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ADNOC GROUP PROJECTS AND ENGINEERING

POWER TRANSFORMER SPECIFICATION

Specification

AGES-SP-02-001

**GROUP PROJECTS & ENGINEERING / PT&CS DIRECTORATE**

CUSTODIAN	Group Projects & Engineering / PT&CS
ADNOC	Specification applicable to ADNOC & ADNOC Group Companies

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In addition, Group Projects & Engineering is responsible for communication and distribution of any changes to this Specification and its version control.

This specification will be reviewed and updated in case of any changes affecting the activities described in this document.

INTER-RELATIONSHIPS AND STAKEHOLDERS

- a) The following are inter-relationships for implementation of this Specification:
 - i. ADNOC Upstream and ADNOC Downstream Directorates and
 - ii. ADNOC Onshore, ADNOC Offshore, ADNOC Sour Gas, ADNOC Gas Processing, ADNOC LNG, ADNOC Refining, ADNOC Fertilisers, Borouge, Al Dhafra Petroleum, Al Yasat
- b) The following are stakeholders for the purpose of this Specification:

ADNOC PT&CS Directorate.
- c) This Specification has been approved by the ADNOC PT&CS is to be implemented by each ADNOC Group company included above subject to and in accordance with their Delegation of Authority and other governance-related processes in order to ensure compliance
- d) Each ADNOC Group company must establish/nominate a Technical Authority responsible for compliance with this Specification.

DEFINED TERMS / ABBREVIATIONS / REFERENCES

“ADNOC” means Abu Dhabi National Oil Company.

“ADNOC Group” means ADNOC together with each company in which ADNOC, directly or indirectly, controls fifty percent (50%) or more of the share capital.

“Approving Authority” means the decision-making body or employee with the required authority to approve Policies & Procedures or any changes to it.

“Business Line Directorates” or **“BLD”** means a directorate of ADNOC which is responsible for one or more Group Companies reporting to, or operating within the same line of business as, such directorate.

“Business Support Directorates and Functions” or **“Non- BLD”** means all the ADNOC functions and the remaining directorates, which are not ADNOC Business Line Directorates.

“CEO” means chief executive officer.

“Group Company” means any company within the ADNOC Group other than ADNOC.

“Specification” means this Power Transformer specification

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GENERAL

1. PURPOSE

The purpose of this specification is to specify the requirements of the design, performance, materials, manufacturing, inspection, testing, documentation and preparation for shipment of power transformers and reactors.

2. SCOPE

- a) This specification provides the requirements of design, manufacture, testing, and supply of power transformers and reactors, and applies to the following equipment.
 - i. Liquid immersed transformers
 - ii. Dry type transformers
 - iii. Auto-transformers
 - iv. On-load tap changers and controls
 - v. Special application transformers such as:
 - ASD transformers
 - Motor unit transformers
 - Generator unit transformers
 - Neutral Earthing Transformers
- b) Throughout the text of this document the term 'transformers' will mean 'transformers and reactors' as applicable.
- c) For the project and site specific additional requirements, refer to supplementary requirements stated in respective project's Purchase Requisition documentation.

3. DEFINED TERMS / ABBREVIATIONS / REFERENCES

3.1 DEFINED TERMS

COMPANY shall mean Abu Dhabi National Oil Company or any of its group companies. It may also include an agent or consultant authorized to act for, and on behalf of the COMPANY

CONTRACTOR shall mean the company contracted to carry out engineering work on behalf of ADNOC

VENDOR shall mean the manufacturer or supplier of the equipment

The term (PSR), where used, shall indicate a process safety requirement.

The word 'Shall' indicates a requirement.

The word 'Should' indicates a recommendation

3.2 ABBREVIATIONS

Abbreviations	
ASD	Adjustable Speed Drive
AVR	Automatic Voltage Regulator
BIL	Basic Insulation Level
BOD	Basis of Design
BS	British Standards
CEO	Chief Executive Officer
CFVV	Constant Flux Variable Voltage
CT	Current Transformer
DETC	De-energised Tap Changer
DGA	Dissolved Gas Analysis
DGS	Design Guidelines Specification
ECMS	Electrical Control and Monitoring System
EN	European Norm
FAT	Factory Acceptance Test
GRP	Glass Reinforced Plastic
HV	High Voltage (above 1000V)
IEC	International Electrotechnical Committee
IMS	Integrated Management System
IOC	International Oil Companies
IP	Ingress Protection
ISO	International Organization for Standardization
ITP	Inspection and Test Plan
KNAN	Synthetic Fluid Natural Air Natural

kV	Kilo volt
kVA	Kilo Volt-ampere (Apparent Power)
kW	Kilo Watt
LED	Light Emitting Diode
LNAF	Liquid Natural Air Forced
LNAN	Liquid Natural Air Natural
LV	Low Voltage (less than 1000V)
MCB	Miniature Circuit Breaker
MVA	Mega Volt-ampere (Apparent Power)
NPV	Net Present Value
OLTC	On-load Tap Changer
PD	Partial Discharge
PE	Protective Earth
PSR	Process Safety Requirement
PTC	Positive Temperature Coefficient (Thermistors)
PT 100	Resistor with expected resistance $R_0 = 100 \Omega$ at 0°C
QA	Quality Assurance
QC	Quality Control
RACI	Responsibility assignment matrix
RIP	(Epoxy) Resin Impregnated Paper
RIS	(Epoxy) Resin Impregnated Synthetics
ROM	Read-only Memory
RCCB	Residual Current Circuit Breaker
RTCC	Remote Tap Changer Cabinet
RTU	Remote Terminal Unit

RTD	Resistance Temperature Detector
SPCC	Society for Protective Coatings
TBC	To Be Confirmed
VT	Voltage Transformer

4. NORMATIVE REFERENCES

4.1 INTERNATIONAL CODES AND STANDARDS

The following documents are referred to in this specification and some or all of their content is therefore deemed to constitute requirements of this specification as set out below.

