BHARAT HEAVY ELECTRICALS LIMITED
TRANSMISSION BUSINESS ENGINEERING MANAGEMENT
NEW DELHI

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TYPE OF DOC.:	TECHNICAL SPECIFICATION	NAME:	JK	SKS	RK/NSR
TITLE: **500MVA, 400/220/33kV Auto Transformer**		SIGN:			
		DATE:	21/2/17		03/03/17
		GROUP:	TBEM		

CUSTOMER:	**Power Grid Corporation of India (POWERGRID)**
PROJECT:	Substation Package -SS01 for Construction of 765/400/220kV Bhuj Pool (New) S/S and Extension of 765kV Banaskantha S/S under Green Energy Corridors: Inter-State Transmission Scheme (ISTS) – Part C; [Part-II] {for 400/220kV (2X500MVA) part of the substation associated bays.
NOA REF.:	**CC-CS/484-WR2/SS-2953/11/G8/NOA-I & II/7130 & 7131 Dtd 27 Dec 2016**

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***Guaranteed Technical Particulars- Not to be submitted with technical bid, however same shall be reviewed and approved during detailed engineering.**

REV	DATE	Altered	Checked	Approved	

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SECTION-1
SCOPE, SPECIFIC TECHNICAL REQUIREMENTS & BILL OF QUANTITIES

1.1 SCOPE

This specification covers design, type testing, engineering, manufacture, testing at factory, delivery at site including all materials, accessories, spares, supervision of unloading, handling, proper storage, erection, testing, and commissioning of 500MVA, 400/220/33kV Auto Transformer.

The scope shall encompass and include all the activities listed above.

This section covers the specific technical requirements, scope and quantities. The specific technical requirements for the above item as specified by the POWERGRID are given in Section-2A & 2B. The offered equipment shall also comply with the general technical requirements for the project as detailed under section-3 of this specification.

500MVA, 400/220/33kV Auto Transformer is required for the following project:

Name of the Customer: **Power Grid Corporation of India (POWERGRID)**

Name of the Project: **Substation Package -SS01 for Construction of 765/400/220kV Bhuj Pool (New) S/S and Extension of 765kV Banaskantha S/S under Green Energy Corridors: Inter-State Transmission Scheme (ISTS) – Part C; [Part-II] {for 400/220kV (2X500MVA) part of the substation associated bays.**

This specification comprises of following sections:
Section-1: Scope, Specific Technical Requirements & Bill of Quantities
Section-2A: Applicable Standards & References
Section-2B: Equipment Specification under Scope of Supplies-Technical Specification **(section–Transformer up to 400kV Class Rev.09)**
Section-3: Project Details & General Technical Requirements
Section-4: Guaranteed Technical Particulars
Section-5: Technical Checklist
Section-6: Schedule of Technical Deviations

In case of any conflict between various sections, order of precedence shall be in the same order as listed above.

The scope of supplies shall be as per commercial terms and conditions enclosed separately with the enquiry.

1.2 SPECIFIC TECHNICAL REQUIREMENTS

1.2.1 Specific Technical Requirements for Auto Transformer

For 500MVA, 400/220/33 kV Auto Transformer				
A.	Voltage ratio (kV)	400/220/33		
B.	Rated frequency (Hz)	50		
C.	Max. Design Ambient Temp. (°C)			
D.	Windings	HV	IV	LV
	(i) System Fault level (KA) / **1 Sec**	63	40	25
	(ii) 1.2/50 micro sec. impulse withstand voltage (kVp)	1300	950	250
	(iii) 20/200/500 micro second switching surge withstand voltage (kVp)	1050	--	--
	(iv) One minute power frequency voltage kV (rms)	570	395	95
	(v) Winding connection	Star	Star	Delta
	(vi) Neutral	Solidly grounded		
	(vii) Insulation	Solidly grounded		
	(viii) Vector Group	YN a0 d11		

Notes:

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. The criteria for Transformer losses shall be **"Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)".**

1.2.2 Maximum Permissible Losses for Auto Transformer

Transformer Rating	Max. No Load Loss/ Iron Loss at rated voltage and frequency (kW)	Max. Load Loss/ Copper Loss at rated current and at 75°C (kW)	Max. Auxiliary Loss/ Cooler Loss at rated voltage and frequency (kW)

500MVA, 400/220/33kV, 3-Ph Auto Transformer	95	500	7

Note:

Bidder is required to offer the Transformer with above specified losses.

1.2.2.1 Guaranteed Losses and Liquidated Damage due to higher loss: The maximum loss at rated condition (voltage, current and frequency, as applicable) for Auto Transformer shall be corrected in accordance with IEC-60076 for the purpose of comparison of maximum losses with measured losses for levy of liquidated damages. If during factory tests, measured loss (es) are found to be more than the specified maximum value(s) (specified in clause 1.2.2 above), BHEL/POWERGRID at his discretion may accept or reject Auto Transformer after assessing the liquidated damages (LD) against the contract as per rates given in clause 1.2.2.3 below and such amount shall be deducted from the contract price or otherwise recovered from Bidder. No cost benefit shall be considered in case measured losses are less than the specified maximum losses.

1.2.2.2 Criterion for calculating Liquidated damage:

Differential losses = Losses measured at the time of testing - corresponding losses (specified in clause 1.2.2 above) (corrected in accordance with IEC-60076)

1.2.2.3 Liquidated Damage due to differential losses on pro-rata basis:
If measured losses are exceeding maximum specified guaranteed losses (specified in clause 1.2.2 above), value by 0 to +5%, the details for liquidated damages on pro-rata basis for the performance of Auto Transformer shall be as follows,

Sl. No.	Equipment Category	Parameter	Value of Liquidated Damages in Indian Rupees per unit of parameter differential with respect to maximum losses
1.	500 MVA, 400/220/33 kV, 3-ph Auto Transformer	Differential Load Loss/ Copper loss (kW)	INR 167,715/- (Indian Rupees One Hundred Sixty Seven Thousand Seven Hundred and Fifteen only) per KW.
		Differential No Load Loss/ Iron loss (kW)	INR 369,960/- (Indian Rupees Three Hundred Sixty Nine Thousand Nine Hundred and Sixty only)
		Auxiliary Loss/ Cooler Loss (kW)	INR 246,640/- (Indian Rupees Two Hundred Forty Six Thousand Six Hundred and Forty only) per KW.

Liquidated damages shall be applied in the following manner depending on the variation of losses with respect to the maximum values:

a) Measured losses exceeding Maximum value by 0 to +5%: Rates of LD mentioned above
b) Measured losses exceeding Maximum value by > +5% to +10%: Twice the rates of LD mentioned above

c) Measured losses exceeding Maximum value by > +10% to +15%: Four times the rates of LD mentioned above

However, the equipment under no circumstances shall be accepted if the measured losses in each category exceed by more than +15 percent of the Maximum losses (as specified in clause 1.2.2 above) at rated conditions.

Please refer **Section-2A & 2B** for detailed specific Technical requirements and Parameters.

1.3 GENERAL TECHNICAL REQUIREMENTS

1.3.1 Paint System and Procedure

Bidder to follow paint system and procure as per **Clause 7.0** and **Annexure-F of Section-2B.**

1.3.2 Grounding/ Earthing work

Supply of grounding/ earthing material (except 40mm Dia MS rod and/or GI Flat) and supervision of erection/fixing of grounding/ earthing of Auto Transformer and its accessories shall be under bidder's scope, based on their design philosophy.

1.3.3 Cabling work

Cabling from Marshalling Box to Auto Transformer and its Cooling Bank is under scope of supply including glands, lugs, tags and ferruling etc. Termination schedule shall be submitted along with drawings.

1.3.4 Auxiliary Supply

Terminals in marshalling box for external power supply coming into marshalling box shall be suitable to requirement.

1.4 BILL OF QUANTITIES

Sr. No.	Description of Item	Unit	Qty
A	**Main Supply Items for 500 MVA, 400/220/33kV, 3-Ph Auto Transformer**		
1	500 MVA, 400/220/33kV, 3-Ph Auto Transformer excluding insulating oil	No	2
2	Insulating Oil for 500 MVA, 400/220/33kV, 3-Ph Auto Transformer (including 10% extra oil as per note1 for each Auto Transformer)	Set	2
3	On line dissolved gas (multi gas) & moisture analyser) (As per technical specification)	No	2
4	On line insulating oil drying system (cartridge type) (As per technical specification)	No	2
5	Digital RTCC panel consist of digital RTCC relays as per technical specification	Set	1
6	Recommended spare parts and maintenance equipment necessary for three (3) years of successful operation of Auto Transformer	Set	1

B	**Mandatory Spares Items for 500 MVA, 400/220/33kV, 3-Ph Auto Transformer**		
1	Oil cooler pump with motor	Set	1
2	Cooler Fan with motor	No.	1
3	Local & Remote WTI with sensing device & contact (each type)	Set	1
4	Buchholz relay complete with float & contacts (Main tank)	Set	1
5	Magnetic oil level gauge	No.	1
6	Starters, contactors, switches & relays for electrical control panels (one set of each type)	Set	1
7	Remote tap position Indicator	No.	1
8	Oil Flow indicator with flow switch	Set	1
9	420kV Bushing with metal parts, gaskets and lifting tools	Set	1
10	245kV Bushing with metal parts, gaskets and lifting tools	Set	1
11	52kV Bushing with metal parts, gaskets and lifting tools	Set	1
12	36kV Bushing with metal parts, gaskets and lifting tools	Set	1
13	Spare insulating oil to be handed over to POWERGRID after commissioning for O&M requirement	KL	10
C	**Service Items for 500 MVA, 400/220/33kV, 3-Ph Auto Transformer**		
1	Supervision of unloading for 500 MVA, 400/220/33kV, 3-Ph Auto Transformer at site	No	2
2	Supervision of erection for 500 MVA, 400/220/33kV, 3-Ph Auto Transformer at site	No	2
3	Supervision of testing for 500 MVA, 400/220/33kV, 3-Ph Auto Transformer at site	No	2
4	Supervision of commissioning for 500 MVA, 400/220/33kV, 3-Ph Auto Transformer at site	No	2
5	Submission of final documentation after handing over to BHEL/POWERGRID	No	2

Note:

1. Ten percent (10%) extra oil shall also be supplied for topping up, in non-returnable containers suitable for outdoor storage. The cost of the same should be included in the quoted price and no price implication will be accepted at later stage.

1.5 TECHNICAL QUALIFYING REQUIREMENT

Bidder should have successfully carried out **Dynamic Short Circuit test on 315MVA, 400/220/33kV Auto Transformer** as on the originally scheduled date of bid opening **i.e. dated 07 April 2015** and shall enclose the relevant Test Report/ Certificate along with bid. In case bidder has not successfully tested 315MVA, 400/220/33kV Auto Transformer for Dynamic Short Circuit test, their bid shall not be considered. Further, design review of offered 400 kV Class Auto transformer shall be carried out based on the design of short circuit tested 315MVA Auto transformer.

1.6 TYPE TESTING

The reports for all type tests as per technical specification shall be furnished by the Bidder along with equipment / material drawings.

The validity of Type Tests **(except dynamic short circuit test)** of Transformer shall be **5 years** as on the originally scheduled date of bid opening **i.e. dated 07 April 2015**, provided that offered transformer design is identical to the type tested transformer and same active materials (CRGO, Conductor and Insulation) of same grade & from the same sub-vendors are used. In case of any change of either active materials or sub-vendors, the type tests shall be carried out by the Bidder at no extra cost to BHEL. Transformer type test report from the same manufacturing plant shall only be acceptable. With regards to validity of dynamic short circuit test once conducted shall be applicable.

Bidder should have successfully carried out **Dynamic Short Circuit test on 315MVA, 400/220/33kV Auto Transformer** as on the originally scheduled date of bid opening **i.e. 07 April 2015** and shall enclose the relevant Test Report/ Certificate along with bid. In case bidder has not successfully tested 315MVA, 400/220/33kV Auto Transformer for Dynamic Short Circuit test, their bid shall be considered technically non responsive. Further, design review of offered 400 kV Class Auto Transformer shall be carried out based on the design of short circuit tested 315MVA Auto Transformer.

Type Tests on Transformer fittings: The test reports submitted, shall be of the tests conducted within last **10 (ten) years** prior to the originally scheduled date of bid opening **i.e. dated 07 April 2015.** In case the test reports are of the test conducted earlier than 10 (ten) years prior to the originally scheduled date of bid opening **i.e. dated 07 April 2015.**, the Bidder shall repeat these test(s) at no extra cost to the BHEL/POWERGRID. The type tests conducted earlier should have either been conducted in accredited laboratory **(accredited based on ISO / IEC Guide 25 / 17025 or EN 45001 by the national accreditation body of the country where laboratory is located)** or witnessed by BHEL/POWERGRID or representative authorized by POWERGRID or Utility or representative of accredited test lab or reputed consultant. Further, in the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design/manufacturing changes (including substitution of components) or due to non-compliance with the requirement stipulated in the Technical Specification or any/all type tests not carried out, same shall be carried out without any additional cost implication to the BHEL/POWERGRID.

The BIDDER shall intimate the BHEL/POWERGRID the detailed program about the tests at least two (2) weeks in advance in case of domestic supplies & six (6) weeks in advance in case

of foreign supplies. Further, in case type tests are required to be conducted / repeated and the deputation of Inspector/Purchaser's representative is required, then all the expenses shall be borne by the Bidder.

In addition to this, Bidder shall submit valid type test reports (as per relevant IEC/IS Standard) for approval in line with clause **5.2 & 3.13.1 of section-2B** and **clause 9.0 of Section-3.** In case type test reports are found to be technically unacceptable to BHEL/POWERGRID, the type test shall be conducted without cost and delivery implication to BHEL/POWERGRID.

1.7 INSPECTION AND TESTING AT WORKS

The Bidder shall carry out a comprehensive inspection and testing programme during manufacture of the equipment as detailed in **section-2B** and **section3**.

1.8 QUALITY PLAN

The Bidder to follow valid and approved POWERGRD Quality Plan as per POWERGRID procedure. In case the bidder does not have POWERGRID approved Quality Plan, it will be the bidder's responsibility to get its Quality plan approved directly from POWERGRID.

1.9 ERECTION, TESTING AND COMMISISONING AT SITE

The Bidder shall supervise a comprehensive erection, testing and commissioning programme at site duly POWERGRID approved as detailed in **section-2B** and **section3.**

1.10 INFORMATION TO BE FURNISHED BY THE CONTRACTOR

Information/ documents to be furnished at the TENDER STAGE shall be as per **Section-2B** and **Section-3**.

1.11 DRAWINGS/ DATA SHEETS

Bidder shall submit POWERGRID approved/Standard drawings wherever available for extension of approval.

1.12 STANDARDS

The equipment to be furnished under this specification shall conform to latest issue with all amendments (as on the originally scheduled date of bid opening i.e**. dated 07 April 2015**) of standard specified under **Section-2A,** unless specifically mentioned in the specification.

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SECTION-2A
APPLICABLE STANDARDS AND REFERENCES

STANDARDS

a. The Indian Electricity Act 2003

b. Indian Electricity Rules

c. Indian Factories Act

d. Normative References

IEC 60076	Power transformers
IEC 60076-1	Part 1: General
IEC 60076-2	Part 2: Temperature rise
IEC 60076-3	Part 3: Insulation levels, dielectric tests and external clearances in air
IEC 60076-4	Part 4: Guide to the lightning impulse and switching impulse testing - Power transformers and reactors
IEC 60076-3-1	Part 3-1: Insulation Levels and Dielectric Tests –External Clearances in Air
IEC 60076-5	Part 5: Ability to withstand short circuit
IEC 60076-6	Part 6: Reactors
IEC 60076-7	Part 7: Loading guide for oil-immersed power transformers
IEC 60076-8	Part 8: Application guide
IEC 60076-10	Part 10: Determination of sound levels
IEC 60076-10-1	Part 10-1: Determination of sound levels - Application guide
IEC 60076-11	Part 11: Dry-type transformers
IEC 60076-12	Part 12: Loading guide for dry-type power transformers
IEC 60076-13	Part 13: Self-protected liquid-filled transformers
IEC 60076-14	Part 14: Design and application of liquid-immersed power transformers using high-temperature insulation materials
IEC 60076-15	Part 15: Gas-filled power transformers
IEC 60076-16	Part 16: Transformers for wind turbine applications
IEC 60076-18	Part 18: Measurement of frequency response
IEC 60076-19	Part 19: Rules for the determination of uncertainties in the measurement of losses in power transformers and reactors
IEC 60076-21	Part 21: Standard requirements, terminology, and test code for step-voltage regulators
IEC 60044	Current transformers

BS 3938	
IEC 60050	International Electrotechnical Vocabulary
IEC 60050(421)	International Electrotechnical vocabulary- Chapter 421 : Power Transformers and Reactors
IEC 60060	High Voltage test techniques
IEC 60060-1	General definitions and test requirements
IEC 60060-2	Measuring systems
IEC 60071	Insulation co-ordination
IEC 60071-1	Part 1: Definitions, principles and rules
IEC 60071-2	Part 2 : Application guide
IEC 60137	Bushing for alternating voltage above 1000V
IEC 60214	On-Load Tap changers
IEC 255-21-3	Relays vibration
IEC 60270	Partial discharge measurements
IEC 60296	Specification for Unused Mineral Oil for Transformers and Switchgear
IEC 60422	Supervision and Maintenance guide for Mineral Insulating Oil in Electrical Equipment
IEC 60475	Method of Sampling Liquid dielectrics
IEC 60529	Classification of Degrees of Protection provided by Enclosures
IEC 60542	Application Guide for On-Load Tap-Changers
IEC 60567	Guide for the Sampling of Gases and of Oil from Oil-filled Electrical Equipment for the Analysis of Free and Dissolved Gases
IEC 60651	Sound Level Meters
IEC 61083	Digital Recorders and Software for High Voltage Impulse testing
IEC 61083-1	Part 1: Requirements for digital recorders in high voltage impulse tests
IEC 61083-2	Part 2: Evaluation of software used for the determination of the parameters of impulse waveforms
CISPR 16	Specification for radio disturbance and immunity measuring apparatus
CISPR 16-1	Radio disturbance and immunity measuring apparatus
CISPR-18	Radio Interference Characteristics of Power Lines and High Voltage Equipment
ISO 9001	Quality system-Model for Quality Assurance in Design /development
Cigre Publication 202	Guidelines for conducting design reviews for transformers 100 MVA and 123 kV and above. August 2002-Cigre Working

	Group 12.22
WG 12-15	Guide for Customers Specifications for Transformers 100 MVA and 123 kV and above
WG 12 19	Short Circuit Performance of Transformers.
BS-4360	Specification for weldable structural steel
BS-5135	Specification for arc welding of carbon and carbon manganese steels
BS-5500	Specification for unfired fusion welded pressure vessels
IS-3618	Specification for phosphate treatment of iron & steel for protection against corrosion
IS-6005	Code of practice for phosphating of Iron and Steel
ISO-8501	Preparation of steel surface before application of Paints and related product
IEC-60599	Mineral oil impregnated electrical equipment in service – guide to the interpretation of dissolved and free gases analysis
IS-10593	Method of evaluating the analysis of gases in oil filled electrical equipment in service
IS-2099	Bushings for alternating voltages above 1000 volts
IS-3347 Part I to 8	Dimension for porcelain transformer bushing
DIN-42530	Bushing up to 1000kV from 250A-5000A for liquid filled Transformer
IS-2026 Part 1 to 5	Power transformer
IS-4691	Degrees of protection provided by enclosure for rotating electrical machinery
IEC-60034-5	Degrees of protection provided by integral design of rotating electrical machines(IP Code) classification
IS:325 / IEC -60034	Performance of cooling fan / oil pump motor
IS-13947 part 1 to 5	Specification for low voltage switchgear and control gear
IS:3400	Methods of test for vulcanised rubber
IS:7016 part 1 to 14	Methods of test for coated and treated fabrics
IS:803	Code of practice for design, fabrication and erection of vertical mild steel cylindrical welded oil storage tanks.
IS:3637	Gas operated Relays
IS:335	New Insulating oils – Specification
IEC-62271-203	Gas insulated metal enclosed switchgear for rated voltage above 52kV
IEC-61639	Direct connection between power transformers and gas-insulated metal enclosed switchgear for rated voltages of 52.5 kV and above.
IS:3400 / BS 903 / IS:7016	Air cell (Flexible Air Separator)

IEC 60529 / IP : 55	Degree of protection for cooler control cabinet , MOLG ,Cooling fan , oil pump, Buchholz Relay
IEC 60529 / IP : 56	Degree of protection for Pressure Relief Device
IEC 60529 / IP : 43	Degree of protection for Remote tap Changer cubicle (RTCC)

IS-5,	-	Colors for Ready Mixed Paints and Enamels.
IS-335,	-	New Insulating Oils.
IS-617,	-	Aluminium and Aluminium Alloy Ingots and Castings for General Engineering Purposes ,
IS-1448 (P1 to P 145)	-	Methods of Test for Petroleum and its Products.
IS-2071 (P1 to P3)	-	Methods of High Voltage Testing.
IS-12063	-	Classification of degrees of protection provided by enclosures of electrical equipment.
IS-2165 P1:1997 P2:1983	-	Insulation Coordination.
IS-3043	-	Code of Practice for Earthing
IS-6103	-	Method of Test for Specific Resistance (Resistivity) of Electrical Insulating Liquids
IS-6104	-	Method of Test for Interfacial Tension of Oil against Water by the Ring Method
IS-6262	-	Method of test for Power factor & Dielectric Constant of Electrical Insulating Liquids.
IS-6792	-	Method for determination of electric strength of insulating oils.
IS-5578	-	Guide for marking of insulated conductors.
IS-11353	-	Guide for uniform system of marking & identification of conductors & apparatus terminals.
IS-8263	-	Methods for Radio Interference Test on High voltage Insulators.
IS-9224 (Part 1,2&4)	-	Low Voltage Fuses
IEC-60 (Part 1 to P4)	-	High Voltage Test Techniques
IEC 66	-	Environmental Test
IEC-117	-	Graphical Symbols
IEC-156,	-	Method for the Determination of the Electrical Strength of Insulation Oils.
IEC-270,	-	Partial Discharge Measurements.
IEC-376	-	Specification and Acceptance of New Sulphur Hexafluoride
IEC-437	-	Radio Interference Test on High Voltage Insulators.
IEC-506,	-	Switching Impulse Tests on High Voltage Insulators.
IEC-507	-	Artificial Pollution Tests on High Voltage Insulators to be used on AC Systems.
IEC-6094	-	Common Specification for High Voltage Switchgear & Control gear Standards.
IEC-815	-	Guide for the Selection of Insulators in respect of Polluted Conditions.
IEC-865 (P1 & P2)	-	Short Circuit Current - Calculation of effects.
ANSI-C.1/NFPA.70	-	National Electrical Code
ANSI-C37.90A	-	Guide for Surge Withstand Capability (SWC) Tests

ANSI-C63.21,	-	Specification for Electromagnetic Noise and
C63.3	-	Field Strength Instrumentation 10 KHz to 1 GHZ
C36.4ANSI-C68.1	-	Techniques for Dielectric Tests
ANSI-C76.1/EEE21	-	Standard General Requirements and Test Procedure for Outdoor Apparatus Bushings.
ANSI-SI-4	-	Specification for Sound Level Meters
ANSI-Y32-2/C337.2	-	Drawing Symbols
ANSI-Z55.11	-	Gray Finishes for Industrial Apparatus and Equipment No. 61 Light Gray
NEMA-107T	-	Methods of Measurements of RIV of High Voltage Apparatus
NEMA-ICS-II	-	General Standards for Industrial Control and Systems Part ICSI-109
CISPR-1	-	Specification for CISPR Radio Interference Measuring Apparatus for the frequency range 0.15 MHz to 30 MHz
CSA-Z299.1-1978h	-	Quality Assurance Program Requirements
CSA-Z299.2-1979h	-	Quality Control Program Requirements
CSA-Z299.3-1979h	-	Quality Verification Program Requirements
CSA-Z299.4-1979h	-	Inspection Program Requirements

CURRENT TRANSFORMERS, VOLTAGE TRANSFORMERS AND COUPLING CAPACITOR VOLTAGE TRANSFORMERS

IS-2705- (P1 to P4)	-	Current Transformers.
IS:3156- (P1 to P4)	-	Voltage Transformers.
IS-4379	-	Identification of the Contents of Industrial Gas Cylinders
IEC-44-1	-	Current transformers.
IEC-44-2	-	Voltage Transformers.
IEC-358	-	Coupling capacitors and capacitor dividers.
IEC-44-4	-	Instrument Transformes: Measurement of Partial Discharges
IEC-481	-	Coupling Devices for power Line Carrier Systems.
ANSI-C5713	-	Requirements for Instrument transformers
ANSIC92.2	-	Power Line Coupling voltage Transformers
ANSI-C93.1	-	Requirements for Power Line Carrier Coupling Capacitors

BUSHING

IS-2099	-	Bushings for Alternating Voltages above 1000V
IEC-137	-	Insulated Bushings for Alternating Voltages above 1000V

SURGE ARRESTERS

IS-3070 (PART2)	-	Lightning arresters for alternating current systems : Metal oxide lightning arrestors without gaps.
IEC-99-4	-	Metal oxide surge arrestors without gaps
IEC-99-5	-	Selection and application recommendation
ANSI-C62.1	-	IEE Standards for S A for AC Power Circuits
NEMA-LA 1	-	Surge Arresters

CUBICLES AND PANELS & OTHER RELATED EQUIPMENT

IS-722, IS-1248, IS-3231, 3231 (P-3)-Electrical relays for power system protection

IS:5039	-	Distributed pillars for Voltages not Exceeding 1000 Volts.
IEC-68.2.2	-	Basic environmental testing procedures Part 2: Test B: Dry heat
IEC-529	-	Degree of Protection provided by enclosures.
IEC-158(upto P3-1985)	-	Low Voltage Control Gear: Contactors.
IEC-439 (P1 & 2)	-	Low Voltage Switchgear and control gear assemblies
ANSI-C37.20	-	Switchgear Assemblies, including metal enclosed bus.
ANSI-C37.50	-	Test Procedures for Low Voltage Alternating Current Power Circuit Breakers
ANSI-C39	-	Electric Measuring instrument
ANSI-C83	-	Components for Electric Equipment
IS: 8623: (Part I to 3)	-	Specification for Switchgear & Control Assemblies.
NEMA-AB	-	Moulded Case Circuit and Systems
NEMA-CS	-	Industrial Controls and Systems
NEMA-PB-1	-	Panel Boards
NEMA-SG-5	-	Low voltage Power Circuit breakers
NEMA-SG-3	-	Power Switchgear Assemblies
NEMA-SG-6	-	Power switching Equipment
NEMA-5E-3	-	Motor Control Centers
1248 (P1 to P9)	-	Direct acting indicating analogue electrical measuring instruments & their accessories.

Protection and control equipment

IEC-51 : (P1 to P9)	-	Recommendations for Direct Acting indicating analogue electrical measuring instruments and their accessories.
IEC-255 (Part 1 to part 23)	-	Electrical relays.
IEC-297 (P1 to P4)	-	Dimensions of mechanical structures of the 482.6mm (19 inches) series.
IEC-359	-	Expression of the performance of electrical & electronic measuring equipment.
IEC-387	-	Symbols for Alternating-Current Electricity meters.
IEC-447	-	Man machine interface (MMI) - Actuating principles.
IEC-521	-	Class 0.5, 1 and 2 alternating current watt hour meters
IEC-547	-	Modular plug-in Unit and standard 19-inch rack mounting unit based on NIM Standard (for electronic nuclear instruments)
ANSI-81	-	Screw threads
ANSI-B18	-	Bolts and Nuts
ANSI-C37.1	-	Relays, Station Controls etc.
ANSI-C37.2	-	Manual and automatic station control, supervisory and associated telemetering equipment
ANSI-C37.2	-	Relays and relay systems associated with electric power apparatus
ANSI-C39.1	-	Requirements for electrical analog indicating instruments

MOTORS

IS-325	-	Three phase induction motors.
IS-4691	-	Degree of protection provided by enclosure for rotating electrical machinery.

IEC-34 (P1 to P19:)	-	Rotating electrical machines
IEC-Document 2	-	Three phase induction motors
(Central Office) NEMA-MGI		Motors and Generators

Electronic equipment and components

MIL-21B, MIL-833 & MIL-2750		
IEC-68 (P1 to P5)		Environmental testing
IEC-326 (P1 to P2) :		Printed boards
		Material and workmanship standards
IS-1363 (P1 to P3)	-	Hexagon head bolts, screws and nuts of product grade C.
IS-1364 (P1 to P5)	-	Hexagon head bolts, screws and nuts of products grades A and B.
IS-3138	-	Hexagonal Bolts and Nuts (M42 to M150)
ISO-898	-	Fasteners: Bolts, screws and studs
ASTM		- Specification and tests for materials

Clamps & connectors

IS-5561	-	Electric power connectors.
NEMA-CC1	-	Electric Power connectors for sub station
NEMA-CC 3	-	Connectors for Use between aluminium or aluminum-Copper Overhead Conductors

Bus hardware and insulators

IS: 2121	-	Fittings for Aluminum and steel cored Al conductors for overhead power lines.
IS-731	-	Porcelain insulators for overhead power lines with a nominal voltage greater than 1000 V.
IS-2486 (P1 to P4)	-	Insulator fittings for overhead power lines with a nominal voltage greater than 1000 V.
IEC-120	-	Dimensions of Ball and Socket Couplings of string insulator units.
IEC-137	-	Insulated bushings for alternating voltages above 1000 V.
IEC-168	-	Tests on indoor and outdoor post insulators of ceramic material or glass for Systems with Nominal Voltages Greater than 1000 V.
IEC-233	-	Tests on Hollow Insulators for use in electrical equipment.
IEC-273	-	Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1000V.
IEC-305	-	Insulators for overhead lines with nominal voltage above 1000V-ceramic or glass insulator units for a.c. systems Characteristics of String Insulator Units of the cap and pin type.
IEC-372 (1984)	-	Locking devices for ball and socket couplings of string insulator units : dimensions and tests.
IEC-383 (P1 and P2)	-	Insulators for overhead lines with a nominal voltage above 1000 V.
IEC-433	-	Characteristics of string insulator units of the long rod type.
IEC-471	-	Dimensions of Clevis and tongue couplings of string insulator units.
ANSI-C29	-	Wet process porcelain insulators
ANSI-C29.1	-	Test methods for electrical power insulators

ANSI-C92.2	-	For insulators, wet-process porcelain and toughened glass suspension type
ANSI-C29.8	-	For wet-process porcelain insulators apparatus, post-type
ANSI-G.8	-	Iron and steel hardware
CISPR-7B	-	Recommendations of the CISPR, tolerances of form and of Position, Part 1
ASTM A-153	-	Zinc Coating (Hot-Dip) on iron and steel hardware

Strain and rigid bus-conductor

IS-2678	-	Dimensions & tolerances for Wrought Aluminum and Aluminum Alloys drawn round tube.
IS-5082	-	Wrought Aluminum and Aluminum Alloy Bars. Rods,Tubes and Sections for Electrical purposes.
ASTM-B 230-82	-	Aluminum 1350 H19 Wire for electrical purposes
ASTM-B 231-81	-	Concentric - lay - stranded, aluminum 1350 conductors
ASTM-B 221	-	Aluminum - Alloy extruded bar, road, wire, shape
ASTM-B 236-83	-	Aluminum bars for electrical purpose (Bus-bars)
ASTM-B 317-83	-	Aluminum-Alloy extruded bar, rod, pipe and structural shapes for electrical purposes (Bus Conductors)

Wires and cables

ASTMD-2863	-	Measuring the minimum oxygen concentration to support candle like combustion of plastics (oxygen index)
IS-694	-	PVC insulated cables for working voltages upto and including 1100 Volts.
IS-1255	-	Code of practice for installation and maintenance of power cables, upto and including 33 kV rating
IS-1554 (P1 and P2)	-	PVC insulated (heavy duty) electric cables (part 1) for working voltage upto and including 1100 V.
	-	Part (2) for working voltage from 3.3 kV upto and including 11kV.
IS:1753	-	Aluminium conductor for insulated cables
IS:2982	-	Copper Conductor in insulated cables.
IS-3961 (P1 to P5)	-	Recommended current ratings for cables.
IS-3975	-	Mild steel wires, formed wires and tapes for armouring of cables.
IS-5831	-	PVC insulating and sheath of electric cables.
IS-6380	-	Elastometric insulating and sheath of electric cables.
IS-7098	-	Cross linked polyethylene insulated PVC sheathed cables for working voltage upto and including 1100 volts.
IS-7098	-	Cross-linked polyethyle insulated PVC sheathed cables for working voltage from 3.3kV upto and including 33 kV.
IS-8130	-	Conductors for insulated electrical cables and flexible cords.
IS-1753	-	Aluminum Conductors for insulated cables.
IS-10418	-	Specification for drums for electric cables.
IEC-96 (part 0 to p4)	-	Radio Frequency cables.
IEC-183	-	Guide to the Selection of High Voltage Cables.
IEC-189 (P1 to P7)	-	Low frequency cables and wires with PVC insulation and PVC sheath.
IEC-227 (P1 to P7)	-	Polyvinyl Chloride insulated cables of rated voltages up to and including 450/750V.
IEC-228	-	Conductors of insulated cables
IEC-230	-	Impulse tests on cables and their accessories.

IEC-287 (P1 to P3)	-	Calculation of the continuous current rating of cables (100% load factor).
IEC-304	-	Standard colours for insulation for low-frequency cables and wires.
IEC-331	-	Fire resisting characteristics of Electric cables.
IEC-332 (P1 to P3)	-	Tests on electric cables under fire conditions.
IEC-502	-	Extruded solid dielectric insulated power cables for rated voltages from 1 kV upto to 30 kV
IEC-754 (P1 and P2)	-	Tests on gases evolved during combustion of electric cables.

Galvanizing

IS-209	-	Zinc Ingot
IS-2629	-	Recommended Practice for Hot-Dip galvanizing on iron and steel.
IS-2633	-	Methods for testing uniformity of coating of zinc coated articles.
ASTM-A-123	-	Specification for zinc (Hot Galvanizing) Coatings, on products Fabricated from rolled, pressed and forged steel shapes, plates, bars and strips.
ASTM-A-121-77	-	Zinc-coated (Galvanized) steel barbed wire

Painting

IS-6005	-	Code of practice for phosphating of iron and steel.
ANSI-Z551	-	Gray finishes for industrial apparatus and equipment
SSPEC	-	Steel structure painting council

Fire protection system

Fire protection manual issued by tariff advisory committee (TAC) of India

HORIZONTAL CENTRIFUGAL PUMPS

IS:1520	-	Horizontal centrifugal pumps for clear, cold and fresh water
IS:9137	-	Code for acceptance test for centrifugal & axial pumps
IS:5120	-	Technical requirement - Rotodynamic special purpose pumps
API-610	-	Centrifugal pumps for general services
	-	Hydraulic Institutes Standards
BS:599	-	Methods of testing pumps
PTC-8.2	-	Power Test Codes - Centrifugal pumps

Other civil works standards

IS-269	-	33 grade ordinary portland cement.
IS2721	-	Galvanized steel chain link fence fabric
IS-278	-	Galvanized steel barbed wire for fencing.
IS-383	-	Coarse and fine aggregates from natural sources for concrete.
IS-432 (P1 and P2)	-	Mild steel and medium tensile steel bars and hard-dawn steel wire for concrete reinforcement.
IS-456	-	Code of practice for plain and reinforced concrete.
IS-516	-	Method of test for strength of concrete.
IS-800	-	Code of practice for general construction in steel.
IS-806	-	Steel tubes for structural purposes.
IS-1172	-	Basic requirements for water supply, drainage and sanitation.

