall be furnished before beginning of each calendar month.

9.06.09 All inspection, measuring and test equipment used by contractor shall be calibrated periodically depending on its use and criticality of the test/measurement to be done. The Contractor shall maintain all the relevant records of periodic calibration and instrument identification, and shall produce the same for inspection by NTPC. Wherever asked specifically, the contractor shall re-calibrate the measuring/test equipment in the presence of Project Manager / Inspector.

10.00 PRE-COMMISSIONING AND COMMISSIONING FACILITIES

The Contractor upon completion of installation of equipments and systems, shall conduct pre-commissioning and commissioning activities, to make the equipment/systems ready for safe, reliable and efficient operation on sustained basis. During commissioning the Contractor shall carry out system checking and reliability trials on various parts of the facilities. All pre- commissioning/commissioning activities considered essential for such readiness of the equipment/systems including those mutually agreed and included in the Contractor's quality assurance programme as well as those indicated in clauses elsewhere in the technical specifications shall be performed by the contractor.

The pre-commissioning and commissioning activities of the equipment/systems furnished and installed by the contractor shall be the responsibility of the Contractor. The Contractor shall provide, in addition, temporary instrumentation and other measuring devices, test instruments, calibrating devices etc. and labour required for successful performance of these operations. If it is anticipated that the above test may prolong for a long time, the Contractor's workmen required for the above test shall always be present at site during such operations.

All erection & commissioning checks shall be as per manufacturer's manual on mutually agreed terms.

(a)As soon as the facilities or part thereof has been completed operationally and structurally and before start-up, each item of the equipment and systems forming part of facilities shall be thoroughly cleaned and then inspected jointly by the Employer and the Contractor for correctness of and completeness of facility or part thereof and acceptability for initial pre- commissioning tests, commissioning and start-up at Site. The list of pre- commissioning tests to be performed shall be as mutually agreed and included in the Contractor's quality assurance programme as well as those included elsewhere in the Technical Specifications.

(b)The Contractor's pre-commissioning/ commissioning/start-up engineers, specially identified as far as possible, shall be responsible for carrying out all the pre-commissioning tests at Site. On completion of inspection, checking and after the pre-commissioning tests are satisfactorily over, the commissioning of the complete facilities shall be commenced during which period the complete facilities, equipments shall be operated integral with sub- systems and supporting equipment as a complete plant.

(c)The time consumed in the inspection and checking of the units shall be considered as a part of the erection and installation period.

(d)The check outs during the pre - commissioning period should be programmed to follow the construction completion schedule. Each equipment/system, as it is completed in construction and turned over for commissioning (start-up), should be checked out and cleaned. The checking and inspection of individual systems should then follow a prescribed commissioning documentation [SCL (Standard Check List) / TS (Testing Schedule) / CS (Commissioning Schedule)] to be furnished by the manufacturer/supplier.

(e)The Contractor shall conduct vibration testing to determine the 'base line' of performance of all plant rotating equipment. These tests shall be conducted when the equipment is running at the base load, peak load as well as lowest sustained operating condition as far as practicable.

11.00 SAFETY ASPECTS DURING CONSTRUCTION AND ERECTION

In addition to the requirements given in Erection Conditions of Contract (ECC) the following shall also cover:

(a)Working platforms should be fenced and shall have means of access.

(b)Ladders in accordance with Employer's safety rules for construction and erection shall be used. Rungs shall not be welded on columns. All the stairs shall be provided with handrails immediately after its erection.

12.00 PACKAGING AND TRANSPORTATION

All the equipment shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. While packing all the materials, the limitation from the point of view of the sizes of railway wagons available in India should be taken account of. The Contractor shall be responsible for any loss or damage during transportation, handling and storage due to improper packing. The Employer's Inspector shall have right to insist for completion of works in shops before dispatch of materials for transportation.

13.00 ELECTRICAL ENCLOSURE

All electrical equipment and devices, including insulation, heating and ventilation devices shall be designed for ambient temperature and a maximum relative humidity as specified elsewhere in the specification/

14.00 INSTRUMENTATION AND CONTROL

All instrumentation and control systems/ equipment/ devices/ components, furnished under this contract shall be in accordance with the requirements stated herein, unless otherwise specified in the detailed specifications.

All instrument scales and charts shall be calibrated and printed in metric units and shall have linear graduation. The ranges shall be selected to have the normal reading at 75% of full scale.