IEC 60034:	Rotating electrical machines
IEC 60076:	Power transformers
IEC 60076-1	General
IEC 60076-2	Temperature rise for liquid-immersed transformers
IEC 60076-3	Insulation Levels, Dielectric Tests and External Clearances in Air
IEC 60076-4	Guide to the lightning impulse and switching impulse testing - Power transformers and reactors
IEC 60076-5	Ability to withstand short circuit
IEC 60076-6	Reactors
IEC 60076-7	Loading guide for oil-immersed power transformers
IEC 60076-8	Application guide
IEC 60076-10	Determination of sound levels
IEC 60076-11	Dry-type power transformers
IEC 60076-12	Loading guide for dry-type power transformers
IEC 60079	Explosive atmospheres -All Parts
IEC 60085:	Electrical insulation – Thermal evaluation and designation
IEC 60099-1:	Surge arresters – Part 1: Non-linear resistor type gapped surge arresters for a.c. systems
IEC 60137:	Insulated bushings for alternating voltages above 1000V
IEC 60146-1-3:	Semiconductor convertors – General requirements and line commutated convertors – Part 1-3: Transformers and reactors
IEC 60214:	Tap-changers
IEC 60214-2:	Tap-changers – Part 2: Application guide

IEC 60270:	High-Voltage test techniques - Partial discharge measurements
IEC 60296	Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear
IEC 60529:	Degrees of protection provided by enclosures (IP Code)
IEC 61099:	Insulating liquids – Specifications for unused synthetic organic esters for electrical purposes
IEC 61378-1	Converter transformers Part 1: Transformers for industrial applications.
IEC 61439:	Low-voltage switchgear and controlgear assemblies
IEC 61869	Instrument Transformers
IEC 62155	Hollow pressurised and unpressurised ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1000V
IEC 62535:	Insulating Liquids - Test method for detection of potentially corrosive sulphur in used and unused insulating oil
IECEX 02	IEC System for Certification to Standards relating to Equipment for use in Explosive Atmospheres (IECEX System)
ISO 8503-2:	Preparation of Steel Substrates before application of paints and related products.
ANSI C-37.2	Electrical Power System Device Function Numbers

Where transformers are defined on datasheets for service on an offshore installation, the equipment shall also conform to requirements for such equipment, as defined in the following standards:

IEC 60092-101	Electrical installations in ships - Part 101: Definitions and general requirements.
IEC 61892-3	Mobile and Fixed Offshore Units - Electrical Installations - Part 3: Equipment.

SECTION A

5. REFERENCE DOCUMENTS

5.1 ADNOC SPECIFICATIONS

AGES-SP-02-007	HV & LV induction motors specification
AGES-SP-02-004	Adjustable speed drives specification
AGES-SP-02-008	Electrical control and monitoring system specification.
LATER	ADNOC tagging and numbering procedure
LATER	ADNOC painting, preservation and shipment specification

5.2 STANDARD DRAWINGS

To be advised

5.3 OTHER REFERENCES (OTHER CODES/IOC STANDARDS) ETC.

Shell DEP, TOTAL.

6. DOCUMENTS PRECEDENCE

The specifications and codes referred to in this specification shall, unless stated otherwise, be the latest approved issue at the time of Purchase Order placement.

It shall be the CONTRACTOR 'S responsibility to be, or to become, knowledgeable of the requirements of the referenced Codes and Standards.

The CONTRACTOR shall notify the COMPANY of any apparent conflict between this specification, the related data sheets, the Codes and Standards and any other specifications noted herein.

Resolution and/or interpretation precedence shall be obtained from the COMPANY in writing before proceeding with the design/manufacture.

In case of conflict, the order of document precedence shall be:

- UAE Statutory requirements

- ADNOC Codes of Practice

- Equipment datasheets and drawings

- Project Specifications and standard drawings

- Company Specifications

- National/International Standards

Any conflicts shall be highlighted to the COMPANY/CONTRACTOR and a resolution proposed.

7. SPECIFICATION DEVIATION/CONCESSION CONTROL

Deviations from this specification are only acceptable where the VENDOR has listed in his quotation the requirements he cannot, or does not wish to comply with, and the COMPANY/CONTRACTOR has accepted in writing the deviations before the order is placed.

In the absence of a list of deviations, it will be assumed that the VENDOR complies fully with this specification.

Any technical deviations to the Purchase Order and its attachments including, but not limited to, the Data Sheets and Narrative Specifications shall be sought by the VENDOR only through Concession Request Format. Concession requests require CONTRACTOR'S and COMPANY'S review/approval, prior to the proposed technical changes being implemented. Technical changes implemented prior to COMPANY approval are subject to rejection.

8. DESIGN CONSIDERATIONS /MINIMUM DESIGN REQUIREMENTS

8.1 DESIGN BASIS

- a) The transformers shall have a minimum design life of 25 years when operating within design parameters.
- b) The transformers shall be suitable for continuous operation at full rating under the service conditions specified for a minimum period of 40,000 hours without the need for planned maintenance requiring a unit shutdown.
- c) Motor, controlgear, assemblies, and components with less than 3 years proven operational service shall only be used if permitted by COMPANY.
- d) If the transformer is to be operated at V/Hz in excess of 5% of rated V/Hz, the same shall be stated in data sheet.