IS-1199	-	Methods of sampling and analysis of concrete.
IS-1566	-	Hard-dawn steel wire fabric for concrete reinforcement.
IS-1742	-	Code of Practice for Building drainage.
IS-1785	-	Plain hard-drawn steel wire for prestressed concrete.
IS-1786	-	High strength deformed Steel Bars and wires for concrete reinforcement.
IS-1811	-	Methods of sampling Foundry sands.
IS-1893	-	Criteria for earthquake resistant design of structures.
IS-2062	-	Steel for general structural purposes.
IS-2064	-	Selection, installation and maintenance of sanitary appliances-code of practices.
IS-2065	-	Code of practice for water supply in buildings.
IS-2090	-	High tension steel bars used in prestressed concrete.
IS-2140	-	Standard Galvanized steel wire for fencing.
IS-2470 (P1 & P2)	-	Code of practice for installation of septic tanks.
IS-2514	-	Concrete vibrating tables.
IS-2645	-	Integral cement waterproofing compounds.
IS-3025 (Part 1 to Part 48)	-	Methods of sampling and test (Physical and chemical) for water and waste water.
IS-4091	-	Code of practice for design and construction of foundations for transmission line towers and poles.
IS-4111 (Part 1 to P5)	-	Code of practice for ancillary structures in sewerage system.
IS-4990	-	Plywood for concrete shuttering work.
IS-5600	-	Sewage and drainage pumps.

National building code of India 1970

USBR E12	-	Earth Manual by United States Department of the interior Bureau of Reclamation
ASTM-A392-81	-	Zinc/Coated steel chain link fence fabric
ASTM-D1557-80	-	test for moisture-density relation of soils using 10-lb (4.5 kg) rame land 18-in. (457 mm) Drop.
ASTM-D1586	-	Penetration Test and Split-Barrel
(1967)	-	Sampling of Soils
ASTM-D2049-69	-	Test Method for Relative Density of Cohesionless Soils
ASTM-D2435	-	Test method for Unconsolidated, (1982)
	-	Undrained Strengths of Cohesive Soils in Triaxial Compression.
BS-5075	-	Specification for accelerating Part I Admixtures, Retarding Admixtures and Water Reducing Admixtures.
CPWD	-	Latest CPWD specifications

ACSR MOOSE CONDUCTOR

IS:6745		Methods for Determination of Mass of zinc coating on zinc coated Iron and Steel Articles	BS:443-1969
IS:8263		Methods for Radio Interference	
IEC:437	-	1973Test on High Voltage Insulators	NEMA:107-1964
		CISPR	
IS:209		Zinc Ingot BS:3436-1961	

IS:398 Part - V	Aluminum Conductors for IEC:209-1966 Overhead Transmission Purposes
BS:215(Part-II)	Aluminium Conductors galvanized IEC:209-1966steel reinforced extra high
BS:215(Part-II)	voltage (400 kV and above)
IS:1778	Reels and Drums forBS:1559-1949 Bare Conductors
IS:1521	Method for Tensile Testing ISO/R89-1959of steel wire
IS:2629	Recommended practice for Hot dip Galvanising on Iron and Steel.
IS:2633	Method for Testing Uniformity of coating of zinc Coated Articles.
IS:4826	Hot dip galvanised coatings on round steel wires ASTMA-472-729

GALVANISED STEEL EARTHWIRE

IS:1521	Method for Tensile Testing ISO/R:89-1959 of Steel Wire
IS:1778	Reels and Drums for Bare Conductors
IS:2629	Recommended practice forHot Dip Galvanising on Ironand Steel.
IS:2633	Methods for testing Uniformityof Coating of Zinc Coated Articles.
IS:4826	Hot dip Galvanised Coatings ASTM:A 475-72a on Round Steel Wires BS:443-1969
IS:6745	Method for Determination BS:443-1969of mass of Zinc Coating on Zinc coated Iron and Steel Articles.
IS:209	Zinc ingot BS:3463-1961
IS:398 (Pt. I to P5:1992)	Aluminum Conductors for BS:215 (Part-II) overhead transmission purposes.

Lighting Fixtures and Accessories

(i)	IS:1913	General and safety requirements for electric lighting fittings.
(ii)	IS:3528	Water proof electric lighting fittings.
(iii)	IS:4012	Dust proof electric lighting fittings.
(iv)	IS:4013	Dust tight proof electric lighting fittings.
(v)	IS:10322	Industrial lighting fittings with metal reflectors.
(vi)	IS:10322	Industrial lighting fittings with plastic reflectors.
(vii)	IS:2206	Well glass lighting fittings for use under ground in mines (non-flameproof type).
(viii)	IS:10322	Specification for flood light.
(ix)	IS:10322	Specification for decorative lighting outfits.
(x)	IS:10322	Lumanaries for street lighting
(xi)	IS:2418	Tubular flourescent lamps
(xii)	IS:9900	High pressure mercury vapour lamps.
(xiii)	IS:1258	Specification for Bayonet lamp flourescent lamp.
(xiv)	IS:3323	Bi-pin lamp holder tubular flourescent lamps.
(xv)	IS:1534	Ballasts for use in flourescent lighting fittings. (Part-I)
(xvi)	IS:1569	Capacitors for use in flourescent lighting fittings.

(xvii)	IS:2215	Starters for flourescent lamps.
(xviii)	IS:3324	Holders for starters for tubular flourescent lamps
(xix)	IS:418	GLS lamps
(xx)	IS:3553	Water tight electric fittings
(xxi)	IS:2713	Tubular steel poles
(xxii)	IS:280	MS wire for general engg. Purposes

Conduits, Accessories and Junction Boxes

(1)	IS:9537	Rigid steel conduits for electrical wiring
(2)	IS:3480	Flexible steel conduits for electrical wiring
(3)	IS:2667	Fittings for rigid steel conduits for electrical wiring
(4)	IS:3837	Accessories for rigid steel conduits for electrical wiring
(5)	IS:4649	Adaptors for flexible steel conduits.
(6)	IS:5133	Steel and Cast Iron Boxes
(7)	IS:2629	Hot dip galvanising of Iron & Steel.
(4)	IS:2551	Danger notice plates
(5)	IS:2705	Current transformers
(6)	IS:9224	HRC Cartridge fuse links for voltage above 650V(Part-2)
(7)	IS:5082	Wrought aluminium and Al. alloys, bars, rods, tubes and sections for electrical purposes.
(8)	IS:8623	Factory built Assemblies of Switchgear and Control Gear for voltages upto and including 1000V AC and 1200V DC.
(9)	IS:1248	Direct Acting electrical indicating instruments

Electrical Installation

(1)	IS:1293	3 pin plug
(2)	IS:371	Two to three ceiling roses
(3)	IS:3854	Switches for domestic and similar purposes
(4)	IS:5216	Guide for safety procedures and practices in electrical work.
(5)	IS:732	Code of practice for electrical wiring installation (system voltage not exceeding 650 Volts.)
(6)	IS:3043	Code of practice for earthing.
(7)	IS:3646	Code of practice of interior illumination part II & III.
(8)	IS:1944	Code of practice for lighting of public through fares.
(9)	IS:5571	Guide for selection of electrical equipment for hazardous areas.
(10)	IS:800	Code of practice for use of structural steel in general building construction.
(11)	IS:2633	Methods of Testing uniformity of coating on zinc coated articles.
(12)	IS:6005	Code of practice for phosphating iron and steel.

(13) INDIAN ELECTRICITY ACT
(14) INDIAN ELECTRICITY RULES

Addundem-1

Amendment to Technical specification for SECTION - UPTO 400KV TRANSFORMER REV-09

<table>
<tr><th>Sl. No.</th><th>Amended as</th></tr>
<tr><td>01</td><td>Clause no. 4 of Section-Upto 400kV Transformer Rev-9 shall be read as :

"Measurable Defects:

The following shall constitute as Measureable Defects for the purpose of Defect Liabilities as per relevant clauses of GCC / SCC of the bidding document:

a) Repair, inside the Transformer and OLTC (including oil migration) either at site or at factory is carried out after commissioning.

b) The concentration of any fault gas is more than values of condition-1 indicated in clause no 6.5 of IEEE-C57.104-2008, which are as detailed below.

<table>
<tr><th>H2</th><th>CH4</th><th>C2H2</th><th>C2H4</th><th>C2H6</th><th>CO</th><th>CO2</th><th>TDCG</th></tr>
<tr><td>100</td><td>120</td><td>1</td><td>50</td><td>65</td><td>350</td><td>2500</td><td>720</td></tr>
</table>

c) The winding tan delta goes beyond 0.005 or increase more than 0.001 within a year w.r.t. pre-commissioning values. No temperature correction factor shall be applicable.

d) The moisture content goes above 12 ppm at any temperature during operation including full load."</td></tr>
<tr><td>02</td><td>Clause no. 6.16.1 of Section- Upto 400kV Transformer Rev-9 is amended as:

The core shall be constructed from high grade, non-ageing, cold rolled, super grain oriented silicon steel laminations (HI-B or better grade). Indian transformer manufacturers shall use core material as per above specification with BIS certification.</td></tr>
<tr><td>03</td><td>Clause 16.2.4 of Section- Upto 400kV Transformer Rev-9 is amended as follows:

16.4 Digital RTCC Panel:

16.4.1 The digital RTCC panel shall have Automatic Tap Changer control and monitoring relay with Automatic Voltage Regulating features (referred as Digital RTCC relay) to remotely control and monitor OLTC. The relay shall be offered from the manufacturer who has already supplied Digital RTCC relay, which is in operation for at-least 2 years for transformer OLTC application.

16.4.2 For new substation, the contractor shall provide Digital RTCC panel consisting of 4 Nos. Digital RTCC relays which shall be used to control 4 banks of transformers (i.e. 12 Nos. 1-Phase units or 4 Nos. 3-Phase units), unless otherwise specified elsewhere. Further, one spare Digital RTCC relay shall also be provided in the same panel.

For existing substations, the requirement of digital RTCC panel and relays are specified in Section-Project/BPS. However, bidders are advised to get clarified about the availability of existing RTCC schemes /Digital RTCC relays to finalise matching digital RTCC relays requirements. The Digital RTCC relays envisaged for existing transformers shall be integrated for parallel operations. All required cables for the same shall be included in the scope.</td></tr>
</table>

Remark - This document shall supersheed Section 2B of Technical Specification

16.4.3 Digital RTCC relay shall be microprocessor based adopting the latest state of the art design & technology with in-built large display for ease of programming and viewing. The unit supplied shall be field programmable so that in the event of change in transformer / location, it could be customized to site conditions without sending back to works. The programming shall be menu driven and easily configurable. If it is designed with draw out type modules, it should take care of shorting all CT inputs automatically while drawing out. The CT / VT ratio shall be field programmable and Relay shall display the actual HV Voltage and current considering suitable multiplying factors. The system shall be self-sufficient and shall not require any additional devices like parallel balancing module etc.

All Digital RTCC Relays shall be of same make for smooth integration of these relays for parallel operations of all transformers in the substation.

16.4.4 The digital RTCC Panel shall be provided with digital RTCC relay having Raise/Lower push buttons, Manual/ Automatic mode selection features, Master / Follower/ Independent/ Off mode selection features and emergency stop Push Button for control of OLTC. Touch screen option in the relay, instead of electrical push button/switch is also acceptable.

16.4.5 **In Manual Mode**: In this mode, power system voltage based automatic control from digital RTCC relay shall be blocked and commands shall be executed manually by raise/lower push buttons.

16.4.6 **In Auto Mode:** In Auto mode, digital RTCC relay shall automatically control OLTC taps based on power system voltage and voltage set points. An interlock shall be provided to cut off electrical control automatically upon recourse being taken to the manual control in emergency.

16.4.7 **Master / Follower/ Independent/ Off mode**

Master Position: If the selector switch is in master position, it shall be possible to control the OLTC units of other parallel operating transformers in the follower mode by operation from the master unit.

Follower Position: If the selector switch is in Follower position control of OLTC shall be possible only from panel where master mode is selected.

Independent Position: In independent position of selector switch, control of OLTC shall be possible only from the panel where independent mode is selected.

Suitable interlock arrangement shall be provided to avoid unwanted/inconsistent operation of OLTC of the transformer

16.4.8 **Raise/Lower control:** The remote OLTC scheme offered shall have provision to raise or lower taps for the complete bank of three 1-phase transformers / 3-Phase Transformers. Individual 1-phase OLTC operation shall not be possible from the remote control panel.

16.4.9 Digital RTCC relays shall communicate with SCADA using IEC 61850 protocols to monitor, parameterise & control the OLTC. Any software required for this purpose shall be supplied. The supplied software shall not have restriction in loading on multiple computers for downloading and analyzing the data. Software shall indicate the current overview of all measured parameters of the connected transformer in real time. The digital RTCC Relay shall have multiple selectable set point voltages and it shall be possible to select these set points from SCADA, with a facility to have the possibility of additional set points command from SCADA.

Communication between the Digital RTCC relays to execute the commands for parallel operation shall be implemented using required communication protocol. IEC- 61850 GOOSE messaging between Digital RTCC relays for OLTC parallel operation is not permitted. Suitable communication

	hardware shall be provided to communicate up to distance of 1km between digital RTCC relays. Scope shall also include communication cables between digital RTCC relays. Cables as required for parallel operation of OLTCs of all transformers (including existing transformers wherever required) from Digital RTCC relays shall be considered included in the scope of bidder. 16.4.10 The Digital RTCC relay shall have programmable Binary Inputs (minimum 7 Nos.) and Binary outputs (minimum 7 Nos.) for Employer's future use. It shall be possible to have additional module for Binary Input / output as well as Analogue input module depending upon requirement. 16.4.11 The relays shall ensure positive completion of lowering/raising of the OLTC tap, once the command is issued from the relay. "Step-by-Step" operation shall be ensured so that only one tap change from each tap changing pulse shall be effected. If the command remains in the "operate" position, lock-out of the mechanism is to be ensured. 16.4.12 Following minimum indications/alarms shall be provided in Digital RTCC relay either through relay display panel or through relay LEDs: a. INCOMPLETE STEP alarm b. OLTC motor overload protection alarm c. Supply to DM Motor fail alarm d. OLTC IN PROGRESS alarm e. Local / Remote Selector switch positions in DM Box f. OLTC upper/lower limits reached alarm g. OLTC Tap position indications for transformer units h. 'Independent-combined-remote selector switch positions of CMB In case of parallel operation or 1-Phase Transformer unit banks OLTC out of step alarm shall be generated in the digital RTCC panel for discrepancy in the tap positions.
04	In Clause no. 20.2 of Section- Upto 400kV Transformer Rev-9, Oxygen (O_2) is considered as optional.
05	Sl. no. 1.21.iii) of Technical Particulars/ Parameters of Transformers–400kV Transformer at Annexure-A is amended as: Lightning Impulse withstand voltage for LV Bushing ---- 250kVp
06	Sl. no. 1.21.iv) of Technical Particulars/ Parameters of Transformers–400kV Transformer at Annexure-A is amended as: Switching Impulse withstand voltage for HV Bushing ---- 1050kVp
07	Sl. no. 1.21.v) of Technical Particulars/ Parameters of Transformers–400kV Transformer at Annexure-A is amended as: One minute Power Frequency withstand voltage for HV Bushing ---- 695kVp
08	The following "Note-4" is added under Annexure-A of Technical Particulars / Parameters of Transformers of Section-Upto 400kV Transformer Rev-9: **Note 4:** The criteria for Transformer losses shall be "**Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)"**

09 Sl. No. A) 5, B) 3 & C) 2 of Annexure-G (Unused inhibited Insulating Oil Parameters) of Section- Upto 400kV Transformer Rev-9 is amended as:

S N	Property	Test Method	Limits
A	**Function**		
5	Electric strength (breakdown voltage)	IEC 60156	(Min.) 50kV (new unfiltered oil) /70kV (after treatment)
9.	Carbon type composition (% of Aromatic, Paraffins and Naphthenic compounds)	IEC 60590 and IS 13155 or ASTM D 2140	Max. Aromatic : 4 to12 % Paraffins : <50% & balance shall be Naphthenic compounds.
B	**Refining/Stability**		
3	Total sulphur content	BS 2000 part 373 or ISO 14596 or ASTM D 2622 or ISO 20847	0.05 % (Max.) (Before oxidation test)
C	**Performance**		
2	Oxidation stability (Rotating Bomb test)	ASTM D2112 (a)	220 Minutes (Min.)

Section: 2B

Technical Specification

SECTION- UPTO 400 KV TRANSFORMER

REV 09

Dec' 2013

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SECTION- UPTO 400 KV TRANSFORMER

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TECHNICAL SPECIFICATION
SECTION: UPTO 400kV TRANSFORMER

1. General

1.1. This specification covers design, engineering, manufacture, testing at manufacturer's works, delivery at site including all materials, accessories, spares, unloading, handling, proper storage at site, erection, testing and commissioning of the equipment specified.

1.2. The transformers shall in general have constant ohmic impedance between HV and IV on all taps. However, in case of parallel operation with the existing transformer,

i) The impedance, vector group, OLTC connection & range etc. of the transformer is to be matched with that of the existing transformer.

ii) Necessary provision is to be kept in the transformer control scheme for parallel operation with the existing OLTC control scheme having provision of Master/Follower/Independent /Off operation.

iii) Matching of physical orientation, mounting rail gauge etc. to facilitate inter-changeability with the existing single phase transformer.

1.3. External or internal reactors shall not be used to achieve the HV/LV and IV/LV impedance specified.

2. Transportation

2.1. The Contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities for the transportation of the equipment. The dimension of the equipment shall be such that when packed for transportation, it will comply with the requirements of loading and clearance restrictions for the selected route. It shall be the responsibility of the contractor to coordinate the arrangement for transportation of the transformer for all the stages from the manufacturer's work to site.

2.2. The contractor shall carry out the route survey along with the transporter and finalise the detail methodology for transportation of transformer and based on route survey; any modification/ extension/ improvement to existing road, bridges, culverts etc. if required, shall be in the scope of the bidder.

2.3. The main tank of the transformer shall be transported on Hydraulic trailers equipped with GPS system for tracking the location of transformer at all times during transportation from manufacturer works to designated site. The contractor shall intimate to Employer about the details of transporter engaged for transportation of the transformer. The requisite details for tracking the transformer during transit shall be provided to Employer. Requirement of Hydraulic trailer is envisaged for 400kV transformer.

2.4. All metal blanking plates and covers which are specifically required to transport and storage of the transformer shall be considered part of the transformer and handed over to the Purchaser after completion of the erection. Bill of quantity of these items shall be included in the relevant drawing/document.

2.5. The Contractor shall despatch the transformer filled with dry air at positive pressure. The necessary arrangement shall be ensured by the contractor to take care of pressure drop of dry air during transit and storage till completion of oil filling during erection. The total duration of storage at site with dry gas shall preferably be limited to three months after which the Transformer shall be processed and filled with oil. The dry air cylinder (s) provided to maintain positive pressure can be taken back by the contractor after oil filling. A gas pressure testing valve with necessary pressure gauge and adaptor valve shall be provided.

The above arrangement is also applicable for turret and other components with insulation assembly transported separately with transformer.

2.6. Transformer shall also be fitted with sufficient number of Electronic impact recorders (on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. The acceptance criteria and limits of impact, which can be withstood by the equipment during transportation and handling in all three directions, shall not exceed"3g" for 50mSec (20Hz) as per POWERGRID pre-commissioning document mentioned at Annexure-D or as per contractor standard, whichever is higher.

3. Performance

3.1. The transformers shall be used for bi-directional flow of rated power. The major technical parameters of single phase and three phase transformer units are defined at **Annexure - A**

3.2. Transformers shall be capable of operating under natural cooled condition up to the specified load. The forced cooling equipment shall come into operation by pre-set contacts of winding temperature indicator and the transformer shall operate as a forced cooling unit initially as ONAF up to specified load and then as OFAF. Cooling shall be so designed that during total failure of power supply to cooling fans and oil pumps, the transformer shall be able to operate at full load for at least ten (10) minutes without the calculated winding hot spot temperature exceeding 140 deg C. Transformers fitted with two coolers, each capable of dissipating 50 per cent of the loss at continuous maximum rating, shall be capable of operating for 20 minutes in the event of failure of the oil circulating pump or blowers associated with one cooler without the calculated winding hot spot temperature exceeding 140degC at continuous max rating. The contractor shall submit supporting calculations for the above and the same shall be reviewed during design review.

3.3. The transformer shall be free from any electrostatic charging tendency (ECT) under all operating conditions when all oil circulation systems are in operation. The manufacturer shall ensure that there is no electrostatic charging tendency in the design. In general, oil flow speed shall not exceed 1.0 m/sec within winding in the oil flow system of the transformers.

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

3.5. The transformers shall be capable of being over loaded in accordance with IEC-60076-7. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.

3.6. The transformer and all its accessories including bushing/ built in CTs etc. shall be designed to withstand without damage, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding for a period of 2 secs. The short circuit level of the HV & IV System to which the transformers will be connected is as follows:

400kV system	- 63kA for 1 sec (sym, rms, 3 phase fault)
220kV system	- 40 kA for 1 sec (sym, rms, 3 phase fault)
132kV system	- 31.5 kA for 1 sec (sym, rms, 3 phase fault)
66kV system	- 25 kA for 1 sec (sym, rms, 3 phase fault)
33kV system	- 25 kA for 1 sec (sym, rms, 3 phase fault)

However, for transformer design purpose, the through fault current shall be considered limited by the transformer self-impedance only (i.e. $Z_s = 0$).

3.7. Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any terminals. Mechanical strength of the transformer shall be such that it can withstand 3-phase and 1- phase through fault for transformer rated voltage applied to HV and / or IV terminals of transformer. The short circuit shall alternatively be considered to be applied to each of the IV, HV and tertiary (LV) transformer terminals as applicable. The tertiary terminals shall be considered not connected to system source. For short circuit on the tertiary terminals, the in-feed from both HV & IV system shall be limited by the transformer self-impedance only and the rated voltage of HV and IV terminals shall be considered. The maximum short circuit output current at the tertiary terminals shall be limited to a safe value to make the transformer short circuit proof.

The transformer shall be designed to withstand for short circuit duration of 2 seconds for Thermal stress and the same shall be verified during design review.

3.8. The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that under 10 % continuous over-voltage condition it does not exceed 1.9 Tesla at all tap positions.

3.9. Transformers shall withstand, without damage heating, combined voltage and frequency fluctuations which produce the following over fluxing conditions:

1.10% for continuous
1.25 % for 1 minute
1.40 % for 5 seconds

110% for continuous
125% for 1 minute
140% for 5 seconds

3.10. The air core reactance of HV winding of transformer shall not be less than 20%.

3.11. The transformer shall be designed to withstand a DC current of 10A per phase without injurious heating, noise and vibration.

3.12. **Tertiary Windings (applicable as per Annexure - A)**

The tertiary windings shall be suitable for connection of reactors or capacitors which would be subjected to frequent switching and shall be suitable for connection to LT Transformer for auxiliary supply. All the windings shall be capable of withstanding these stresses that may be caused by such switching.

The Tertiary winding shall be designed to withstand mechanical and thermal stresses due to dead short circuit on its terminals.

3.13. **Radio Interference and Noise Level**

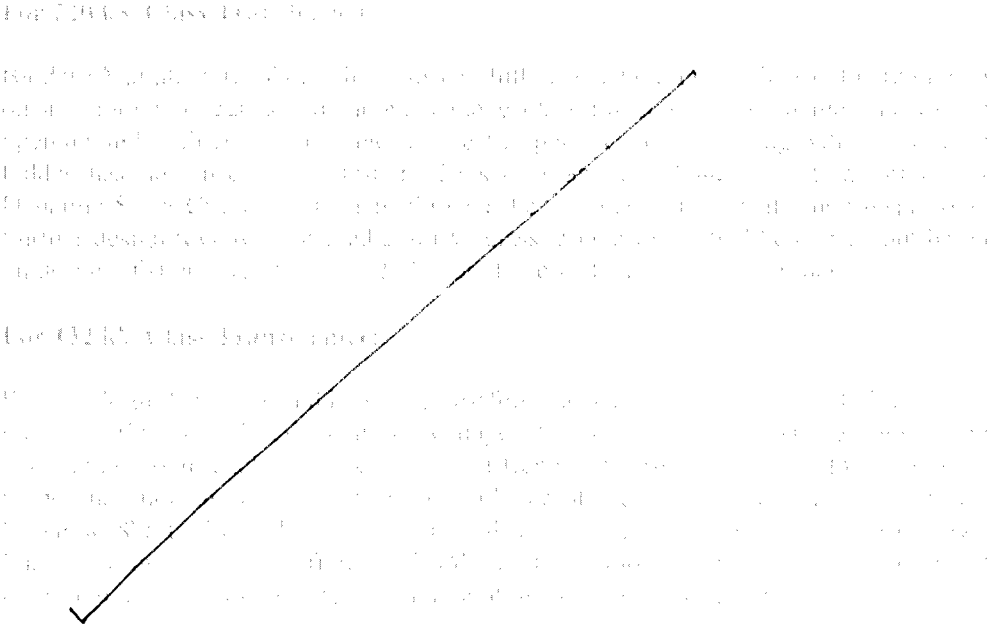
The transformers shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth so as to minimise interference with communication circuit.

The noise level of transformer, when energised at normal voltage and frequency with fans and pumps running shall not exceed the values specified at Annexure - A, when measured under standard conditions.

3.14. **Dynamic Short Circuit Test requirement**

3.14.1. **For 400 kV Class Auto transformer**

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit test on 315MVA, 400/220/33kV Auto transformer as on the date of bid opening and shall enclose the relevant Test Report/certificate along with bid. In case bidder has not successfully tested 315MVA, 400/220/33kV Auto transformer for Dynamic Short Circuit test, their bid shall be considered technically non responsive. Further, design review of offered 400 kV Class Auto transformer shall be carried out based on the design of short circuit tested 315MVA Auto transformer.



3.14.4. In case Dynamic Short circuit test is specified in Bid Price Schedule (BPS), submission of Dynamic short circuit test report of transformer as mention above is not required by Bidder along with bid document.

4. Additional Warrantee

As per S1.01 of Addendum 1

Manufacturer shall provide additional warrantee of five years (in addition to the warrantee specified in the bidding documents) for the Transformer in case any of the followings is observed within specified warrantee period:

a) Repair, inside the Transformer and OLTC (including oil migration) either at site or at factory is carried out after commissioning.

b) The concentration of any fault gas is more than values of condition-1 indicated in clause no 6.5 of IEEE-C57.104-2008, which are as detailed below.

H2	CH4	C2H2	C2H4	C2H6	CO	CO2	TDCG
100	120	1	50	65	350	2500	720

c) The winding tan delta goes beyond 0.005 or increase more than 0.001 within a year w.r.t. pre-commissioning values. No temperature correction factor shall be applicable.

d) The moisture content goes above 12 ppm at any temperature during operation including full load.

5. Design review

5.1. The transformer shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. Adequate safety margin w.r.t thermal, mechanical, dielectric and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc. in order to achieve long life of transformer with least maintenance.

5.2. Raw material and sub-vendors used by transformer manufacturer shall be declared before commencement of manufacturing. **The validity of Type tests (except dynamic short circuit test) of Transformer shall be 5 years as on the originally scheduled date of bid opening,** provided that offered transformer design is identical to the type tested transformer and same active materials (CRGO, Conductor and Insulation) of same grade & from the same sub-vendors are used. In case of any change of either active materials or sub-vendors, the type tests shall be carried out by the contractor at no extra cost to Employer. Transformer type test report from the same manufacturing plant shall only be acceptable. With regard to Validity of Dynamic short circuit test once conducted shall be applicable.

5.3. Design reviews shall be conducted by Purchaser or an appointed consultant during the procurement process for transformers; however the entire responsibility of design shall be with the manufacturer. Purchaser may also visit the manufacturers works to inspect design, manufacturing and test facilities at any time.

5.4. The design review will commence after placement of award with the successful bidder and shall be finalised before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the transformer under the scope of this specification. It shall be conducted generally following the "Guidelines for conducting design reviews for transformers - 100 MVA and 123 kV and above" prepared by CIGRE SC 12 Working Group 12.22.

5.5. The manufacturer shall provide all necessary information and calculations to demonstrate that the transformer meets the requirements for short circuit strength and durability. The latest recommendations of IEC and Cigre SC 12 shall be applied for short circuit withstand evaluation.

5.6. The manufacturer will be required to demonstrate the use of adequate safety margins for thermal, mechanical, dielectric and vibration etc. in design to take into account the uncertainties of his design and manufacturing processes. The scope of such design review shall include but not limited to the requirement as mentioned at **Annexure – E.**

6. Construction Details

The construction details and features of each power transformer shall be in accordance with the requirement stated hereunder. The components and fitting associated with transformers are subject to Purchaser's approval and design review.

6.1. Tank

6.1.1. Tank shall be of welded construction and fabricated from tested quality low carbon steel of adequate thickness. Unless otherwise approved, metal plate, bar and sections for fabrication shall comply with BS-4360 / IS 2062. Material Samples, technical literature, drawings, test reports and list of the names of the principal users with experience gained shall be supplied on request.

6.1.2. All seams and joints which are not required to be opened at site, shall be factory welded, and wherever possible they shall be double welded. Welding shall conform to BS-5135 / IS 9595. After fabrication of tank and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing members. The requirement of post weld heat treatment of tank / stress relieving shall be based on recommendation of BS-5500 table 4.4.3.1 / IS 10801.

6.1.3. Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.

6.1.4. The tank shall be of proven design either bell type with bolted /welded joint or conventional type with welded / bolted top cover. Bell type tank shall be provided with joint at about 500 mm above the bottom of the tank. The welded joint shall be provided with flanges suitable for repeated welding. The joint shall be provided with a suitable gasket to prevent weld splatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise at the joint.

6.1.5. Tank shall be provided with:

a. Lifting lugs: Four symmetrically placed lifting lugs shall be provided so that it will be possible to lift the complete transformer when filled with oil without structural damage to any part of the transformer. The factor of safety at any one point shall not be less than 2.

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

c. Each jacking pad shall be designed to support with an adequate factor of safety at least half of the total mass of the transformer filled with oil allowing in addition for maximum possible misalignment of the jacking force to the centre of the working surface.

d. Suitable haulage holes shall be provided.

e. Provision of 04 nos. of Gate valves for UHF sensors for PD Measurements at various locations. Location of valves shall be finalized during detailed engineering.

f. Suitable provisions of pockets for OTI, WTI & RTDs including two spare pockets.

6.1.6. The tank shall be designed in such a way that it can be mounted either on the plinth directly or on rollers, as per manufacturer's standard practice.

6.1.7. The base of each tank shall be so designed that it shall be possible to move the complete transformer unit by skidding in any direction without damage when using plates or rails.

6.1.8. **Tank hotspot**-under extreme conditions, the maximum temperature on any metal part shall not exceed 130 Deg. Celsius.

6.2. **Tank Cover**

6.2.1. The tank cover shall be designed to prevent retention of water and shall not distort when lifted. The internal surface of the top cover shall be shaped to ensure efficient collection and direction of free gas to the buchholz relay.

6.2.2. At least two adequately sized inspection openings one at each end of the tank, shall be provided for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25 kg. Handles shall be provided on the inspection cover to facilitate lifting.

6.2.3. The tank cover shall be provided with pockets for oil and winding temperature indicators. The location of pockets shall be in the position where oil reaches maximum temperature. Further, it shall be possible to remove bulbs of OTI/WTI/RTD without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.

6.2.4. Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

6.2.5. All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression.

6.2.6. **Currents flowing in tank cover and bushing turrets** - To allow for the effect of possible induced and capacitive surge current, the tank cover and bushing turret shall be fixed to the transformer in such a way that good electrical contact is maintained around the perimeter of the tank and turrets.

6.2.7. The transformer shall be provided with a suitable diameter pipe flange, butterfly valve, bolted blanking plate and gasket shall be fitted at the highest point of the transformer for maintaining vacuum in the tank. For smaller rating

Gas venting - The transformer cover and generally the internal spaces of the transformer and all pipe connections shall be designed so as to provide efficient venting of any gas in any part of the transformer to the Buchholz relay. The space created under inspection /manhole covers shall be filled with suitable material to avoid inadvertent gas pockets. The Covers shall be vented at least at both longitudinal ends. The design for gas venting shall take into accounts the slopes of the plinth (if any) on which the transformer is being mounted.

6.3. **Gasket for tank & cover**

All gasketed joints shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. All gasketed joints unless otherwise approved shall be of the O-ring and groove type. The Gaskets / O-Ring in contact with oil shall be Nitrile rubber or any other better approved quality.

The properties of all the above gaskets / O-Rings shall comply with the requirements of IS-11149. Gaskets and O-rings shall be replaced every time whenever the joints are opened.

6.4. **Roller Assembly**

The roller mounted transformers are to be provided with flanged bi-directional wheels and axles. This set of wheels and axles shall be suitable for fixing to the under carriage of transformer to facilitate its movement on rail track. Suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of transformer. The rail track gauge shall be 1676 mm.

6.5. **Foundation and Anti Earthquake Clamping Device**

To prevent transformer movement during earthquake, suitable clamping devices shall be provided for fixing the transformer to the foundation.

6.6. **Conservator**

6.6.1. Main conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture. Conservator shall be fitted with magnetic oil level gauge with potential free high and low oil level alarm contacts and prismatic oil level gauge.

6.6.2. Conservator tank shall have adequate capacity with highest and lowest visible-levels to meet the requirements of expansion of total cold oil volume in the transformer and cooling equipment from minimum ambient temperature to top oil temperature of 110 deg C. The capacity of the conservator tank shall be such that the transformer shall be able to carry the specified overload without overflowing of oil.

6.6.3. The conservator shall be fitted with lifting lugs in such a position so that it can be removed for cleaning purposes. Suitable provision shall be kept to replace air cell and cleaning of the conservator as applicable.

6.6.4. Conservator shall be positioned so as not to obstruct any electrical connection to transformer.

6.6.5. The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator. The main conservator tank shall be stencilled on its underside with the words **"Caution: Air cell fitted".** Lettering of at least 150 mm size shall be used in such a way to ensure clear legibility from ground level when the transformer is fully installed. To prevent oil filling into the air cell, the oil filling aperture shall be clearly marked. The transformer rating and diagram plate shall bear a warning statement that the **"Main conservator is fitted with an air cell".**

6.6.6. Contact of the oil with atmosphere is prohibited by using a flexible air cell of nitrile rubber reinforced with nylon cloth. The temperature of oil in the conservator is likely to raise up to $110^{O}C$ during operation. As such air cell used shall be suitable for operating continuously at this temperature.

6.6.7. The transformer manual shall give full and clear instructions on the operation, maintenance, testing and replacement of the air cell. It shall also indicate shelf life, life expectancy in operation, and the recommended replacement intervals.

6.6.8. The conservator tank and piping shall be designed for complete vacuum / filling of the main tank and conservator tank. Provision must be made for equalising the pressure in the conservator tank and the air cell during vacuum / filling operations to prevent rupturing of the air cell.

6.6.9. The contractor shall furnish the leakage rates of the rubber bag/ air cell for oxygen and moisture. It is preferred that the leakage rate for oxygen from the air cell into the oil will be low enough that the oil will not generally become saturated with oxygen before 10 years. Air cells with well proven long life characteristics shall be preferred.

6.6.10. OLTC shall have conventional type conservator with magnetic oil level gauge with potential free oil level alarm contact and prismatic oil level gauge.

6.7. **Piping works for conservator**

6.7.1. Pipe work connections shall be of adequate size preferably short and direct. Only radiused elbows shall be used.

6.7.2. The feed pipe to the transformer tank shall enter the transformer cover plate at its highest point and shall be straight for a distance not less than five times its internal diameter on the transformer side of the Buchholz relay, and straight for not less than three times that diameter on the conservator side of the relay. Gas-venting pipes shall be connected to the final rising pipe between the transformer and Buchholz relay as near as possible in an axial direction and preferably not less than five times pipe diameters from the Buchholz relay.

6.7.3. This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degrees.

6.7.4. A double flange valve of preferably 50 mm and 25 mm size shall be provided to fully drain the oil from the main tank conservator and OLTC conservator tank respectively.

6.7.5. The feed pipe diameter for the main conservator shall be not less than 80mm.

6.7.6. Pipe work shall neither obstruct the removal of tap changers for maintenance or the opening of inspection or manhole covers.