All scales and charts shall be calibrated and printed in Metric Units

All instruments and control devices provided on panels shall be of miniaturized design, suitable for modular flush mounting on panels with front draw out facility and flexible plug-in connection at rear.
All electronic modules shall have gold plated connector fingers and further all input and output modules shall be short circuit proof. These shall also be tropicalised & components shall be of industrial grade or better.

15.00 ELECTRICAL NOISE CONTROL

The equipment furnished by the Contractor shall incorporate necessary techniques to eliminate measurement and control problems caused by electrical noise. Areas in Contractor's equipment which are vulnerable to electrical noise shall be hardened to eliminate possible problems. Any additional

equipment, services required for effectively eliminating the noise problems shall be included in the proposal. The equipment shall be protected against ESD as per IEC-801- 2. Radio Frequency interference (RFI) and Electro Magnetic Interference (EMI) protection against hardware damage and control system mal-operations/errors shall be provided for all systems.

16.00 ELECTRONIC MODULE/COMPONENT DETAILS

The Contractor shall have to furnish all technical details including circuit diagrams, specifications of components, etc., in respect of each and every electronic card/module as employed on the various solid state as well as microprocessor based systems and equipment including conventional instruments, peripherals etc.

It is mandatory for the Contractor to identify clearly the custom built ICs used in the package. The Contractor shall also furnish the details of any equivalents of the same.

PART- D

ERECTION CONDITIONS OF CONTRACT

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ERECTION CONDITIONS OF CONTRACT

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ERECTION CONDITIONS OF CONTRACT

1.00.00 GENERAL

1.01.00 The following provisions shall supplement the conditions already contained in the other parts of these specifications and documents and shall govern that portion of the work of this contract which is to be performed at site. The erection requirements and procedures not specified in these documents shall be in accordance with the recommendations of the equipment manufacturer, or as mutually agreed to between the Employer and the Contractor prior to commencement of erection work.

1.02.00 The Contractor upon signing of the Contract shall, in addition to a Project Co-ordinator, nominate another responsible officer as his representative at Site suitably designated for the purpose of overall responsibility and co- ordination of the Works to be performed at Site. Such a person shall function from the Site office of the Contractor during the pendency of Contract.

2.00.00 CODE REQUIREMENTS

The erection requirements and procedures to be followed during the installation of the equipment shall be in accordance with the relevant Government of India Rules & Codes, accepted good practices in the industry and shall fulfill all statutory requirements.

3.00.00 ELECTRICAL SAFETY REGULATIONS

The contractor shall ensure that entire electrical installation work is executed by adopting applicable statutory safety regulations and best practices in the industry. The Contractor shall employ the necessary number of qualified, full time electricians to maintain his temporary electrical installation.

4.00.00 INSPECTION AND TESTING INSPECTION CERTIFICATES

The provisions of the clause entitled Inspection and Testing in the Technical Specification, shall also be applicable to the erection portion of the Works. The Employer shall have the right to re-inspect any equipment though previously inspected and approved by him at the Contractor's works, before and after the same are erected at Site. If by the above inspection, the Employer rejects any equipment, the Contractor shall make good for such rejections either by replacement or modification/ repairs as may be necessary to the satisfaction of the Employer. Such replacements will also include the replacements or re-execution of such of those works of other Contractors and/or agencies, which might have got damaged or affected by the replacements or re-work done to the Contractor's work.

5.00.00 CONTRACTOR'S SITE OFFICE ESTABLISHMENT

The Contractor shall establish an Office at the Site and keep posted an authorised representative for the purpose of the Contract. Any written order

or instruction of the Employer or his duly authorised representative shall be communicated to the said authorised resident representative of the Contractor and the sameshall be deemed tohave been communicated to the Contractor at his legal address

6.00.00 CONTRACTOR'S FIELD OPERATION

The Contractor shall keep the Employer informed in advance regarding his field activity plans and schedules for carrying out each part of the works. Any review of such plan or schedule or method of work by the Employer shall not relieve the Contractor of any of his responsibilities towards the field activities. Such reviews shall also not be considered as an assumption of any risk or liability by the Employer or any of his representatives and no claim of the Contractor will be entertained because of the failure or inefficiency of any such plan or schedule or method of work reviewed. The Contractor shall be solely responsible for the safety, adequacy and efficiency of plant and equipment and his erection methods.

The Contractor shall have the complete responsibility for the conditions of the Work-Site including the safety of all persons employed by him or his Sub-Contractor and all the properties under his custody during the performance of the work. This requirement shall apply continuously till the completion of the Contract and shall not be limited to normal working hours. The construction review by the Employer is not intended to include review of Contractor's safety measures in, on or near the Work-Site, and their adequacy or otherwise.