8.2 DESIGN PARAMETERS

Refer to data sheet

8.3 ENVIRONMENTAL AND SITE DATA

- a) Transformers shall be suitable for installation outdoor or indoor as stated on the data sheet.
- b) Outdoor Conditions
 - i. Without protective shelter, exposed to direct sunlight.
 - ii. That has a saliferous, sulphurous and dusty environment in conformance with ISO 12944 parts 2 and 5 classes:
 - iii. C5-I for onshore facilities.
 - iv. C5-M for offshore facilities.

Table 1 Outdoor ambient air temperature and humidity

	Max ambient (°C)	Hottest monthly average temp.(°C)	Annual average temp. (°C)	Min temp. (°C)	Max relative humidity
ONSHORE	54	44	34	> 5	97% at 43°C
OFFSHORE	48	38	28	> 5	97% at 43°C

c) Indoor Conditions

Table 2 Indoor ambient air temperature and humidity

	Max ambient (°C)	Hottest monthly average temp.(°C)	Annual average temp. (°C)	Min temp. (°C)	Max relative humidity
ONSHORE and OFFSHORE	40	30	20	> 5	< 90%

8.4 AREA CLASSIFICATION

- a) Transformers for installation in hazardous area shall conform to IEC 60079.
- b) Equipment installed in hazardous area shall be certified in accordance with IECEx System by an approved Certification Body.

SECTION B

9. TECHNICAL REQUIREMENTS

9.1 BASE STANDARDS:

The transformers shall comply with

IEC 60076-1

IEC 60076-11

IEC 60214-1

Associated standards referenced in the above standards.

9.2 ADDITIONS AND AMENDMENTS TO CLAUSES RELATING TO IEC 60076-1

IEC Clause 4.2 b) - Normal Service Conditions

1. Transformers shall be rated for continuous operation in the site conditions given in section 8.3 of this specification unless specified otherwise on the data sheets.

IEC Clause 5.1.1 (Rating) General

1. Transformer up to and including 2500 kVA are required to be capable of delivering rated current at up to 105% of rated voltage continuously. Where specified in the data sheet higher rated transformers shall also be capable of delivering rated current at 105 % rated voltage.

IEC Clause 5.1.4 Loading Beyond Rated Power

1. General Service Transformers feeding a group of motors shall be capable of withstanding infrequent restarting loads of up to 1.8 times the transformer rated current. Five such restarts may take place in succession at 5 second intervals.

IEC Clause 5.2 Cooling Mode

- 1 Unless specified otherwise, the transformer shall be naturally cooled. The cooling medium will be specified on Data Sheet.
- 2 Where a provision for forced cooling is specified in the Data Sheet, the forced cooling shall increase the rated power by 25% minimum.
- 3 Requirements for redundant cooling fans and N+1 radiators shall be stated in the data sheet.
- 4 Liquid-immersed transformers shall be cooled by means of removable, bolted, flange mounted radiators.
- 5 It shall be possible to remove radiators without draining liquid from the tank or header.
- 6 Header tanks shall be provided with isolation valves and vent pipes to the conservator to allow bleeding of air.

IEC Clause 5.7.1 Transformer Classification

1. Motor unit transformers shall be capable of withstanding three successive motor starts and a further two successive starts after a half-hour cooling-off period.

IEC Clause 5.7.2 Winding Connection and Number of Phases

- 1 The winding arrangement shall be Dyn11, unless otherwise specified on the data sheet.
- 2 Winding connections inside transformers shall be brazed or crimped.
- 3 The open delta of tertiary winding shall be brought out and shall be shorted and grounded by solid copper bars.
- 4 Transformer winding shall be made of copper. The use of Aluminium winding shall be subject to COMPANY approval.
- 5 Winding insulation level shall be as below.
 - a) For cable connected liquid immersed transformers: Lower of the two options given in IEC 60076-3 Table 2
 - b) For overhead line connected liquid immersed transformers: Upper of the two options given in IEC 60076-3 Table 2
 - c) For dry type transformers: As given in the IEC 60076-11, Table 3
- 6 Where specified on data sheet transformers shall be provided with an earthed metallic screen between HV and LV windings.
- 7 Insulation:
 - a) For transformers installed onshore, the insulation liquid shall be one of the following types as specified on the data sheet.
 - i. Mineral type shall conform to IEC 60296.
 - ii. Silicone liquid shall conform to IEC 60836.
 - iii. Synthetic organic esters shall conform to IEC 61099.
 - b) For transformers installed offshore, synthetic organic esters shall be used.
 - c) Where environmental and/or fire protection requirements prohibit the use of mineral oil, a higher flash point fluid such as natural or synthetic ester to be used

IEC Clause 5.7.3 Sound Level

The VENDOR shall submit with his quotation the maximum sound level of the transformer with forced cooling in operation.

Unless otherwise agreed, the following sound levels at the stated measuring distances as proposed in IEC 60076-10 shall be adhered to:

- 1 For Distribution type transformers: 65 dB(A) at 0.3m
- 2 For Dry-type transformers, without enclosure: 65 dB(A) at 1.0m
- 3 For all other transformers: 65 dB(A) at 1.0m
- 4 For Dry-type transformers with forced cooling facilities operating (with or without enclosure): 80 dB(A) at 1.0m
- 5 For all other transformers, with forced cooling facilities operating: 80 dB(A) at 2.0m

IEC Clause 5.7.4.1 Transport Limitation

Transport and Handling:

- 1 Transport limitation including size, weight, acceleration in excess of 1g or any special consideration shall be specified on the data sheet/project documentation.
- 2 Transformer shall be shipped filled with insulating liquid or dry air in an upright position. If shipped without insulating liquid, the transformer shall be liquid filled under vacuum after delivery as outlined in the installation procedures.
- 3 Transformer and associated cooling equipment when transported separately shall each be provided with lifting lugs to facilitate transport and assemble at site.
- 4 Removable covers on the tank shall be provided with additional lug.
- 5 Transformer with assembled mass more than 2000 Kg shall be provide with jacking pads.
- 6 Unless otherwise specified on the data sheet, transformer shall be designed for skid movement in all directions without the use of rollers, plates or rails.
- 7 Lifting and jacking points shall be provided on tanks, enclosures and frames. Location of lifting and jacking points shall be clearly indicated on the general arrangement drawings and marked on the tanks, enclosure and frame.
- 8 Transformers rated 1 MVA and above shall be shipped with 3-axis impact recorder attached.
- 9 In addition, a sweep frequency response analysis shall be conducted before transport and again at site, after installation, for all transformers rated 100MVA and above.