6.8. **Dehydrating Silicagel Filter Breather**

Conservator of Main Tank and OLTC shall be fitted with a dehydrating silicagel filter breather. Connection shall be made to a point in the oil conservator not less than 50 mm above the maximum working oil level by means of a pipe with a minimum diameter of 25 mm. Breathers having a mass less than 10 kg may be supported by the connecting pipe, whereas units of 10 kg and above shall be supported independent of the connecting pipe. Connecting pipes shall be securely clamped to the transformer, or other structure supplied by the contractor, in such a manner so as to eliminate undesirable vibration and noise. In the case where a breather of less than 10 kg is supported by the pipe, there shall be a cleat directly above the breather flange. The design shall be such that:

a) Passage of air is through silicagel.
b) Silicagel is isolated from atmosphere by an oil seal.
c) Moisture absorption indicated by a change in blue (cobalt type) colour of the tinted crystals can be easily observed from a distance.
d) Breather is mounted approximately 1200 mm above rail top level.
e) To minimise the ingress of moisture three breathers (of identical size) shall be connected in series for main tank conservator and two in series of identical size (each of 2.5 litres minimum volume)shall be connected to OLTC Conservator.
f) Contractor shall provide flexible connection pipes to be used during replacement of any silicagel breather.

6.9. **Pressure Relief Device**

Adequate number of pressure relief devices shall be provided at suitable locations. These shall be of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage to equipment. The device shall operate at a static pressure less than the hydraulic test pressure of the transformer tank. It shall be mounted directly on the tank. One set of electrically insulated contacts shall be provided for alarm/tripping. Discharge of pressure relief device shall be properly taken through pipes and directed away from the transformer/other equipment and this shall be prevented from spraying on the tank. The terminal box/boxes of PRD should conform to degree of protection as per IP-55 of IEC- 60529.

One set of potential free contacts (**with plug & socket type arrangement suitable for 2.5sq.mm control cable**) per device shall be provided for alarm/tripping. Following routine tests shall be conducted on PRD:

a) Air pressure test
b) Liquid pressure test
c) Leakage test
d) Contact operation test
e) Dielectric test on contact terminals

6.10. **Sudden Pressure Relay**

Adequate number of Sudden Pressure relay with alarm/trip contacts **(Terminal connection plug & socket type arrangement suitable for 2.5 sq.mm control cable)** shall be provided on tank of transformer. Operating features, size and quantity shall be reviewed during design review.

6.11. **Buchholz Relay**

A double float, reed type Buchholz relay shall be provided in series of the connecting pipe between the oil conservator and the transformer tank with minimum distance of five times pipe diameters between them. Any gas evolved in the transformer shall be collected in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling while the transformer in service. Each device shall be provided with two potential free contacts **(Plug & socket type arrangement suitable for 2.5sq.mm control cable)**, one for alarm / trip on gas accumulation and the other for tripping on sudden rise of pressure.

The Buchholz relay shall not operate during starting/ stopping of the transformer oil circulation pumps under any oil temperature conditions. The pipe or relay aperture baffles shall not be used to decrease the sensitivity of the relay. The relay shall not mal-operate for through fault conditions or be influenced by the magnetic fields around the transformer during the external fault conditions.

6.12. **Oil Temperature Indicator (OTI)**

All transformers shall be provided with a dial type thermometer of around 150 mm diameter for top oil temperature indication. It shall have adjustable, potential free alarm and trip contacts **(Plug & socket type arrangement suitable for 2.5sq.mm control cable)** besides that required for control of cooling equipment if any. A temperature sensing element suitably located in a pocket on top oil shall be provided. This shall be connected to the OTI by means of capillary tubing. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. Accuracy of OTI shall be ± 3.0 deg C or better or better for a temperature of 100 deg C.

The setting of alarm and tripping contacts shall be adjustable at site. For alarm & trip settings refer POWERGRID Pre-Commissioning Procedures and formats for switchyard equipment (enclosed at Annexure-D).

In addition to the above, the following accessories shall be provided for remote indication of oil temperature:

a) Temperature transducer with Pt100 sensor

RTD shall be provided with Pt100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The Pt100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The Pt100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil, for OTI system and shall provide dual output 4-20mA for remote OTI and SCADA system individually. The transducer shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between Pt100 temperature sensor and transducer, shall be in the scope of Contractor.

b) Remote oil temperature indicator

It shall be suitable for flush mounting on Employer's control panel/ digital RTCC panel and shall operate on 4-20mA input available from the above transducer. Any special cable required for shielding purpose, for connection among Individual Marshalling Box, Common Marshalling Box/Cooler control cabinet and remote OTI control circuit, shall be in the scope of Contractor.

6.13. **Winding Temperature Indicator (WTI)**

A device for measuring the hot spot temperature of each winding (HV, IV and LV) shall be provided. All transformers shall be provided with 150 mm dial type thermometer for winding temperature indication and shall have adjustable potential free alarm and trip contacts (**Plug & socket type arrangement suitable for 2.5sq.mm control cable**) besides that required for control of cooling equipment if any. WTI shall have Temperature sensing element, Image coil and Auxiliary CTs, if required to match the image coil, shall be mounted in the cooler control cabinet. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. Accuracy of OTI shall be ± 3.0 deg C or better for a temperature of 100 deg C.

The setting of alarm and tripping contacts shall be adjustable at site. For alarm & trip settings refer POWERGRID Pre-Commissioning Procedures and formats for switchyard equipment (enclosed at **Annexure-D**).

In addition to the above, the following accessories shall be provided for remote indication of oil temperature:

a) Temperature transducer with Pt100 sensor for each winding

RTD shall be provided with Pt100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The Pt100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The Pt100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil, Auxiliary CTs, if required to match the image coil, for WTI system and shall provide dual output 4-20mA for remote WTI and SCADA system individually. The transducer, Auxiliary CT shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between Pt100 temperature sensor and transducer, shall be in the scope of Contractor.

b) Remote winding temperature indicator (RWTI)

It shall be suitable for flush mounting on Employer's control panel/ digital RTCC panel and shall operate on 4-20mA input available from the above transducer. Any special cable required for shielding purpose, for connection among Individual Marshalling Box / Cooler control cabinet, Common Marshalling Box and remote WTI control circuit, shall be in the scope of Contractor.

Only one RWTI with suitable selector switches or separate individual RWI shall be provided for display of temperature of all the three windings (HV, IV and LV as applicable).

6.14. **Optical sensors**

16 numbers optical temperature sensors shall be fitted on each unit. The optical sensors measuring system shall be of direct measurement non calibrating type. All the sensors shall be brought out to separate optical sensor box mounted on transformer tank to facilitate measurement of temperature during service life on each unit.

In order to facilitate measurement of temperature from the optical sensors, temperature measuring unit/system having at least 16 channels shall be mounted in above optical sensor box (stainless steel, IP 55 Protection) for each transformer unit. The measuring unit shall be capable to retain temperature data for at least 30 days with facility to download these data.

Temperature measuring unit/system housed in above box shall be suitable for satisfactory operation with ambient conditions and IEC 61850 compliant to interface with Employer's SCADA system.

Location of optical temperature sensors inside the transformer shall be decided during design review.

6.15. **Earthing Terminals**

6.15.1. Two (2) earthing pads (each complete with two (2) nos. holes, M16 bolts, plain and spring washers) suitable for connection to 75 x 12 mm galvanised steel grounding flat shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

6.15.2. Two earthing terminals suitable for connection to 75 x 12 mm galvanised steel flat shall also be provided on each cooler, individual/common marshalling box and any other equipment mounted separately. For the tank-mounted equipment like online drying/ Online DGA/ Optical Sensor Box etc. double earthing shall be provided through the tank for which provision shall be made through tank and connected through two flexible insulated copper link.

6.15.3. Equipotential flexible copper link of suitable size at least 4 Nos. for Tank mounted turret with tank and tank with cover and or Bell shall be provided. For other components like - pipes, conservator support etc. connected to tank shall also be provided with equipotential flexible copper link.

6.16. **Core** as per Sr 2 of Addendum 1

6.16.1. The core shall be constructed from high grade, non-ageing, cold rolled, super grain oriented silicon steel laminations (HI-B or better grade).

6.16.2. The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angles to the plane of laminations which may cause local heating.

6.16.3. The temperature of any part of the core or its support structure in contact with oil shall not exceed 120 deg C under normal operating condition and 130 deg C under most extreme operating condition. Adequate temperature margin shall be provided to maintain the long life expectancy for this material.

6.16.4. Core and winding shall be capable of withstanding the shock during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

6.16.5. All steel sections used for supporting the core shall be thoroughly sand/shot blasted after cutting, drilling and welding.

6.16.6. Each core lamination shall be insulated with a material that will not deteriorate due to pressure and hot oil.

6.16.7. The supporting frame work of the core shall be so designed as to avoid presence of pockets which would prevent complete emptying of tank through drain valve or cause trapping of air during oil filling.

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

6.16.9. The core shall be earthed to the core clamping structure at one point only, through a removable external link of minimum size of 80 sq. mm copper suitably located and protected to facilitate testing after installation of the transformer. The removable links shall have adequate section to carry ground fault current. Separate identification name plate/labels shall be provided for the 'Core' and 'Core clamp' on the outside of tank cover.

6.16.10. In case core laminations are divided into sections by insulating barriers or cooling ducts parallel to the plane of the lamination, tinned copper bridging strips shall be inserted to maintain electrical continuity between sections.

6.17. **Windings**

6.17.1. The Contractor shall ensure that windings of all transformers are made in dust proof and conditioned atmosphere.

6.17.2. The conductors shall be of electrolytic grade copper free from scales and burrs.

6.17.3. The insulation of transformer windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse and shall be non-catalytic and chemically inactive in transformer oil during service.

6.17.4. Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.

6.17.5. The coils would be made up, shaped and braced to provide for expansion and contraction due to temperature changes.

6.17.6. The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalise the distribution of currents and temperature along the winding.

6.17.7. The windings shall be designed to withstand the dielectric tests specified. The type of winding used shall be of time tested. An analysis shall be made of the transient voltage distribution in the windings, and the clearances used to withstand the various voltages. Margins shall be used in recognition of manufacturing tolerances and considering the fact that the system will not always be in the new factory condition.

6.17.8. The barrier insulation including spacers shall be made from high- density pre-compressed pressboard (1.1 gm/cc minimum for load bearing and 1 to 1.3 gm/cc minimum for non-load bearing) to minimize dimensional changes.

6.17.9. All spacers shall have rounded edges. Radially stepped spacers between winding disks will not be accepted.

6.17.10. The conductor insulation shall be made from high-density (at least 0.75 gm/cc) paper having high mechanical strength. The characteristics for the paper will be reviewed at the time of design review.

6.17.11. An electrostatic shield, made from material that will withstand the mechanical forces, will be used to shield the high voltage windings from the magnetic circuit unless otherwise approved.

6.17.12. All winding insulation shall be processed to ensure that there will be no detrimental shrinkage after assembly. All windings shall be pre-sized before being clamped.

6.17.13. Windings shall be provided with clamping arrangements which will distribute the clamping forces evenly over the ends of the winding.

6.17.14. The bracing of the windings and connections shall be such that these parts shall safely withstand the cumulative effects of stresses which may occur during handling, transportation, installation and service including line-to–line and line-to–ground faults.

6.18. **Current carrying connections**

The mating faces of bolted connections shall be appropriately finished and prepared for achieving good long lasting, electrically stable and effective contacts. All lugs for crimping shall be of the correct size for the conductors. Connections shall be carefully designed to limit hot spots due to circulating eddy currents.

6.19. **Winding terminations into bushings**

6.19.1. Winding termination interfaces with bushings shall be designed to allow for repeatable and safe connection under site conditions to ensure the integrity of the transformer in service.

6.19.2. The winding end termination, insulation system and transport fixings shall be so designed that the integrity of the insulation system generally remains intact during repeated work in this area.

6.19.3. Allowances shall be made on the winding ends for accommodating tolerances on the axial dimensions of the set of bushings and also for the fact that bushings may have to be rotated to get oil level inspection gauges to face in a direction for ease of inspection from ground level.

6.19.4. In particular, rotation or straining of insulated connections shall be avoided during the fastening of conductor pads (or other methods) on the winding ends onto the termination surfaces of the bushing.

6.19.5. Suitable inspection and access facilities into the tank in the bushing oil-end area shall be provided to minimize the possibility of creating faults during the installation of bushings.

7. Paint system and procedures

The typical painting details for transformer main tank, pipes, conservator tank, radiator, control cabinet/ marshalling box / oil storage tank etc. shall be as given in **Annexure – F**. The proposed paint system shall generally be similar or better than this. The quality of paint should be such that its colour does not fade during drying process and shall be able to withstand temperature up to 120 deg C. The detailed painting procedure shall be finalized during award of the contract.

8. Unused inhibited Insulating Oil

The insulating oil shall be virgin high grade inhibited, conforming to IEC-60296 & all parameters specified at **Annexure – G**, while tested at supplier's premises. The contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned at **Annexure – G**, prior to despatch of oil from refinery to site. Under no circumstances, poor quality oil shall be filled into the transformer and thereafter be brought up to the specified parameter by circulation within the transformer. The Unused inhibited Insulating Oil parameters including parameters of oil used at manufacturer's works, processed oil, oil after filtration and settling are attached at **Annexure – G**. The oil test results shall form part of equipment test report.

Sufficient quantity of oil necessary for maintaining required oil level in case of leakage in tank, radiators, conservator etc. till the completion of warranty period shall be supplied.

Inhibited oil used for first filling, testing and impregnation of active parts at manufacturer's works shall be of same type of oil (in line with IEC 60076-3) which shall be supplied at site and shall meet parameters as per specification.

8.1. Particles in the oil

The particle analysis shall be carried out in an oil sample taken after completion of the oil filtration at site. The procedure and interpretation shall be in accordance with the recommendation of CIGRE report WG-12.17 - "Effect of particles on transformer dielectric strength".

8.2. Moisture content in the solid insulation

Dummy insulation test block shall be inserted in the active part of Transformer at factory and same shall be used to detect the volume moisture content. Before application of vacuum and oil filling in the Transformer, it will be ensured that moisture content in the dummy insulation test block is less than 0.5%. Measurement shall be carried out as per IEC.

8.3. Oil filling

8.3.1. Procedures for site drying, oil purification, oil filling etc. shall be done as per POWERGRID Field Quality Plan (FQP).

8.3.2. The duration of the vacuum treatment shall be demonstrated as adequate by means of water measurement with a cold trap or other suitable method but shall generally not be less than 72 hours for 400kV and 48 Hours for 220kV and below transformer. The vacuum shall be measured on the top of the Transformer tank and should be less than 1mbar.

8.3.3. Oil filling under vacuum at site shall be done with transformer oil at a temperature not exceeding 65°C. Vacuum shall not be broken until the Transformer is oil filled up to the Buchholz relay.

8.3.4. The minimum safe level of oil filling (if different from the Buchholz level) to which the Transformer shall be oil filled under vacuum, shall be indicated in the manual.

8.3.5. The Ultra High Vacuum type oil treatment plant of suitable capacity (**minimum 6000** litres per hour) suitable for treatment of oil in EHV class Transformer shall be used in order to achieve properties of treated oil. The plant shall be capable of treatment of new oil (as per IEC 60296 and reconditioning of used oil (as per IS: 1866/IEC: 60422 for oil in service) at rated capacity on single pass basis as follow:

i) Removal of moisture from 100 ppm to 3 ppm (max.)
ii) Removal of dissolved gas content from 10% by Vol. to 0.1% by vol.
iii) Improvement of dielectric strength break down voltage from 20 to 70 KV
iv) Vacuum level of degassing chamber not more than 0.15 torr/0.2 mbar at rated flow and at final stage. Machine shall have minimum of two degassing chambers and these should have sufficient surface areas to achieve the final parameters.
v) Filter shall be capable of removing particle size more than 0.5 micron in the filtered oil.
vi) Processing temperature shall be automatically controlled and have an adjustable range from 40°C to 80°C.

8.3.6. **Transportation of Oil**

The insulating oil for the transformer shall be delivered at site generally not before 90 days from the date of commissioning, with prior information to the Employer.

Insulating oil shall be delivered to the site in returnable oil drums / flexi bag / tanker. The oil drums / flexi bag / tanker shall be taken back without any extra cost to Employer within generally 45 days after utilisation of oil but in any case before contract closing. However, the spare oil shall be delivered in non-returnable drums.

9. Preparation for long term storage of spare units

The spare transformer shall be completely erected, oil filled and commissioned similar to the other transformers and kept on the foundation after completing all necessary activities for long term storage. Any special maintenance procedure required during long term storage shall be clearly brought out in the instruction manual. All pre commissioning tests on the spare Transformer similar to the unit kept in service shall be carried out by the contractor.

Purchaser intends to replace any of the Transformer (1-Phase) unit by the completely assembled oil filled spare Transformer (1-Phase units) fitted with bushings, cooler etc by isolator switching arrangement and without physically shifting the Transformer.

In case, due to space limitation, Isolator based switching arrangement is not possible, the completely assembled oil filled Transformer is to be shifted by manual pulling through rail track/road from its foundation to the other location within the substation. As any unit may be designated as the spare, all units must be prepared accordingly.

10. Bushings

10.1. Bushings shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout and movement along with the spare transformer with bushing erected and provided with proper support from one foundation to another foundation within the substation area. The electrical and mechanical characteristics of bushings shall be in accordance with IEC: 60137/DIN 42530. All details of the bushing shall be submitted for approval and design review.

10.2. Bushing for voltage of 52 kV and above shall be RIP bushing with composite insulator. 36 kV bushing shall be solid porcelain or oil communicating type.

10.3. RIP type bushing shall be provided with tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable.

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

10.5. Bushings of identical rating shall be interchangeable to optimise the requirement of spares. Mounting dimensions of bushing shall be as per drawing mentioned at **Annexure – D.**

10.6. Porcelain used in bushing manufacture shall be homogenous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

10.7. Polymer / composite insulator shall be seamless sheath of a silicone rubber compound. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences, external pollution and humidity. It shall be extruded or directly moulded on the core. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core. The technique being followed with detailed procedure and sampling shall be decided during finalization of MQP.

The weather sheds of the insulators shall be of alternate shed profile as per IEC 60815-3. The weather sheds shall be vulcanized to the sheath (extrusion process) or moulded as part of the sheath (injection moulding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection moulding shall be at high temperature & high pressure. Any seams / burrs protruding axially along the insulator, resulting from the injection moulding process shall be removed completely without causing any damage to the housing. The track resistance

of housing and shed material shall be class 1A4.5 according to IEC60587. The strength of the weather shed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively, sealed to prevent moisture ingress, effectiveness of sealing system must be supported by test documents. All surfaces of the metal parts shall be perfectly smooth with the projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

The hollow silicone composite insulators shall comply with the requirements of the IEC publications IEC 61462 and the relevant parts of IEC 62217. The design of the composite insulators shall be tested and verified according to IEC 61462 (Type & Routine test).

10.8. Clamps and fittings shall be of hot dip galvanised/stainless steel.

10.9. Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.

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

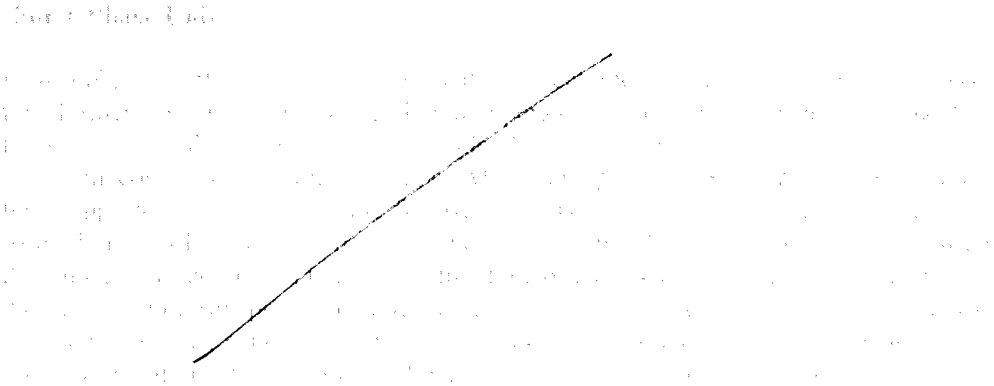
10.11. Spare Bushing shall be specially packed suitable for long storage with non-returnable packing, the details of which shall be provided to the purchaser

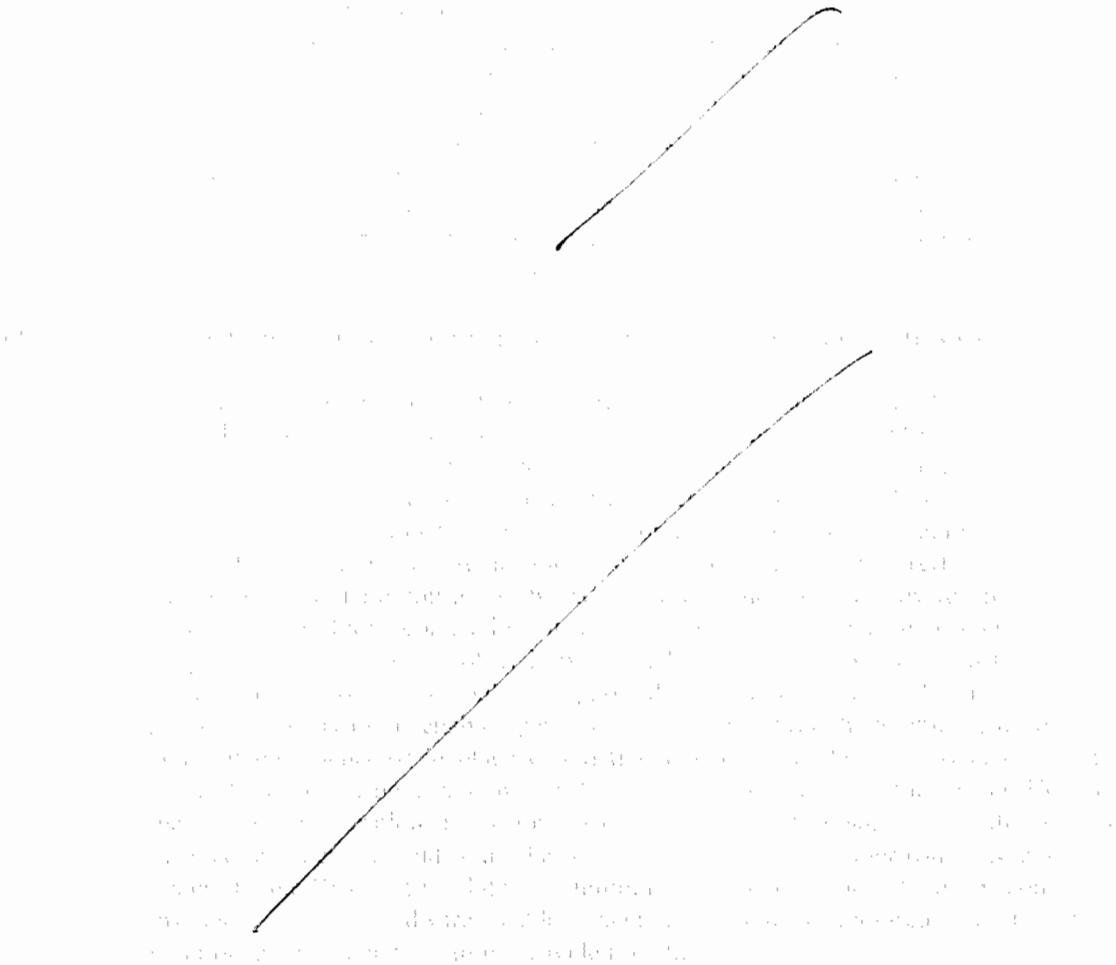
10.12. The terminal marking and their physical position shall be as per IEC: 60076.

11. Neutral Formation and Earthing Arrangement

11.1. For 3-Phase Unit

The neutral terminal of 3-phase transformer shall be brought to the ground level by a brass/tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the brass/tinned copper bar shall be brought to the bottom of the tank, at a convenient point, for making bolted connection to two (2) 75 x 12 mm galvanized steel flats connected to Employer's grounding mat.





14. Cooling Equipment and its Control

14.1. Cooling Equipment

14.1.1. The cooler shall be designed using 2 x 50% radiator banks. Design of cooling system shall satisfy the performance requirements.

14.1.2. Each radiator bank shall have its own cooling fans, oil pumps, oil flow indicator, shut off valves at the top and bottom (80 mm size), lifting lugs, top and bottom oil filling valves, air release plug at the top, a drain and sampling valve and thermometer pocket fitted with captive screw cap on the inlet and outlet.

14.1.3. Required number of standby fans of approximately 20% capacity shall also be provided with each radiator bank.

14.1.4. Cooling fans shall not be directly mounted on radiator bank which may cause undue vibration. These shall be located so as to prevent ingress of rain water. Each fan shall be suitably protected by galvanised wire guard. The exhaust air flow from cooling fan shall not be directed towards the main tank in any case.

14.1.5. Two (2), 100% centrifugal or axial on line oil pumps (out of which one pump shall be standby) shall be provided with each radiator bank. Measures shall be taken to prevent

mal-operation of Buchholz relay when all oil pumps are simultaneously put into service. The pump shall be so designed that upon failure of power supply to the pump motor, the pump impeller will not limit the natural circulation of oil.

14.1.6. An oil flow indicator shall be provided for the confirmation of the oil pump operating in a normal state. An indication in the flow indicator and for remote shall be provided to indicate low oil flow.

14.1.7. Valves shall be provided across the pump and oil flow indicator to avoid oil drain and long outage during maintenance / replacement of pump and oil flow indicator.

14.1.8. Cooling fans and oil pump motors shall be suitable for operation from 415 volts, three phase 50 Hz power supply and shall conform to IS: 325. Each cooling fan and oil pump motors shall be provided with starter thermal overload and short circuit protection. The motor winding insulation shall be conventional class 'B' type. Motors shall have hose proof enclosure equivalent to IP: 55 as per IS: 4691.

14.1.9. The cooler pipes, support structure including radiators and its accessories shall be hot dip galvanised or corrosion resistant paint should be applied to external surface of it.

14.1.10. Expansion joint shall be provided, one each on top and bottom cooler pipe connections.

14.1.11. Air release device and oil plug shall be provided on oil pipe connections. Drain valves shall be provided in order that each section of pipe work can be drained independently.

14.2. **Unit cooler arrangement for transformer (if applicable)**

14.2.1. The cooler shall be designed using 5 x 25% unit Cooler arrangement. Design of cooling system shall satisfy the performance requirements.

14.2.2. Each Unit Cooler shall have its own cooling fans, oil pumps, oil flow indicator, shut off valves at the top and bottom of at least 80 mm size, lifting lugs, top and bottom oil filling valves, air release plug at the top, a drain and sampling valve and thermometer pocket fitted with captive screw cap on the inlet and outlet.

14.2.3. An oil flow indicator shall be provided for the confirmation of the oil pump operating in a normal state. An indication shall be provided in the flow indicator to indicate reverse flow of oil/loss of oil flow.

14.2.4. Valves shall be provided across the pump and oil flow indicator to avoid oil drain and long outage during maintenance / replacement of pump and oil flow indicator.

14.2.5. Cooling fans and oil pump motors shall be suitable for operation from 415 volts, three phase 50 Hz power supply and shall conform to IS: 325/IEC34. Each cooling fan and oil pump motors shall be provided with starter thermal overload and short circuit protection. The motor winding insulation shall be conventional class 'B' type. Motors shall have hose proof enclosure equivalent to IP:55 as per IS:4691/IEC:34-5

14.2.6. The cooler, pipes, support structure and its accessories shall be hot dip galvanised or corrosion resistant paint should be applied to external surface of it.

14.2.7. Expansion joint shall be provided on top and bottom cooler pipe connections as per requirement.

14.2.8. Air release device and oil plug shall be provided on oil pipe connections. Drain valves shall be provided in order that each section of pipe work can be drained independently.

14.3. **Cooling Equipment Control (OFAF or ODAF) Cooling**

i) Suitable manual control facility for unit cooler shall be provided.

ii) The changeover to standby unit cooler bank oil pump in case of failure of any service unit cooler shall be automatic.

iii) Selector switches and push buttons shall also be provided in the cooler control cabinet to disconnect the automatic control and start/stop the unit cooler manually.

iv) Cooler fans & oil pumps of all unit coolers (except standby cooler) shall operate continuously. The starting of unit cooler shall be done as soon the Circuit Breaker of HV/IV/LV AS APPLICABLE side is switched on.

v) Once started the cooling shall remain in operation as long as the transformer is in service. When the transformer is switched off the cooling shall continue to run for a further duration of 30 minutes. This timer shall be at least adjustable from 15 to 60 minutes. Starting the pumps on load shall provide the cooling system a lead on the temperature that is about to follow during high loading conditions. Spurious operation should however be avoided by appropriate settings.

vi) Adequate warning/ safety labels are required to indicate that the fans may start at any time.

vii) All settings shall be adjustable.

viii) If any one group(s) is out of service and isolated, this shall not affect the automatic starting of the other unit cooler.

ix) Indicating Devices

Following lamp indications shall be provided in cooler control cabinet:

a) Cooler Supply failure (main).
b) Cooler supply changeover.
c) Cooler Supply failure (standby).
d) Control Supply failure.
e) Cooler unit failure for each unit cooler
f) No oil flow/reverse oil flow for pumps.
g) Thermal overload trip for each fan / pump.

One potential free initiating contact for all the above conditions shall be wired independently to the terminal blocks of cooler control cabinet and for single ph. unit connection shall be extended further to CMB.

14.3.1. **Cooling Equipment Control**

14.3.1.1. Automatic operation control of fans/pumps shall be provided (with temperature change) from contacts of winding temperature indicator. The Contractor shall recommend the setting of WTI for automatic changeover of cooler control over entire cooling option. The setting shall be such that hunting i.e. frequent start-up operations for small temperature differential do not occur.

14.3.1.2. Suitable manual control facility for cooler fans and oil pumps shall be provided.

14.3.1.3. The changeover to standby oil pump in case of failure of service oil pump shall be automatic.

14.3.1.4. In addition to the traditional starting of fan and pump by oil temperature, the starting of forced cooling shall be done if the load exceeds a current setting of 0.6 p.u. for 5 seconds.

14.3.1.5. Selector switches and push buttons shall also be provided in the cooler control cabinet to disconnect the automatic control and start/stop the fans and pump manually.

14.3.1.6. Following lamp indications shall be provided in cooler control cabinet:

a) Control Supply failure.
b) Cooling fan failure for each bank.
c) Cooling pump failure for each pump.
d) Common thermal overload trip

One potential free initiating contact for all the above conditions shall be wired independently to the terminal blocks of cooler control cabinet and for single ph. unit connection shall be extended further to CMB.

14.3.2. The cooler control cabinet / Individual Marshalling box shall have all necessary devices meant for cooler control and local temperature indicators. All the contacts of various protective devices mounted on the transformer and all the secondary terminals of the bushing CTs shall also be wired upto the terminal board in the cooler control cabinet/Individual Marshalling box. All the CT secondary terminals in the cooler control cabinet shall have provision for shorting to avoid CT open circuit while it is not in use.

14.3.3. All the necessary terminations for remote connection to Purchaser's panel shall be wired upto the Common Marshalling box.

14.3.4. Control and power supplies are to be given for Cooler circuits. In case of single phase unit Control and power supplies are to be given after suitable selection at Common Marshalling Box. Necessary isolating switches and protective devices shall be provided at suitable points as per Purchaser's approved scheme.

14.3.5. The Contractor shall derive AC power for Cooler Control Circuitry from the AC feeder as mentioned above. In case auxiliary power supply requirement for Cooler Control Mechanism is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor. Details of stationed auxiliary power supply are mentioned in GTR specification.

14.3.6. The temperature indicators shall be so mounted that the dials are about 1200 mm from ground level. Glazed door of suitable size shall be provided for convenience of reading.

14.4. **Auxiliary Power Supply of OLTC, Cooler Control and Power Circuit**

14.4.1. **For Single Phase unit**

14.4.1.1. Two auxiliary power supplies, 415 volt, three phase four (4) wire shall be provided at common marshalling box. All loads shall be fed by one of the two sources through an electrically interlocked automatic transfer scheme housed in the CMB. Power supply to individual phase unit shall be extended from the CMB. Power supply to spare unit shall be extended from nearest CMB only. Suitably rated power contactors, separate MCBs/MCCBs shall be provided in the Common Marshalling Box for each circuit.

14.4.1.2. For each circuit, suitably rated MCBs/MCCBs as required for further distribution of auxiliary power supply to DM boxes, Online Gases and moisture monitoring system, Online drying system and Fibre optic sensor Box etc. (as applicable), shall be provided by contractor, in individual marshalling boxes /cooler control boxes.

14.4.1.3. Auxiliary power supply distribution scheme shall be submitted for approval. Supply and laying of Power, Control and special cables from common marshalling box to individual MB/Cooler Control Cubicle (including spare unit) & further distribution from IMB/CCC to all accessories is in the scope of the contractor. Further any special cable (if required) from CMB to Owner's Control Panels/Digital RTCC panels is also in the scope of the contractor.

14.4.1.4. Connection arrangement for spare unit shall be in such a way that spare unit of transformer can be connected in place of faulty unit without physically shifting and all the control, protection, indication signals of spare unit shall also be brought in common marshalling box of all the banks. Necessary arrangement in schematic of Common marshalling box is required to facilitate change-over of all the signals of faulty units to spare unit of Transformer, to ensure flow of control, protection and indication signals between Purchaser's Control panels / Digital RTCC Panel / SCADA and individual units under operation (i.e. any designated unit for bank or spare unit, if it replace any designated unit). To facilitate change-over of spare unit signals with faulty unit in CMB, male-female plug-in connector or better arrangement shall be provided to reduce the outage time.

14.4.2. **For Three Phase Transformer**

14.4.2.1. Two auxiliary power supplies, 415 volt, three phase four (4) wire shall be provided by the Purchaser at cooler control cabinet. All loads shall be fed by one of the two sources through an electrically interlocked automatic transfer scheme housed in the cooler control cabinet.

14.4.2.2. For each circuit, suitably rated power contactors, MCBs / MCCBs as required for entire auxiliary power supply distribution scheme including distribution to DM boxes, Online Gases and moisture monitoring system, Online drying system and Fibre optic sensor Box etc. (as applicable), shall be provided by contractor in cooler control cabinet.

14.4.2.3. Auxiliary power supply distribution scheme shall be submitted for approval. Supply and laying of Power, Control and special cables from marshalling box to all accessories is in the scope of the contractor. Further any special cable (if required) from MB to Owner's Control Panels/Digital RTCC panels is also in the scope of the contractor.

14.4.3. **Design features of the transfer scheme** shall include the following:

a) Provision for the selection of one of the feeder as normal source and other as standby.
b) Upon failure of the normal source, the loads shall be automatically transferred after an adjustable time delay to standby sources.
c) Indication to be provided at cooler control cabinet for failure of normal source and for transfer to standby source and also for failure to transfer.
d) Automatic re-transfer to normal source without any intentional time delay following re-energization of the normal source.
e) Both the transfer and the re-transfers shall be dead transfers and AC feeders shall not be paralleled at any time.

14.5. **Valves**

14.5.1. All valves upto and including 100 mm shall be of gun metal or of cast steel/cast iron. 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 clock wise when facing the hand wheel.

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

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

14.5.4. All valves flanges shall have machined faces.

14.5.5. All valves in oil line shall be suitable for continuous operation with transformer oil at 115 deg C.

14.5.6. The oil sampling point for main tank shall have two identical valves put in series. Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.

14.5.7. Valves or other suitable means shall be provided to fix various on line condition monitoring systems to facilitate continuous monitoring. The location & size of the same shall be finalised during detail design review.

14.5.8. **Flow sensitive conservator Isolation valve**

a) In order to restrict the supply of oil in case of a fire in transformer, flow sensitive valve shall be provided to isolate the conservator oil from the main tank.

b) A valve which shall be flow sensitive and shut off when the flow in the pipe is more than the flow expected in the permissible normal operating conditions. This valve shall be located in the piping between the conservator and the buchholz relay and shall not affect the flow of oil from and to the conservator in normal conditions.

c) When the flow from conservator to main tank is more than the normal operating conditions, the valve shall shut off by itself and will have to be reset manually. It shall be provided with valve open/close position indicator along with alarm contact indication in control room during closing operation of valve. This valve shall be provided with locking arrangement for normal position and oil filling / filtration position.

d) A suitable platform / ladder shall be provided to approach the valve for manual reset.

14.5.9. All valves shall be painted with a shade (preferably red or yellow distinct and different from of main tank surface and as per the painting system and procedure specified.