7.00.00 PROTECTION OF WORK

The Contractor shall have total responsibility for protecting his works till it is finally taken over by the Employer. No claim will be entertained by the Employer or the representative of the Employer for any damage or loss to the Contractor's works and the Contractor shall be responsible for complete restoration of the damaged works to original conditions to comply with the specification and drawings. Should any such damage to the Contractor's Works occur because of any other agency/individual not being under his supervision or control, the Contractor shall make his claim directly with the party concerned. The Contractor shall not cause any delay in the repair of such damaged Works because of any delay in the resolution of such disputes. The Contractor shall proceed to repair the Work immediately and no cause thereof will be assigned pending resolution of such disputes.

8.00.00 FACILITIES TO BE PROVIDED BY THE CONTRACTOR

Contractor's site office Establishment

The Contractor shall establish a site office at the site and keep posted an authorized representative for the purpose of the contract.

Tools, tackles and scaffoldings

The Contractor shall provide all the construction equipments, tools, tackles and scaffoldings required for pre-assembly, installation, testing, commissioning and

conducting Guarantee tests of the equipments covered under the Contract. The Contractor shall arrange machinery & equipment such as Dozer, Hydra, Cranes, Trailer, etc. wherever required for the purpose of fabrication, erection and commissioning.

Testing Equipment and Facilities:

The contractor shall provide the necessary testing, equipment and facilities.

Testing of construction material at the site:

Contractor shall make arrangements for the testing of construction material at the site wherever required, under the scope of services of the contract.

First-aid

The Contractor shall provide necessary first-aid facilities for all his employees, representatives and workmen working at the Site. Enough number of Contractor's personnel shall be trained in administering first- aid.

Water

Contractor shall make all arrangements himself for the supply of construction water as well as potable water for labour and other personnel at the worksite/colony.

9.00.00 FIRE PROTECTION

The work procedures that are to be used during the erection shall be those which minimise fire hazards to the extent practicable. Combustible materials, combustible waste and rubbish shall be collected and removed from the Site regularly. Fuels, oils and volatile or flammable materials shall be stored away from the construction and equipment and materials storage areas in safe containers. Untreated canvas, paper, plastic or other flammable flexible materials shall not at all be used at Site for any other purpose unless otherwise specified. If any such materials are received with the equipment at the Site, the same shall be removed and replaced with acceptable material before moving into the construction or storage area.

All materials used for storage or for handling of materials shall be of water proof and flame resistant type. All the other materials such as working drawings, plans etc. which are combustible but are essential for the works to be executed shall be protected against combustion resulting from welding sparks, cutting flames and other similar fire sources.

All the Contractor's supervisory personnel and sufficient number of workers shall be trained for fire-fighting and shall be assigned specific fire protection duties. Enough of such trained personnel must be available at the

Site during the entire period of the Contract.

The Contractor shall provide suitable quantity & type fire protection equipment for the warehouses, office, temporary structures etc.

10.00.00 SECURITY

The Contractor shall have total responsibility for all equipment and materials in his custody stores, loose, semi-assembled and/or erected by him at Site. The Contractor shall make suitable security arrangements including employment of security personnel to ensure the protection of all materials, equipment and works from theft, fire, pilferage and any other damages and loss.

11.00.00 PACKAGING AND TRANSPORTATION

All the equipments shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. While packing all the materials, the limitation from the point of view of the sizes of railway wagons available in India should be taken account of. The Contractor shall be responsible for any loss or damage during transportation, handling and storage due to improper packing. The Contractor shall ascertain the availability of Railway wagon sizes from the Indian Railways or any other agency concerned in India well before effecting dispatch of equipment. Before dispatch it shall be ensured that complete processing and manufacturing of the components is carried out at shop, only restricted by transport limitation, in order to ensure that site works like grinding, welding, cutting & preassembly to bare minimum. The Employer's Inspector shall have right to insist for completion of works in shops before dispatch of materials for transportation.

12.00.00 CRATING

All equipment and materials shall be suitably coated, wrapped, or covered and boxed or crated for moist humid tropical shipment and to prevent damage or deterioration during handling and storage at the site.

Equipment shall be packed with suitable desiccants, sealed in water proof vapour-proof wrapping and packed in lumber of plywood enclosures, suitably braced, tied and skidded. Lumber enclosures shall be solid, not slatted.