IEC Clause 6.2 Tapping Voltage

Unless otherwise specified on the data sheet:

- 1 Either de-energised (DETC) or on-line (OLTC) tap changer shall be provided.
- 2 DETC shall have following constant kVA taps, unless specified otherwise on data sheet or single line diagrams.
 - a) Centre tap at rated voltage
 - b) 2.5% and 5% above rated voltage
 - c) 2.5% and 5% below rated voltage

- 3 OLTC tapping voltage variation shall be of constant flux variation (CFVV) category, and shall have the following taps:
 - a) Centre tap at rated voltage
 - b) 10% above rated voltage with 8 tap positions of 1.25% steps
 - c) 10% below rated voltage with 8 tap positions of 1.25%
- 4 All tapplings shall be provided on the HV side

IEC Clause 6.3 Tapping Power. Full-power tapplings – reduced-power tapplings

The tapplings shall be full power tapplings unless otherwise stated in the data sheet.

IEC Clause 6.5 Specification of Short-circuit Impedance

The VENDOR shall specify short circuit impedance at all tapplings.

IEC Clause 8.1 General (Rating Plates)

- 1 Rating plates shall be
 - a) Stainless steel.
 - b) Easily accessible.
 - c) Mounted on non-removable part of the transformer.
- 2 The nameplate diagram shall include full details of current transformers mounted within the transformer.

IEC Clause 9.2 Dimensioning of neutral connection

- 1 The transformer neutral as a minimum shall be fully rated for the full rated current.

IEC Clause 9.3 Liquid Preservation System

- 1 Unless otherwise specified, liquid-immersed transformers up to 2000 kVA shall be hermetically sealed type.
- 2 Transformers rated above 2000 kVA and up to 3150 kVA may be either hermetically sealed or of the conservator type
- 3 Unless otherwise specified in the data sheet liquid-immersed transformers above 3150 kVA shall be conservator type.

IEC Clause 9.5 Centre of Gravity Marking

The centre of gravity of the transformer shall be shown on transformer general arrangement drawing for both operating and transportation conditions.

IEC Clause 10 Tolerances

- 1 Unless otherwise specified the design tolerances shall conform to Table 1 of IEC 60076-1.
- 2 The VENDOR shall provide guaranteed values for the following
 - a) No-load losses
 - b) Load losses.
 - c) Forced cooling electrical load consumption.

IEC Clause 11.0 Test

- 1 Routine tests shall be performed on all transformers and reactors.
- 2 Routine tests for liquid immersed transformers shall conform to IEC 60076-1.
- 3 Routine tests for dry type transformers shall conform to IEC 60076-11.
- 4 Routine tests for reactors shall conform to IEC 60076-6.
- 5 Rated short duration power frequency withstand voltage shall be selected from:
 - a) IEC 60076-3, Table 2 for liquid immersed transformers.
 - b) IEC 60076-11 for dry type transformers.
- 6 Where type test certificates are not available for identical transformers, the first unit shall be type tested in conformance to the relevant part of IEC 60076.
- 7 Requirements for type and special tests can be waived if corresponding certification is made available for equipment of identical design and rating, as defined in IEC 60076-1.
- 8 If specified on data sheets additional tests shall be identified by supplier and subject to agreement by Company responsible engineer prior to Purchase Order.
- 9 Sealed tank transformers shall be filled with liquid and subject to a leak test of 1 bar(g) without loss of pressure for 24 h.
- 10 Conservator type transformers shall be subjected to a leak test of 0,3 bar(g) without loss of pressure for 24 h.
- 11 Transformers not of a standard prototype design previously tested shall be impulse tested in conformance to IEC 60076.

Annex F Facilities for Future Fitting of Condition Monitoring Systems

- 1 Where specified in the requisition online condition monitoring as below shall be provided.
- 2 Transformers shall be provided with digitally enabled instrumentation for online continuous monitoring as below, including OLTC as applicable.
 - a) Oil-filled transformers

- i. Top liquid temperature
 - ii. Winding temperature
 - iii. Ambient temperature
 - iv. Liquid level
 - v. Tank pressure.
 - b) Oil-filled transformers rated 10MVA and above
 - i. Dissolved Gas Analysis (DGA) monitors
 - ii. Partial Discharge (PD) sensors
 - c) Dry-type transformers
 - i. Winding temperature
 - ii. Ambient temperature
 - iii. Partial Discharge (PD) sensors, where specified
- 3 All monitored quantities shall be communicated to the ECMS by way of Modbus RTU and/or IEC 61850 protocols.