14.5.10. All hardware used shall be hot dip galvanised / stainless steel.

15. Cabling

All interconnecting control and power cables between various parts of Transformers like turret CT, MBs, Fans, pumps, Buchholz, PRD etc. shall be routed through covered cable tray or GI conduit and shall be properly dressed. All cables shall be armoured type. Un-armoured cables (if provided) in any circuitry, shall be through GI conduit and no part shall be exposed. Cable terminations shall be through stud type TB and ring type lugs. Typical Technical specification for cables is attached at **Annexure-I**. Contractor shall provide type tested cables from approved sources. No type testing for cables is envisaged.

16. Tap Changing Equipment

Each transformer shall be provided with Off load tap / On Load Tap changing equipment

16.1. Off load tap Change switch general requirement

The off load switch handle will be provided with a locking arrangement along with tap position indicator thus enabling the switch to be locked in position. A warning plate indicating that switch shall be operated only when the transformer is de-energised shall be fitted.

For three phase transformer the tap change switch shall simultaneous switch the similar taps on the three phases.

16.2. ON Load Tap Changing (OLTC) Equipment

16.2.1. Main OLTC Gear Mechanism

16.2.1.1. Each single / three phase transformer shall be provided with voltage control equipment of the tap changing type for varying its effective transformation ratio whilst the transformers are on load.

16.2.1.2. OLTC shall be motor operated suitable for local as well as remote operation. The diverter switch or arcing switch shall be designed so as to ensure that its operation once commenced shall be completed independently of the control relays or switches, failure

of auxiliary supplies etc. To meet any contingency which may result in incomplete operation of the diverter switch, adequate means shall be provided to safeguard the transformer and its ancillary equipment.

16.2.1.3. The current diverting contacts shall be housed in a separate oil chamber not communicating with the oil in main tank of the transformer. The contacts shall be accessible for inspection without lowering oil level in the main tank and the contacts shall be replaceable.

16.2.1.4. Necessary safeguards shall be provided to avoid harmful arcing at the current diverting contacts in the event of operation of the OLTC gear under overload conditions of the transformer.

16.2.1.5. The OLTC oil chamber shall have oil filling and drain valve, oil sampling valve, relief vent and level glass. Oil sampling valve of minimum size, accessible from ground, shall be provided to take sample of oil from the OLTC chamber. It shall also be fitted with an oil surge relay which shall be connected between OLTC oil chamber and separate conservator tank.

16.2.1.6. Tap changer shall be so mounted that bell cover of transformer can be lifted without removing connections between windings and tap changer.

16.2.2. **Local OLTC Control Cabinet (Drive Mechanism Box)**

Each transformer unit of OLTC gear shall have following features:

16.2.2.1. OLTC shall be suitable for manually handle operated and electrically motor operated. For local manual operation from Local OLTC Control cabinet (Drive Mechanism Box), an external handle shall be provided.

16.2.2.2. OLTC's Local control cabinet shall be mounted on the tank in accessible position. The cranking device for manual operation for OLTC gear shall be removable and suitable for operation by a man standing at ground level. The mechanism shall be complete with the following.

- Mechanical tap position indicator which shall be clearly visible from near the transformer.
- A mechanical operation counter of at least five digit shall be fitted to indicate the number of operations completed and shall have no provision for resetting.
- Mechanical stops to prevent over-cranking of the mechanism beyond the extreme tap positions.
- The manual control considered as back up to the motor operated on load tap changer control shall be interlocked with the motor to block motor start-up during manual operation.
- The manual operating mechanism shall be labelled to show the direction of operation for raising the voltage and vice-versa.
- An electrical interlock to cut-off a counter impulse for reverse step change being initiated during a progressing tap change and until the mechanism comes to rest and resets circuits for a fresh position.

16.2.2.3. For electrical operation from local as well as remote, motor operated mechanism shall be provided. It shall not be possible to operate the electric drive when the manual

operating gear is in use. It shall not be possible for any two controls to be in operation at the same time. Transfer of source in the event of failure of one AC supply shall not affect the tap changer. Thermal device or other means shall be provided to protect the motor and control circuit.

16.2.2.4. The Local OLTC Drive Mechanism Box shall house all necessary devices meant for OLTC control and indication. It shall be complete with the followings:

i. A circuit breaker/contactor with thermal overload devices for controlling the AC Auxiliary supply to the OLTC motor
ii. Cubicle light with door switch
iii. provided with anti-condensation metal clad heaters to prevent condensation of moisture
iv. Padlocking arrangement for hinged door of cabinet
v. Cable terminal glands for power and control cables to the OLTC gear
vi. All contactors relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi etc.
vii. The cabinet shall be tested at least IP 55 protection class.

16.2.2.5. All relays and operating devices shall operate correctly at any voltage within the limits specified in GTR. In case auxiliary power supply requirement for OLTC DM Box is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor.

16.2.2.6. Operating mechanism for on load tap changer shall be designed to go through one step of tap change per command only, until the control switch is returned to the off position between successive operations / repeat commands.

16.2.2.7. Limit switches shall be provided to prevent overrunning of the mechanism and shall be directly connected in the control circuit of the operating motor provided that a mechanical de-clutching mechanism is incorporated. In addition, a mechanical stop shall be provided to prevent over-running of the mechanism under any condition. An interlock to cut-out electrical control when it tends to operate the gear beyond either of the extreme tap positions.

16.2.2.8. OLTC local control cabinet shall be provided with tap position indication for the transformer. The contractor shall also provide a set of instruments for tap position indication in the control room (in Digital RTCC or control panel).

16.2.2.9. 'Local-remote' selector switch shall be provided in the local OLTC control cabinet. In Local mode, all electrical commands from remote (from CMB, Digital RTCC, SCADA etc.) shall be cut-off/blocked. Electrical operations to change tap positions shall be possible by using raise/lower push buttons under local mode from DM Box. In remote mode electrical commands from CMB/ Digital RTCC/SCADA etc. shall be executed. The remote-local selector switch shall be having at-least two spare contacts per position.

16.2.2.10. Following minimum contacts shall be available in DM Box, which shall be wired to CMB (for single phase unit). Further these contacts shall be wired to Digital RTCC panel:

a. INCOMPLETE STEP which shall not operate for momentary loss of auxiliary power.

b. OLTC motor overload protection
c. Supply to DM Motor fail
d. OLTC IN PROGRESS
e. Local / Remote Selector switch
f. OLTC upper/lower limits reached

16.2.2.11. OLTC Tap position indication shall be provided in DM Box. Drive Mechanism shall be equipped with a fixed resistor network capable of providing discrete voltage steps or provide 4-20mA transducer outputs for tap position indication in CMB (for single phase unit) and input to Digital RTCC/SCADA system.

16.2.2.12. All relays, switches, fuses etc. shall be mounted in the OLTC local control cabinet and shall be clearly marked / labelled for the purpose of identification. Both ends of all the wires (control & power) connected to Drive Mechanism Box must be provided with proper ferrule nos. for tracing and maintenance.

16.2.2.13. A permanently legible lubrication chart if required shall be fitted within the OLTC local control cabinet.

16.2.3. **OLTC Control from Common Marshalling Box (CMB)**

16.2.3.1. It shall be possible to monitor, control/operate, the OLTC of all the three 1-ph of a transformer bank from Common Marshalling Box. The control and monitoring terminations of a spare transformer unit shall be brought to CMB. The necessary switching arrangement through male-female plug-in TB assembly shall be provided for replacing spare unit with any one of the faulty phase unit for monitoring & control from CMB.

16.2.3.2. 'Independent-combined-remote selector switch and raise/lower switch shall be provided in the common marshalling box.

16.2.3.3. When the selector switch is in **independent** position, the OLTC control shall be possible from individual Local OLTC Control Cabinet (DM Box) only.

16.2.3.4. In **'combined position'**, raise-lower switch (provided in the CMB), shall be used to operate for bank of three single phase transformers from CMB.

16.2.3.5. In **'remote position'** control of OLTC shall be possible from Digital RTCC/SCADA etc.

16.2.3.6. From CMB, the operation of OLTC shall be for 3-phases of transformer units without producing phase displacement. Independent operation of each single phase transformer from CMB/ Digital RTCC/SCADA will be prevented.

16.2.3.7. Following minimum **LED indications** shall be provided in CMB:

a. INCOMPLETE STEP
b. OLTC motor overload protection
c. Supply to DM Motor fail
d. OLTC IN PROGRESS
e. Local / Remote Selector switch positions of DM
f. OLTC upper/lower limits reached
g. 415V Main AC supply ON

h. 415V Standby AC supply ON

Following **contacts** shall be wired to digital RTCC Panel:

a. INCOMPLETE STEP
b. OLTC motor overload protection
c. Supply to DM Motor fail
d. OLTC IN PROGRESS
e. Local / Remote Selector switch positions of DM
f. OLTC upper/lower limits reached
g. 'Independent-combined-remote' selector switch positions of CMB
h. 415V Main AC supply Fail
i. 415V Standby AC supply Fail

Further, OLTC Tap position Digital indications for all three 1-Ph Transformer units either separately or through selector switch shall be provided in CMB. The same shall also be wired to Digital RTCC Panel to display tap positions for all three 1-ph unit separately.

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16.2.4. **Digital RTCC Panel (Applicable for 400kV Transformer only)**

16.2.4.1. It shall be possible to remotely control and monitor OLTC from Digital RTCC panel. The digital RTCC panel shall have Automatic Tap Changer control and monitoring relay with Automatic Voltage Regulating features (referred as **Digital RTCC relay**). The relay shall be of reputed make and shall be in successful operation for at-least 2 years for transformer OLTC application.

16.2.4.2. Digital RTCC relay should be microprocessor based adopting the latest state of the art design & technology with in-built large display for ease of programming and viewing. The unit supplied shall be field programmable so that in the event of change in transformer / location, it could be customized to site conditions without sending back to works. The programming shall be menu driven and can be easily configurable. If it is supplied as a draw out type module, it should take care of shorting all CT inputs automatically while drawing out. The CT / VT ratio shall be field programmable and Relay shall display the actual HV Voltage and current considering suitable multiplying factors.

16.2.4.3. The digital RTCC Panel shall be provided with digital RTCC relay, Raise/Lower push buttons, Manual/ Automatic mode selector switch and Master / Follower/ Independent/ Off mode selector switch for control of OLTC. The digital RTCC Relay shall have multiple selectable set point voltages and it shall be possible to select these set points from SCADA, with a facility to have the possibility of additional set points command from SCADA.

16.2.4.4. **In Manual Mode**: In this mode, power system voltage based automatic control from digital RTCC relay shall be blocked and commands shall be executed manually by raise/lower push buttons.

16.2.4.5. **In Auto Mode:** In Auto mode, digital RTCC relay shall automatically control OLTC taps based on power system voltage and voltage set points. An interlock shall be provided to cut off electrical control automatically upon recourse being taken to the manual control in emergency.

16.2.4.6. **Master / Follower/ Independent/ Off mode**

Master Position: If the selector switch is in master position, it shall be possible to control the OLTC units of other transformer banks/three phase transformer in the follower made by operation the master unit.

Follower Position: If the selector switch is in Follower position control of OLTC shall be possible only from panel where master mode is selected.

Independent Position: In independent position of selector switch, control of OLTC shall be possible only from the panel where independent mode is selected.

16.2.4.7. **Raise/Lower:** The remote OLTC scheme offered shall have provision to raise or lower taps only for the complete bank of three 1-phase transformers. Individual single phase OLTC operation shall not be possible from the remote control panel.

16.2.4.8. The Digital RTCC relay shall incorporate all the control facilities specified in this specification. The Digital RTCC relay shall be provided for controlling all three phases of a transformer bank. Each Digital RTCC relay shall have integration feature for parallel operation of at least 7 nos. 3-ph transformers or 21nos, 1-ph transformers working in parallel. The system shall be self-sufficient and shall not require any additional devices like parallel balancing module etc.

16.2.4.9. Communication between the Digital RTCC relays in order to execute the commands for parallel operation shall be implemented using hardware and communication protocol, suitable up to a maximum length of 1km.

16.2.4.10. Digital RTCC relays shall communicate with SCADA using IEC 61850 protocols to monitor, parameterise & control OLTC. Any software required for this purpose shall be supplied. The software supplied will not have restriction in loading of multiple computers for downloading and analysing the data. The vendor shall provide necessary provision for SCADA integration with the existing/ future SCADA system. Software shall indicate the current overview of all measured parameters of the connected transformer on-line in real time.

16.2.4.11. It shall be possible to communicate/integrate with all digital RTCC relays of different make located at different locations in the substation by making hardwire and using IEC 61850 communication link. The integration of existing conventional RTCC panel with Digital RTCC panel of different make shall also be possible.

16.2.4.12. The Digital RTCC relay shall have programmable Binary Inputs (minimum 7 Nos.) and Binary outputs (minimum 7 Nos.) for Employers future use. It shall be possible to have additional module for Binary Input / output as well as Analogue input module depending upon requirement.

16.2.4.13. Reinforcement of the initiating impulse for a tap change, ensuring a positive completion once initiated to the next (higher or lower) tap.

16.2.4.14. "Step-by-Step" operation ensuring only one tap change from each tap changing impulse and a lock-out of the mechanism if the control switch (or push button) remains in the "operate" position.

16.2.4.15. Following minimum indications/alarms shall be provided in Digital RTCC panel either through relay display panel or through LEDs:

a. INCOMPLETE STEP alarm
b. OLTC motor overload protection alarm
c. Supply to DM Motor fail alarm
d. OLTC IN PROGRESS alarm
e. OLTC upper/lower limits reached alarm
f. 415V Main AC supply Fail alarm
g. 415V Standby AC supply Fail alarm
h. Local / Remote Selector switch positions in DM Box
i. OLTC Tap position indications for all three 1-Ph transformer units separately
j. 'Independent-combined-remote selector switch positions of CMB

16.2.4.16. For 220kV and below rating transformer conventional RTCC shall be provided instead of digital RTCC. Accordingly all the control signals (Alarm and trip) shall be provided in this panel without **Digital RTCC relay.**

17. Constructional features of Cooler Control Cabinet/ Individual Marshalling Box/ Common Marshalling Box and Digital RTCC Panel / Conventional RTCC

17.1. Each single phase transformer unit shall be provided with local OLTC Drive Mechanism Box, cooler control cabinet /individual marshalling box. Digital RTCC panel and common marshalling (for a bank of three 1-phase units) shall be provided.

17.2. Common marshalling box shall be floor mounted and of size not less than 1600mm (front) X 650mm (depth) X 1800mm (height). Individual Marshalling Box and Cooler control Box shall be tank mounted.

17.3. The cooler control cabinet (individual marshalling box), common marshalling box, shall be made of stainless steel sheet of at least 1.6 mm thick. Digital / Conventional RTCC panel shall be CRCA sheet of minimum thickness of 2.5mm and shall be painted suitably as per **Annexure –F**.

17.4. The degree of protection shall be IP: 55 for outdoor and IP:43 for indoor in accordance with IS: 13947/IEC: 60947.

17.5. All doors, removable covers and plates shall be gasketed all around with suitably profiled. All gasketed surfaces shall be smooth straight and reinforced if necessary to minimize distortion to make a tight seal. For Control cubicle / Marshalling Boxes etc. which are outdoor type, all the sealing gaskets shall be of EPDM rubber or any better approved quality, whereas for all indoor control cabinets / Digital RTCC panel, the sealing gaskets shall be of neoprene rubber or any better approved quality. The gaskets shall be tested in accordance with approved quality plan, IS: 1149 and IS: 3400.

17.6. Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh of brass. All the control cabinets shall be provided with suitable lifting arrangement. A space heater and cubicle lighting with ON-OFF switch shall be provided in each panel.

17.7. All the cabinets except common marshalling box &Digital RTCC shall be tank mounted. All the separately mounted cabinets and panels shall be free standing floor mounted type and have domed or sloping roof.

18. Fittings & accessories

The following fittings & accessories shall be provided with each transformer covered in this specification. The fittings listed below are not exhaustive and other fittings which are required for satisfactory operation of the transformer are deemed to be included.

a. Conservator for main tank with aircell, oil filling hole and cap, isolating valves, drain valve, magnetic oil level gauge with low level alarm contacts and dehydrating breather

b. Conservator for OLTC with drain valve, oil surge Relay, filling hole with cap, prismatic oil level gauge and dehydrating breather

c. Pressure relief devices with trip contacts

d. Sudden pressure relief relay with alarm contacts (**for 400kV Transformer only**)

e. Buchholz relay double float, reed type with isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm / trip contacts.

f. Air release plug.

g. Inspection openings and covers.

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

i. Winding & Oil temperature indicators for local and remote mounting.

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

k. Protected type mercury or alcohol in glass thermometer or magnetic or micro-switch type dial type temperature indicator.

l. Bottom and top filter valves with threaded male adaptors, bottom sampling valve and drain valve.

m. Rating and diagram plates on transformers and auxiliary apparatus.

n. On load tap changing gear, OLTC DM Box, Off Circuit Tap Changer (OCTC) individual marshalling box / Cooler control cabinet, Common Marshalling Box, Fibre optic sensor box and Digital RTCC Panel as applicable

o. Cooling equipment

p. Bushing current transformers

q. Oil flow indicator if required

r. Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently

s. Terminal marking plates

t. Valves schedule plate

u. Ladder to climb up to the Transformer tank cover with suitable locking arrangement to prevent climbing during charged condition

v. On line insulating oil drying system

w. On line dissolved gases and moisture monitor (for 400kV Transformer only)

x. Fibre optic sensor based temperature measuring system (for 400kV Transformer only)

y. Flow sensitive conservator Isolation valve

z. Flanged bi-directional wheels

aa. Nitrogen Injection Type Fire Prevention & Extinguishing System (if specified in BPS) as per **Annexure – K**

19. Current Transformer

19.1. Current transformers shall comply with IEC-60044-1.

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

19.3. Current transformer secondary leads shall be brought out to a weatherproof terminal box near each bushing. These terminals shall be wired out to cooler control cabinet/ marshalling box using separate cables for each core.

19.4. Bushing Current transformer parameters indicated in this specification are tentative and liable to change within reasonable limits. The Contractor shall obtain Purchaser's approval before proceeding with the design of bushing current transformers.

19.5. Technical Parameters of Bushing CTs and Neutral CTs (outdoor type) are enclosed at **Annexure – H.** The CT's used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

19.6. One number single phase current transformer for earth fault protection shall be provided for each bank of transformer and shall be located in the neutral conductor connecting common neutral point with earth.

20. Online Dissolved Gas (Multi-gas) and Moisture Analyser

20.1. Online Dissolved Gas (Multi-gas) and Moisture Analyser (if specified in BPS) along with all required accessories shall be provided with each transformer for measurement & analysis of dissolved gases and moisture in the oil. Interpretations shall be as per IEC 60599-1999.

refer SOO4 of Addendum 1

20.2. The equipment shall detect, measure and analyse the following gases:

Gases & Moisture Parameters	Typical Detection Range
H_2	5 – 5,000 ppm
CH_4	5 – 5,000 ppm
C_2H_6	5 – 5,000 ppm
C_2H_4	3 – 5,000 ppm
C_2H_2	1 – 3,000 ppm
CO	10 – 10,000 ppm
CO_2	20 – 30,000 ppm
O_2	500 – 25,000 ppm
H_2O	2 – 100 % RS should have facility for measurement of moisture in oil in ppm

20.3. The analyser should measure (not calculate) all above gases and should have 100% sensitivity. The equipment shall be capable of transferring data to sub-station automation system confirming to IEC 61850. Necessary interface arrangement shall be provided by the contractor for integration with automation system. The necessary type test report for such confirmation shall be submitted during detailed engineering.

20.4. Equipment shall have facility to give SMS alert to at least three users whenever any fault gas violates the predefined limit.

20.5. Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All the necessary power and control cables, communication cables, cable accessories as required shall be provided by the supplier.

20.6. Online DGA shall be installed out door on transformer in harsh ambient and noisy condition (Electromagnetic induction, Corona, and capacitive coupling). Suitable arrangement shall be provided to take care of vibration for tank mounting. The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55 Stainless Steelenclosure, suitable for 55 ^{0}C ambient temperature and EMI and EMC compatibility.The Equipment must carry a minimum of two (2) years manufacturer's Warranty.

20.7. The equipment shall connect to the transformer's main body in two locations. One Connection is for the supply of oil from the transformer. Second connection is for the return of the oil to the transformer.The connecting oil lines must be of Stainless Steel rigid pipes or flexible hoses.

20.8. The equipment shall be able to measure gas concentration and when downloaded should immediately compare it with user selected alarm & caution level for immediate display. The sampling rate shall be selectable as 2 or 4 or 6 or 12 hours etc. The equipment shall have inbuilt memory to store these results for complete one year even if sampling is done at the lowest interval.

20.9. The Equipment must have an automatic Calibration facility at fixed intervals. For calibration if anything required including cylinder must be mounted with the Equipment.

20.10. The technical feature of the equipment shall be as under:

Accuracy	± 10%
Repeatability	±3% to 10% depending upon gases
Oil temperature range	- 20^0 C to + 120^0 C
External Temp. Range	- 20^0 C to + 55^0 C (External temp range of 55^0 C is important and should not be compromise due to Indian ambient & operating conditions.)
Humidity range	10 to 95 %
Operating Voltage	230 Vac; 50 Hz (±20% variation)
Communications	USB & IEC 61850 compliant

20.11. Software for fault indication and fault diagnostics shall include following:
Fault indication:

i) IEEE, IEC or user configurable levels of dissolved gases
ii) Rate of change trending

Fault Diagnosis:

i) Key gases
ii) Ratios (Rogers, IEC. etc.)
iii) Duval's Triangle

20.12. The equipment shall be supplied with all necessary accessories required for carrying out DGA of oil sample complete in all respect as per the technical specification. The following shall be also form a part of supply.

i) Software
ii) Operation Manual (2 set for every unit),
iii) Software Manual and
iv) Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

21. On-line insulating oil drying system (Cartridge type)

In addition to provision of air cell in conservators for sealing of the oil system against the atmosphere, each transformer shall be provided with an on line insulating oil drying system of adequate rating with proven field performance. This system shall be tank/cooler bank mounted and no separate foundation shall be provided. This on line insulating oil drying system shall be

i. Designed for very slow removal of moisture that may enter the oil system or generated during cellulose decomposition. Oil flow to the equipment shall be controlled through pump of suitable capacity.

ii. The equipment shall display the moisture content in oil (PPM) of the inlet and outlet oil from the drying system.

iii. Minimum capacity of moisture extraction shall be 10 Litres before replacement of cartridge. Calculation to prove the adequacy of sizing of the on line insulating oil drying system along with make and model shall be submitted for approval of purchaser during detail engineering.

The equipment shall be supplied with Operation Manual (2 set for every unit), Software (if any), and Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

22. Oil Storage Tank

22.1. Oil storage tank shall be of minimum 20 / 10 cubic meter capacity (as specified in BPS) along with complete accessories. The oil storage tank shall be designed and fabricated as per relevant Indian Standards e.g. IS: 803 or other internationally acceptable standards. Transformer oil storage tanks shall be towable on pneumatic tyres and rested on manual screw jacks of adequate quantity & size. The tank shall be cylindrical in shape and mounted horizontally and made of mild steel plate of adequate thickness. Diameter of the tank shall be 2.0 meter approximately. The tank shall be designed for storage of oil at a temperature of 100°C.

22.2. The maximum height of any part of the complete assembly of the storage tank shall not exceed 4.0 metres above road top.

22.3. The tank shall have adequate number of jacking pad so that it can be kept on jack while completely filled with oil. The tank shall be provided with suitable saddles so that tank can be rested on ground after removing the pneumatic tyres.

22.4. The tank shall also be fitted with manhole, outside & inside access ladder, silica gel breather assembly, inlet & outlet valve, oil sampling valve with suitable adopter, oil drainage valve, air vent etc. Pulling hook on both ends of the tank shall be provided so that the tank can be pulled from either end while completely filled with oil. The engine capacity in horse power to pull one tank completely fitted with oil shall be indicated. Oil level indicator shall be provided with calibration in terms of litre so that at any time operator can have an idea of oil in the tank. Solenoid valve (Electro-mechanically operated) with Centrifugal pump shall be provided at bottom inlet so that pump shall be utilised both ways during oil fill up and draining. Suitable arrangement shall also be provided to prevent overflow and drain form the tank.

22.5. The following accessories shall also form part of supply along with each Oil storage tank.

i) Four numbers of 50NB suitable rubber hoses for transformer oil application up to temperature of 100°C, full vacuum and pressure up to 2.5 Kg/ cm2 with couplers and unions each not less than 10 metre long shall be provided.

ii) Two numbers of 100NB suitable for full vacuum without collapsing and kinking vacuum hoses with couplers and unions each not less than 10 metre long shall also be provided.

iii) One number of digital vacuum gauge with sensor capable of reading up to 0.001 torr, operating on 240V 50Hz AC supply shall be supplied. Couplers and unions for sensor should block oil flow in the sensor. Sensor shall be

provided with at-least 8 meter cable so as to suitably place the Vacuum gauge at ground level.

22.6. The painting of oil storage tank and its control panel shall be as per technical specification.

22.7. The tank shall contain a self-mounted centrifugal oil pump with inlet and outlet valves, with couplers suitable for flexible rubber hoses and necessary switchgear for its control. There shall be no rigid connection to the pump. The pump shall be electric motor driven, and shall have a discharge of not less than 6.0 kl/hr. with a discharge head of 8.0m. The pump motor and the control cabinet shall be enclosed in a cubicle with IP-55 enclosure.

23. Oil Sampling Bottle

Oil sampling bottles (if specified in BPS) shall be suitable for collecting oil samples from transformers and shunt Transformers, for Dissolved Gas Analysis. Bottles shall be robust enough, so that no damage occurs during frequent transportation of samples from site to laboratory.

Oil sampling bottles shall be made of stainless steel having a capacity of 1litre. Oil Sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.

The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week.

An impermeable oil-proof, transparent plastic or rubber tube of about 5 mm diameter, and of sufficient length shall also be provided with each bottle along with suitable connectors to fit the tube on to the oil sampling valve of the equipment and the oil collecting bottles respectively.

24. Oil Syringe

The glass syringe and three way stop cock valve shall meet the following specification (if specified in BPS):

The tentative dimensions are given below

Dimensions	
Volume	50 ml ± 1.5 %
Piston outside diameter	27.45 ± 0.20 mm
Barrel Diameter (OD)	32.35 ± 0.55 mm
Barrel Diameter (OD)	44.00 ± 0.75 mm
Barrel Diameter (OD)	34.05 ± 0.65 mm
Length (L)	178.00 mm ± 0.50 mm
Increment	2.0 ml

The syringe shall be made from Heat resistant borosilicate Glass. The material and construction should be resistant to breakage from shock and sudden temperature changes. Reinforced at luer lock tip Centre and barrel base.

The cylinder-Plunger fit is leak proof and shall meet the requirement of IEC-60567. Plunger shall be individually ground and fitted to barrel for smooth movement with no back flow. Barrel rim should be flat on both sides tom prevent rolling and should be wide enough for convenient fingertip grip. The syringe shall be custom fit and uniquely numbered for matching. The syringe shall be clearly marked with graduations of 2.0 ml and 10.0 ml and shall be permanently fused for life time legibility.

25. Hand Tools

One set of hand tools of reputed make packed in a carry bag/box broadly comprising of double ended spanners (open jaws, cranked ring, tubular with Tommy bar each of sizes 9mm to 24mm, one set each), adjustable wrenches (8 &12 inch one set), gasket punches (of different sizes used - one set), pliers (flat nose, round nose & side cutting one of each type), hammer with handle (one), files with handle (two), knife with handle (one), adjustable hacksaw (one), and cold chisel (one), bushing handling and lifting tools with nylon rope/belt, chain block (2 Nos.) and D-Shackle shall be supplied per Substation for which cost shall be deemed included.

26. Test Kit

- BDV Kit (if specified in BPS)as per **Annexure-J** of specification
- Portable DGA Kit (if specified in BPS)as per **Annexure-J** of specification

27. Inspection and Testing

The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the equipment. The inspection envisaged by the Purchaser is given below. This is however not intended to form a comprehensive programme as it is Contractor's responsibility to draw up and carry out such a programme in the form of detailed quality plan duly approved by Purchaser for necessary implementation.

27.1. **Inspection**

27.1.1. **Tank and Conservator**

a. Certification of chemical analysis and material tests of plates
b. Check for flatness
c. Electrical interconnection of top and bottom by braided tinned copper flexible
d. Welder's qualification and weld procedure
e. Testing of electrodes for quality of base materials and coatings
f. Inspection of major weld preparation
g. Crack detection of major strength weld seams by dye penetration test
h. Measurement of film thickness of:
   i. Oil insoluble varnish
   ii. Zinc chromate paint
   iii. Finished coat
i. Check correct dimensions between wheels, demonstrate turning of wheels through 90 degree and further dimensional check.
j. Check for physical properties of materials for lifting lugs, jacking pads, etc. All load bearing welds including lifting lug welds shall be subjected to Non Destructive Testing.

k. Leakage test of the conservator
l. Certification of all test results

27.1.2. **Core**

a. Sample testing of core materials for checking specific loss, bend properties, magnetisation characteristics and thickness
b. Check on the quality of varnish if used on the stampings:
   i) Measurement of thickness and hardness of varnish on stampings
   ii) Solvent resistance test to check that varnish does not react in hot oil
   iii) Check overall quality of varnish by sampling to ensure uniform shining colour, no bare spots, no over burnt varnish layer and no bubbles on varnished surface
c. Check on the amount of burrs
d. Bow check on stampings
e. Check for the overlapping of stampings. Corners of the sheet are to be part.
f. Visual and dimensional check during assembly stage
g. Check for inter-laminar insulation between core sectors before and after pressing
h. Visual and dimensional checks for straightness and roundness of core, thickness of limbs and suitability of clamps
i. High voltage test (2 kV for one minute) between core and Yoke clamps, Yoke clamps to tank and Core to Tank
j. Certification of all test results

27.1.3. **Insulation Material**

a. Sample check for physical properties of materials
b. Check for dielectric strength
c. Visual and dimensional checks
d. Check for the reaction of hot oil on insulating materials
e. Dimension stability test at high temperature for insulating material
f. Tracking resistance test on insulating material
g. Certification of all test results

27.1.4. **Winding**

a. Sample check on winding conductor for mechanical properties and electrical conductivity
b. Visual and dimensional checks on conductor for scratches, dent marks etc.
c. Sample check on insulating paper for pH value, bursting strength and electric strength
d. Check for the reaction of hot oil on insulating paper
e. Check for the bonding of the insulating paper with conductor
f. Check and ensure that physical condition of all materials taken for windings is satisfactory and free of dust
g. Check for absence of short circuit between parallel strands
h. Check for brazed joints wherever applicable
i. Measurement of voltage ratio to be carried out when core/yoke is completely restacked and all connections are ready
j. Conductor enamel test for checking of cracks, leakage and pin holes
k. Conductor flexibility test
l. Heat shrink test for enamelled wire

m. Certification of all test results

27.1.5. **Checks Before Drying Process**

a. Check condition of insulation on the conductor and between the windings.
b. Check insulation distance between high voltage connections, cables and earth and other live parts
c. Check insulating distances between low voltage connections and earth and other parts
d. Insulation of core shall be tested at 2 kV/minute between core and Yoke clamps, Yoke clamps to tank and Core to Tank
e. Check for proper cleanliness and absence of dust etc.
f. Certification of all test results

27.1.6. **Checks During Drying Process**

a. Measurement and recording of temperature, vacuum and drying time during drying process
b. Check for completeness of drying by periodic monitoring of dryness
c. Certification of all test results

27.1.7. **Assembled Transformer**

a. Check completed transformer against approved outline drawings, provision for all fittings, finish level etc.
b. Test to check effective shielding of the tank
c. Jacking test with oil on all the assembled transformers
d. Dye penetration test shall be carried out after the jacking test

27.1.8. **Bought Out Items**

The makes of all major bought out items shall be subject to Purchaser's approval for the following components:

a) Buchholz Relay
b) Axles and wheels
c) Winding temperature indicators for local and remote mounting
d) Oil temperature indicators
e) Bushings
f) Bushing current transformers
g) Cooler control cabinet/ Individual Marshalling box and common marshalling box as applicable
h) Cooling equipment
i) Oil pumps
j) Fans/Air Blowers
k) Tap change gear
l) Pressure relief device

The above list is not exhaustive and the Contractor shall also include other bought-out items in his programme.

27.2. **Factory Tests**

The manufacturer shall be fully equipped to perform all the required tests as specified. Bidder shall confirm the capabilities of the proposed manufacturing plant in this regard when submitting the bid. Any limitations shall be clearly stated in.

The contractor shall bear all additional costs related to tests which are not possible to carry out at his own works.

The contractor shall submit an Inspection and test plan (ITP) for approval. A typical test plan is indicated in "**Annexure-B".**

All tests shall be done in line with IEC: 60076 and the test procedures as mentioned in "**Annexure-B".** Complete test report shall be submitted to purchaser after proper scrutiny and signing on each page by the test engineer of the contractor.

27.3. **Type Tests on fittings:**

All the following fittings shall conform to type tests and the type test reports shall be furnished by the contractor along with the drawings of equipment/ fittings as per the Section – GTR. The list of fittings and the type test requirement is:

1) Bushing (Type Test as per IEC:60137 including Snap back/Seismic test for 400 kV and above voltage class bushing)

2) OLTC (Test as per IEC:60214 and IP-55 test on driving mechanism box)

3) Buchholz relay (Type Test as per IS: 3637 and IP-55 Test on terminal box)

4) Cooler Control cabinet, Individual Marshalling & common marshalling box (IP-55 test)

5) Pressure Relief device Test

   The pressure Relief Device of each size shall be subjected to increase in oil pressure. It shall operate before reaching the test pressure specified in transformer tank pressure test above... The operating pressure shall be recorded. The device shall seal off after excess pressure has been released.

   The terminal box / boxes of PRD should conform to degree of protection of IS 13947/Equivalent IEC standard.

6) Sudden Pressure Relay Test

7) Magnetic Oil Level gauge & Terminal Box for IP-55 degree of protection.

8) Air Cell (Flexible air separator) - Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per IS: 3400/ BS: 903/ IS: 7016

9) OTI & WTI

10) Oil pump

11) Cooling fan and motor assembly

27.4. **Pre-Shipment Checks at Manufacturer's Works**

27.4.1. Check for inter-changeability of components of similar transformers for mounting dimensions.

27.4.2. Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, fans, control cubicle, connecting pipes, conservator etc.

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

27.4.4. Gas tightness test to confirm tightness and record of dew point of gas inside the tank. Derivation of leakage rate and ensure the adequate reserve gas capacity.

27.5. **Inspection and Testing at Site**

The Contractor shall carry out a detailed inspection and testing programme for field activities covering areas right from the receipt of material stage up to commissioning stage. An indicative programme of inspection as envisaged by the Purchaser is given below. However, it is contractor's responsibility to draw up and carry out such a programme duly approved by the Purchaser. Testing of oil sample at site shall be carried out as per specification.

27.6. **Receipt and Storage Checks**

27.6.1. Check and record condition of each package, visible parts of the transformer etc. for any damage.

27.6.2. Check and record the gas pressure in the transformer tank as well as in the gas cylinder.

27.6.3. Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.

27.6.4. Check and record reading of impact recorder at receipt and verify the allowable limits as per manufacturer's recommendations.

27.7. **Installation Checks**

27.7.1. Inspection and performance testing of accessories like tap changers, cooling fans, oil pumps etc.

27.7.2. Check the direction of rotation of fans and pumps and Check the bearing lubrication.

27.7.3. Check whole assembly for tightness, general appearance etc.

27.7.4. Oil leakage test

27.7.5. Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.

27.7.6. Leakage check on bushing before erection.

27.7.7. Measure and record the dew point of gas in the main tank before assembly.

27.8. **Commissioning Checks**

27.8.1. Check the colour of silicagel in silicagel breather.

27.8.2. Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.

27.8.3. Check the bushing for conformity of connection to the lines etc.,

27.8.4. Check for correct operation of all protection devices and alarms/trip :

i. Buchholz relay
ii. Excessive winding temperature
iii. Excessive oil temperature
iv. Low oil flow
v. Low oil level indication
vi. Fan and pump failure protection

27.8.5. Check for the adequate protection on the electric circuit supplying the accessories.

27.8.6. Check resistance of all windings on all steps of the tap changer. Insulation resistance measurement for the following:

i) Control wiring
ii) Cooling system motor and control
iii) Main windings
iv) Tap changer motor and control

27.8.7. Check for cleanliness of the transformer and the surroundings

27.8.8. Phase out and vector group test

27.8.9. Ratio test on all taps

27.8.10. Magnetising current test

27.8.11. Capacitance and Tan delta measurement of winding and bushing

27.8.12. Frequency response analysis (FRA). FRA equipment shall be arranged by purchaser.

27.8.13. DGA of oil just before commissioning and after 24 hours energisation at site.

27.8.14. Gradually put the transformer on load, check and measure increase in temperature in relation to the load and check the operation with respect to temperature rise and noise level etc.