Desiccants shall be either silica gel or calcium sulphate, sufficiently ground to provide the required surface area and activated prior to placing in the packaging. Calcium sulphate desiccants shall be of a chemical nature to absorb moisture. In any case, the desiccant shall not be of a type that will absorb enough moisture to go into solution. Desiccants shall be packed in porous containers, strong enough to withstand handling encountered during normal shipment. Enough desiccant shall be used for the volumes enclosed in wrapping.

Packaging or shipping units shall be designed within the limitations of unloading facilities and the equipment which will be used for transport.

Complications involved with ocean shipment and the limitations of ports, railways and roads shall be considered. It shall be the Contractor's responsibility to investigate these limitations and to provide suitable packaging to permit safe handling during transit and at the job site.

Electrical equipment, control and instrumentation shall be protected against moisture and water damage. All external gasket surfaces and flange faces, couplings, motor pump shafts, bearing and like items shall be thoroughly cleaned and coated with rust preventive compound as specified above and protected with suitable wood, metal or other substantial type covering to ensure their full protection.

Equipment having antifriction or sleeve bearings shall be protected by weather tight enclosures.

Coated surfaces shall be protected against impact, abrasion, discolouration and other damage. Surfaces which are damaged shall be repaired.

All exposed threaded parts shall be greased and protected with metallic or other substantial type protectors. All female threaded openings shall be closed with forged steel plugs. All pipings, tubing, and conduit equipment and other equipment openings shall be sealed with metallic or other rough usage covers and tapped to seal the interior of the equipment piping, tubing, or conduit.

Provisions shall be made to ensure that water does not enter any equipment during shipment or in storage at the plant site.

Returnable containers and special shipping devices shall be returned by the manufacturer's field representative at the Contractor's expense.

While packaging the material, care shall be taken for the limitation from the point of view of availability of railway wagon sizes in India.

13.00.00 MATERIALS HANDLING AND STORAGE

All the equipments furnished under the Contract and arriving at Site shall be promptly received, unloaded and transported and stored in the storage spaces by the Contractor.

Contractor shall be solely responsible for any shortages or damage in transit, handling and / or in storage and erection of the equipment at Site. Any demurrage, wharfage and other such charges claimed by the trans- porters, railways etc. shall be to the account of the Contractor.

The equipment stored shall be properly protected to prevent damage either to the equipment or to the floor where they are stored. The equipment from the store shall be moved to the actual location at the appropriate time so as to avoid damage of such equipment at Site.

All electrical panels, controls gear, motors and such other devices shall be properly dried by heating before they are installed and energised. Motor bearings, slip rings, commutators and other exposed parts shall be protected against moisture ingress and corrosion during storage and periodically inspected. Heavy rotating parts in assembled conditions shall be periodically rotated to prevent corrosion due to prolonged storage.

All the electrical equipment such as motors, etc. shall be periodically tested for insulation resistance from the date of receipt till the date of commissioning and a record of such measured insulation values maintained by the Contractor. Such records shall be open for inspection by the Employer.

The Contractor shall ensure that all the packing materials and protection devices used for the various equipments during transit and storage are removed before the equipment are installed.

The consumables and other supplies likely to deteriorate due to storage must be thoroughly protected and stored in a suitable manner to prevent damage or deterioration in quality by storage.
All the materials stored in the open or dusty location must be covered with suitable weatherproof and flameproof covering material wherever applicable.

14.00.00 CONSTRUCTION MANAGEMENT

Contractor shall be responsible for performance of his works in accordance with the specified construction schedule. If at any time, the Contractor is falling behind the schedule, he shall take necessary action to make good for such delays by increasing his work force or by working overtime or otherwise accelerate the progress of the work to comply with the schedule and shall communicate such actions in writing to the Employer, satisfying that his action will compensate for the delay. The Contractor shall not be allowed any extra compensation for such action.

The Employer shall however not be responsible for provision of additional labour and/or materials or supply or any other services to the Contractor.

15.00.00 FIELD OFFICE RECORDS

The Contractor shall maintain at his Site Office up-to- date copies of all drawings, specifications and other Contract Documents and any other supplementary data complete with all the latest revisions thereto. The Contractor shall also maintain in addition the continuous record of all changes to the above Contract Documents, drawings, specifications, supplementary data, etc. effected at the field and on completion of his total assignment under the Contract shall incorporate all such changes on the drawings and other Engineering data to indicate as installed conditions of the equipment furnished and erected under the Contract. Such drawings and Engineering data shall be available for inspection & review to the Employer.

16.00.00 PROTECTION OF PROPERTY AND CONTRACTOR'S LIABILITY

The Contractor shall be responsible for any damage resulting from his operations. He shall also be responsible for protection of all persons including members of public and employees of the Employer and his own employees and all public and private property including structures, building, other plants and equipments and utilities either above or below the ground.