9.3 ADDITIONS AND AMENDMENTS TO CLAUSES RELATING TO IEC 60076-11 (DRY TYPE TRANSFORMERS)

IEC Clause 4.2 Normal Service Conditions

- 1 Transformers shall be rated for continuous operation in the site conditions given in section 8.3 of this specification unless specified otherwise on the data sheets.
- 2 The transformer shall be suitable for Climatic Class C1, Environmental Class E2 and Fire Behaviour Class F1

IEC Clause 5.4 Transport and Storage

- 1 Dry type transformers shall have a minimum of two lifting lugs welded or bolted to the enclosure in a location that prevents tipping of the transformer when lifted.
- 2 If bus connection is used, dry type transformers shall have skids that allow movement in four directions to allow alignment of primary bushing.
- 3 Transformers rated 1 MVA and above shall be shipped with 3-axis impact recorder attached.

IEC Clause 5.12 Components and Materials

- 1 The transformers shall be one of the following design as specified on the data sheet.
 - a) HV/LV dry type transformers shall be cast resin encapsulated or air open wound with a minimum insulation class F
 - b) LV/LV dry type transformers shall be either cast resin encapsulated with an insulating class F or impregnated with an insulating class H.

- c) Encapsulated design shall be used in offshore living quarters
- 2 The core laminations shall be specially treated to avoid moisture ingress and consequent core corrosion.

IEC Clause 6.0 Tappings

- 1 Unless otherwise specified on the data sheet, Off-load tap changer on dry type transformer shall be bolted links link type.
- 2 The tapping range shall be $\pm 5\%$ in steps of 2.5% (5 tap positions).
- 3 The tap position shall be visible from outside the transformer panel enclosure.

9.4 ADDITIONS AND AMENDMENTS TO CLAUSES RELATING TO IEC 60214-1 (ON-LOAD TAP CHANGERS)

IEC Clause 5 Requirements for On-load Tap Changers

Included in section 10.9

IEC Clause 5.1.4.4 Pressure Relief Device

Included in section 10.2.5

IEC Clause 7.1.3 Handles and Drives

- 1 The operating handle shall be of metal.
- 2 It shall allow operation without the need for tools.
- 3 It shall be located in a directly accessible position, not requiring the removal of any covers.
- 4 One handle shall operate all phases simultaneously.

IEC Clause 7.1.5 Interlocks

The operating handle shall be provided with padlock facilities to lock the tap changer in each position.

10. ADDITIONAL DATA TO REFERENCED IECs

10.1 DEGREE OF PROTECTION

- a) Unless specified otherwise on the data sheet the minimum degree of protection for all equipment in accordance with IEC 60529 shall be as below. This applies to all enclosures, cable boxes, marshalling boxes and accessories.
 - i. IP31 for indoor installations onshore
 - ii. IP55 for outdoor installations onshore
 - iii. IP56 for outdoor installations offshore

10.2 TRANSFORMER TANKS AND RADIATORS:

10.2.1 General:

- a) Transformer tanks and radiators shall be constructed of steel.
- b) Radiators and corrugated tanks shall be hot-dip galvanised
- c) Each transformer shall be fitted with one filling/filter connection valve near the top of the tank and one drain/filter valve near the bottom of the tank.
- d) Transformer tanks shall be provided with a minimum one liquid sampling valve for each independent fluid compartment with unrestricted access (e.g., for DGA measurements).

10.2.2 Sealed tanks:

- a) The tank cover shall be welded to the tank with a continuous weld.
- b) The use of bolted covers shall be subject to approval by the COMPANY.
- c) Pressure relief devices with trip contact shall be fitted on the tank cover.

10.2.3 Transformers with Conservators

Conservators shall be removable for transport purposes and be provided with:

- a) Buchholz relays with alarm and trip contacts
- b) Level indicator.
- c) Filling hole with valve.
- d) Combined filter and drain valve.
- e) Detachable end plate.
- f) Lockable isolating valve.
- g) Regenerative type dehydrating breather.
- h) Sump shall be provided to prevent sludge and moisture from being drawn into transformer.
- i) Electrical connections shall not be obstructed by the position of the conservator.
- j) Conservators shall be provided with either a prismatic or magnetic liquid level indicator, readable from ground level.
- k) Where specified on the data sheet a conservator that prevents contact between the oil in the transformer tank and the ambient air shall be used, e.g., either the membrane type or multi-compartment type of split conservator.

10.2.4 OLTC Diverter Switch:

- a) The diverter switch liquid compartment shall preferably be connected to a separate conservator section of the main conservator of the transformer. A segregated section may be used subject to COMPANY approval.

- b) The diverter switch oil compartment shall be provided with the following facilities:
 - i. Liquid sampling connection at bottom of compartment;
 - ii. One filling/filter connection valve and one drain/filter connection valve;
 - iii. A dehydrating breather;
 - iv. Liquid-flow controlled relay.

10.2.5 Pressure Relief Devices:

- a) Pressure relief device shall be provided for transformers 1600 kVA and above.
- b) The pressure relief device shall:
 - i. Have a minimum two pair of changeover contacts.
 - ii. Be spring-loaded, self-resetting type.
 - iii. Be capable of operating without electrical power.
 - iv. Be mounted on the tank cover
- c) Discharge of liquid from the relief device shall be directed in a safe direction and clear of any operating position.
- d) The pressure devices shall operate at a static pressure which shall be less than the test pressure on tank.

10.2.6 Radiators

The radiators shall be provided with

- a) Inlet isolating valves
- b) Outlet isolating valves
- c) Liquid filling plug
- d) Liquid drain valve with cap and padlock or requiring special tools to operate.

10.2.7 Valves

The following shall apply:

- a) Valves shall be provided with permanently marked position indication for open or closed position.
- b) It shall be possible to padlock each valve in either the "open" or "closed" position. Alternatively, the valve shall require special tool to operate.
- c) Drain valves and those provided for connection of mobile liquid filtration equipment shall have screwed plugs.