27.8.15. Continuously observe the transformer operation at no load for at least 24hours.

27.8.16. Contractor shall prepare a comprehensive commissioning report including all commissioning test results as per Pre-Commissioning Procedures enclosed at **Annexure – D** and forward to Purchaser for future record.

Annexure – A

1.0 Technical Particulars / Parameters of Transformers – 400kV Transformer

Clause No.	Description	Unit	Technical Parameters				
1.1.	Voltage ratio		400/220/33	400/220/33	(400/√3)/(220/√3)/33	(400/√3)/(220/√3)/33	400/132/33
1.2.	Single / Three Phase Design		3 (THREE)	3 (THREE)	1 (SINGLE)	1 (SINGLE)	3 (THREE)
1.3.	Type of Transformer		Auto Transformer, Constant Ohmic impedance type (Refer note 1)				
1.4.	Rated Capacity						
	HV	MVA	500				
	IV	MVA	500				
	LV (Tertiary) : Active + Reactive loading	MVA	166.67				
1.5.	Applicable Standard		IEC 60076				
1.6.	Cooling & Percentage Rating at different cooling		ONAN/ONAF/(OFAF or ODAF) : 60% / 80%/100% OR ONAN/ONAF1/ONAF2: 60% / 80%/100% OR OFAF (unit cooler) : 100%				
1.7.	Frequency	Hz	50	50	50	50	50
1.8.	Impedance at 75 Deg C						
	HV - IV						
	Max. Voltage tap	%	10.3				
	Principal tap	%	12.5				
	Min. Voltage tap	%	15.4				
	HV - LV						
	Principal tap (minimum)	%	60.0				
	IV - LV						
	Principal tap (minimum)	%	45.0				
1.9.	Service		Outdoor				
1.10.	Duty		Continuous				
1.11.	Overload Capacity		IEC-60076-7				
1.12.	Temperature rise over 50deg C ambient Temp						

Refer Sr. No. 5, 6, 7 & 8 addendum 1

i)	Top oil measured by thermometer	^{o}C	50	50 50 50 50
ii)	Average winding measured by resistance method	^{o}C	55	
1.13.	Max. design Ambient temp	^{o}C	50	
1.14.	Windings			
i)	System Fault level			
	HV	kA	63	
	IV	kA	40	
	LV	kA	25	
ii)	Lightning Impulse withstand Voltage			
	HV	kV_p	1300	
	IV	kV_p	950	
	LV	kV_p	250	
	Neutral	kV_p	95	
	Switching Impulse withstand Voltage			
	HV	kV_p	1050	
	IV	kV_p	-	
	LV	kV_p	-	
	Neutral	kV_p	-	
iii)	One Minute Power Frequency withstand Voltage			
	HV	kV_{rms}	570	
	IV	kV_{rms}	395	
	LV	kV_{rms}	95	
	Neutral	kV_{rms}	38	
1.15.	Neutral Grounding			
1.16.	Insulation			
	HV		Graded	
	IV		Graded	
	LV		Uniform	
1.17.	Tertiary Connection		Ungrounded Delta	
1.18.	Tan delta of winding	%	< 0.5	
1.19.	Vector Group (3 –ph)		YNaOd11	

1.20.	Tap Changer		OLTC	OLTC	OLTC	OLTC	OLTC	
i)	Tap changer Location at winding		On the 220 kV side of the series winding				On the 132 kV side of the series winding	
ii)	Tap range		± 10% of HV variation in the step of 1.25%					
iii)	Design		Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I					
iv)	Tap control		Full capacity - on load tap changer suitable for group / independent, remote /local electrical and local manual operation and bi-directional power flow					
1.21.	Bushing							
i)	Rated voltage							
	HV	kV	420					
	IV	kV	245					
	LV	kV	52					
	Neutral	kV	36					
ii)	Rated current (Min.)							
	HV	A	1250					
	IV	A	2000					
	LV	A	3150					
	Neutral	A	2000					
iii)	Lightning Impulse withstand Voltage							
	HV	kV_p	1425					
	IV	kV_p	1050					
*	LV 250 kVp	kV_p	305					
	Neutral	kV_p	170					
iv)	Switching Impulse withstand Voltage							
*	HV 1050 kVp	kV_p	1175					
	IV	kV_p	850					
	LV	kV_p	-					
	Neutral	kV_p	-					
v)	One Minute Power Frequency withstand Voltage							
*	HV 695 kVp	kV_{rms}	750					
	IV	kV_{rms}	505					
	LV	kV_{rms}	105					

Refer Sr 5, 6, 7 of addendum)

	Neutral	kV_{rms}	77	77	77	77	77
vi)	Minimum total creepage distances						
	HV	mm	10500				
	IV	mm	6125				
	LV	mm	1300				
	Neutral	mm	900				
vii)	Tan delta of bushings						
	HV	%	< 0.4				
	IV	%	< 0.4				
	LV	%	< 0.4				
	Neutral						
viii)	Max Partial discharge level at U_m						
	HV	pC	< 10				
	IV	pC	< 10				
	LV	pC	< 10				
	Neutral		-				
1.22.	Max Partial discharge level at 1.58 * U_r / $\sqrt{3}$	pC	< 100				
1.23.	Noise level at rated voltage and at principal tap on full load and all cooling active	dB	< 80				

Notes:

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.
2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
3. Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.
4. The criteria for transformer losses shall be "Copper Loss (Load – Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)"

ref Sr 08 & Addendum-1

Annexure -B

Test Plan

No.	Test	$U_m < 170kV$	$U_m \geq 170kV$
1.	Measurement of winding resistance	Routine	Routine
2.	Voltage ratio measurement	Routine	Routine
3.	Polarity test	Routine	Routine
4.	No-load loss and current measurement	Routine	Routine
5.	Magnetic balance test (for three phase Transformer only)	Routine	Routine
6.	Impedance and load loss measurement	Routine	Routine
7.	Measurement of insulation resistance & Polarization Index	Routine	Routine
8.	Measurement of insulation power factor and capacitance between winding and earth and Bushings	Routine	Routine
9.	Chopped wave lightning impulse test for the line terminals (LIC)	Routine	Routine
10.	Measurement of transferred surge on LV (Tertiary) as applicable due to HV lightning impulse and IV lighting impulse.	Routine	Routine
11.	Switching impulse test for the line terminal (SI)	Routine	Routine
12.	Line terminal AC withstand voltage test (LTAC)	Routine	Routine
13.	Induced voltage withstand test (IVW)	Routine	-
14.	Applied voltage test (AV)	Routine	Routine
15.	Induced voltage test with PD measurement (IVPD)	Routine	Routine
16.	On-load tap changer test(Ten complete cycle before LV test)	Routine	Routine
17.	Gas-in-oil analysis	Routine	Routine
18.	Core assembly dielectric and earthing continuity test	Routine	Routine
19.	Oil leakage test on transformer tank	Routine	Routine
20	Appearance, construction and dimension check	Routine	Routine
21.	Short duration heat run test (Not Applicable for unit on which temperature rise test is performed)	Routine	Routine
22.	Measurement of no load current & Short circuit Impedance with 415 V, 50 Hz AC.	Routine	Routine
23.	Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports)	Routine	Routine
24.	High voltage with stand test on auxiliary equipment and wiring after assembly	Routine	Routine
25.	Tank vacuum test	Routine	Routine
26	Tank pressure test	Routine	Routine
27.	Lightning impulse test for the neutral terminals (LIN)	*Type	*Type
28.	Temperature rise test	*Type	*Type
29.	Measurement of Zero seq. reactance (for three phase Transformer only)	*Type	*Type
30.	Measurement of harmonic level in no load current	*Type	*Type
31.	Measurement of acoustic noise level	*Type	*Type
32.	Measurement of power taken by fans and oil pumps (Not applicable for ONAN)	*Type	*Type
33.	Dynamic Short circuit withstand test (If specified in BPS)	*Type	*Type

* Type test shall be carried out at first unit manufactured against the LOA at each manufacturing plant if applicable (refer technical specification clause 5.2).

Annexure - C

Test Procedures

1. Core assembly dielectric and earthing continuity test

After assembly each core shall be tested for 1 minute at 2000 Volts between all yoke clamps, side plates and structural steel work (core to frame, frame to tank & core to tank).

The insulation of core to tank, core to yoke clamp (frame) and yoke clamp (frame) to tank shall be able to withstand a voltage of 2 kV (rms) for 1 minute. Insulation resistance shall be minimum 2 GΩ for all cases mentioned above.

2. Short term heat run test (Not Applicable for unit on which temperature rise test is performed)

In addition to the type test for temperature rise conducted on one unit, each cooling combination shall routinely be subjected to a short term heat run test to confirm the performance of the cooling system and the absence of manufacturing defect such as major oil flow leaks that may bypass the windings or core.

DGA samples shall be taken at intervals to confirm the gas evolution.

For ODAF or OFAF cooling, the short term heat run test shall be done with the minimum number of pumps for full load operation in order to shorten the temperature build up. Each short term heat run test is nevertheless expected to take about 3 hours.

For ODAF or OFAF cooled transformers an appropriate cross check shall be performed to prove the effective oil flow through the windings. For this purpose the effect on the temperature decay by switching the pumps off/ on at the end of the heat run should demonstrate the effectiveness of the additional oil flow. Refer to SC 12, 1984 cigre 1984 SC12-13 paper by Dam, Felber, Preiniger et al.
Short term heat run test may be carried out with the following sequence:
Heat run test with pumps running but oil not through coolers.
Raise temperature to specified full load temperature.
Stop power input and pumps for 6 minutes and observe cooling down trend
Restart pumps and observe increased cooling trend due to forced oil flow

3. Temp. Rise Test as per IEC: 60076

Gas chromatographic analysis on oil shall also be conducted before, during and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC 60567.

The temperature rise test shall be conducted at a tap for the worst combination of loading (3-Winding Loss) on the windings of the transformer.

3-Winding Loss = $HV_{(Max\ MVA)} + IV_{(Max\ MVA)} + LV_{(Max\ MVA)}$.

The Contractor before carrying out such test shall submit detailed calculations showing alternatives possible, on various taps and for the three types of ratings of the transformer and shall recommend the combination that results in highest temperature rise for the test.

The Temperature rise type test results shall serve as a "finger print" for the units to be tested only with short term heat run test.

Oil sample shall be drawn before and after heat run test and shall be tested for dissolved gas analysis. Oil sampling to be done 2 hours prior to commencement of temperature rise test. Keep the pumps running for 2 hours before and after the heat run test. Take oil samples during this period. For ONAN/ONAF cooled transformers, sample shall not be taken earlier than 2 hours after shut down. The acceptance norms with reference to various gas generation rates shall be as per IEC 61181.

The DGA results shall generally conform to IEC/IEEE/CIGRE guidelines.

i. Test conditions for temperature rise test:

- This test shall be generally carried out in accordance with IEC 60076-2
- For each cooling combination with cooler bank, tests shall be done on the maximum current tap for a minimum of 12 hours for ONAN/ONAF and 24 hours for ODAF or OFAF or ONAF2 with saturated temperature for at least 4 hours while the appropriate power and current for core and load losses are supplied.
- The total testing time, including ONAN heating up period, steady period and winding resistance measurements is expected to be about 48 hours.
- DGA tests shall be performed before and after heat run test and DGA results shall generally conform to IEC/IEEE/CIGRE guidelines.

ii. Test records:

Full details of the test arrangements, procedures and conditions shall be furnished with the test certificates and shall include at least the following.

iii. General:

- Purchaser's order number and transformer site designation.
- Manufacturer's name and transformer serial number.
- Rating of transformer
- MVA
- Voltages and tapping range
- Number of phases
- Frequency
- Rated currents for each winding
- Vector Group
- Cooling Type
- Measured no-load losses and load losses at 75° C.
- Altitude of test bay.
- Designation of terminals supplied and terminals strapped.

iv. Top oil temperature rise test:

A log of the following quantities taken at a minimum of 30 minute intervals:

- time
- Voltage between phases
- Current in each phase and total power
- Power in each phase and total power
- Ambient temperature
- Top oil temperature
- Cooler inlet and outlet oil temperatures
- Hot spot temperatures (make use of probes)
- Colour photographs of the four sides and top of the transformer together with the corresponding series of thermal images (colour) during starting of the test then after every two hours till the temperature stabilised and finally during temperature stabilised for each rating (ONAN/ONAF/OFAF or (ODAF) or ONAN/ONAF1/ONAF2)

Notes:

The probes may be left in position provided the reliability and integrity of unit will not be jeopardized during its long life expectancy.

v. Winding temperature rise test

- Record the weight of conductor in each winding, and the losses in watts per kilogram, the 'cold' resistance of each winding and the simultaneous top oil and ambient air temperatures, together with the time required for the effect to disappear.
- Record the thermal time constant of the winding.
- Log the half –hourly readings of the quantities as for the top oil temperature rise test.
- Provide a table of readings, after shut-down of power, giving the following information ;

    a) Time after shut- down:
    b) Time increment:
    c) Winding resistance:
    d) Resistance increment:
    e) X, where x is the time after shut-down divided by the thermal time constant of the winding: and
    f) Y, where Y = 100 (1-e –x)

- (Any graphical/computer method used to determine the temperature of a winding by extrapolation to the instant of power shut-down shall produce a linear curve.)
- Provide a record of all calculations, corrections and curves leading to the determination of the winding temperatures at the instant of shut-down of power.
- Record any action taken to remedy instability of the oil surge device during initiation of the oil circulating pumps.

Temperature measurements as per special probes or sensors (fibre optic) placed at various locations shall also be recorded.

4. Tank Tests

i. Oil Leakage Test

All tanks and oil filled compartments shall be completely filled with air or oil of a viscosity not greater than that of insulating oil conforming to IEC 60296 at the ambient temperature and subjected to a pressure equal to normal head of oil plus 35 kN/sq.m (5 psi) measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours for oil and 1 hour for air during which no leakage shall occur.

ii. Vacuum Test

All transformer tanks 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 flat plate after the vacuum has been released shall not exceed the values specified below:

Horizontal Length of flat plate (in mm)	**Permanent deflection (in mm)**
Up to and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5
2001 to 2250	11.0
2251 to 2500	12.5
2501 to 3000	16.0
Above 3000	19.0

iii. Pressure Test

All transformer tanks, its radiator, conservator and other fittings together or separately shall be subjected to a pressure corresponding to twice the normal head of oil or normal oil head pressure plus 35 KN/sq.m whichever is lower, measured at the base of the tank and maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the figure specified above for vacuum test.

5. Dynamic short circuit withstand test shall be carried out as per IEC 60076-5. Dynamic short circuit test shall be carried out in HV-IV combination at nominal & extreme tap positions. For LV winding, dynamic short circuit shall be carried out either on HV-LV or IV-LV combination, whichever draws higher short circuit current as per calculation. Type tests shall be carried out before short circuit test. Following shall also be conducted before and after Short Circuit test:

i) Dissolved gas analysis
ii) Frequency response analysis
iii) All routine tests

Detail test procedure shall be submitted by contractor & shall be approved before short circuit test.

6. Routine test on bushings shall be done as per IEC 60137

Annexure –D

Reference Drawings

The list of drawings indicated below forms a part of this specification.

Sr. No	Drawing Description	Drawing No.
i)	Standard Foundation Drawing	0000-000-T-E-A-003
ii)	Standard dimensions for RIP Condenser bushings (Lower portion)	0000-T-E-A-001 R02
iii)	Typical arrangement of transformer with regulating winding at the end of the series winding.	000S3-YE4-014
iv)	Conceptual drawing for optical fiber sensor	C/ENGG/STD/ optical fiber sensor/AT-SR, REV 0
v)	Pre-Commissioning Procedures and formats for switchyard equipment	D-2-01-03-01-04, issued on 01-04-2013 or latest.
vi)	Conceptual drawing for showing power and control cable connection for operation of 1-ph unit with spare unit	C/ENGG/TR/SPARE/STD; REV00
vii)	Conceptual drawing for showing power and control cable connection for operation of 3-ph unit	C/ENGG/STD/CABLE/TR

Annexure–E

Design Review Document

Sr. No.	Description
1.	Core and Magnetic Design
2.	Over-fluxing characteristics upto $1.7U_m$
3.	Inrush-current characteristics while charging from HV & IV respectively.
4.	Winding and tapping design
5.	Short-circuit withstand capability including thermal stress for min. 2 Sec.
6.	Thermal design including review of localised potentially hot area.
7.	Cooling design
8.	Overload capability
9.	Eddy current losses
10.	Seismic design, as applicable
11.	Insulation co-ordination
12.	Tank and accessories
13.	Bushings
14.	Tap changers
15.	Protective devices
16.	Fans, pumps and radiators
17.	Sensors and protective devices– its location, fitment, securing and level of redundancy
18.	Oil and oil preservation system
19.	Corrosion protection
20.	Electrical and physical Interfaces with substation
21.	Earthing (Internal & External)
22.	Processing and assembly
23.	Testing capabilities
24.	Inspection and test plan
25.	Transport and storage
26.	Sensitivity of design to specified parameters
27.	Acoustic Noise
28.	Spares, inter-changeability and standardization
29.	Maintainability
30.	PRD and SPR (number & locations)
31.	Conservator capacity calculation
32.	Winding Clamping arrangement details with provisions for taking it "in or out of tank"
33.	Conductor insulation paper details
34.	Location of Optical temperature sensors
35.	The design of all current connections
36.	Location & size of the Valves

Annexure – F

Painting Procedure

PAINTING	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thick-ness (DFT)	Colour shade
Main tank, pipes, conservator tank, oil storage tank& DM Box etc. (external surfaces)	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40µm)	Epoxy high build Micaceous iron oxide (HB MIO) (75µm)	Aliphatic polyurethan e (PU) (Minimum 50µm)	Minimum 155µm	RAL 7035
Main tank, pipes (above 80 NB), conservator tank, oil storage tank & DM Box etc. (Internal surfaces)	Shot Blast cleaning Sa 2 ½*	Hot oil proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint	--	--	Minimum 30µm	Glossy white for paint
Radiator (external surfaces)	Chemical / Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40µm)	Epoxy base Zinc primer (30-40µm)	PU paint (Minimum 50µm)	Minimum 100µm	Matching shade of tank/ different shade aestheticall y matching to tank
	contractor may also offer Radiators with hot dip galvanised in place of painting with minimum thickness of 40µm (min)					
Radiator and pipes up to 80 NB (Internal surfaces)	Chemical cleaning, if required	Hot oil proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint	--	--	--	--
Digital RTCC Panel	Seven tank process as per IS:3618 & IS:6005	Zinc chromate primer (two coats)	--	EPOXY paint with PU top coat or POWDER coated	Minimum 80µm / for powder coated minimum 100µm	RAL 7035 shade for exterior and Glossy white for interior
Control cabinet / Marshalling Box - No painting is required.						

Note: (*) indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

* as per Addendum 1 Sr No 09

Annexure – G

Unused inhibited Insulating Oil Parameters

	Sl. No.	Property	Test Method	Limits
	A	**Function**		
	1a.	Viscosity at 100degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.) 3 mm2/s
	1b.	Viscosity at 40degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.)12 mm2/s
	1c.	Viscosity at -30degC	ISO 3104 or ASTM D445 or ASTM D7042	(Max.)1800 mm2/s
	2.	Appearance	A representative sample of the oil shall be examined in a 100 mm thick layer, at ambient temperature	The oil shall be clear and bright, transparent and free from suspended matter or sediment
	3.	Pour point	ISO 3016 or ASTM D97	(Max.)- 40degC
	4.	Water content a) for bulk supply b) for delivery in drums	IEC 60814 or ASTM D1533	(Max.) 30 mg/kg 40 mg/kg
*	5.	Electric strength (breakdown voltage)	IEC 60156 or ASTM D1298	(Min.)50 kV(new unfiltered oil) / 70 kV (after treatment)
	6.	Density at 20 deg C	ISO 3675 or ISO 12185 or ASTM D 4052	0.820 - 0.895 g/ml
	7.	Dielectric dissipation factor (tan delta) at 90 deg C	IEC 60247 or IEC 61620 Or ASTM D924	(Max) 0.0025
	8.	Negative impulse testing KVp @ 25 deg C	ASTM D-3300	145 (Min.)
*	9.	Carbon type composition (% of Aromatic, Paraffins and Naphthenic compounds)	IEC 60590 or ASTM D 2140	Max. Aromatic : 4 to12 % Paraffins : <50% & balance shall be Naphthenic compounds.
	B	**Refining/Stability**		
	1.	Acidity	IEC 62021-1 or ASTM D974	(Max) 0.01 mg KOH/g
	2.	Interfacial tension at 27degC	ISO 6295 or ASTM D971	(Min) 0.04 N/m
*	3.	Total sulphur content	BS 2000 part 373 or ISO 14596 or ASTM D129	0.15 % (Max.)
	4.	Corrosive sulphur	IEC 62535	Non-Corrosive on copper and paper
			ASTM D1275B	Non-Corrosive
	5.	Presence of oxidation inhibitor	IEC 60666 or ASTM D2668 or D4768	0.08% (Min.) to 0.4% (Max.) Oil should contain no other additives .Supplier should declare presence of additives, if any.

* of addendum-1 Sr 09

6.	2-Furfural content	IEC 61198 or ASTM D5837	25 Microgram/litre (Max.)
C	**Performance**		
1	Oxidation stability -Total acidity -Sludge - Dielectric dissipation factor (tan delta) at 90degC	IEC 61125 (method c) Test duration 500 hour IEC 60247	 Max 0.3 mg KOH/g Max 0.05 % Max 0.05
* 2.	Oxidation stability (Rotating Bomb test)	IEC : 61125(Method B) / ASTM D2112 (e)	220 Minutes (Min.)
D	**Health, safety and environment (HSE)**		
1.	Flash point	ISO 2719	(Min.)135degC
2.	PCA content	BS 2000 Part 346	Max 3%
3.	PCB content	IEC 61619 or ASTM D4059	Not detectable (Less than 2 mg/kg)
E	**Oil used (inhibited) for first filling, testing and impregnation of active parts at manufacturer's works shall be same type of oil which shall be supplied at site and shall meet parameters as mentioned below:**		
1	Break Down voltage (BDV)		70kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.005 (max)
4	Interfacial tension		0.04 N/m (min)
F	**Each lot of the processed oil shall be tested prior to filling in main tank at site for the following:**		
1	Break Down voltage (BDV)		70 kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.0025 (Max)
4	Interfacial tension		More than 0.04 N/m
G	**After filtration & settling and prior to energisation at site oil shall be tested for following:**		
1	Break Down voltage (BDV)	IS: 1866 / IEC 60422	70 kV (min.)
2	Moisture content at hot condition		5 ppm (max.)
3	Tan-delta at 90°C		0.005 (Max)
4	Interfacial tension		More than 0.04 N/m
5	*Oxidation Stability	Test method as per IEC 61125 method C, Test duration: 500hour for inhibited oil	
	a) Acidity		0.3 (mg KOH /g) (max.)
	b) Sludge		0.05 % (max.)
	c) Tan delta at 90 °C		0.05 (max.)
6	*Total PCB content		Not detectable (less than 2 mg/kg total)
	* Separate oil sample shall be taken and test results shall be submitted within 45 days after commissioning for approval of POWERGRID.		

2.0 Current Transformer Parameters (On each phase) for 3-ph 500MVA and 1-ph, 167 MVA, 400/220/33 kV Transformers

Description	Current Transformer Parameters (Transformer)		
	HV Side	IV Side	Neutral Side
(a) Ratio			
CORE 1	1600/1	1600/1	1600/1
CORE 2	1000/1	1600/1	
(b) Minimum knee point voltage or burden and accuracy class			
CORE 1	1600V, TPS	1600V, TPS	1600V, TPS
CORE 2	0.2 Class 30VA ISF≤5	0.2 Class 30VA ISF ≤ 5	
(c) Maximum CT Secondary Resistance			
CORE 1	4.0 Ohm	4.0 Ohm	4.0 Ohm
CORE 2	-	-	
(d) Application			
CORE 1	Restricted Earth Fault	Restricted Earth Fault	Restricted Earth Fault
CORE 2	Metering	Metering	
(e) Maximum magnetization current (at knee point voltage)			
CORE 1	25 mA	25 mA	25 mA
CORE 2	-	-	

NOTE:

vi) Accuracy class PS as per IEC 60044.

vii) Class (for the relevant protection and duties) as per IEC 60185.

viii) Parameters of WTI CT for each winding shall be provided by the contractor.

ix) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.

x) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

ANNEXURE - I

1.1 KV GRADE POWER & CONTROL CABLES

1.1 Separate cables shall be used for AC & DC.

1.2 Separate cables shall be used for DC1 & DC2.

1.3 At least one (1) core shall be kept as spare in each copper control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be two (2) for control cables of 10 core or higher size.

1.4 The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects. All aluminium used in the cables shall be of H2 grade.

1.5 The fillers and inner sheath shall be of non-hygroscopic, fire retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

1.6 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of all cables.

1.7 Strip wire armouring method (a) mentioned in Table 5, Page-6 of IS: 1554 (Part 1) – 1988 shall not be accepted for any of the cables. For control cables only round wire armouring shall be used.

1.8 The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

1.9 All the cables shall conform to fire resistance test as per IS: 1554 (Part - I).

1.10 The normal current rating of all PVC insulated cables shall be as per IS: 3961.

1.11 Repaired cables shall not be accepted.

1.12 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

1.13 **PVC Power Cables**

1.13.1 The PVC (70°C) insulated 1100V grade power cables shall be of FR type, C1 category, conforming to IS: 1554 (Part-I) and its amendments read along with this specification and shall be suitable for a steady conductor temperature of 70°C. The conductor shall be stranded aluminium. The Insulation shall be extruded PVC to type-A of IS: 5831. A distinct inner sheath shall be provided in all multi core cables. For multi core armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC to Type ST-1 of IS: 5831 for all cables.

1.14 **PVC Control Cables**

1.14.1 The 1100V grade control cables shall be of FR type C1 category conforming to IS: 1554 (Part-1) and its amendments, read along with this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC to type A of IS: 5831. A distinct inner sheath shall be provided in all cables whether armoured or not. The over sheath shall be extruded PVC to type ST-1 of IS: 5831 and shall be grey in colour except where specifically advised by the Employer to be black.

1.14.2 Cores shall be identified as per IS: 1554 (Part-1) for the cables up to five (5) cores and for cables with more than five (5) cores the identification of cores shall be done by printing legible Hindu Arabic Numerals on all cores as per clause 10.3 of IS : 1554 (Part - 1).

STANDARD TECHNICAL DATA SHEET (11kV GRADE XLPE POWER CABLES)

Sr. No	Description	Parameters	
1a	Name of manufacturer	As per approved list	
b	Cable Sizes	1 C x 630	3½ C x 300
c	Manufacturer's type designation	A2XWaY	A2XWY
2	Applicable standard	IS: 7098/PT-I/1988 & its referred specifications	
3	Rated Voltage(volts)	1100 V Grade	
4	Type & Category	FR & C1	FR & C1
5	Suitable for earthed or unearthed system	for both	
6	Continuous current rating when laid in air in a ambient temp. of 50°C and for maximum conductor temp. of 70 °C of PVC Cables[For information only]	732	410
7	Rating factors applicable to the current ratings for various conditions of installation	As per IS-3961-Pt-II-67	
8	Short circuit Capacity		
a	Guaranteed Short Circuit Amp. (rms) KA for 0.12 sec duration at rated conductor temperature of 90 degree C, with an initial peak of 105 KA	45kA	45kA
b	Maximum Conductor temp. allowed for the short circuit duty (deg C.) as stated above	250°C	
9	Conductor		
a	Material	Stranded Aluminium as per Class 2 of IS : 8130	
b	Grade	H 2 (Electrolytic grade)	
c	Cross Section area (Sq.mm.)	630	300/150
d	Number of wires(No.) minimum	53	30/15
e	Form of Conductor	Stranded and compacted circular	Stranded compacted circular/sector shaped
f	Direction of lay of stranded layers	Outermost layer shall be R.H lay & opposite in successive layers	
10	Conductor resistance (DC) at 20 °C per km-maximum	0.0469	0.1/0.206
11	Insulation		
a	Composition of insulation	Extruded XLPE as per IS-7098 Part(1)	
b	Nominal thickness of insulation(mm)	2.8	1.8/1.4
c	Minimum thickness of insulation	2.42	1.52/1.16
12	Inner Sheath		
a	Material	Extruded PVC type ST-2 as per IS-5831-84	
b	Calculated diameter over the laid up cores,(mm)	NA	52
c	Thickness of Sheath (minimum)mm	NA	0.6
d	Method of extrusion	NA	Pressure/Vacuum extrusion
13	Armour		
a	Type and material of armour	Al wire [H4 grade]	Gal. Steel wire
b	Direction of armouring	Left hand	
c	Calculated diameter of cable over inner sheath (under armour), mm	33.9	53.2
d	Nominal diameter of round armour wire (minimum)	2	2.5
e	Guaranteed Short circuit capacity of the armour for 0.12 sec at room temperature.	45kA	45kA
f	DC resistance at 20 °C (Ω/Km)	$	0.577
14	Outer Sheath	ST-2 & FR	ST-2 & FR

A	Material (PVC Type)	38.3	59.50
B	Calculated diameter under the sheath	1.72	2.36
C	Min. thickness of sheath(mm)	Min 29.0	Min 29.0
D	Guaranteed value of minimum oxygen index of outer sheath at 27 °C	Min 250	Min 250
E	Guaranteed value of minimum temperature index at 21 oxygen index	Black	Black
f	colour of sheath	$	$
15a	Nominal Overall diameter of cable	+2/-2 mm	
b	Tolerance on overall diameter (mm)	shall conform to IS 10418 and technical specification	
16	Cable Drums	1000/500	1000/500
a	Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)		
b	Non-standard drum lengths	Maximum one(1) non-standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)	
17	Whether progressive sequential marking on outer sheath provided atl meter interval 18	Yes	
18	Identification of cores		
a	colour of cores	As per IS 7098 Part(1)	
b	Numbering	NA	
19	Whether Cables offered are ISI marked	Yes	
20	Whether Cables offered are suitable for laying as per IS 1255	Yes	

$'- As per manufacturer design data

STANDARD TECHNICAL DATA SHEET - 1.1kV kV GRADE PVC POWER CABLES

Name of manufacturer: As per approved list

SN	Description	Parameters					
1a	Cable Sizes	1 c x 150	3.5 cx 70	3.5 cx 35	4 c x 16	4c x 6	2 c x 6
1b	Manufacturer's type designation	AYWaY	AYFY	AYFY	AYFY	AYWY	AYWY
2	Applicable standard	IS: 1554/PT-I/1988 & its referred standards					
3	Rated Voltage(volts)	1100 V grade					
4	Type & Category	FR & C1	FR & C1	FR & C1	FR & C1	FR & C1	FR & C1
5	Suitable for earthed or unearthed system	for both					
6	Continuous current rating when laid in air in a ambient temp. of 50oC and for maximum conductor temp. of 70 oC of PVC Cables[For information only]	202	105	70	41	24	28
7	Rating factors applicable to the current ratings for various conditions of installation:	As per IS-3961-Pt-II-67					
8	Short circuit Capacity						
a)	Short Circuit Amp. (rms)KA for 1 sec duration	11.2	5.22	2.61	1.19	0.448	0.448
b)	Conductor temp. allowed for the short circuit duty (deg C.)	160^0C					
9	Conductor						
a)	Material	STRANDED ALUMINIUM					
b)	Grade	H 2 (Electrolytic grade)					
c)	Cross Section area (Sq.mm.)	150	M-70 N-35	M-35 N-16	16	6	6
d)	Number of wires(No.)	as per Table 2 of IS 8130					
e)	Form of Conductor	Non-compacted Stranded circular	shaped conductor	shaped conductor	shaped conductor	Non-compacted Stranded circular	Non-compacted Stranded circular
f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay & opposite in successive layer					
10	Conductor resistance (DC) at 20 oC per km-maximum	0.206	0.443/0 .868	0.868/ 1.91	1.91	4.61	4.61
11	Insulation						
a)	Composition of insulation	Extruded PVC type A as per IS-5831-84					
b)	Nominal thickness of insulation(mm)	2.1	1.4/1.2	1.2/1.0	1.0	1.0	1.0
c)	Minimum thickness of insulation	1.79	1.16/0.9 8	0.98/0. 8	0.8	0.8	0.8
12	Inner Sheath						
a)	Material	Extruded PVC type ST-I as per IS-5831-84					
b)	Calculated diameter over the laid up cores,(mm)	N.A	27.6	20.4	15.7	11.6	9.6
c)	Thickness of Sheath (minimum) mm	N.A	0.4	0.3	0.3	0.3	0.3
13	Armour	as per IS 3975/88					
a)	a) Type and material of armour	Al. Wire[H4 grade]	Gal.steel strip	Gal.steel strip	Gal.steel strip	Gal.steel wire	Gal.steel wire

b)	b) Direction of armouring	left hand					
c)	c) Calculated diameter of cable over inner sheath (under armour), mm	18	28.4	21	16.3	12.2	10.2
d)	d) Nominal diameter of round armour wire/strip	1.6 4	0.8 4	0.8 4	0.8	1.4	1.4
e)	e) Number of armour wires/strips	Armouring shall be as close as practicable					
f)	f) Short circuit capacity of the armour along for 1 sec-for info only	K x A√t (K Amp)(where A = total area of armour in mm^2& t = time in seconds), K=0.091 for Al & 0.05 for steel					
g)	g) DC resistance at 20 oC (Ω/Km)	0.44	2.57	3.38 4	3.99	3.76	4.4
14	Outer Sheath						
a)	a) Material (PVC Type)	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR
b)	b) Calculated diameter under the sheath	21.2	30.1	22.6	17.9	15	13
c)	c) Min. thickness of sheath(mm)	1.4	1.56	1.4	1.4	1.4	1.24
d)	d) Guaranteed value of minimum oxygen index of outer sheath at 27oC	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
e)	e) Guaranteed value of minimum temperature index at 21 oxygen index	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
f)	f) colour of sheath	Black	Black	Black	Black	Black	Black
15a)	a) Overall diameter of cable	$					
b)	b) Tolerance on overall diameter (mm)	+2/-2 mm					
16	Cable Drums	shall conform to IS 10418 and technical specification					
a)	a) Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)	1000/500	1000/500	1000/500	1000/500	1000/500	1000/500
b)	b) Non standard drum lengths	Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)					
17	Whether progressive sequential marking on outer sheath provided	Yes					
18	Identification of cores						
a)	a) colour of cores	Red	R,Y,Bl & Bk	R,Y,Bl& Bk	R,Y,Bl & Bk	R,Y,Bl & Bk	Red & Bk
b)	b) Numbering	N.A	N.A	N.A	N.A	N.A	N.A
19	Whether Cables offered are ISI marked	YES					
20	Whether Cables offered are suitable for laying as per IS 1255	YES					

$'- As per manufacturer design data

STANDARD TECHNICAL DATA SHEET - 1.1kV kV GRADE PVC CONTROL CABLES

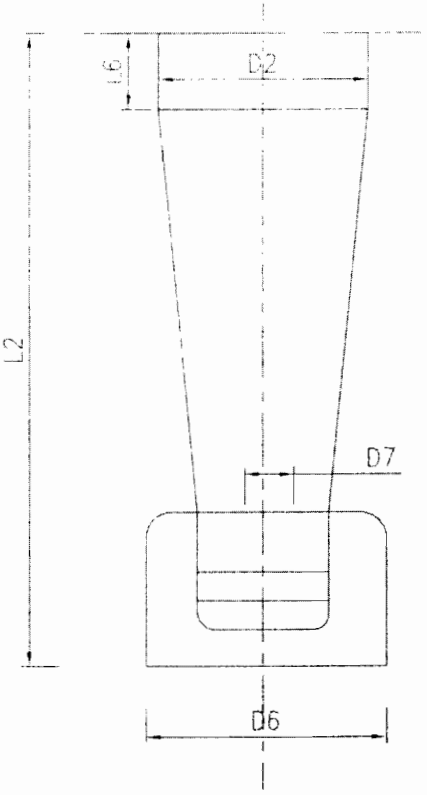
Name of manufacturer: As per approved list