The Contractor will ensure provision of necessary safety equipment such as barriers, sign - boards, warning lights and alarms, etc. to provide adequate protection to persons and property.

17.00.00 PAINTING

All exposed metal parts of the equipment including pipings, structure railings, etc. wherever applicable, after installation unless otherwise surface protected, shall be first painted in accordance with relevant codes
& standards, after throughly cleaning all such parts of all dirt, rust, scales, greases, oils and other foreign materials by wire brushing, scraping or sand blasting.

18.00.00 UNFAVOURABLE WORKING CONDITIONS

The Contractor shall confine all his field operations to those works which can be performed without subjecting the equipment and materials to adverse effects during inclement weather conditions, like monsoon, storms, etc. and during other unfavourable construction conditions.No field activities shall be performed by the Contractor under conditions which might adversely affect the quality and efficiency thereof, unless special precautions or measures are taken by the Contractor in a proper and satisfactory manner in the performance of such Works and with the concurrence of the Employer. Such unfavourable construction conditions will in no way relieve the Contractor of his responsibility to perform the Works as per the schedule.

19.00.00 PROTECTION OF MONUMENTS AND REFERENCE POINTS

The Contractor shall ensure that any finds such as relic, antiquity, coins, fossils, etc. which he may come across during the course of performance of his Works either during excavation or elsewhere, are properly protected and handed over to the Employer.

20.00.00 FOUNDATION DRESSING & GROUTING FOR EQUIPMENT/ EQUIPMENT BASES

The surfaces of foundations shall be dressed to bring the top surface of the foundationstotherequired level, prior to placement of equipment/equipment bases on the foundations.

All the equipment/ equipment bases shall be grouted and finished as per these specifications unless otherwise recommended by the equipment manufacturer.

The concrete foundation surfaces shall be properly prepared by chipping, grinding as required to bring the top of such foundation to the required level, to provide the necessary roughness for bondage and to assure enough bearing strength.

20.01.00 GROUT (IF APPLICABLE)

The grout shall be high strength grout having a minimum characteristic compressive strength of 60 N/mm^2 at 28 days. The grout shall be chloride - free, cement based, free flowing, non-metallic grout.

The Grout shall have good flowability even at very low water/ grout powder ratio.

The Grout shall have characteristics of controlled expansion to be able to occupy its original volume to fill the voids and to compensate for shrinkage. Grout shall be of pre-mix variety so that only water needs to be added before use.

The mixing of the Grout shall conform to the recommendations of the manufacturer of the Grout.

20.02.00 PLACING OF GROUT (IF APPLICABLE)

After the base has been prepared, its alignment and level has been checked and approved and before actually placing the grout, a low dam shall be set around the base at a distance that will permit pouring and manipulation of the grout. The height of such dam shall be at least 25mm above the bottom of the base. Suitable size and number of chains shall be introduced under the base before placing the grout, so that such chains can be moved back & forth to push the grout into every part of the space under the base.

The grout shall be poured either through grout holes if provided or shall be poured at one side or at two adjacent sides to make the grout move in a solid mass under the base and out in the opposite side. Pouring shall be continued until the entire space below the base is thoroughly filled and the grout stands at least 25 mm higher all around than the bottom of the base. Enough care should be taken to avoid any air or water pockets beneath the bases.

In addition to the above, recommendations of Grout manufacturer shall also be followed.

20.03.00 FINISHING OF THE EDGES OF THE GROUT (IF APPLICABLE)

The poured grout should be allowed to stand undisturbed until it is well set. Immediately thereafter, the dam shall be removed and grout which extends beyond the edges of the structural or equipment base plates shall be cut off, flushed and removed.The edges of the grout shall then be pointed and finished with 1:2 cement mortar pressed firmly to bond with the body of the grout and smoothened with a tool to present a smooth vertical surface. The work shall

be done in a clean and scientific manner and the adjacent floor spaces, exposed edges of the foundations, and structural steel and equipment base plates shall be thoroughly cleaned of any spillage of the grout.

21.00.00 SHAFT ALIGNMENTS (IF APPLICABLE)

All the shafts of rotating equipment shall be properly aligned to those of the matching equipments to as perfect accuracy as practicable.The equipment shall be free from excessive vibration so as to avoid overheating of bearings or other conditions which may tend to shorten the life of the equipment. The vibration level of rotating equipments measured at bearing housing shall conform to VDI 2056. All bearings, shafts and other rotating parts shall be thoroughly cleaned and suitably lubricated before starting.

