BHARAT HEAVY ELECTRICALS LIMITED
TRANSMISSION BUSINESS ENGINEERING MANAGEMENT
NEW DELHI

DOCUMENT NO.:	**TB-392-316-001**	REV: **01**	Prepared	Checked	Approved
TYPE OF DOC.:	**TECHNICAL SPECIFICATION**	NAME:	**JK**	**SKS**	**RK**
TITLE: **500MVA, 400/220/33kV Auto Transformer**		SIGN:			
		DATE:	18/10/17	18/10/17	
		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.**

01	**18.10.2017**				Section-1 & Section-5 updated
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 and unloading at site including all materials, accessories, spares, supervision of 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
Addendum-1: Addendum-1 to Section 2B
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. **However bidder is clarified that there is no existing 400/220/33 transformer is present at BHUJ SS.**

2. **BHUJ Project is a 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). Further, one spare Digital RTCC relay shall also be provided in the same panel**

(Hence 5 nos. in total).

3. No external or internal Transformers / Reactors are to be used to achieve the specified HV/IV, HV/LV and IV/LV impedances.
4. Tan delta of Winding & Bushing shall be measured at ambient temperature. No temperature correction factor shall be applied.
5. The criteria for Transformer losses shall be **"Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)".**

1.2.2 Guaranteed Losses for Auto Transformer – at rated parameters i.e. voltage etc.

Transformer Rating	Guaranteed Iron Loss (kW)	Guaranteed Copper Loss (kW)	Guaranteed Cooler Loss (kW)
500MVA, 400/220/33kV, 3-Ph Auto Transformer	95	500	7

Note:

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

1.2.3 Guaranteed Losses and Liquidated Damage due to higher loss:

In the event the actual losses attained in **guarantee tests** are higher than the guaranteed losses at rated voltage, specified in para 1.2.2 above, but the actual losses are not more than the limit specified in para 1.2.4 below, and the Bidder elects to pay liquidated damages to the BHEL in lieu of making changes, modifications and/or additions to the Facilities then the Bidder shall pay (deducted from the contract price) liquidated damages as per rates given under:

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 Copper loss (KW)	INR 167,715/- (Indian Rupees One Hundred Sixty Seven Thousand Seven Hundred and Fifteen only) per KW.
		Differential Iron loss (KW)	INR 369,960/- (Indian Rupees Three Hundred Sixty Nine Thousand Nine Hundred and Sixty only)
		Differential Cooler loss (kW)	INR 246,640/- (Indian Rupees Two Hundred Forty Six Thousand Six Hundred and Forty only) per KW.

1.2.4

The guaranteed loss at rated parameters i.e. voltage, etc. for each equipment shall be corrected in accordance with IEC- 60076 for the purpose of comparison of guaranteed losses with measured losses for levy of liquidated damages. However, the equipment under no circumstances shall be accepted if the measured losses are more than +15 percent of the guaranteed losses (each type individually) at rated parameters i.e. voltage, specified at para 1.2.2 above.

No cost benefit shall be considered in case measured losses are less than the specified maximum losses.

1.2.5

The liquidated damages for shortfall in guaranteed parameters and for delay in completion are independent of each other and shall be levied separately and concurrently.

Note - 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. Refer "annexure-Cable scope"

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

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	**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.

2. Unloading of Autotransformer in complete including all accessories & insulation oil, etc. are in bidder's scope.

1.5 TECHNICAL QUALIFYING REQUIREMENT

Technical Qualification Requirement -

A. **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. 07.04.2015.** This shall be applicable for 400kV class 500MVA Auto Transformer specified in Technical Specification. Further, for 400kV class 500MVA Auto Transformer design review shall be carried out based on the design of short circuit tested 315MVA Auto Transformer.

B. The 500MVA 400kV Auto Transformer being offered are from manufacturer(s) who should have designed, manufactured, type tested and supplied, installed & commissioned (or supervised Installation & Commissioning) 345kV or above class transformers of at least 200MVA (or equivalent capacity in banks of single phase units). Transformers should have been in satisfactory operation# for at least two (2) years as on the originally scheduled date of bid opening **i.e. 07.04.2015.**

Satisfactory operation means certificate issued by the Employer certifying the operation without any adverse remark.

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/R89-1959 of 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

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>

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

CONTENTS
SECTION- UPTO 400 KV TRANSFORMER

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.

3.14.2. **For 220 kV Class Transformer:**

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on any rating of 220 kV or above voltage class 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 220 kV or above voltage class transformer for Dynamic Short Circuit Test, their bid shall be considered technically non-responsive. Further design review of offered 220 kV class transformers shall be carried out based on design of short circuit tested 220 kV or above voltage class transformer.

3.14.3. **For 132 kV Class Transformer:**

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on any rating of 132 kV or above voltage class 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 132 kV or above voltage class transformer for Dynamic Short Circuit Test, their bid shall be considered technically non-responsive. Further design review of offered 132 kV class transformers shall be carried out based on design of short circuit tested 132 kV or above voltage class 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 Sl.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.