SN	Description	Parameters							
1a	Cable Sizes	2 c x 2.5	3c cx 2.5	5c x 2.5	7 c x 2.5	10 c x 2.5	14 c x 2.5	19 c x 2.5	27 c x 2.5
1b	Manufacturer's type designation	YWY	YWY	YWY	YWY	YWY	YWY	YWY	YWY
2	Applicable standard	IS: 1554/PT-I/1988 & its referred standards							
3	Rated Voltage(volts)	1100 V grade							
4	Type & Category	FR & C1							
5	Suitable for earthed or unearthed system	for both							
6	Continuous current rating when laid in air in a ambient temp. of 50oC and for maximum conductor temp. of 70 oC of PVC Cables[For information only]	22	19	19	14	12	10.5	9.7	8
7	Rating factors applicable to the current ratings for various conditions of installation:	As per IS-3961-Pt-II-67							
8	Short circuit Capacity								
a)	Short Circuit Amp. (rms)KA for 1 sec duration	0.285	0.285	0.285	0.285	0.285	0.285	0.285	0.285
b)	Conductor temp. allowed for the short circuit duty (deg C.)	160^0C							
9	Conductor								
a)	Material	Plain annealed High Conductivity stranded Copper (as per IS 8130/84)							
b)	Grade	Electrolytic							
c)	Cross Section area (Sq.mm.)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
d)	Number of wires(No.)	as per Table 2 of IS 8130							
e)	Form of Conductor	Non-compacted Stranded circular shaped conductor							
f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay							
10	Conductor resistance (DC) at 20 oC per km-maximum	7.41	7.41	7.41	7.41	7.41	7.41	7.41	7.41
11	Insulation								
a)	Composition of insulation	Extruded PVC type A as per IS-5831-84							
b)	Nominal thickness of	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

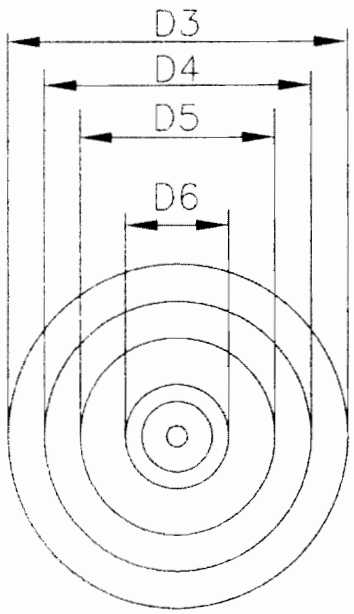
	insulation(mm)								
c)	Minimum thickness of insulation	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
12	Inner Sheath								
a)	Material	Extruded PVC type ST-I as per IS-5831-84							
b)	Calculated diameter over the laid up cores,(mm)	7.2	7.8	9.7	10.8	14.4	15.9	18	22.1
c)	Thickness of Sheath (minimum)mm	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
13	Armour	as per IS 3975/99							
a)	Type and material of armour	Gal. Steel Wire							
b)	Direction of armouring	left hand							
c)	Calculated diameter of cable over inner sheath (under armour), mm	7.8	8.4	10.3	11.4	15	6.5	18.6	22.7
d)	Nominal diameter of round armour wire/strip	1.4	1.4	1.4	1.4	1.6	1.6	1.6	1.6
e)	Number of armour wires/strips	Armouring shall be as close as practicable							
f)	Short circuit capacity of the armour along for 1 sec-for info only	0.05 x A$\sqrt{t}$ (K Amp)(where A = total area of armour in mm2 & t = time in seconds)							
g)	DC resistance at 20 oC (Ω/Km) & Resistivity	As per IS 1554 Part (1), wherever applicable and IS 3975-1999							
14	Outer Sheath								
a)	Material (PVC Type)	ST-1& FR							
b)	Calculated diameter under the sheath	10.6	11.2	13.1	14.2	18.2	19.7	21.8	25.9
c)	Min.thickness of sheath(mm)	1.24	1.24	1.24	1.24	1.4	1.4	1.4	1.56
d)	Guaranteed value of minimum oxygen index of outer sheath at 27oC	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
e)	Guaranteed value of minimum temperature index at 21 oxygen index	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
f)	colour of sheath	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey
15a)	Overall diameter of cable	$							
b)	Tolerance on overall diameter (mm)	+2/-2 mm							
16	Cable Drums	shall conform to IS 10418 and technical specification							
a)	Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)	1000/500							

b)	Non standard drum lengths	Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)							
17	Whether progressive sequential marking on outer sheath provided								
18	Identification of cores	Yes							
a)	colour of cores	R & Bk	R, Y & Bl	Red R,Y,Bl	Grey	Grey	Grey	Grey	Grey
b)	Numbering	N.A	N.A	N.A	Numerals in black ink				
19	Whether Cables offered are ISI marked	YES							
20	Whether Cables offered are suitable for laying as per IS 1255	YES							

$'- As per manufacturer design data



VOLTAGE RATING KV	420	245	145	72.5	52
BIL (kV_p)	1425	1050	650	325	250
CREEPAGE (MM) (Min.)	10500	6125	3625	1810	1300
CURRENT RATING (A) (Min.)	800 1250	1250 2000	800	800	3150
L2 ± 5 (FOR DIFF. VALUES OF L6)	1640	1130 1230	600#/800	695	475
L6 (MIN.)	400	300	100#/300	300	100
D2 (Max.)	350	270	165	115	165
D3±2	720	450	335	225	335
D4±1	660	400	290	185	290
D5xN	24x12	20x12	15x12	15x6	15x12
D6 (MAX)	350	270	165	115	115
D7 (Min)	60	48 –	38	---	---

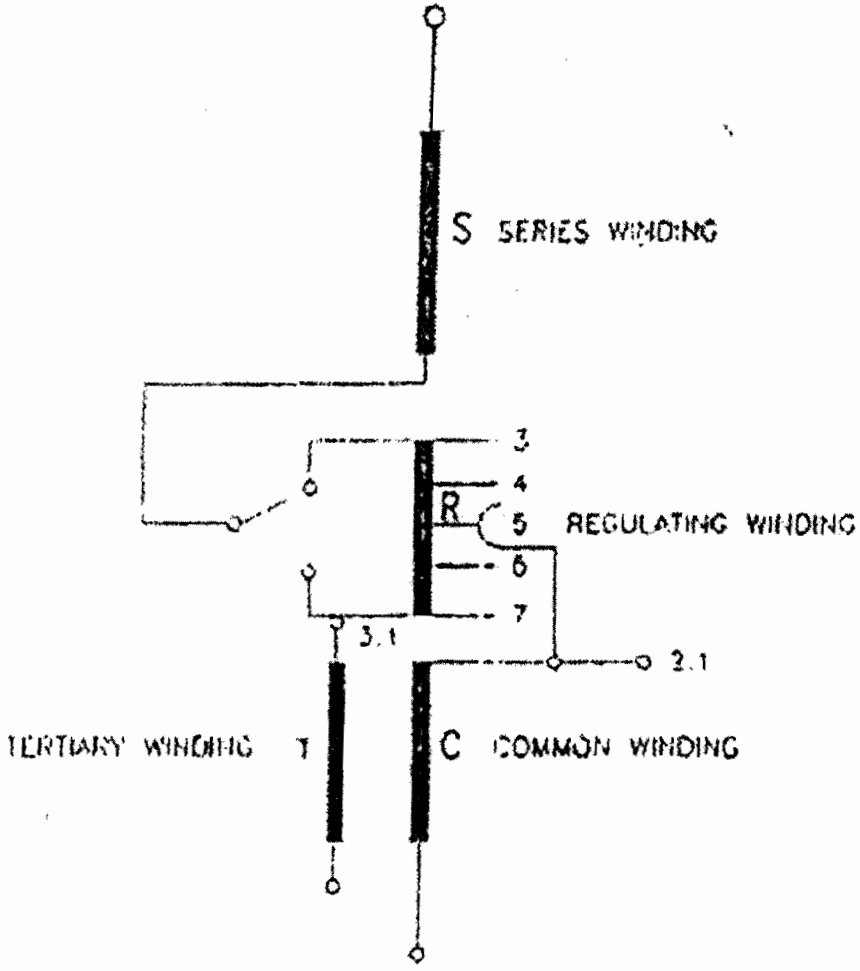


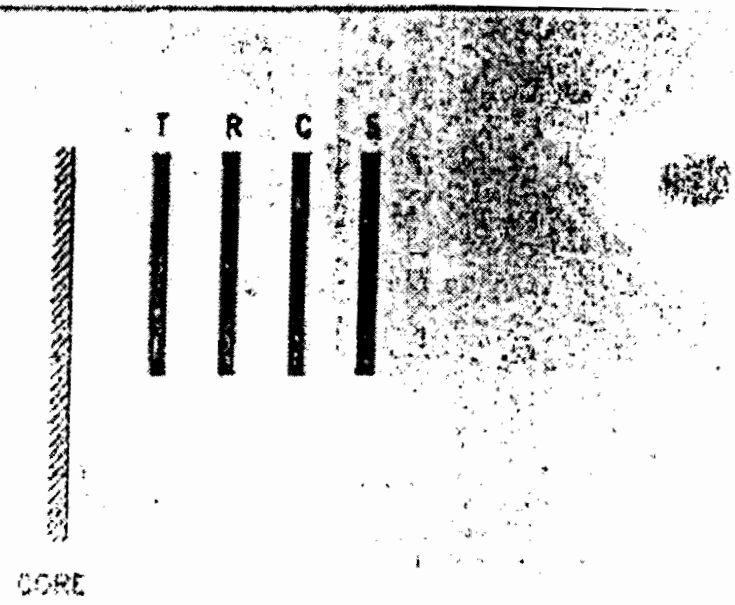
NOTE:

1. ALL DIMENSIONS ARE IN MM
2. NO POSITIVE TOL. WHERE MAX. DIMENSION SPECIFIED AND NO NEG. TOL. WHERE MIN. DIMENSION IS SPECIFIED

APPLICABLE FOR SHUNT REACTOR

PREPARED BY	CHECKED BY	APPROVED BY	TITLE	DRG NO
			STD DIMN. FOR R/P CONDENSER BUSHINGS (LOWER PORTION)	400-T-E-A-001-R02



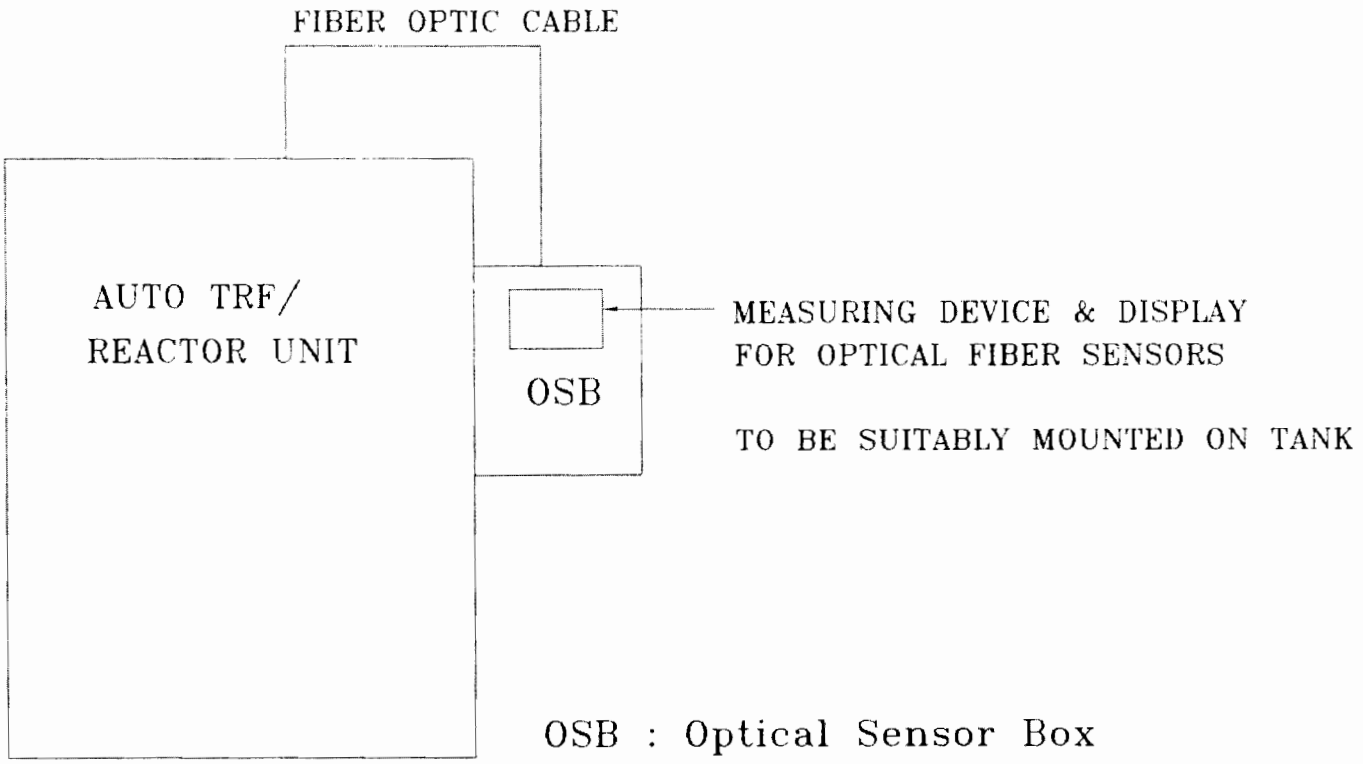


A TYPICAL MARKINGS FOR ONE PHASE OF AUTO TRANSFORMER WITH TAPPED WINDING AT THE END OF SERIES WINDING (COMMON FOR ALL TYPE OF AUTO TRANSFORMER)

B POSITIONING OF REGULATING WINDING WITH RESPECT TO OTHER WINDINGS.

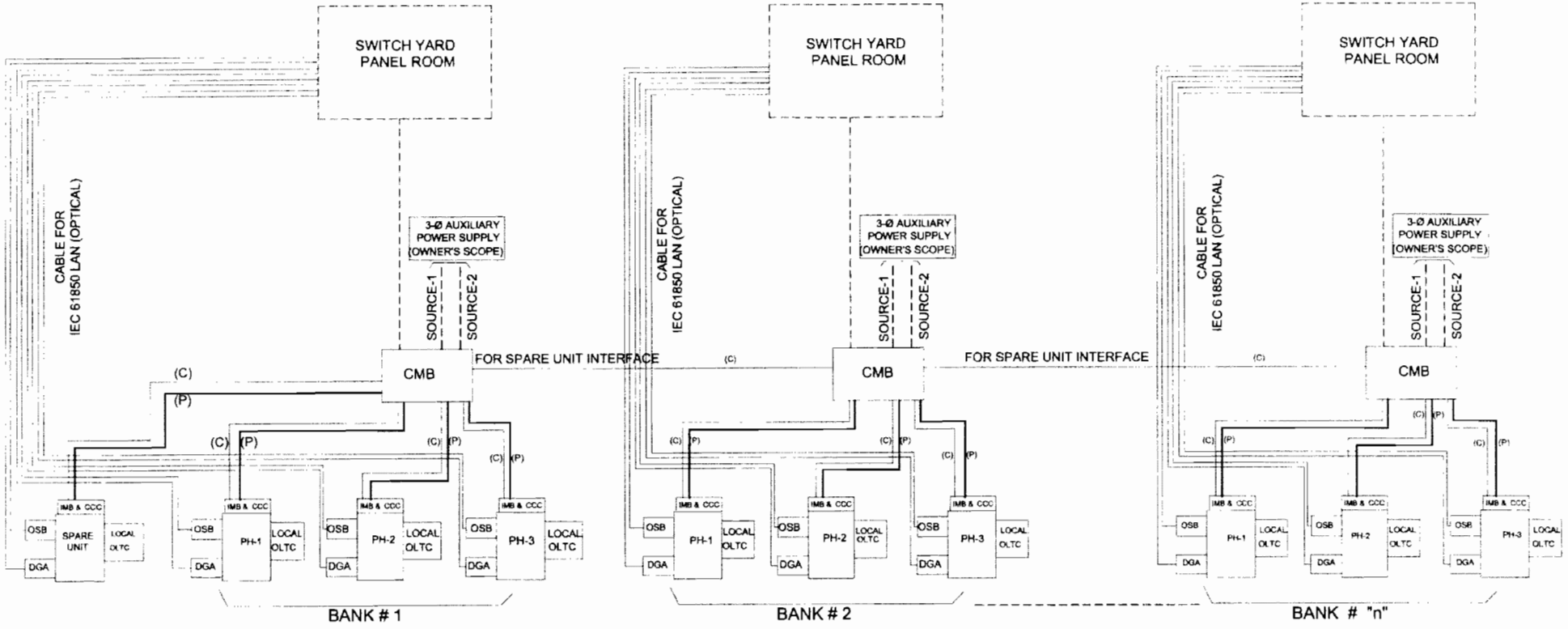
APPLICABLE FOR CONSTANT OHMIC (IMPED) TYPE AUTO TRANSFORMERS ONLY.

REV	DATE	DPT	CHKD	APPD	TITLE	PROJECT	
C	25.7.97	[illegible]	[illegible]	[illegible]	TYPICAL ARRANGEMENT FOR ONE PHASE OF AUTO TRANSFORMER WITH REGULATING WINDING AT THE END OF SERIES WINDING	STANDARDISATION	POWER GRID CORPORATION OF INDIA LIMITED
						DRG. NO. 0053-TE4-014	



OSB : Optical Sensor Box

PREPARED BY	CHECKED BY	APPROVED BY	TITLE	DRG NO	REV.
			CONCEPTUAL DRG FOR OPTICAL FIBER SENSOR	C/ENGG/STD/OPTICAL FIBER SENSOR/AT-RX	0



LEGEND-

- - - - - - - OWNER' S SCOPE (HOWEVER, ALL SPECIAL CABLE ARE IN BIDDER'S SCOPE)

(C) CONTROL CABLE & SPACAL CABLE AS APPLICABLE (BIDDER'S SCOPE)

——————— (P) POWER CABLE (BIDDER'S SCOPE)

FOR TENDER PURPOSE ONLY

POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)

PROJECT : 765KV & 400KV 1-PH TRANSFORMER

TITLE : CONCEPTUAL DRG. FOR SHOWING POWER AND CONTROL CABLE CONNECTION FOR OPERATION WITH SPARE UNIT

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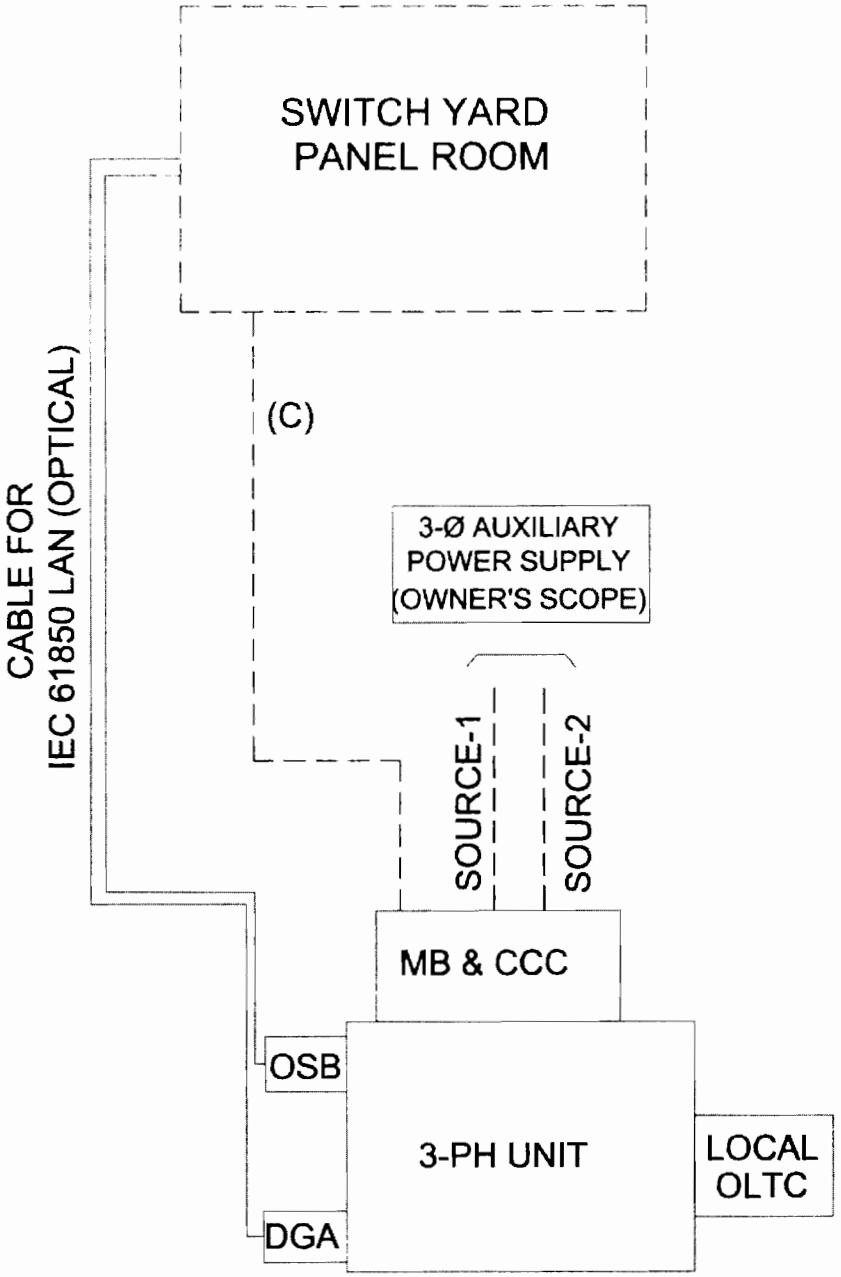

LEGEND-

- - - - - - OWNER' S SCOPE (HOWEVER, ALL SPECIAL CABLE ARE IN BIDDER'S SCOPE)

——————— (C) CONTROL CABLE & SPACAL CABLE AS APPLICABLE (BIDDER'S SCOPE)

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PREPARED BY	CHECKED BY	APPROVED BY	TITLE	DRG. NO	REV.
			CONCEPTUAL DRG. FOR SHOWING POWER & CONTRO. CABLE FOR OPERATION OF 3-PH TRANSFORMER	C/ENGG/STD/CABLE/TR	0

SECTION-3
PROJECT DETAILS & GENERAL TECHNICAL REQUIREMENTS

SITE INFORMATION

Sl No	Particulars	Details
PROJECT DETAILS		
a)	Owner	Power Grid Corporation of India (POWERGRID)
b)	Customer	Power Grid Corporation of India (POWERGRID)
c)	Project Title	Substation Package -SS01 for Construction of 765/400/220kV Bhuj Pool (New) S/S and Extension of 765kV Banaskantha S/S under Green Energy Corridors: Inter-State Transmission Scheme (ISTS) – Part C; [Part-II] {for 400/220kV (2X500MVA) part of the substation associated bays.
d)	Location	BHUJ
e)	Transport Facilities	Road/ Train/Air Connectivity: Nearest Railway Station BHUJ
SITE CONDITIONS		
a)	Max. ambient air temp.	50°C
b)	Min. ambient air temp.	0°C
c)	Max. design ambient emp.	50°C
d)	Design reference temp.	50°C
e)	Average Humidity	Shall be provided during detailed engineering.
f)	Special corrosion conditions	Shall be provided during detailed engineering.
g)	Solar Radiation	Shall be provided during detailed engineering.
h)	Atmospheric UV radiation	Shall be provided during detailed engineering.
i)	Altitude above sea level	Less than 1000 meter above sea level (MSL)
j)	Snow Fall	NIL
k)	Seismic Zone	**As per the seismic zone defined in the relevant BIS / IEC-62271-300** but not less than 0.3g Horizontal
l)	Wind Zone	As per IS 875
MAIN ELECTRICAL PARAMETRS:		
a)	Fault Levels	**765kV: 50kA for 1 sec** **400kV: 63kA for 1 sec** **220kV: 40kA for 1 sec**
a)	Creepage Distance	**31mm/kV**

Remark – **(a.) All switchgear/equipment's, insulator strings, bushings (including bushings for 400/220kV Autotransformers & 420kV Reactor), bus post insulators at**

Bhuj Pool substation shall be designed for minimum creepage distance of 31mm/kV instead of 25mm/kV mentioned elsewhere in other sections of technical specification.

(b.) Zinc coating for galvanized lattice and pipe structures (excluding foundation bolts & fasteners) at Bhuj Pool substation shall not be less than 900 gm/sq-m irrespective of other values mentioned elsewhere in technical specification/ drawings.

1.0 GENERAL

This Chapter covers Technical Requirements and requirements of auxiliary items.

a) Equipment furnished shall be complete in every respect with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or needed for erection, completion and safe operation of the equipment as required by applicable codes unless included in the list of exclusions.

b) Material and components not specifically stated in this specification but which are necessary for satisfactory operation of the equipment and accessories specified in this specification shall be deemed to be included unless specifically excluded and shall be supplied at no extra cost.

c) Whenever a material or article is specified or described by the name of a particular brand, manufacturer or vendor, the specific name mentioned shall be understood as establishing type, function and quality and not as limiting competition.

d) In case any Deviation Schedule, Bid Proposal Sheet, Schedule of Data Requirements (DRS), test reports or any other document/information are not furnished along-with the bid, the bid is liable to be rejected. Unless brought out clearly, the Bid will be deemed to conform to the specification scrupulously. All deviations from the specification shall be clearly brought out in the respective deviation schedule.

e) The Bidder shall clearly indicate in the bid, the specific standards in accordance with which the works will be carried out.

f) The equipment must be new, of highest grade, the best quality of their kind, to best engineering practice and latest state of art, and in accordance with purpose for which they are intended and ensure satisfactory performance throughout the service life.

g) All similar parts of the equipment shall be made to gauge and shall be interchangeable with and shall be made of same materials and workmanship as the corresponding parts of the equipment. Where feasible, common components, units shall be employed in different pieces of equipment in order to optimize the spare part stock-up and utilization.

h) The requirement regarding external RIV as specified for equipment shall include the terminal fittings and the equipment shall have been tested preferably with fittings, if any.

3.0 STANDARDS

3.1 The works covered by the specification shall be designed, engineered, manufactured, built, tested and commissioned in accordance with the Acts, Rules, Laws and Regulations of India.

3.2 The equipment to be furnished under this specification shall conform to latest issue with all amendments (as on the originally scheduled date of bid opening) of standard specified under Section-2 (Section-2A & 2B), unless specifically mentioned in the specification.

3.3 The Bidder shall note that standards mentioned in the specification are not mutually exclusive or complete in themselves, but intended to complement each other.

3.4 The Bidder shall also note that list of standards presented in this specification is not complete. Whenever necessary the list of standards shall be considered in conjunction with specific IS/IEC/CIGRE/IEEE/NEMA.

3.5 When the specific requirements stipulated in the specifications exceed or differ than those required by the applicable standards, the stipulation of the specification shall take precedence.

3.6 Other internationally accepted standards which ensure equivalent or better performance than that specified in the standards specified under Section-2 (Section-2A & 2B) individual sections for various equipment shall also be accepted; however the salient points of difference shall be clearly brought out in additional information schedule of the bid along with English language version of such standard. The equipment conforming to standards other than specified under Section-2A/ individual sections for various equipment shall be subject to Purchaser's approval.

4.0 SERVICES TO BE PERFORMED BY THE EQUIPMENT BEING FURNISHED

4.1 All equipment shall perform satisfactorily under various electrical, electromechanical and meteorological conditions of the site of installation.

4.2 All equipment shall be able to withstand all external and internal mechanical, thermal and electromechanical forces due to various factors like wind load, temperature variation, ice & snow (wherever applicable), short circuit etc. for the equipment.

4.3 The bidder shall design terminal connectors of the equipment taking into account various forces that are required to withstand.

4.4 The equipment shall also comply with the following:

a) To facilitate erection of equipment, all items to be assembled at site shall be "match marked".
b) All piping, if any between equipment control cabinet / operating mechanism to marshalling box of the equipment, shall bear proper identification to facilitate the connection at site.

5.0 ENGINEERING DATA AND DRAWINGS

5.1 The list of drawings/documents which are to be submitted to the BHEL/POWERGRID shall be discussed and finalised by the BHEL/POWERGRID at the time of award. An indicative list of such drawings and documents for transformer are enclosed in **Annexure-A**. The Bidder shall necessarily submit all the drawings/ documents

unless anything is waived.

5.2 The Bidder shall submit 4 (four) sets of drawings/ design documents /data /detailed bill of quantity and 1 (one) set of test reports for the approval of the Purchaser. The Bidder shall also submit the softcopy of the above documents in addition to hardcopy.

5.3 **Drawings**

5.3.1 All drawings submitted by the Bidder shall be in sufficient detail to indicate the type, size, arrangement, material description, Bill of Materials, weight of each component, break-up for packing and shipment, dimensions, internal & the external connections, fixing arrangement required and any other information specifically requested in the specifications.

5.3.2 Each drawing submitted by the Bidder shall be clearly marked with the name of the POWERGRID, the unit designation, the specifications title, the specification number and the name of the Project. POWERGRID has standardized a large number of drawings/ documents of various make including type test reports which can be used for all projects having similar requirements and in such cases no project specific approval (except for list of applicable drawings along with type test reports) is required. However, distribution copies of standard drawings/ documents shall be submitted as per provision of the contract. All titles, noting, markings and writings on the drawing shall be in English. All the dimensions should be in SI units.

5.4 The review of these data by the BHEL/POWERGRID will cover only general conformance of the data to the specifications and documents interfaces with the equipment provided under the specifications, external connections and of the dimensions which might affect substation layout. This review by the BHEL/POWERGRID may not indicate a thorough review of all dimensions, quantities and details of the equipment, materials, any devices or items indicated or the accuracy of the information submitted. This review and/or approval by the BHEL/POWERGRID shall not be considered by the Bidder, as limiting any of his responsibilities and liabilities for mistakes and deviations from the requirements, specified under these specifications and documents.

5.5 All manufacturing and fabrication work in connection with the equipment prior to the approval of the drawings shall be at the Bidder's risk. The Bidder may make any changes in the design which are necessary to make the equipment conform to the provisions and intent of the Contract and such changes will again be subject to approval by the BHEL/POWERGRID. Approval of Bidder's drawing or work by the BHEL/POWERGRID shall not relieve the Bidder of any of his responsibilities and liabilities under the Contract.

5.6 All engineering data submitted by the Bidder after final process including review and approval by the BHEL/POWERGRID shall form part of the Contract Document and the entire works performed under these specifications shall be performed in strict conformity, unless otherwise expressly requested by the Purchaser in Writing.

5.7 Approval Procedure

The scheduled dates for the submission of the drawings as well as for, any data/information to be furnished by the Purchaser would be discussed and finalized at the time of award. The following schedule shall be followed generally for approval

and for providing final documentation.

Sr. No.	Description	Schedule
i)	Approval/comments/by Purchaser on initial submission	As per agreed schedule
ii)	Resubmission (whenever required)	Within 3 (three) weeks from date of comments
iii)	Approval or comments	Within 3 (three) weeks of receipt of resubmission
iv)	Furnishing of distribution copies (5 hard copies per substation and one scanned copy (pdf format, GA and foundation in AutoCAD also for Corporate Centre)	2 weeks from the date of approval
v)	Furnishing of distribution copies of test reports a) Type test reports (one scanned softcopy in pdf format per substation plus one for corporate centre & one hardcopy per substation) b) Routine Test Reports (one copy for each substation)	2 weeks from the date of final approval -do-
vi)	Furnishing of instruction/operation manuals (2 copies per substation and one softcopy (pdf format) for corporate centre & per substation)	As per agreed schedule
vii)	As built drawings (two sets of hardcopy per substation & one softcopy (pdf format) for corporate centre& per substation)	On completion of entire works

NOTE:

1) The Bidder may please note that all resubmissions must incorporate all comments given in the earlier submission by BHEL/POWERGRID or adequate justification for not incorporating the same must be submitted failing which the submission of documents is likely to be returned.

2) All drawings should be submitted in softcopy form, however substation design drawings like SLD, GA, all layouts etc. shall also be submitted in AutoCAD Version. SLD, GA & layout drawings shall be submitted for the entire substation in case of substation extension also.

3) The instruction Manuals shall contain full details of drawings of all equipment being supplied under this contract, their exploded diagrams with complete instructions for storage, handling, erection, commissioning, testing, operation, trouble shooting, servicing and overhauling procedures.

4) If after the commissioning and initial operation of the substation, the instruction manuals require any modifications/ additions/changes, the same shall be incorporated and the updated final instruction manuals shall be submitted by the supplier to BHEL/POWERGRID.

5) The Bidder shall furnish to the BHEL/POWERGRID catalogues of spare parts.

6) All As-built drawings/ documents shall be certified by site indicating the changes before final submission.

6.0 MATERIAL/ WORKMANSHIP

6.1 General Requirement

6.1.1 Where the specification does not contain references to workmanship, equipment, materials and components of the covered equipment, it is essential that the same must be new, of highest grade of the best quality of their kind, conforming to best engineering practice and suitable for the purpose for which they are intended.

6.1.2 In case where the equipment, materials or components are indicated in the specification as "similar" to any special standard, the Purchaser shall decide upon the question of similarity. When required by the specification or when required by the Purchaser the Bidder shall submit, for approval, all the information concerning the materials or components to be used in manufacture. Machinery, equipment, materials and components supplied, installed or used without such approval shall run the risk of subsequent rejection, it being understood that the cost as well as the time delay associated with the rejection shall be borne by the Bidder.

6.1.3 The design of the Works shall be such that installation, future expansions, replacements and general maintenance may be undertaken with a minimum of time and expenses. Each component shall be designed to be consistent with its duty and suitable factors of safety, subject to mutual agreements. All joints and fastenings shall be devised, constructed and documented so that the component parts shall be accurately positioned and restrained to fulfill their required function. In general, screw, threads shall be standard metric threads. The use of other thread forms will only be permitted when prior approval has been obtained from the BHEL/POWERGRID.

6.1.4 Whenever possible, all similar part of the Works shall be made to gauge and shall also be made interchangeable with similar parts. All spare parts shall also be interchangeable and shall be made of the same materials and workmanship as the corresponding parts of the Equipment supplied under the Specification. Where feasible, common component units shall be employed in different pieces of equipment in order to minimize spare parts stocking requirements. All equipment of the same type and rating shall be physically and electrically interchangeable.

6.1.5 All materials and equipment shall be installed in strict accordance with the Bidder's recommendation(s). Only first-class work in accordance with the best modern practices will be accepted. Installation shall be considered as being the erection of equipment at its permanent location. This unless otherwise specified, shall include unpacking, cleaning and lifting into position, grouting, levelling, aligning, coupling of or bolting down to previously installed equipment bases/foundations, performing the alignment check and final adjustment prior to initial operation, testing and commissioning in accordance with the manufacturer's tolerances, instructions and the Specification. All factory assembled rotating

machinery shall be checked for alignment and adjustments made as necessary to re-establish the manufacturer's limits suitable guards shall be provided for the protection of personnel on all exposed rotating and / or moving machine parts and shall be designed for easy installation and removal for maintenance purposes. The spare equipment(s) shall be installed at designated locations and tested for healthiness.

6.1.6 The Bidder shall apply oil and grease of the proper specification to suit the machinery, as is necessary for the installation of the equipment. Lubricants used for installation purposes shall be drained out and the system flushed through where necessary for applying the lubricant required for operation. The supplier shall apply all operational lubricants to the equipment installed by him.

6.1.7 All oil, grease and other consumables used in the Works/ Equipment shall be purchased in India unless the Contractor/ Supplier has any special requirement for the specific application of a type of oil or grease not available in India. In such is the case he shall declare in the proposal, where such oil or grease is available. He shall help Purchase/BHEL/POWERGRID in establishing equivalent Indian make and Indian Contractor/ Supplier. The same shall be applicable to other consumables too.