22.00.00 DOWELLING (IF APPLICABLE)

All the motors and other equipment shall be suitably doweled after alignment of shafts with tapered machined dowels as per the direction of the Employer.

23.00.00 CABLING

All cables shall be supported by conduits or cable tray run in air or in cable channels. These shall be installed in exposed runs parallel or perpendicular to dominant surfaces with right angle turn made of symmetrical bends or fittings. When cables are run on cable trays, they shall be clamped at a minimum intervals of 2000mm.

Each cable, whether power or control, shall be provided with a metallic or plastic tag of an approved type, bearing a cable reference number indicated in the cable and conduit list (prepared by the Contractor), at every 5 meter run or part thereof and at both ends of the cable adjacent to the terminations. Cable routing is to be done in such a way that cables are accessible for any maintenance and for easy identification.

Sharp bending and kinking of cables shall be avoided. Installation of other cables like high voltage, coaxial, screened, compensating, mineral insulated shall be in accordancewith the cable manufacturer's recommendations. Wherever cables cross roads and water, oil, sewage or gaslines, special care should be taken for the protection of the cables in designing the cable channels.

In each cable run some extra length shall be kept at a suitable point to enable one or two straight through joints to be made, should the cable develop fault at a later date.

Control cable terminations shall be made in accordance with wiring diagrams, using identifying codes subject to the Employer's approval. Multicore control cable jackets shall be removed as required to train and terminate the conductors. The cable jacket shall be left on the cable, as far as possible, to the point of the first conductor branch. The insulated conductors from which the jacket is removed shall be neatly twined in bundles and terminated. The

bundles shall be firmly but not tightly tied utilising plastic or nylon ties or specifically treated fungus protected cord made for this purpose. Control cable conductor insulation shall be securely and evenly cut.

The connectors for control cables shall be covered with a transparent insulating sleeve so as to prevent accidental contact with ground or adjacent terminals and shall preferably terminate in Elmex terminals and washers. The insulating sleeve shall be fire resistant and shall be long enough to over pass the conductor insulation. All control cables shall be fanned out and connection made to terminal blocks and test equipment for proper operation before cables are corded together.

24.00.00 EQUIPMENT INSTALLATION

24.01.00 General Requirements

The Contractor shall furnish all construction materials, tools and equipment and shall perform all work required for complete installation of all control and instrument equipment furnished under this specification.

Contractor shall prepare detailed installation drawings for each equipment furnished under this specification. Installation of all equipment/systems furnished by this specification shall be as per installation drawings.

Erection procedures not specified herein shall be in accordance with the recommendations of the equipment manufacturers. The procedures shall be acceptable to the Employer.

The Contractor shall coordinate his work with other suppliers where their instruments and devices are to be installed under specifications.

24.02.00 Installation Materials

All materials required for installation, testing and commissioning of the equipment shall be furnished by the Contractor.

24.03.00 Regulatory Requirements

All installation procedures shall confirm with the accepted good engineering practice and with all applicable governmental laws, regulations and codes.

24.04.00 Cleaning

All equipment shall be cleaned of all sand, dirt and other foreign materials immediately after removal from storage and before the equipment is installed.

24.05.00 Installation of Field Mounted Instruments/Devices and Non-free Standing Equipment

Theinstallationdrawings for all field mounted equipment/instrument/devices furnished under this specification shall meet the requirements of this specification, applicable codes and standards and recommendations of manufacturers of instruments/devices. In addition to above relevant Portion as specified elsewhere in technical specification may be referred.

Field mounted instruments and accessories shall be bracket or sub panel mounted on the nearest suitable firm steel work or masonry.The brackets, stands, supports and other miscellaneous hardware required for mounting instruments and accessories such as receiver gauge, air set, valve manifold, purge-meter etc. shall be furnished and installed. No field mounted instruments shall be installed such that it depends for support or rigidity on the impulse piping or on electrical connection to it.

All free standing instrumentation cabinets and panels shall be located within the construction tolerances of +/- 3 mm of the location dimensions indicated on the plant arrangement drawings.

Non-free standing local enclosures and cabinets shall be mounted in accessible locations on columns, walls, or stands. Bracket and stands shall be fabricated as required to install the local enclosures and cabinets in a workman like manner. Rough edges and welds on all fabricated supports shall be ground smooth. The supports shall be finished with two coats of primer and two coats of paint as specified in this part.

24.06.00 Defects

All defects in erection shall be corrected to the satisfaction of the Employer and the Project Manager. The dismantling and reassembly of Contractor furnished equipment to remove defective parts, replace parts, or make adjustments shall be included as a part of the work under these specifications.