10.3 COOLING FANS

- a) Forced air cooled transformers shall be provided with duty and standby motor driven cooling fans.
- b) External fans shall be either of non-corroding material or shall be treated with a corrosion resistant coating.
- c) Fan covers shall be made of metallic material and treated with a corrosion resistant coating. The use of fan covers made of non-metallic material requires approval from the COMPANY.
- d) Special consideration shall be given to the fan design if it is located in a Hazardous Area.
- e) Air duct and fan protective covers shall be provided to prevent:
 - i. Accidental contact with fan blades or other moving parts.
 - ii. Ingress of harmful matter.
- f) Unless otherwise specified, liquid immersed transformers rated greater than 10 MVA shall be provided with two stages of forced cooling for example ONAN/ONAF1/ONAF2.

10.4 ELECTRIC MOTORS

- a) Electric motors installed on transformer package shall comply with ADNOC motor specification (Specification reference to be advised).
- b) Motors shall have Class F insulation with temperature rise limited to Class B.
- c) Motors in hazardous area shall be certified for installation in the hazardous area as specified in the Data Sheet.

10.5 TEMPERATURE MONITORING LIQUID TRANSFORMERS

- a) Temperature monitoring for liquid transformers shall consist of thermometer pocket, thermometer or thermocouple sensors, and dial type indicator.
- b) Thermometer pockets shall be in accordance with:
 - i. A tubular pocket shall be welded into the tank cover plate to accommodate either a thermometer or a thermocouple probe. The pocket shall be oil-filled to provide proper heat transfer.
 - ii. Thermometer pockets shall have a sealing cap held captive by an external chain.
 - iii. Thermometer pockets shall be located such that thermometer readings indicate top liquid temperature.
- c) Hot liquid temperature indicators shall have:
 - i. A dial calibrated in degrees Centigrade.
 - ii. Total of four adjustable setting contacts two each for remote alarm and trip purposes.
 - iii. Two adjustable contacts to control cooling fans
 - iv. A hand-reset pointer to register the highest temperature attained.

10.6 BUSHING INSULATORS

Bushing Insulators shall comply with the following:

- a) HV bushings shall conform to IEC 60137
- b) Bushings shall be suitable for operation in the environmental conditions defined for the transformer.
- c) Unless specified on data sheets, creepage distances for bushings shall be sized for heavy contamination where directly exposed to atmosphere, as defined in IEC 60137. Creepage for bushings fully enclosed shall be rated for light contamination.
- d) Elastimold type bushings and elbow connections shall be used for connections rated up to 11kV and current up to 1250 Amps. HV bushings for higher ratings shall be either Epoxy Resin Impregnated Paper (RIP) type or Epoxy Resin Impregnated Synthetics (RIS).
- e) Porcelain or silicone rubber insulator sheds shall be used on the bushings, where applicable.
- f) Each end of the HV bushings shall be compatible with the medium into which it will be terminated.
- g) Transformer internal winding ends that are tied to the bushings, shall always remain under the transformer liquid level.
- h) It shall be possible to remove any bushing completely without removing tank covers. Easy access shall also be provided for internal connections of bushings without extensive dismantling of external mountings such as radiators, terminal boxes, etc.
- i) A suitable manhole for checking of the bushing internal connections shall be provided at a location easily accessible from the tank cover.

10.7 CABLE TERMINATION BOXES

- a) Separate cable boxes shall be provided for the following.
 - i. High-voltage side cables
 - ii. Low-voltage side Cables
 - iii. Neutral cable box for earthing of the neutral
 - iv. Instrumentation, alarm and trip devices, CT secondary cables
 - v. Forced cooling devices cables.
 - vi. On-load tap changer cables
- b) Positioning of Cable Boxes:
 - i. H.V. & L.V. cable boxes shall be preferably positioned on opposite side walls of the transformer. Top mounted cable boxes for larges transformers may be acceptable, subject to COMPANY approval.
 - ii. Cable boxes with pressure relief facilities shall be positioned to vent gases to a safe area.
 - iii. Auxiliary cable boxes shall be mounted on the side of the transformer in an accessible position.
- c) Cable Box Design and Construction:
 - i. Cable boxes shall be air-filled phase insulate.
 - ii. Cable boxes shall be designed to prevent accumulation of condensation.

- iii. Cable boxes shall be designed to prevent exposure to ultraviolet sun rays.
- iv. Cable box covers shall be secured, using gasket and non-loosening bolts or screws.
- v. Cable box covers shall not be removable without the use of tools.
- vi. Cable boxes shall allow single-core conductors to be connected straight on to the terminating point without the need to bend the conductors.
- vii. Cable boxes shall be suitable for the Short Circuit rating as specified in the data sheet.
- viii. For outdoor cable boxes canopies with an overhang of at least 50 mm on all sides shall be fitted over for protection against sun and water. An air space of at least 50 mm above the top cover shall be provided for ventilation.
- ix. All connections shall be sized to carry the maximum continuous current, including overloads and through-fault currents. Test certificates or calculations shall be available for all main cable boxes to confirm short circuit withstands capability.
- x. Removable cover access plates shall be provided with handles or, when having a mass of 25 kg or more, shall be provided with lifting lugs.
- xi. For outdoor environments, nuts, bolts, studs, and washers shall be stainless steel. Painted surfaces shall be protected by nylon washers placed between the steel washer and the painted surface.
- xii. Cable Testing Provision: Each cable box shall have isolating and earthing facilities to allow high voltage dielectric testing of the cable and transformer.

d) Cable Terminations shall be designed as detailed below:

- i. Cable terminations shall be provided for cables types and sizes shall be as specified on the Data Sheet.
- ii. The Internal arrangement shall keep the various circuits clearly separate from each other, permitting easy and safe maintenance access from ground level.
- iii. Gland plates shall be sized for cables as specified on the data sheets.
- iv. Gland plates for single core cables shall be non-magnetic material.
- v. Threaded entries shall be tapped ISO metric with a constant pitch of 1.5 mm.
- vi. Up to 33kV, cables shall be terminated using compression type connectors. Where specified in the requisition, the cables shall be terminated using Elastimold type terminations or approved equivalent.
- vii. Single core phase and neutral cable terminations shall be provided with suitably selected compression-type cable glands, mounted on a non-magnetic gland plate.
- viii. Main cable boxes shall be provided with an earth bar for termination of cable screens.
- ix. If required, bus duct termination shall be air filled, phase insulated, phase separated or phase segregated, as specified on data sheets.
- x. On four wire systems the neutral shall be brought out to the main cable box as well as to neutral cable box.