6.1.8 Corona and radio interference voltage test and seismic withstand test (for 132kV and above voltage level) procedures for equipment shall be in line with the procedure given at **Annexure-B and C** respectively.

6.2 Provisions For Exposure to Hot and Humid climate

Outdoor equipment supplied under the specification shall be suitable for service and storage under tropical conditions of high temperature, high humidity, heavy rainfall and environment favourable to the growth of fungi and mildew. The indoor equipments located in non-air conditioned areas shall also be of same type.

6.2.1 Space Heaters

6.2.1.1 The heaters shall be suitable for continuous operation at 240V as supply voltage. On-off switch and fuse shall be provided.

6.2.1.2 One or more adequately rated thermostatically connected heaters shall be supplied to prevent condensation in any compartment. The heaters shall be installed in the compartment and electrical connections shall be made sufficiently away from below the heaters to minimize deterioration of supply wire insulation. The heaters shall be suitable to maintain the compartment temperature to prevent condensation.

6.2.1.3 Suitable anti condensation heaters with the provision of thermostat shall be provided.

6.2.2 FUNGI STATIC VARNISH

Besides the space heaters, special moisture and fungus resistant varnish shall be applied on parts which may be subjected or predisposed to the formation of fungi due to the presence or deposit of nutrient substances. The varnish shall not be applied to any surface of part where the treatment will interfere with the operation

or performance of the equipment.Such surfaces or parts shall be protected against the application of the varnish.

6.2.3 Ventilation opening

Wherever ventilation is provided, the compartments shall have ventilation openings with fine wire mesh of brass to prevent the entry of insects and to reduce to a minimum the entry of dirt and dust. Outdoor compartment openings shall be provided with shutter type blinds and suitable provision shall be made so as to avoid any communication of air / dust with any part in the enclosures of the Control Cabinets, Junction boxes and Marshalling Boxes, panels etc.

6.2.4 Degree of Protection

The enclosures of the Control Cabinets, Junction boxes and Marshalling Boxes, panels etc. to be installed shall provide degree of protection as detailed here under:

a) Installed out door: IP- 55
b) Installed indoor in air conditioned area: IP-31
c) Installed in covered area: IP-52
d) Installed indoor in non air conditioned area where possibility of entry of water is limited: IP-41.
e) For LT Switchgear (AC & DC distribution Boards): IP-52

The degree of protection shall be in accordance with IS: 13947 (Part-I) / IEC-60947(Part-I) / IS 12063 / IEC-60529. Type test report for degree of protection test, shall be submitted for approval.

6.3 RATING PLATES, NAME PLATES AND LABELS

Each main and auxiliary item of substation is to have permanently attached to it in a conspicuous position a rating plate of non-corrosive material upon which is to be engraved manufacturer's name, year of manufacture, equipment name, type or serial number together with details of the loading conditions under which the item of substation in question has been designed to operate, and such diagram plates as may be required by the Purchaser. The rating plate of each equipment shall be according to IEC requirement.

All such nameplates, instruction plates, rating plates of transformers, reactors, CB, CT, CVT, SA, Isolators, C&R panels and PLCC equipments 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.

6.4 FIRST FILL OF CONSUMABLES, OIL AND LUBRICANTS

All the first fill of consumables such as oils, lubricants, filling compounds, touch up paints, soldering/brazing material for all copper piping of circuit breakers and essential chemicals etc. which will be required to put the equipment covered under the scope of the specifications, into successful Operation, shall be furnished by the supplier unless specifically excluded under the exclusions in these specifications and documents.

7.0 DESIGN IMPROVEMENTS / COORDINATION

7.1 The Bidder shall note that the equipment offered by him in the bid only shall be accepted for supply. However, the Purchaser or the Contractor may propose changes in the specification of the equipment or quality thereof and if the Purchaser & contractor agree upon any such changes, the specification shall be modified accordingly.

7.2 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 change in 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.

7.3 The supplier shall be responsible for the selection and design of appropriate equipments to provide the best co-ordinated performance of the entire system. The basic design requirements are detailed out in this Specification. The design of various components, sub-assemblies and assemblies shall be so done that it facilitates easy field assembly and maintenance.

7.4 The supplier has to coordinate designs and terminations with the agencies (if any) who are Consultants/Contractor for the Purchaser. The names of agencies shall be intimated to the successful bidders.

7.5 The supplier will be called upon to attend design co-ordination meetings with the Engineer, other Contractor's and the Consultants of the Purchaser (if any) during the period of Contract. The Contractor shall attend such meetings at his own cost at POWERGRID Corporate Centre, Gurgaon (Haryana) or at mutually agreed venue as and when required and fully cooperate with such persons and agencies involved during those discussions.

8.0 QUALITY ASSURANCE PROGRAMME

8.1 To ensure that the equipment and services under the scope of this Contract whether manufactured or performed within the supplier's Works or at his Sub-contractor's premises or at the Purchaser's site or at any other place of Work are in accordance with the specifications, the supplier shall adopt suitable quality assurance programme to control such activities at all points necessary. The detailed programme shall be submitted by the contractor after the award for reference. A quality assurance programme of the supplier shall generally cover the following.

a) His organization structure for the management and implementation of the proposed quality assurance programme.
b) Documentation control system;
c) Qualification data for bidder's key personnel;
d) The procedure for purchases of materials, parts components and selection of sub-Contractor's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.
e) System for shop manufacturing and site erection controls including process controls and fabrication and assembly control;
f) Control of non-conforming items and system for corrective actions;
g) Inspection and test procedure both for manufacture and field activities.
h) Control of calibration and testing of measuring instruments and field activities.

i) System for indication and appraisal of inspection status;
j) System for quality audits;
k) System for authorising release of manufactured product to the BHEL/POWERGRID.
l) System for maintenance of records;
m) System for handling storage and delivery; and
n) A quality plan detailing out the specific quality control measures and procedures adopted for controlling the quality characteristics relevant to each item of equipment furnished and/or services rendered BHEL/POWERGRID or his duly authorised representative reserves the right to carry out quality audit and quality surveillance of the system and procedure of the supplier/his vendor's quality management and control activities.

8.2 Quality Assurance Documents

The supplier would be required to submit all the Quality Assurance Documents as stipulated in the Quality Plan at the time of Purchaser/POWERGRID/BHEL inspection of equipment/material.

9.0 TYPE TESTING, INSPECTION, TESTING & INSPECTION CERTIFICATE

9.1 All equipment being supplied shall conform to type tests as per technical specification and shall be subject to routine tests in accordance with requirements stipulated under respective sections.

9.2 The reports for all type tests as per technical specification shall be furnished by the Bidder along with equipment / material drawings.

Type Tests on Transformer & Reactor fittings: The test reports submitted, shall be of the tests conducted within last 10 (ten) years prior to the originally scheduled date of bid opening i.e. **08.08.2016**. In case the test reports are of the test conducted earlier than 10 (ten) years prior to the originally scheduled date of bid opening i.e. **08.08.2016**, the contractor/ Supplier shall repeat these test(s) at no extra cost to the BHEL/POWERGRID. The type tests conducted earlier should have either been conducted in accredited laboratory (accredited based on ISO / IEC Guide 25 / 17025 or EN 45001 by the national accreditation body of the country where laboratory is located) or witnessed by POWERGRID or representative authorized by POWERGRID or Utility or representative of accredited test lab or reputed consultant. Further, in the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design/manufacturing changes (including substitution of components) or due to non-compliance with the requirement stipulated in the Technical Specification or any/all type tests not carried out, same shall be carried out without any additional cost implication to the BHEL/POWERGRID. The Contractor shall intimate the Purchaser the detailed program about the tests at least two (2) weeks in advance in case of domestic supplies & six (6) weeks in advance in case of foreign supplies.

9.3 For outdoor receptacles, trefoil clamps, diesel engine, alternator, motors, cable glands, lighting fixtures, ACSR/AAC conductor, IPS aluminium tube and junction boxes, type test reports are not required to be submitted for the makes indicated at **Annexure-D** POWERGRID approved list of sub-vendors. For the new makes (other than those indicated at **Annexure-D** POWERGRID approved list of sub-vendors), type test reports as per relevant standard shall be submitted for purchaser's

approval.

9.4 The BHEL/POWERGRID, his duly authorised representative and/or outside inspection agency acting on behalf of the BHEL/POWERGRID shall have at all reasonable times free access to the Bidder's premises or Works and shall have the power at all reasonable times to inspect and examine the materials and workmanship of the Works during its manufacture or erection if part of the Works is being manufactured or assembled at other premises or works, the Bidder shall obtain for the Engineer and for his duly authorised representative permission to inspect as if the works were manufactured or assembled on the Bidder's own premises or works. Inspection may be made at any stage of manufacture, despatch or at site at the option of the Purchaser and the equipment if found unsatisfactory due to bad workmanship or quality, material is liable to be rejected.

9.5 The Bidder shall give the BHEL/POWERGRID/Inspector fifteen (15) days written notice for on-shore and six (6) weeks' notice for off-shore material being ready for joint testing including Bidder and POWERGRID. Such tests shall be to the Bidder's account except for the expenses of the Inspector. The BHEL/POWERGRID /inspector, unless witnessing of the tests is virtually waived, will attend such tests within fifteen (15) days of the date of which the equipment is notified as being ready for test/inspection, failing which the Contractor may proceed alone with the 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 tests in triplicate.

9.6 The BHEL/POWERGRID or Inspector shall, within fifteen (15) days from the date of inspection as defined herein give notice in writing to the Bidder, of any objection to any drawings and all or any equipment and workmanship which in his opinion is not in accordance with the Contract. Bidder shall give due consideration to such objections and shall either make the modifications that may be necessary to meet the said objections or shall confirm in writing to the BHEL/POWERGRID /Inspector giving reasons therein, that no modifications are necessary to comply with the Contract.

9.7 When the factory tests have been completed at the Bidder's works, the BHEL/POWERGRID/inspector shall issue a certificate to this effect within fifteen (15) days after completion of tests but if the tests are not witnessed by the BHEL/POWERGRID/inspector, the certificate shall be issued within fifteen (15) days of receipt of the Contractor's Test certificate by the Engineer/Inspector. Failure of the BHEL/POWERGRID/Inspector to issue such a certificate shall not prevent the Bidder from proceeding with the Works. The completion of these tests or the issue of the certificate shall not bind the Purchaser to accept the equipment should, it, on further tests after erection, be found not to comply with the Contract. The equipment shall be dispatched to site only after approval of test reports and issuance of CIP by the Purchaser.

9.8 In all cases where the Contract provides for tests whether at the premises or at the works of the Bidder, the Bidder except where otherwise specified shall provide free of charge such items as labour, materials, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the BHEL/POWERGRID /Inspector or his authorised representative to carry out effectively such tests of the equipment in accordance with the Contract and shall give facilities to the BHEL/POWERGRID/Inspector or to his authorised representative to accomplish testing.

9.9 The inspection by BHEL/POWERGRID and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Bidder in respect of the agreed quality assurance programme forming a part of the Contract.

9.10 The BHEL/POWERGRID will have the right of having at his own expenses any other test(s) of reasonable nature carried out at Contractor's premises or at site or in any other place in addition of aforesaid type and routine tests, to satisfy that the material comply with the specification.

9.11 The BHEL/POWERGRID reserves the right for getting any field tests not specified in respective sections of the technical specification conducted on the completely assembled equipment at site. The testing equipment for these tests shall be provided by the BHEL/POWERGRID.

10.0 TESTS

10.1 Pre-commissioning Tests

On completion of erection of the equipment and before charging, each item of the equipment shall be thoroughly cleaned and then inspected jointly by the Purchaser and the Contractor for correctness and completeness of installation and acceptability for charging, leading to initial pre-commissioning tests at Site. The list of pre-commissioning tests to be performed are given in respective chapters and shall be included in the Contractor's quality assurance programme.

10.2 Commissioning Tests

10.2.1 The available instrumentation and control equipment will to be used during such tests and the Purchaser will calibrate, all such measuring equipment and devices as far as practicable.

10.2.2 Any special equipment, tools and tackles required for the successful completion of the Commissioning Tests shall be provided by the Contractor, free of cost.

10.2.3 The specific tests requirement on equipment have been brought out in the respective chapters of the technical specification.

10.3 The Bidder shall be responsible for obtaining statutory clearances from the concerned authorities for commissioning the equipment and the switchyard. However necessary fee shall be reimbursed by BHEL/POWERGRID on production of requisite documents.

11.0 PACKAGING & PROTECTION

11.1 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. On request of the BHEL/POWERGRID, the Bidder shall also submit packing details/associated drawing for any equipment/material under his scope of supply, to facilitate the Purchaser to repack any equipment/material at a later date, in case the need arises. While packing all the materials, the limitation from the point of view of availability of Railway wagon sizes in India should be taken into account. The Bidder shall be responsible for any loss or damage during transportation, handling and storage due to improper packing. Any demurrage, wharfage and other such charges claimed by

the transporters, railways etc. shall be to the account of the Bidder. Purchaser takes no responsibility of the availability of the wagons.

11.2 All coated surfaces shall be protected against abrasion, impact, discolouration and any other damages. All exposed threaded portions shall be suitably protected with either a metallic or a non-metallic protecting device. All ends of all valves and piping and conduit equipment connections shall be properly sealed with suitable devices to protect them from damage.

12.0 FINISHING OF METAL SURFACES

12.1 All metal surfaces shall be subjected to treatment for anti-corrosion protection. All ferrous surfaces for external use unless otherwise stated elsewhere in the specification or specifically agreed, shall be hot-dip galvanized after fabrication. High tensile steel nuts & bolts and spring washers shall be electro galvanized to service condition 4.All steel conductors including those used for earthing/grounding (above ground level) shall also be galvanized according to IS:2629.

12.2 HOT DIP GALVANISING

12.2.1 The minimum weight of the zinc coating shall be 610 gm/sq.m and minimum average thickness of coating shall be 86 microns for all items having thickness 6mm and above. For items lower than 6mm thickness requirement of coating thickness shall be as per relevant ASTM. For surface which shall be embedded in concrete, the zinc coating shall be **610 gm/sq. m minimum.**

12.2.2 The galvanized surfaces shall consist of a continuous and uniform thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be clean and smooth and shall be free from defects like discoloured patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel globules, spiky deposits, blistered surface, flaking or peeling off, etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

12.2.3 After galvanizing, no drilling or welding shall be performed on the galvanized parts of the equipment excepting that nuts may be threaded after galvanizing. Sodium dichromate treatment shall be provided to avoid formation of white rust after hot dip galvanization.

12.2.4The galvanized steel shall be subjected to six one minute dips in copper sulphate solution as per IS-2633.

12.2.5 Sharp edges with radii less than 2.5 mm shall be able to withstand four immersions of the Standard Preece test. All other coatings shall withstand six immersions. The following galvanizing tests should essentially be performed as per relevant Indian Standards.

- Coating thickness
- Uniformity of zinc
- Adhesion test
- Mass of zinc coating

12.2.6 Galvanized material must be transported properly to ensure that

galvanised surfaces are not damaged during transit. Application of zinc rich paint at site shall not be allowed.

12.3 PAINTING

12.3.1 All sheet steel work shall be degreased, pickled, and phosphated in accordance with the IS-6005 "Code of practice for phosphating iron and sheet". All surfaces, which will not be easily accessible after shop assembly, shall beforehand be treated and protected for the life of the equipment. The surfaces, which are to be finished painted after installation or require corrosion protection until installation, shall be shop painted with at least two coats of primer. Oil, grease, dirt and swaf shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

12.3.2 After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying. The phosphate coating shall be sealed with application of two coats of ready mixed, stoving type zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved.

12.3.3 After application of the primer, two coats of finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after inspection of first coat of painting.

12.3.4 The exterior and interior colour of the paint in case of new substations shall preferably be RAL 7032 for all equipment, marshalling boxes, junction boxes, control cabinets, panels etc. Unless specifically mentioned under respective sections of the equipment. Glossy white color inside the equipment /boards/panels/junction boxes is also acceptable. The exterior colour for panels shall bematching with the existing panels in case of extension of a substation. Each coatof primer and finishing paint shall be of slightly different shade to enable inspection of the painting. A small quantity of finishing paint shall be supplied for minor touching up required at site after installation of the equipment.

12.3.5 In case the Bidder proposes to follow his own standard surface finish and protection procedures or any other established painting procedures, like electrostatic painting etc., the procedure shall be submitted alongwith the Bids for Purchaser's review & approval.

12.3.6 The colour scheme as given below shall be followed for Fire Protection and Air Conditioning systems

Sr. No.	PIPE LINE	Base color	Band color
Fire Protection System			
1	Hydrant and Emulsifier system pipeline	FIRE RED	-
2	Emulsifier system detection line –	FIRE RED	Sea Green
3	Emulsifier system detection line – Air	FIRE RED	Sky Blue

4	Pylon support pipes	FIRE RED	
Air Conditioning System			
5	Refrigerant gas pipeline – at compressor suction	Canary Yellow	-
6	Refrigerant gas pipeline – at compressor discharge	Canary Yellow	Red
7	Refrigerant liquid pipeline	Dark Admiralty Green	-
8	Chilled water pipeline	Sea Green	-
9	Condenser water pipeline	Sea Green	Dark Blue

12.3.7 For aluminium casted surfaces, the surface shall be with smooth finish. Further, in case of aluminium enclosures, the surface shall be coated with powder (coating thickness of 60 microns) after surface preparation for painting.

13.0 HANDLING, STORING AND INSTALLATION

13.1 In accordance with the specific installation instructions as shown on Bidder's drawings or as directed by the BHEL/POWERGRID or his representative, the Bidder shall unload, store, erect, install, wire, test and place into commercial use all the equipment included in the contract. Equipment shall be installed in a neat, workmanlike manner so that it is level, plumb, square, and properly aligned and oriented. Commercial use of switchyard equipment means completion of all site tests specified and energisation at rated voltage.

13.2 BHEL/POWERGRID may engage Bidder's Engineers to supervise the unloading, transportation to site, storing, testing and commissioning of the various equipment being procured by them separately. Bidder shall unload, transport, store, erect, test and commission the equipment as per instructions ofthe manufacturer's supervisory Engineer(s) and shall extend full cooperation to them.

13.3 The Bidder shall have to ensure that the hard and flat indoor and outdoor storage areas are in place prior to commencement of delivery of material at site. Bidder shall also ensure availability of proper unloading and material handling equipment like cranes etc. and polyester/nylon ropes of suitable capacity to avoid damage during unloading and handling of material at site. All indoor equipments shall be stored indoors. Outdoor equipment may be stored outdoors but on a hard and flat raised area properly covered with waterproof and dustproof covers to protect them from water seepage and moisture ingress. However, all associated control panels, marshalling boxes operating boxes etc. of outdoor equipments are to be stored indoors only.Storage of equipment on top of another one is not permitted if the wooden packing is used. Material opened for joint inspection shall be repacked properly as per manufacturer's recommendations. During storage of material regular periodic monitoring of important parameters like oil level / leakage, SF6 / Nitrogen pressure etc. shall be ensured by the contractor.

13.4 In case of any doubt/ misunderstanding as to the correct interpretation of manufacturer's drawings or instructions, necessary clarifications shall be obtained from the BHEL/POWERGRID. Bidder shall be held responsible for any damage to the equipment consequent to not following manufacturer's drawings/instructions correctly.

13.5 Where assemblies are supplied in more than one section, Bidder shall make all necessary mechanical and electrical connections between sections including the connection between buses. Bidder shall also do necessary adjustments/alignments necessary for properoperation of circuit breakers, isolators and their operating mechanisms. All components shall be protected against damage during unloading, transportation, storage, installation, testing and commissioning. Any equipment damaged due to negligence or carelessness or otherwise shall be replaced by the Bidder at his own expense.

13.6 Bidder shall be responsible for examining all the shipment and notify the BHEL/POWERGRID immediately of any damage, shortage, discrepancy etc. for the purpose of BHEL/POWERGRID's information only. The Bidder shall submit to the BHEL/POWERGRID every week a report detailing all the receipts during the weeks. However, the Bidder shall be solely responsible for any shortages or damages in transit, handling and/ or in storage and erection of the equipment at Site. Any demurrage, wharfage and other such charges claimed by the transporters, railways etc. shall be to the account of the Bidder.

13.7 The Bidder shall be fully responsible for the equipment/ material until the same is handed over to the BHEL/POWERGRID in an operating condition after commissioning. Bidder shall be responsible for the maintenance of the equipment/ material while in storage as well as after erection until taken over by BHEL/POWERGRID, as well as protection of the same against theft, element of nature, corrosion, damages etc.

13.8 Where material/ equipment is unloaded by BHEL/POWERGRID before the Bidder arrives at site or even when he is at site, BHEL/POWERGRID by right can hand over the same to Bidder and there upon it will be the responsibility of Bidder to store the material in an orderly and proper manner.

13.9 The Bidder shall be responsible for making suitable indoor storage facilities, to store all equipment which requires indoor storage.

13.10 The words 'erection' and 'installation' used in the specification are synonymous.

13.11 Exposed live parts shall be placed high enough above ground to meet the requirements of electrical and other statutory safety codes.

13.12 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 agreed to by the Purchaser. Each base plate shall 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.

14.0 TOOLS

14.1 TOOLS & PLANTS (T&P)

The Bidder shall arrange all T&P (such as necessary supports, cranes, ladders, platforms etc.) for erection, testing & commissioning of the system at his own cost. Further, all consumables, wastage and damages shall be to the account of Bidder.

14.2 SPECIAL TOOLS AND TACKLES

The bidder shall include in its proposal the deployment of all special tools and tackles required for Operation and Maintenance of equipment. The special tools and tackles shall only cover items which are specifically required for the equipment offered and are proprietary in nature. However a list of all such devices should be indicated in the relevant schedule provided in the Bid Price Schedule.

In addition to this, the Bidder shall also furnish a list of special tools and tackles for the various equipment in a manner to be referred by the BHEL/POWERGRID during the operation of these equipment. The scope of special tools and tackles are to be decided during detail engineering and the list of special tools and tackles, if any shall be finalized.

15.0 AUXILIARY SUPPLY

15.1 The sub-station auxiliary supply is normally met through a system indicated under section "Electrical & Mechanical Auxiliaries" having the following parameters. The auxiliary power for station supply, including the equipment drive, cooling system of any equipment, air-conditioning, lighting etc shall be designed for the specified Parameters as under. The DC supply for the instrumentation and PLCC system shall also conform the parameters as indicated in the following.

Normal Voltage	Variation in Voltage	Frequenc y in HZ	Phase/W ire	Neutral connectio
415V	± 10%	50 ± 5%	3/4 Wire	Solidly Earthed.
240V	± 10%	50 ± 5%	1/2 Wire	Solidly Earthed.
220V	190V to 240V	DC	-	Isolated 2 wire System
48V	_	DC	_	2 wire system (+) earthed

Combined variation of voltage and frequency shall be limited to ± 10%.

16.0 SUPPORT STRUCTURE (If in the scope of Bidder)

16.1 The equipment support structures shall be suitable for equipment connections at the first level i.e 14.0 meter, 8.0 meter and 5.9 meter from plinth level for 765 kV, 420 kV and 245 kV substations respectively. All equipment support structures shall be supplied alongwith brackets, angles, stools etc. for attaching the operating mechanism, control cabinets & marshalling box (wherever applicable) etc.

16.2 Support structure shall meet the following mandatory requirements:

16.2.1 The minimum vertical distance from the bottom of the lowest porcelain part of

the bushing, porcelain enclosures or supporting insulators to the bottom of the equipment base, where it rests on the foundation pad shall be 2.55 metres.

17.0 CLAMPS AND CONNECTORS INCLUDING TERMINAL CONNECTORS

17.1 All power clamps and connectors shall conform to IS: 5561 & NEMA CC1 and shall be made of materials listed below:

a)	For connecting ACSR conductors	Aluminum alloy casting, conforming to designation A6 of IS:617 and all test shall conform to IS:617
b)	For connecting equipment ter-minals made of copper with ACSR conductors	Bimetallic connectors made from aluminum alloy casting, conforming to designation A6 of IS:617 with 2mm thick bimetallic liner and all test shall conform to IS:617
c)	For connecting G.I	Galvanised mild steel shield
d)	i) Bolts, nuts & Plain, washers	i) Electrogalvanised for sizes below M12, for others hot dip galvanised.
	ii) Spring washers items 'a' to 'c'	ii) Electro-galvanised mild for steel suitable for atleast service condition-3 as per IS: 1573

17.2 Necessary clamps and connectors shall be supplied for all equipment and connections.The requirement regarding external corona and RIV as specified for any equipment shall include its terminal fittings. If corona rings are required to meet these requirements they shall be considered as part of that equipment and included in the scope of work.

17.3 Where copper to aluminum connections are required, bi-metallic clamps shall be used, which shall be properly designed to ensure that any deterioration of the connection is kept to a minimum and restricted to parts which are not current carrying or subjected to stress.

17.4 Low voltage connectors, grounding connectors and accessories for grounding equipment as specified in any particular case, are also included in the scope of Work.

17.5 No current carrying part of any clamp shall be less than 10 mm thick. All ferrous parts shall be hot dip galvanised. Copper alloy liner of minimum 2 mm thickness shall be cast integral with aluminum body or 2 mm thick bi-metallic strips shall be provided for Bi-metallic clamps.

17.6 All casting shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be blurred and rounded off.

17.7 Flexible connectors, braids or laminated straps made for the terminal clamps for bus posts shall be suitable for both expansion or through (fixed/sliding) type connection of 4" IPS AL. tube as required. In both the cases the clamp height (top of the mounting pad to centre line of the tube) should be same.

17.8 Clamp shall be designed to carry the same current as the conductor and the temperature rise shall be equal or less than that of the conductor at the specified ambient temperature. The rated current for which the clamp/connector is designed with respect to the specified reference ambient temperature, shall also be indelibly marked on each component of the clamp/connector, except on the hardware.

17.9 All current carrying parts shall be designed and manufactured to have minimum contact resistance.

17.10 Clamps and connectors shall be designed to be corona controlled.

17.11 Tests

17.11.1 Clamps and connectors should be type tested as per IS:5561 and shall also be subjected to routine tests as per IS:5561. Following type test reports shall be submitted for approval as per clause 9.2 above except for sl. no.(ii) & (iii) for which type test once conducted shall be applicable (i.e. The requirement of test conducted within last ten years shall not be applicable).

i) Temperature rise test (maximum temperature rise allowed is 35°C over 50°C ambient)

ii) Short time current test

iii) Corona (dry) and RIV (dry) test (for 220 KV and above voltage level Clamps)

iv) Resistance test and tensile test

18.0 CONTROL CABINETS, JUNCTION BOXES, TERMINAL BOXES & MARSHALLING BOXES FOR OUTDOOR EQUIPMENT

18.1 All types of boxes, cabinets etc. shall generally conform to & be tested in accordance with IS-5039/IS-8623, IEC-60439, as applicable, and the clauses given below:

18.2 Control cabinets, junction boxes, Marshalling boxes & terminal boxes shall be made of sheet steel or aluminum enclosure and shall be dust, water and vermin proof. Sheet steel used shall be atleast 2.0 mm thick cold rolled or 2.5 mm hot rolled or alternately 1.6 mm thick stainless steel can also be used. The box shall be properly braced to prevent wobbling. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation. In case of aluminum enclosed box the thickness of aluminum shall be such that it provides adequate rigidity and long life as comparable with sheet steel of specified thickness.

18.3 A canopy and sealing arrangements for operating rods shall be provided inmarshalling boxes / Control cabinets to prevent ingress of rain water.

18.4 Cabinet/boxes shall be provided with double hinged doors with padlocking arrangements. The distance between two hinges shall be adequate to ensure uniform sealing pressure against atmosphere. The quality of the gasket shall be such that it does not get damaged/cracked during the operation of the equipment.

18.5 All doors, removable covers and plates shall be gasketed all around with suitably profiled EPDM/Neoprene gaskets. The gasket shall be tested in accordance with approved quality plan, IS: 11149 and IS: 3400. Ventilating

Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh made of brass.

18.6 All boxes/cabinets shall be designed for the entry of cables from bottom by mean of weather proof and dust-proof connections. Boxes and cabinets shall be designed with generous clearances to avoid interference between the wiring entering from below and any terminal blocks or accessories mounted within the box or cabinet. Suitable cable gland plate above the base of the marshalling kiosk/box shall be provided for this purpose along with the proper blanking plates. Necessary number of cable glands shall be supplied and fitted on this gland plate. Gland plate shall have provision for some future glands to be provided later, if required. The Nickel plated glands shall be dust proof, screw on & double compression type and made of brass. The gland shall have provision for securing armour of the cable separately and shall be provided with earthing tag. The glands shall conform to BS: 6121.

18.7 A 240V, single phase, 50 Hz, 15 amp AC plug and socket shall be provided in the cabinet with ON-OFF switch for connection of hand lamps. Plug and socket shall be of industrial grade.

18.8 For illumination, a fluorescent tube or CFL of approximately 9 to 15 watts shall be provided. The switching of the fittings shall be controlled by the door switch.

For junction boxes of smaller sizes such as lighting junction box, manual operated earth switch mechanism box etc., plug socket, heater and illumination is not required to be provided.

18.9 All control switches shall be of MCB/rotary switch type and Toggle/piano switches shall not be accepted.

18.10 Positive earthing of the cabinet shall be ensured by providing two separate earthing pads. The earth wire shall be terminated on to the earthing pad and secured by the use of self etching washer. Earthing of hinged door shall be done by using a separate earth wire.

18.11 The bay marshalling kiosks shall be provided with danger plate and a diagram showing the numbering/connection/feruling by pasting the same on the inside of the door.

18.12 a) The following routine tests alongwith the routine tests as per IS:5039 shall also be conducted:

i) Check for wiring

ii) Visual and dimension check

b) The enclosure of bay marshalling kiosk, junction box, terminal box shall conform to IP-55 as per IS:13947 including application of, 2.5 KV rms for 1 (one) minute, insulation resistance and functional test after IP-55 test.

19.0 Deleted.

20.0 TERMINAL BLOCKS AND WIRING

20.1 Control and instrument leads from the switchboards or from other equipment will be brought to terminal boxes or control cabinets in conduits. All inter-phase and external connections to equipment or to control cubicles will be made through terminal blocks.

20.2 Terminal blocks shall be 650V grade and have continuous rating to carry the maximum expected current on the terminals and non breakable type. These shall be of moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Screw clamp, overall insulated, insertion type, rail mounted terminals can be used in place of stud type terminals. But preferably the terminal blocks shall be non-disconnecting stud type of Elmex or Phoenix or Wago
or equivalent make.

20.3 Terminal blocks for current transformer and voltage transformer secondary leads shall be provided with test links and isolating facilities. The current transformer secondary leads shall also be provided with short circuiting and earthing facilities.

20.4 The terminal shall be such that maximum contact area is achieved when a cable is terminated. The terminal shall have a locking characteristic to prevent cable from escaping from the terminal clamp unless it is done intentionally.

20.5 The conducting part in contact with cable shall preferably be tinned or silver plated however Nickel plated copper or zinc plated steel shall also be acceptable.

20.6 The terminal blocks shall be of extensible design.

20.7 The terminal blocks shall have locking arrangement to prevent its escape from the mounting rails.

20.8 The terminal blocks shall be fully enclosed with removable covers of transparent, non-deteriorating type plastic material. Insulating barriers shall be provided between the terminal blocks. These barriers shall not hinder the operator from carrying out the wiring without removing the barriers.

20.9 Unless otherwise specified terminal blocks shall be suitable for connecting the following conductors on each side.

a)	All circuits except CT/PT circuits	Minimum of 2 nos. of 2.5 sq mm Copper flexible.
b)	All CT/PT circuits	Minimum of 4 nos. of 2.5 sq mm Copper flexible.

20.10 The arrangements shall be in such a manner so that it is possible to safely connect or disconnect terminals on live circuits and replace fuse links when the cabinet is live.

20.11 Atleast 20 % spare terminals shall be provided on each panel/cubicle/box and these spare terminals shall be uniformly distributed on all terminals rows.

20.12 There shall be a minimum clearance of 250 mm between the First/bottom row of terminal block and the associated cable gland plate for outdoor ground mounted marshalling box and the clearance between two rows of terminal blocks shall be a minimum of 150 mm.

20.13 The supplier shall furnish all wire, conduits and terminals for the necessary interphase electrical connections (where applicable) as well as between phases and common terminal boxes or control cabinets. For equipments rated for 400 kV and above the wiring required in these items shall be run in metallic ducts or shielded cables in order to avoid surge overvoltages either transferred through the equipment or due to transients induced from the EHV circuits.

20.14 All input and output terminals of each control cubicle shall be tested for surgewithstand capability in accordance with the relevant IEC Publications, in both longitudinal and transverse modes. The Contractor shall also provide all necessary filtering, surge protection, interface relays and any other measures necessary to achieve an impulse withstand level at the cable interfaces of the equipment.

21.0 LAMPS & SOCKETS

21.1 Sockets

All sockets (convenience outlets) shall be suitable to accept both 5 Amp & 15 Amp pin round Standard Indian plugs. They shall be switched sockets with shutters.

21.2 Hand Lamp:

A 240 Volts, single Phase, 50 Hz AC plug point shall be provided in the interior of each cubicle with ON-OFF Switch for connection of hand lamps.

21.3 Switches and Fuses:

21.3.1 Each panel shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of DC and AC supplies for various control, signalling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with miniature circuit breaker / switchfuse units. Selection of the main and Sub-circuit fuse ratings shall be such as to ensure selective clearance of sub-circuit faults. Potential circuits for relaying and metering shall be protected by HRC fuses.

21.3.2 All fuses shall be of HRC cartridge type conforming to IS: 9228 mounted on plug-in type fuse bases. Miniature circuit breakers with thermal protection and alarm contacts will also be accepted. All accessible live connection to fuse bases shall be adequately shrouded. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage.

22.0 Bushings, Hollow Column Insulators, Support Insulators:

22.1 Bushings shall be manufactured and tested in accordance with IS:2099 & IEC- 60137 while hollow column insulators shall be manufactured and tested in accordance with IEC-62155/IS:5621.The support insulators shall be manufactured and tested as per IS:2544/IEC-60168 and IEC-60273. The insulators shall also conform to IEC-60815 as applicable.The bidder may also offer composite hollow insulators, conforming to IEC-61462.

22.2 Support insulators, bushings and hollow column insulators shall be manufactured from high quality porcelain. Porcelain used shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified tough and impervious to moisture.

22.3 Glazing of the porcelain shall be uniform brown in colour, free from blisters, burrs and similar other defects.

22.4 Support insulators/bushings/hollow column insulators shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which

they will be used.

22.5 When operating at normal rated voltage there shall be no electric discharge between the conductors and bushing which would cause corrosion or injury to conductors, insulators or supports by the formation of substances produced by chemical action. No radio interference shall be caused by the insulators/bushings when operating at the normal rated voltage.

22.6 Bushing porcelain shall be robust and capable of withstanding the internal pressures likely to occur in service. The design and location of clamps and the shape and the strength of the porcelain flange securing the bushing to the tank shall be such that there is no risk of fracture. All portions of the assembled porcelain enclosures and supports other than gaskets, which may in any way be exposed to the atmosphere shall be composed of completely non hygroscopic material such as metal or glazed porcelain.

22.7 All iron parts shall be hot dip galvanised and all joints shall be air tight. Surface of joints shall be trued up porcelain parts by grinding and metal parts by machining. Insulator/bushing design shall be such as to ensure a uniform compressive pressure on the joints.

22.8 Tests

In bushing, hollow column insulators and support insulators shall conform to type tests and shall be subjected to routine tests in accordance with IS: 2099 & IS:2544 & IS : 5621.

23.0 MOTORS

Motors shall be "Squirrel Cage" three phase induction motors of sufficient size capable of satisfactory operation for the application and duty as required for the driven equipment and shall be subjected to routine tests as per applicable standards. The motors shall be of approved make.

23.1 Enclosures

a) Motors to be installed outdoor without enclosure shall have hose proof enclosure equivalent to IP-55 as per IS: 4691. For motors to be installed indoor i.e. inside a box, the motor enclosure, shall be dust proof equivalent to IP-44 as per IS: 4691.

b) Two independent earthing points shall be provided on opposite sides of the motor for bolted connection of earthing conductor.

c) Motors shall have drain plugs so located that they will drain water resulting from condensation or other causes from all pockets in the motor casing.

d) Motors weighing more than 25 Kg. shall be provided with eyebolts, lugs or other means to facilitate lifting.