The removal of control and instrument equipment in order to allow bench calibration, if required, and the re-installation of the said equipment after calibration shall also be included as a part of the work under these specifications.

24.07.00 Equipment Protection

All equipment to be erected under these specifications shall be protected from damage of any kind from the time of contract award until commissioning of each unit.

The equipment shall be protected during storage as described herein.

Equipment shall be protected from weld spatter during construction.

Suitable guards shall be provided for protection of personnel on all exposed rotating or moving machine parts. All such guards withnecessary spares and accessories shall be designed for easy removal and maintenance.

Equipment having glass components such as gauges, or equipment having other easily breakable components, shall be protected during the construction period with plywood enclosures or other suitable means. Broken, stolen, or lost

components shall be replaced by the Contractor.

Machine finished surfaces, polished surfaces, or other bare metal surfaces which are not to be painted, such as machinery shafts and couplings shall be provided temporary protection during storage and constructional periods by a coating of a suitable non- drying, oily type, rust preventive compound.

25.00.00 DEVIATIONS DISPOSITIONING:

Any deviation to the contract and employer approved documents shall be properly recorded in the format prescribed by NTPC. All the deviations shall be bought to the knowledge of employer's representative for suitable dispositioning.

26.00.00 STATUTORY REQUIREMENTS

In addition to the local laws and regulations, the Contractor shall also comply with the Minimum Wages Act and the Payment of Wages Act (both of the Government of India) and the rules made there under in respect of its labour and the labour of its sub-contractors currently employed on or connected with the contract.

All registration and statutory inspection fees, if any, in respect of his work pursuant to this Contract shall be to the account of the Contractor. However, any registration, statutory inspection fees lawfully payable under the provisions of any statutory laws and its amendments from time to time during erection in respect of the plant equipment ultimately to be owned by the Employer, shall be to the account of the Employer. Should any such inspection or registration need to be re-arranged due to the fault of the Contractor or his Sub-Contractor, the additional fees for such inspection and/or registration shall be borne by the Contractor.

27.00.00 EMPLOYMENT OF LABOUR

In addition to all local laws and regulations pertaining to the employment of labour to be complied with by the Contractor pursuant to GCC, the Contractor will be expected to employ on the work only his regular skilled employees with experience of the particular work. No female labour shall be employed after darkness. No person below the age of eighteen years shall be employed.

All travelling expenses including provisions of all necessary transport to and from Site, lodging allowances and other payments to the Contractor's employees shall be the sole responsibility of the Contractor.

In case the Employer becomes liable to pay any wages or dues to the labour or any Government agency under any of the provisions of the Minimum Wages Act, Workmen Compensation Act, Contact Labour Regulation Abolition Act or any other law due to act of omission of the Contractor, the Employer may make such payments and shall recover the same from the Contractor's Bills.

28.00.00 WORK & SAFETY REGULATIONS

The Contractor shall ensure proper safety of all the workmen, materials, plant and equipments belonging to him or to Employer or to others, working at the Site. The Contractor shall also be responsible for provision of all safety notices and safety equipment required both by the relevant legislation and the Employer as he may deem necessary.

28.01.00 Where it is necessary to provide and/or store petroleum products or petroleum mixtures and explosives, the contractor shall be responsible for carrying-out such provision and/or storage in accordance with the rules and regulations laid down in petroleum act 1934, explosives act, 1948, and petroleum and carbide of calcium manual published by the chief inspector of explosives of india. All such storage shall have prior approval of the employer. In case, any approvals are necessary from the chief inspector (explosives) or any statutory authorities, the contractor shall be responsible for obtaining the same.

Where explosives are to be used, the same shall be used under the direct control and supervision of an expert, experienced, qualified and competent person strictly in accordance with the Code of Practices/Rules framed under Indian Explosives Act pertaining to handling, storage and use of explosives.

28.02.00 All equipment used in construction and erection by Contractor shall meet Indian/International Standards and where such standards do not exist, the Contractor shall ensure these to be absolutely safe. All construction and erection equipments shall be strictly operated and maintained by the Contractor in accordance with statutory safety regulations. Periodical Examinations and all tests for all lifting/ hoisting equipment & tackles shall be carried-out in accordance with the relevant provisions of Factories Act 1948, Indian Electricity Act 1910 and associated Laws/Rules in force from time to time.