- xi. The spacing between supports/clamps for the main cables shall not exceed 500 mm
- xii. The routing of cables shall not obstruct transformer cooling.
- xiii. A marshalling box shall be provided for cabling the external connections to instrument and auxiliary devices. See Appendix 1 for wiring details.

e) Bus Duct Terminations are detailed below

- i. Where bus duct is specified for the secondary connection, the terminal box shall be provided with flange to match up to the equipment which will be provided by others. The VENDOR will be required to coordinate his termination designs with the selected VENDOR of bus duct.
- ii. Adequate provision shall be made for the support and fastening of the ducting at the throat of the ducting to the throat of the transformer.
- iii. The transformer terminals shall provide a sufficient pre-drilled contact area for accepting flexible connectors, and proper access shall be provided for bushings inside the transformer throat while the duct remains in place.

f) Where the transformer connection is to Gas Insulated Busducts:

- i. Top mounted bolt flanged oil-to-gas high voltage bushings shall be provided for connection to SF6 gas insulated busducts.
- ii. Special provisions may be necessary in the event of connection directly to the TRANSCO National Grid.

10.8 SURGE ARRESTORS

Where surge arrestors are specified on the Data Sheet, the cable boxes shall be designed for direct connection of silicone-type, metal oxide surge arrestors and the related bushings (double flange bushings). Surge Arrestors shall be compliant with IEC 60099-4 (2014). They shall be provided with the polymeric housing of silicone which shall be of an explosion and shatter-resistant design. Arresters shall be fitted with mA meter to show the leakage current and operation counter.

10.9 CURRENT TRANSFORMERS

- a) Current transformers shall be provided in accordance with the data sheet and single line diagram
- b) Current transformers shall conform to IEC 61869-2.
- c) All secondary terminals of current transformers shall be wired to a terminal block in the transformer auxiliary cable box.
- d) Current transformer secondary circuits shall be provided with shorting links at outgoing terminals.

10.10 TAP CHANGERS

10.10.1 De-energised Tap Changers (DETC):

De-energised or on-load tap changer shall be provided as specified on the data sheet, and as follows:

- a) The tapping switch shall be positively located in each tap position and lockable only in those positions
- b) The operating handle shall be provided with a padlock to lock the tap changer in each position.
- c) Mechanical end stops shall be provided.
- d) The operating handle shall be of metal and sized to allow operation without tools.
- e) The handle shall be located in a directly accessible position and not requiring the removal of any covers.
- f) Tap positions shall be clearly marked in line with the data listed on the rating plate.
- g) One handle shall operate all phases simultaneously.

10.10.2 On-load Tap Changer (OLTC):

Where specified each transformer shall be equipped with OLTC including control panels as detailed below.

- a) Motor operated on-load-tap-changer (OLTC):
 - i. OLTC shall be tank mounted or shall be installed in a separate tank
 - ii. The tap changer shall be a polyphase unit with a single drive mechanism
 - iii. One filling/filter connection valve and one drain/filter connection valve.
 - iv. Regenerative-type, dehydrating breather, located at an accessible position
 - v. The insulating medium for the tap changer shall be the same as for the HV windings, unless stated otherwise in the Data Sheet
- b) Local tap changer control panel:

The local control panel shall be mounted on the transformer tank at an accessible height. The following controls shall be available from this panel as a minimum.

 - i. The OLTC gear shall have diverter resistance. The current diverting contacts shall be housed in a separate liquid chamber segregated from the main tank of the transformer. The contacts shall be accessible for inspection and their tips shall be replaceable.
 - ii. The tap changer operation shall start on a "Raise" or "Lower" impulse of short duration and shall "seal-in" and complete the step by itself. The duration of a signal beyond the time required for operation shall not initiate a second operation.
 - iii. Electrical and mechanical interlocks shall be provided on the "Raise" and "Lower" contactors.
 - iv. Tap changer motor protection shall consist of an overcurrent and single phase protection automatic air circuit breaker with manual reset, or alternatively, a contactor with an isolating device. An alarm shall be communicated to the RTCC of operation of any motor protective devices.
 - v. Means shall be provided to ensure that the operating mechanism can be locked only when the switches are closed and making full contact.
 - vi. Local/Off/Remote selection (remote control is from RTCCP)

- vii. Tap raise and lower push buttons
- viii. Emergency stop
- ix. Tap position indicator.
- x. "Tap change in progress" indicating lamp (white).
- xi. "Tap changer fault" indicating lamp (red).
- xii. Individual fault indications with two sets of voltage-free changeover contacts
- xiii. A six-figure counter.
- xiv. Crank handle for manual operation in the event of an auxiliary supply failure

c) Remote tap changer control (RTCC) panel

The following control and monitoring functions shall be provided at the RTCC as a minimum. The control panel shall be located inside an electrical room in the local substation.