23.2 Operational Features

a) Continuous motor rating (name plate rating) shall be at least ten (10) percent above the maximum load demand of the driven equipment at design duty point and the motor shall not be over loaded at any operating point of driven equipment that will rise in service.

b) Motor shall be capable at giving rated output without reduction in the expected life span when operated continuously in the system

having the particulars as given in Clause 15.0 of this Section.

23.3 Starting Requirements:

a) All induction motors shall be suitable for full voltage direct-on-line starting. These shall be capable of starting and accelerating to the rated speed alongwith the driven equipment without exceeding the acceptable winding temperature even when the supply voltage drops down to 80% of the rated voltage.

b) Motors shall be capable of withstanding the electrodynamic stresses and heating imposed if it is started at a voltage of 110% of the rated value.

c) The locked rotor current shall not exceed six (6) times the rated full load current for all motors, subject to tolerance as given in IS:325.

d) Motors when started with the driven equipment imposing full starting torque under the supply voltage conditions specified under Clause 15.0 shall be capable of withstanding atleast two successive starts from cold condition at room temperature and one start from hot condition without injurious heating of winding. The motors shall also be suitable for three equally spread starts per hour under the above referred supply condition.

e) The locked rotor withstand time under hot condition at 110% of rated voltage shall be more than starting time with the driven equipment of minimum permissible voltage by at least two seconds or 15% of the accelerating time whichever is greater. In case it is not possible to meet the above requirement, the Bidder shall offer centrifugal type speed switch mounted on the motor shaft which shall remain closed for speed lower than 20% and open for speeds above 20% of the rated speed. The speed switch shall be capable of withstanding 120% of the rated speed in either direction of rotation.

23.4 Running Requirements:

a) The maximum permissible temperature rise over the ambient temperature of 50 degree C shall be within the limits specified in IS:325 (for 3 - phase induction motors) after adjustment due to increased ambient temperature specified.

b) The double amplitude of motor vibration shall be within the limits specified in IS: 4729. Vibration shall also be within the limits specified by the relevant standard for the driven equipment when measured at the motor bearings.

c) All the induction motors shall be capable of running at 80% of rated voltage for a period of 5 minutes with rated load commencing from hot condition.

23.5 TESTING AND COMMISSIONING

An indicative list of tests is given below. Bidder shall perform any additional test based on specialities of the items as per the field Quality Plan/ Instructions of the equipment without any extra cost to the BHEL/POWERGRID. The Bidder shall arrange all instruments required for conducting these tests alongwith calibration certificates and shall furnish the list of instruments to the Purchaser for approval.

(a) Insulation resistance.
(b) Phase sequence and proper direction of rotation.
(c) Any motor operating incorrectly shall be checked to determine the cause and the conditions corrected.

ANNEXURE-A
INDICATIVE LIST OF DRAWINGS FOR TRANSFORMER

1. Outline General Arrangement (OGA) drawing of transformer

a) Plan
b) Elevation
c) End View
d) Neutral formation of three phase bank
e) Delta formation of three phase bank

List of all accessories with detailed weights, dimensions, clearances, spacing of wheels in direction, center of gravity, location of cooler etc.

2. Foundation Plan showing reaction at points of support, clamping arrangement & location of jacking pads.

3. Technical Data requirement sheet of transformer

4. Over fluxing withstand duration curve

5. Inrush current characteristics while charging from HV & IV side respectively.

6. Schematic wiring and diagram of cooling arrangement along with write up on scheme

7. Schematic wiring and diagram of OLTC along with write up on scheme

8. Mounting Arrangement and wiring diagram of remote WTI along with write up

9. Bushing Drawing showing electrical and mechanical characteristics

a) HV Bushing
b) IV Bushing
c) LV Bushing
d) Neutral bushing

10. Outline and General Arrangement of Cooler Control Cabinet

11. Cooler Control cabinet schematic and wiring diagram

12. Magnetisation Characteristics of bushing CTs

13. Hysteresis Characteristics of iron core

14. Rating and Diagram Plate

15. Overall Transport dimension drawing of transformer

16. Drawing showing typical sectional view of the windings with details of insulation, cooling circuit method of cooling and core construction etc.

17. Oil Flow Diagram

18. Valve Schedule Plate drawing

19. Twin Bi-directional Roller

20. Connection Diagram of all protective devices to marshalling box showing physical location

21. List of spares

22. Technical Literature on all fittings and accessories.

23. Calculation to support short circuit withstand capacity of transformer

24. Calculation of hot spot temperature

25. Value of air core reactance with a typical write-up of calculation

26. Oil sampling Bottle details
27. Typical heating and cooling curves
28. OGA of RTCC panel
29. RTCC panel schematic and wiring diagram
30. Outline and General Arrangement drawing of Common Marshalling Box
31. Schematic wiring and diagram of Common Marshalling Box
32. OGA of Ladder for transformer
33. Transformer oil storage tank drawing
34. 33 KV Neutral CT drawing and technical data sheet
35. Customer inspection schedule
36. Test procedure of transformer
37. Type test Reports of transformer
38. O & M manual of transformer

ANNEXURE-B
CORONA AND RADIO INTERFERENCE VOLTAGE (RIV) TEST

1. General

Unless otherwise stipulated, all equipment together with its associated connectors, where applicable, shall be tested for external corona (for 400kV & above) both by observing the voltage level for the extinction of visible corona under falling power frequency voltage and by measurement of radio interference voltage (RIV) for 132kV and above.

2. Test Levels:

The test voltage levels for measurement of external RIV and for corona extinction voltage are listed under the relevant clauses of the specification.

3. Test Methods for RIV:

3.1 RIV tests shall be made according to measuring circuit as per International Special-Committee on Radio Interference (CISPR) Publication 16-1(1993) Part -1. The measuring circuit shall preferably be tuned to frequency with 10% of 0.5 Mhz but other frequencies in the range of 0.5 MHz to 2 MHz may be used, the measuring frequency being recorded. The results shall be in microvolts.

3.2 Alternatively, RIV tests shall be in accordance with NEMA standard Publication No. 107 - 1964, except otherwise noted herein.

3.3 In measurement of, RIV, temporary additional external corona shielding may be provided. In measurements of RIV only standard fittings of identical type supplied with the equipment and a simulation of the connections as used in the actual installation will be permitted in the vicinity within 3.5 meters of terminals.

3.4 Ambient noise shall be measured before and after each series of tests to ensure that there is no variation in ambient noise level. If variation is present, the lowest ambient noise level will form basis for the measurements. RIV levels shall be measured at increasing and decreasing voltages of 85%, 100%, and 110% of the specified RIV test voltage for all equipment unless otherwise specified. The specified RIV test voltage for 765kV, 400 kV, 220 KV is listed in the detailed specification together with maximum permissible RIV level in microvolts.

3.5 The metering instruments shall be as per CISPR recommendation or equivalent device so long as it has been used by other testing authorities.

3.6 The RIV measurement may be made with a noise meter. A calibration procedure

of the frequency to which noise meter shall be tuned shall establish the ratio of voltage at the high voltage terminal to voltage read by noise meter.

4. Test Methods for Visible Corona

The purpose of this test is to determine the corona extinction voltage of apparatus, connectors etc. The test shall be carried out in the same manner as RIV test described above with the exception that RIV measurements are not required during test and a search technique shall be used near the onset and extinction voltage, when the test voltage is

raised and lowered to determine their precise values. The test voltage shall be raised to 110% of specified corona extinction voltage and maintained there for five minutes. In case corona inception does not take place at 110%, test shall be stopped, otherwise test shall be continued and the voltage will then be decreased slowly until all visible corona disappears. The procedure shall be repeated at least 4 times with corona inception and extinction voltage recorded each time. The corona extinction voltage for purposes of determining compliance with the specification shall be the lowest of the four values at which visible corona (negative or positive polarity) disappears. Photographs with laboratory in complete darkness shall be taken under test conditions, at all voltage steps i.e. 85%, 100%, and 110%. Additional photographs shall be taken at corona inception and extinction voltages. At least two views shall be photographed in each case using Panchromatic film with an ASA daylight rating of 400 with an exposure of two minutes at a lens aperture of f/5.6 or equivalent. The photographic process shall be such that prints are available for inspection and comparison with conditions as determined from direct observation. Photographs shall be taken from above and below the level of connector so as to show corona on bushing, insulators and all parts of energised connectors. The photographs shall be framed such that test object essentially, fills the frame with no cut-off.

For recording purpose, modern devices utilizing UV recording methods such as image intensifier may also be used.

4.1 The test shall be recorded on each photograph. Additional photograph shall be taken from each camera position with lights on to show the relative position of test object to facilitate precise corona location from the photographic evidence.

4.2 In addition to photographs of the test object preferably four photographs shall be taken of the complete test assembly showing relative positions of all the test equipment and test objects. These four photographs shall be taken from four points equally spaced around the test arrangement to show its features from all sides. Drawings of the laboratory and test set up locations shall be provided to indicate camera positions and angles. The precise location of camera shall be approved by Purchaser's inspector, after determining the best camera locations by trial energisation of test object at a voltage which results in corona.

4.3 The test to determine the visible corona extinction voltage need not be carried out simultaneously with test to determine RIV levels.

4.4 However, both test shall be carried out with the same test set up and as little time duration between tests as possible. No modification on treatment of the sample between tests will be allowed. Simultaneous RIV and visible corona extinction voltage testing may be permitted at the discretion of Purchaser's inspector if, in his opinion, it will not prejudice other test.

5. Test Records:

In addition to the information previously mentioned and the requirements specified as per CISPR or NEMA 107-1964 the following data shall be included in test report:

a) Background noise before and after test.
b) Detailed procedure of application of test voltage.

c) Measurements of RIV levels expressed in micro volts at each level.
d) Results and observations with regard to location and type of interference sources detected at each step.
e) Test voltage shall be recorded when measured RIV passes through 100microvolts in each direction.
f) Onset and extinction of visual corona for each of the four tests required shall be recorded.

ANNEXURE-C
SEISMIC WITHSTAND TEST PROCEDURE

The seismic withstanding test on the complete equipment (for 132kV and above) shall be carried out along with supporting structure.

The Bidder shall arrange to transport the structure from his Contractor's premises/POWERGRID sites for the purpose of seismic withstand test only.

The seismic level specified shall be applied at the base of the structure. The accelerometers shall be provided at the Terminal Pad of the equipment and any other point as agreed by the Purchaser. The seismic test shall be carried out in all possible combinations of the equipment. The seismic test procedure shall be furnished for approval of the Purchaser.

ANNEXURE-D
LIST OF THE MAKES FOR WHICH TYPE TEST REPORTS NOT REQUIRED TO BE SUBMITTED

S.NO.	ITEM DESCRIPTION	MAKE
1.	OUT DOOR RECEPTACLES	CGL/ B&C / BCH / SAKTI, CHENNAI/ INDO ASIAN
2.	TREFOIL CLAMP	MOULDED FIBRE GLASS PRODUCTS.
3.	DIESEL ENGINE	CUMMINS / RUSTON & HORNSBY
4.	ALTERNATOR	AVK / KIRLOSKAR / STAMFORD
5.	MOTORS	KEC / SIEMENS/ NGEF/CROMPTON/ABB
6.	CABLE GLANDS	SUNIL & CO. / ARUP/ COMET / QPIE
7.	JUNCTION BOX	SARVANA / ECS / C&S /VIKAS
8.	LIGHTING FIXTURES	PHILLIPS/CGL/BAJAJ
9.	ACSR CONDUCTOR	STERLITE APAR HVPL/ SHARAVATHY/HIREN
10.	AAC CONDUCTOR (BULL)	STERLITE CABCON
11.	TERMINAL CONNECTOR	NOOTAN ENGGINEERING VADODARA / M/S MILIND ENGG MUMBAI / M/S PEEVEE ENGG. BANGALORE / M/S KLEMMEN ENGG. CORP., CHENNAI / M/S VINAYAK TRANSMISSION PRODUCTS PVT. LTD., MUMBAI / NANJING TERUI POWER MATERIAL CO. LTD / ENALT. MUMBAI ASBESCO, KOLKATA VENSUN, CHENNAI / MEGHA, CHENNAI
12	G.S. EARTHWIRE	SHARAVATHY/BHARAT WIRE ROPES / RAMSWARUP
	765KV CLASS TRANSFORMER & REACTOR	
13	BUCHHOLZ RELAY	EMB CONTROL AB, SWEDEN / M/S CEDESPE, ITLAY / ETI, ITALY / SHENYANG YINHAI ELECTRICAL CO., LTD
14	PRESSURE RELIEF DEVICE	QUALITROL CORPORATION, USA / MESSKO, GERMANY / SHENYANG STI ELECT TECH CO. LTD / SHENYANG KEQI ELECTRICAL EQUIPMENT CO., LTD
15	MAGNETIC OIL LEVEL	COMEM, ITALY / TAIJIN INDUSTRIES,SOUTH KOREA / SHENYANG YINHAI ELECTRICAL CO., LTD / MESSKO , GERMANY / QUALITROL, USA
16	AIR CELL (FLEXIBLE AIR SEPARATOR)	M/S PRONAL FRANCE / FUJIKURA,JAPAN / PRONAL ASIA, MALAYSIYA / SHENYANG HONGDA GENERAL RUBBER FACTORY BAODING XINKE RUBBER PRODUCT INSTITUTE, CHINA /
17	OTI & WTI	MESSKO , GERMANY / QUALITROL AKM, SWEDEN / HONGZHAOU KEHONG INSTRUMENTS / DALIAN SHIYOU ELECTRIC POWER TECHNOLOGY CO., LTD
18	OIL PUMP	GEA / BEIJING FUTE DISC MOTOR FAN LTD./ ABB, SWEDEN / FLOWWELL PUMPS & METERS,

		UNITII, BANGALORE
19	COOLING FAN AND MOTOR ASSEMBLY	M/S CALIFORNIA TURBO,USA / ZIEHL-ABEGG SVER / ZHEJIANG MINGXIN FAN CO., LTD.
UPTO 400KV CLASS TRANSFORMER & REACTOR		
20	BUCHHOLZ RELAY	M/S ATVUS KOLTATA / M/S INSTRUMENTS & CONTROL VADODARA / M/S A.J.SERVICES (PRAYOG) BOMBAY / M/S WEIR ELECTRIC, UK / M/S VEB, GERMANY / M/S ASPE, ITALY
21	PRESSURE RELIEF DEVICE	M/S SKURUT UDYOG, PUNE / M/S QUALITROL COMPANY USA / M/S MESSKO, GERMANY
22	MAGNETIC OIL LEVEL	M/ S SUKRUT UDYOG PUNE / M/S YOGYA ENTERPRISES, JHANSI / M/S MESSKO, GERMANY
23	AIR CELL (FLEXIBLE AIR SEPARATOR)	M/S THE RUBBER PRODUCTS MUMBAI / M/S UNIRUB TECHNO PUNE THRO SUKURUT UDYOG PUNE / M/S PRONAL FRANCE
24	OTI & WTI	M/S PERFECT CONTROL CHENNAI / M/S PRESIMEASURE BANGALORE / M/S AKM, SWEDEN / M/S ACCURATE CONTROL, UK / M/S MESSKO, GERMANY
25	OIL PUMP	M/ S BEST & CROMPTON ENGG. LTD., CHENNAI / M/S FLOW WEL BANGALORE / M/S CROMPTON GREAVES, MUMBAI / M/S SPP, UK
26	COOLING FAN AND MOTOR ASSEMBLY	M/S MARATHON LTD KOLKATA / M/S KHAITAN PVT LTD KOLKATA / M/S EPC – KOLKATA
27	UNIT COOLER	M/S LUVATA Soderkoping AB, SWEDEN/ M/S GEI HAMON BHOPAL / M/S SERKHEAT TRANFER, UK / M/S TADA ELECTRIC JAPAN / M/S BHEL, BHOPAL / M/S LUVATA HEAT TRANSFER SOLUTION (WUXI), CHINA

NOTE:

1. For a new make other than above/POWERGRID approved list of sub vendor, type test Reports as per relevant standard shall be submitted for Purchaser's approval.

2. Items listed for 765kV Transformer & Reactor shall be also applicable for up to 400kV Transformer & Reactor.

SECTION-4
GUARANTEED TECHNICAL PARTICULARS

1. Technical Particulars/ Parameters for 500MVA, 400/220/33kV 3-Phase Auto Transformer

Sr. No.	Description	Unit	Data to be furnished by Bidder
1.1	Rated Capacity		
	(i) HV	MVA	
	(ii) IV	MVA	
	(iii) LV (Tertiary): Active + Reactive loading	MVA	
1.2	Voltage ratio (Line to Line)		
1.3	Single / Three Phase Design		
1.4	Applicable Standard		
1.5	Frequency	Hz	
1.6	Cooling & Percentage Rating at different cooling		
1.7	Type of Transformer		
1.8	Impedance at 75 ^{0}C		
	(i) HV-IV		
	Max. Voltage tap	%	
	Principal tap	%	
	Min Voltage tap	%	
	(ii)HV-LV		
	Principal tap (minimum)	%	
	(ii)IV-LV		
	Principal tap (minimum)	%	
1.9	Tolerance on Impedance (HV-IV)	%	
1.10	Service		
1.11	Duty		
1.12	Overall Capacity		
1.13	Temperature rise over 50deg C ambient Temp		
	(i) Top oil measured by thermometer	^{0}C	
	(ii) Average winding measured by resistance method	^{0}C	
1.14	Windings		
	(i) System Fault level		
	HV	kA	
	IV	kA	
	LV	kA	

	(ii) Lightening Impulse withstand Voltage		
	HV	KVp	
	IV	KVp	
	LV	KVp	
	Neutral	KVp	
	(iii) Switching Impulse withstand Voltage		
	HV	KVp	
	(iv) One Minute Power Frequency Withstand Voltage		
	HV	KVrms	
	IV	KVrms	
	LV	KVrms	
	Neutral	KVrms	
	(v) Neutral Grounding		
	(vi) Insulation		
	HV		
	IV		
	LV		
	(vii) Tertiary Connection		
	(viii) Tan delta of winding	%	
1.15	Vector Group (3-ph) (unless specified differently elsewhere)		
1.16	Tap Changer		
	(i) Tap Range & No. of steps		
	(ii) Location of Tap changer		
	(iii)Design		
	(iv)Tap control		
1.17	Bushing		
	(i) Rated voltage		
	HV	kV	
	IV	kV	
	LV	kV	
	Neutral	kV	
	(ii) Rated current (Min.)		
	HV	A	
	IV	A	
	LV	A	
	Neutral	A	
	(iii) Lightening Impulse withstand Voltage		
	HV	KVp	
	IV	KVp	

	LV	KVp	
	Neutral	KVp	
	(iv) Switching Impulse withstand Voltage		
	HV	KVp	
	IV	KVp	
	(v) One Minute Power Frequency withstand Voltage		
	HV	KVrms	
	IV	KVrms	
	LV	KVrms	
	Neutral	KVrms	
	(vi) Minimum total creepage distances		
	HV	mm	
	IV	mm	
	LV	mm	
	Neutral	mm	
	(vii) Tan delta of bushings		
	HV	%	
	IV	%	
	LV	%	
	Neutral		
	(viii) Max Partial discharge level at Um		
	HV	pC	
	IV	pC	
	LV	pC	
	Neutral		
1.18	Max Partial discharge level at 1.58 * Ur /√3	pC	
1.19	Max Noise level at rated voltage and at principal tap on full load and all cooling active	dB	
1.20	Maximum Permissible Losses for Auto Transformer		
	(i) Max. No Load Loss/ Iron Loss at rated voltage and frequency	kW	
	(ii) Max. Load Loss/ Copper Loss at rated current and at 75°C	kW	
	(iii) Max. Auxiliary Loss/ Cooler Loss at rated voltage and frequency	kW	

Notes:

1. For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.

2. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.

3. Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.

4. The criteria for Transformer losses shall **be "Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)"**.

1. **Technical Particulars/ Parameters for Current Transformer (On each phase) for 3-ph 500MVA, 400/220/33 kV Transformers**

Description	Current Transformer Parameters (Transformer)		
	HV Side	IV Side	Neutral Side
(a) Ratio			
Core 1			
Core 2			
(b) Minimum knee point voltage or burden and accuracy class			
Core 1			
Core 2			
(c) Maximum CT Secondary Resistance			
Core 1			
Core 2			
(d) Application			
Core 1			
Core 2			
(e) Maximum magnetization current (at knee point voltage)			
Core 1			
Core 2			

NOTE:

i) For TPS class CT's, Dimensioning parameter "K", Secondary VA shall be considered 1.5 and 20 respectively. Class (for the relevant protection and duties) as per IEC 60185.

ii) Rated continuous thermal current rating shall be 200% of rated primary current.

iii) Parameters of WTI CT for each winding shall be provided by the contractor.

iv) For estimation of spares, one set of CTs shall mean one CT of each type used in transformer.

v) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

SECTION-5
TECHNICAL CHECK LIST

Technical Checklist for information to be furnished with technical offer. Return this technical checklist as a part of technical offer duly signed

BHEL ENQUIRY. NO.:
BIDDER OFFER REF.:

It is to be noted that,

a) The technical offer shall not be considered if this technical checklist duly filled, and signed are not enclosed with this technical offer.
b) Bidder shall ensure the completeness of their technical offer in this regard.

Sr. No.	Description	Reply by Bidder	
1	**Technical Qualifying Requirements**		
1.1	Documents for meeting qualifying criteria submitted with the technical offer. *The evaluation of bidder against qualifying criteria specified under clause **1.5 of Section-1 of technical specification** shall be based on the documentary proof submitted by bidder along with the technical offer.	Confirmed	Yes/ No
1.2	The bid shall be submitted by the Supplier/ Manufacturer only. The bidder's scope includes supply and services i.e. supervision of unloading, installation, testing and commissioning etc.	Confirmed	Yes/ No
1.3	All the documents shall be submitted in English. Translated pages should be attested by the bidder. All the dimensions shall be in SI units.	Confirmed	Yes/ No
2	**Un-priced Bill of Quantities**		
2.1	Confirm that all items have been quoted. *Confirmation shall be done by writing "Quoted" against each item. In case, if any item has not been quoted, the same shall be confirmed by writing "Not quoted" and reasons for the same is specifically brought out in Schedule of Technical Deviation	Confirmed	Yes/ No
2.2	The Specification envisages design, type	Confirmed	Yes/ No

	testing, engineering, manufacture, testing, delivery at site including all materials, accessories, spares, supervision of unloading, erection, testing and commissioning of the equipment specified/ 500MVA, 400/220/33kV Auto Transformer to the satisfaction of BHEL/POWERGRID.		
2.3	Any other item/ service required for the execution for the complete work is deemed to be included in the offer, whether specifically mentioned in the specification or not. List of items required for completeness of work is to be attached, if required and prices for same deemed to be included in prices of main items.	Additional Supply(s)/ Service(s) required	Yes/ No
3	**Technical Requirements**		
3.1	**Maximum Permissible losses for Autotransformer**		
3.1.1	Max. No Load Loss/ Iron Loss at rated voltage and frequency (kW)	**95 kW**	Yes/ No
3.1.2	Max. Load Loss/ Copper Loss at rated current and at 75°C (kW)	**500 kW**	Yes/ No
3.1.3	Max. Auxiliary Loss/ Cooler Loss at rated voltage and frequency (kW)	**7 kW**	Yes/ No
3.1.4	Bidder to ensure the Autotransformer with above specified losses.	Confirmed	Yes/ No
3.2	**Guaranteed Losses and Liquidated Damage due to higher loss:** The maximum loss at rated condition (voltage, current and frequency, as applicable) for Auto Transformer shall be corrected in accordance with IEC-60076 for the purpose of comparison of maximum losses with measured losses for levy of liquidated damages. If during factory tests, measured loss (es) are found to be more than the specified maximum value(s) (specified in section-1, clause 1.2.2), BHEL/POWERGRID at his discretion may accept or reject Auto Transformer after assessing the liquidated damages (LD) against the contract as per	Confirmed	Yes/ No

	rates given in section-1, clause 1.2.2.3 and such amount shall be deducted from the contract price or otherwise recovered from Bidder. No cost benefit shall be considered in case measured losses are less than the specified maximum losses.		
3.3	**Criterion for calculating Liquidated damage:** Differential losses = Losses measured at the time of testing-corresponding losses (specified in section-1, clause 1.2.2) (corrected in accordance with IEC-60076)	Confirmed	Yes/ No
3.5	**Liquidated Damage due to differential losses on pro-rata basis:** If measured losses are exceeding maximum specified guaranteed losses (specified in clause 1.2.2 above), value by 0 to +5%, the details for liquidated damages on pro-rata basis for the performance of Auto Transformer shall be as follows, 1. Rs.1, 67,715/kW differential No Load Loss/ Iron Loss 2. Rs.3, 69,950/KW differential Load Loss/ Copper Loss 3. Rs.2, 46,640/KW differential Auxiliary Loss/ Cooler Loss	Confirmed	Yes/ No
3.6	Liquidated damages shall be applied in the following manner depending on the variation of losses with respect to the maximum values: a) Measured losses exceeding Maximum value by 0 to +5%: Rates of LD mentioned above b) Measured losses exceeding Maximum value by > +5% to +10%: Twice the rates of LD mentioned above c) Measured losses exceeding Maximum value by > +10% to +15%: Four times the rates of LD mentioned above	Confirmed	Yes/ No

	However, the equipment under no circumstances shall be accepted if the measured losses in each category exceed by more than +15 percent of the Maximum losses (as specified in clause 1.2.2 above) at rated conditions.		
4	**Technical Particulars**		
4.1	Rated Capacity		
	(i) HV	500MVA	Yes/ No
	(ii) IV	500MVA	Yes/ No
	(iii) LV (Tertiary): Active + Reactive loading	1/3rd of rated capacity of HV winding	Yes/ No
4.2	Voltage ratio (Line to Line)	400/220/33kV	Yes/ No
4.3	Single / Three Phase Design	3 (Three)	Yes/ No
4.4	Applicable Standard	IEC 60076	Yes/ No
4.5	Frequency	50Hz	Yes/ No
4.6	Cooling & Percentage Rating at different cooling	ONAN/ONAF/(OFAF or ODAF) : 60% / 80%/100% OR ONAN/ONAF1/ONAF2: 60% / 80%/100% OR OFAF (with 5 x 25% unit cooler)	Yes/ No
4.7	Type of Transformer	Constant Ohmic impedancetype	Yes/ No
4.8	Impedance at 75 Deg C		
	(i) HV-IV		
	Max. Voltage tap	10.3%	Yes/ No
	Principal tap	12.5%	Yes/ No
	Min Voltage tap	15.4%	Yes/ No
	(ii)HV-LV		
	Principal tap (minimum)	60.0%	Yes/ No
	(ii)IV-LV		
	Principal tap (minimum)	45.0%	Yes/ No
4.9	Tolerance on Impedance (HV-IV)	As per IEC	Yes/ No

4.10	Service	Outdoor	Yes/ No
4.11	Duty	Continuous	Yes/ No
4.12	Overall Capacity	IEC-60076-7	Yes/ No
4.13	Temperature rise over 50deg C ambient Temp		
	(i) Top oil measured by thermometer	50 ^{0}C	Yes/ No
	(ii) Average winding measured by resistance method	55 ^{0}C	Yes/ No
4.14	Windings		
	(i) System Fault level for **1 Sec**		
	HV	63kA	Yes/ No
	IV	40kA	Yes/ No
	LV	25kA	Yes/ No
	(ii) Lightening Impulse withstand Voltage		
	HV	1300KVp	Yes/ No
	IV	950KVp	Yes/ No
	LV	250KVp	Yes/ No
	Neutral	95KVp	Yes/ No
	(iii) Switching Impulse withstand Voltage		
	HV	1050KVp	Yes/ No
	(iv) One Minute Power Frequency Withstand Voltage		
	HV	570KVrms	Yes/ No
	IV	395KVrms	Yes/ No
	LV	95KVrms	Yes/ No
	Neutral	38KVrms	Yes/ No
	(v) Neutral Grounding	Solidly grounded	Yes/ No
	(vi) Insulation		
	HV	Graded	Yes/ No
	IV	Graded	Yes/ No
	LV	Uniform	Yes/ No
	(vii) Tertiary Connection	Ungrounded Delta	Yes/ No
	(viii) Tan delta of winding	<0.5%	Yes/ No
4.15	Vector Group (3-ph) (unless specified differently elsewhere)	YNa0d11	Yes/ No
4.16	Tap Changer	OLTC	Yes/ No
	(i) Tap Range & No. of steps	± 10% of HV	Yes/ No

		variation in the step of 1.25%, 16 steps	
	(ii) Location of Tap changer	On the 220 kV side of the series winding	Yes/ No
	(iii)Design	Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I	Yes/ No
	(iv)Tap control	Full capacity - on load tap changer suitable for group / independent, remote /local electrical and local manual operation and bi-directional power flow	Yes/ No
4.17	Bushing		
	(i) Rated voltage		
	HV	420kV	Yes/ No
	IV	245kV	Yes/ No
	LV	52kV	Yes/ No
	Neutral	36kV	Yes/ No
	(ii) Rated current (Min.)		
	HV	1250A	Yes/ No
	IV	2000A	Yes/ No
	LV	3150A	Yes/ No
	Neutral	2000A	Yes/ No
	(iii) Lightening Impulse withstand Voltage		
	HV	1425KVp	Yes/ No
	IV	1050KVp	Yes/ No
	LV	250KVp	Yes/ No
	Neutral	170KVp	Yes/ No
	(iv) Switching Impulse withstand Voltage		
	HV	1050KVp	Yes/ No
	IV	850KVp	Yes/ No

	(v) One Minute Power Frequency withstand Voltage		
	HV	695KVrms	Yes/ No
	IV	505KVrms	Yes/ No
	LV	105KVrms	Yes/ No
	Neutral	77KVrms	Yes/ No
	(vi) Minimum total creepage distances		
	HV	10500mm	Yes/ No
	IV	6125mm	Yes/ No
	LV	1300mm	Yes/ No
	Neutral	900mm	Yes/ No
	(vii) Tan delta of bushings		
	HV	<0.4%	Yes/ No
	IV	<0.4%	Yes/ No
	LV	<0.4%	Yes/ No
	Neutral	--	Yes/ No
	(viii) Max Partial discharge level at Um		
	HV	10pC	Yes/ No
	IV	10pC	Yes/ No
	LV	10pC	Yes/ No
	Neutral	--	Yes/ No
4.18	Max Partial discharge level at 1.58 * Ur /√3	100pC	Yes/ No
4.19	Max Noise level at rated voltage and at principal tap on full load and all cooling active	80dB	Yes/ No
4.20	For parallel operation with existing transformer, the impedance, OLTC connection & range and the winding configuration (if necessary) is to be matched.	Confirmed	Yes/ No
4.21	No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.	Confirmed	Yes/ No
4.22	Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.	Confirmed	Yes/ No
5	**Technical Deviations**		
5.1	Confirm that the Complete systems have been offered as per the requirements of	Confirmed	Yes/ No

	Technical Specification and Technical Deviation sheet has been submitted. Deviations mentioned elsewhere in the bid will not be considered.		
5.2	Schedule of Technical Deviation is enclosed.	Confirmed	Yes/ No
6	**General Requirements**		
6.1	**Paint System and Procedure:** Bidder to follow paint system and procedure as per **Clause 7.0** and **Annexure-F of Section-2B.**	Confirmed	Yes/ No
6.2	**Grounding:** Supply of grounding/ earthing material (except 40mm Dia MS rod and/or GI Flat) and supervision of erection/fixing of grounding/ earthing of Auto Transformer and its accessories shall be under bidder's scope, based on their design philosophy.	Confirmed	Yes/ No
6.3	**Cabling:** Cabling from Marshalling Box to Auto Transformer and its Cooling Bank is under scope of supply including glands, lugs, tags and ferruling etc. Termination schedule shall be submitted along with drawings.	Confirmed	Yes/ No
6.4	**Auxiliary Supply:** Terminals in marshalling box for external power supply coming into marshalling box shall be suitable to requirement.	Confirmed	Yes/ No
7	**Type Testing**		
7.1	The validity of Type Tests **(except dynamic short circuit test)** of Transformer shall be **5 years** as on the originally scheduled date of bid opening **i.e. dated 07 April 2015**, provided that offered transformer design is identical to the type tested transformer and same active materials (CRGO, Conductor and Insulation) of same grade & from the same sub-vendors are used. In case of any change of either active materials or sub-vendors, the type tests shall be carried out by the Bidder at no extra cost to BHEL. Transformer type test report from the same manufacturing plant shall only be acceptable. With regards to validity of dynamic short circuit test once conducted shall be applicable.	Confirmed	Yes/ No

7.2	Bidder should have successfully carried out **Dynamic Short Circuit test on 315MVA, 400/220/33kV Auto Transformer** as on the originally scheduled date of bid opening **i.e. 07 April 2015** and shall enclose the relevant Test Report/ Certificate along with bid. In case bidder has not successfully tested 315MVA, 400/220/33kV Auto Transformer for Dynamic Short Circuit test, their bid shall be considered technically non responsive. Further, design review of offered 400 kV Class Auto Transformer shall be carried out based on the design of short circuit tested 315MVA Auto Transformer.	Confirmed	Yes/ No
7.3	**Type Tests on Transformer fittings:** The test reports submitted, shall be of the tests conducted within last **10 (ten) years** prior to the originally scheduled date of bid opening **i.e. 07 April 2015.** In case the test reports are of the test conducted earlier than 10 (ten) years prior to the originally scheduled date of bid opening **i.e. 07 April 2015.**, the Bidder shall repeat these test(s) at no extra cost to the BHEL/POWERGRID.	Confirmed	Yes/ No
7.4	In case type test reports are found to be technically unacceptable to BHEL/POWERGRID, the type test shall be conducted without cost and delivery implication to BHEL/POWERGRID.	Confirmed	Yes/ No
8	**Inspection and Testing at Works**		
8.1	The Bidder shall carry out a comprehensive inspection and testing programme during manufacture of the equipment as detailed in **section-2B** and **section3**.	Confirmed	Yes/ No
9	**Quality Plan**		
9.1	The Bidder to follow valid and approved POWERGRD Quality Plan as per POWERGRID procedure. In case the bidder does not have POWERGRID approved Quality Plan, it will be the bidder's responsibility to get its Quality plan approved directly from POWERGRID.	Confirmed	Yes/ No
10	**Erection, Testing and Commissioning at Site**		

10.1	The Bidder shall supervise a comprehensive erection, testing and commissioning programme at site duly POWERGRID approved as detailed in **section-2B** and **section3.**	Confirmed	Yes/ No
11	**Information to be furnished by the Bidder**		
11.1	Information/ documents to be furnished at the TENDER STAGE shall be as per **Section-2B** and **Section-3**.	Confirmed	Yes/ No
12	**Drawings/ Data Sheets**		
	Bidder shall submit POWERGRID approved/Standard drawings wherever available for extension of approval.	Confirmed	Yes/ No
13.	**Standards**		
	The equipment to be furnished under this specification shall conform to latest issue with all amendments (as on the originally scheduled date of bid opening i.e. **07 April 2015**) of standard specified under **Section-2A,** unless specifically mentioned in the specification.	Confirmed	Yes/ No
14	**Documents to be submitted with Technical Offer**		
14.1	All documents as mentioned in Technical Specification are enclosed.	Confirmed	Yes/ No
14.2	OGA drawings are enclosed	Confirmed	Yes/ No
14.3	Documents for meeting Qualifying Requirements are enclosed.	Confirmed	Yes/ No
14.4	Bidder will submit detailed bar chart/ activity schedule indicating all the milestones from Engineering till manufacturing/ testing, dispatch to site and commissioning.	Confirmed	Yes/ No

SECTION-6
SCHEDULE OF TECHNICAL DEVIATIONS

Bidder shall list all the technical deviation/(s), clause wise with respect to technical specifications

Sr. No.	Page No.	Clause No.	Description	Deviations Sought	Reasons/ Justifications

Any deviation/(s) not specifically brought out in this section shall not be admissible for any commercial/ technical implication at later stage. Except the technical deviation/(s) listed in this schedule, Bidder's offer shall be considered in full compliance to technical specifications, irrespective of any such deviations indicated/ taken elsewhere in the submitted technical offer.

Date: Bidder's Stamp and Signature