28.03.00 The Contractor shall provide suitable safety equipment of prescribed standard to all employees and workmen according to the need, as may be directed by Employer who will also have right to examine these safety equipments to determine their suitability, reliability, acceptability and adaptability.
(a) Working platforms should be fenced and shall have means of access.
(b) Ladders in accordance with stautory safety rules for construction and erection shall be used. Rungs shall not be welded on columns. All the stairs shall be provided with handrails immediately after its erection.

The Contractor shall provide safe working conditions to all workmen and employees at the Site including safe means of access, railings, stairs, ladders, scaffoldings etc. The scaffoldings shall be erected under the control and supervision of an experienced and competent person. For erection, good and standard quality of material only shall be used by the Contractor.

28.04.00 The Contractor employing more than 250 workmen whether temporary, casual, probationer, regular or permanent or on contract, shall employ atleast one full time officer exclusively as Safety Officer to supervise safety aspects of the equipments and workmen, who will co- ordinate with the Employer Safety

Officer. In case of work being carried out through sub-Contractors, the Sub-Contractor's workmen/employees will also be considered as the Contractor's employees/workmen for the above purpose.

In case any accident occurs during the construction/ erection or other associated activities undertaken by the Contractor thereby causing any minor or major or fatal injury to his employees due to any reason, what- soever, it shall be the responsibility of the Contractor to promptly inform the same to the Employer and also to all the authorities envisaged under the applicable laws.

The Contractor shall follow and comply with relevant provisions of applicable laws pertaining to the safety of workmen, employees plant and equipment as may be prescribed from time to time without any demur, protest or contest or reservation.

If the Contractor does not take all safety precautions and/or fails to comply with the Safety Rules as prescribed by the Employer or under the applicable law for the safety of the equipment and plant and for the safety of personnel and the Contractor does not prevent hazardous conditions which cause injury to his own employees or employees of other Contractors, or the Employer's employees or any other person who are at Site or adjacent thereto, the Contractor shall be responsible for payment of compensation to Employer as per the following schedule:-

1	Fatal injury or accident. These are causing death applicable	Rs. 1,00,000/- per person
2	Major injuries or accident	Rs. 20,000/- per personfor death/ causing 25% or more injury to any permanent disablement to person workmen or employees whosoever

Permanent disablement shall have same meaning as indicated in Workmen's Compensation Act. The compensation mentioned above shall be in addition to the compensation payable to the workmen/employees under the relevant provisions of the Workmen's Compensation Act and rules framed thereunder or any other applicable laws as applicable from time to time. In case the Employer is made to pay such Compensation then the Contractor is liable to reimburse the Employer such amount in addition to the compensation indicated above.

If the Contractor observes all the Safety Rules and Codes, Statutory Laws and Rules during the currency of Contract awarded by the Employer and no accident occurs then the Employer may consider the performance of the Contractor and award suitable "ACCIDENT FREE SAFETY MERITORIOUS AWARD" as per schemeas may be announced separately from time to time.

29.00.00 INSURANCE

29.01.00 WORKMEN'S COMPENSATION INSURANCE

This insurance shall protect the Contractor against all claims applicable under the Workmen's Compensation Act, 1948 (Government of India). This policy shall also cover the Contractor against claims for injury, disability disease or death of his or his Sub-Contractor's employees, which for any reason are not covered under the

Workmen's Compensation Act, 1948. The liabilities shall not be less than the following:

Workmen's Compensation Provisions	-	As per Statutory
Employee's Liability Provisions	-	As per Statutory

29.02.00 COMPREHENSIVE AUTOMOBILE INSURANCE

This insurance shall be in such a form to protect the Contractor against all claims for injuries, disability, disease and death to members of public including the Employer's men and damage to the property of other arising from the use of motor vehicles during on or off the Site operations, irrespective of the Ownership of such vehicles. The liability covered shall be as herein indicated:

Fatal Injury person	:	Rs.100,000 each
	:	Rs.200,000 each occurrence
Property Damage occurrence	:	Rs.100,000 each

29.03.00 COMPREHENSIVE GENERAL LIABILITY INSURANCE

The insurance shall protect the Contractor against all claims arising from injuries, disabilities, disease or death of members of public or damage to property of others, due to any act or omission on the part of the Contractor, his agents, his employees, his representatives and Sub-Contractors or from riots, strikes and civil commotion.

The hazards to be covered will pertain to all the Works and areas where the Contractor, his Sub-Contractors, his agents and his employees have to perform work pursuant to the Contract.

The above are only illustrative list of insurance covers normally required and it will be the responsibility of the Contractor to maintain all necessary insurance coverage to the extent both in time and amount to take care of all his liabilities either direct or indirect, in pursuance of the Contract.