- i. RTCCP/OFF/ECMS control selector switch
- ii. Tap position indicator
- iii. Winding temperature indicator
- iv. Oil temperature indicator
- v. Voltage higher/lower control switch
- vi. Annunciator panel for all transformer trips/alarms
- vii. Interface with ECMS via serial link to enable full control and monitoring from ECMS
- viii. Automatic voltage regulator relay (AVR)
- ix. AVR auto/manual selector switch
- x. Master/follower controls for transformers operating in parallel

10.10.3 Control Panels

- a) Dual redundant feeders with auto transfer system shall be provided for control power supplies to each control panel. Auto transfer will be prevented if the feeder is tripped due to a fault downstream of the supply MCB.
- b) The local control panel and the remote panel shall comply with the requirements given in Annexure 1.

10.10.4 Tap Changer ECMS Interface

Unless otherwise specified the following control and monitoring signals shall be communicated to EMCS.

- a) Common Alarm
- b) Common Tripped
- c) Control Mode
- d) Tap Changing in Progress

- e) AVR Control Mode - Automatic
- f) AVR Control Mode - Manual
- g) Tap Changer Fault Alarm
- h) Tap Position Indication
- i) OLTC Tap Raise / Lower Commands
- j) Set points
- k) Winding and oil temperatures

10.11 EARTHING AND BONDING

10.11.1 Frame and Core Earthing

- a) Transformers shall be provided with two earth terminals on the outside of the transformer mainframe or tank wall, for connection to an external earthing grid.
- b) Each earth connection shall consist of a brass or stainless steel M 10 bolt with nuts and washers, unless specified otherwise.
- c) The magnetic core shall be earthed to the tank cover at one point only through removable links. Disconnection of this link will enable the insulation between the core and tank be tested at voltages up to 2.5 kV.
- d) Where specified in the data sheet, an earth fault detection scheme shall be installed on the transformer tank. The protection shall comprise a fast-acting protection device and all necessary components to trip the supply to the transformer in the event of an internal earth fault. In this case, the tank shall be fully insulated from the base frame and travelling wheels or fixed supports. The mounting of all accessories shall consider and maintain the integrity of the tank earth fault protection scheme. The VENDOR shall propose a suitable protection scheme to fulfil this requirement.

10.11.2 Bonding:

- a) All metallic components, such as cable boxes and their internal earthing bars or studs, shall be bonded to the transformer mainframe or tank.
- b) All flange joints, which are separated from the main transformer tank by gaskets, shall be connected thereto via adequately rated copper earthing connections. Connecting bolts shall not serve the purpose of earth continuity.
- c) Internal earthing wires of cable boxes shall be connected to frame of cable boxes.
- d) A copper earthing bar complete with nuts, bolts, and washers shall be provided for earthing cable protective screens and armouring in all cable boxes.

10.12 TEMPERATURE MEASUREMENT FOR DRY TYPE TRANSFORMERS

The following temperature monitoring facilities shall be provided

- a) Thermistors or PT 100 resistance temperature sensors for each phase shall be provided.
- b) Temperature sensors shall be cabled to a control panel mounted on the transformer enclosure.
- c) The thermistors shall be of the positive temperature coefficient (PTC) type.

- d) The thermistors or resistance elements shall be supplied complete with the auxiliary equipment necessary to initiate remote alarms/trips via voltage-free changeover contacts.
- e) Temperature measurements shall be available to communicate to the ECMS.
- f) The thermistors and resistance elements shall avoid the transfer of over-voltages to auxiliary or external connections.

10.13 ECO DESIGN

- a) Transformers shall be optimised for lifetime costs. The vendors can offer low loss eco-design transformers. The vendor shall carry out the calculations, using the formula given below, and using the factors and cost data stated in the CONTRACTORS documents:

$$NPV = (Po + a2.Pk) \times 8760 \times b \times c$$

where: Po = no-load loss (kW)

Pk = load loss (kW)

a = loading factor (% of transformer rating/100)

b = energy unit cost (cost/kWh)

c = capital

- b) The tolerances of the losses, on which the calculation of the NPV is based, shall be reduced from those normally allowed by IEC 60076-1, Table I, as follows:
 - i. Total loss : + 5% instead of 10% -
 - ii. Component loss : +10% instead of 15% -
 - iii. These more demanding tolerances shall be guaranteed.

10.14 SPECIAL APPLICATION TRANSFORMERS

- a) Unless otherwise stated on the data sheet tap changers for auto-transformers shall be variable flux design with neutral end taps.
- b) ASD Transformers shall be designed, manufactured and tested in accordance with IEC 61378-1 and IEC 61800-4, the ASD Data Sheet and single line diagrams
- c) ASD transformers and Generator step-up shall not be equipped with foil windings.
- d) Motor unit transformers shall be capable of withstanding three successive motor starts and a further two successive starts after a half-hour cooling-off period.
- e) Where included, Neutral Earthing Transformers shall comply with the requirements of IEC 60076-6.

SECTION C

11. DETAILS SCOPE OF SUPPLY (AS APPLICABLE)

The scope of supply of Transformer shall include:

- a) Detailed design
- b) Supply of materials
- c) Factory and site inspection and testing
- d) Documentation including certification
- e) Installation, commissioning and start-up assistance; where specified in the requisition
- f) Spare parts for 2 years operation

Refer to the project requisition document for detailed requirements

12. QUALITY CONTROL AND ASSURANCE

Equipment shall only be purchased from Vendors approved by ADNOC Category Management. This approval indicates that the VENDOR has an approved Quality management system and a proven track record in supply of this equipment type.

12.1 SUBCONTRACTORS/SUBVENDORS

The VENDOR shall assume unit responsibility and overall guarantee for the equipment package and associated equipment.

The VENDOR shall transmit all relevant purchase order documents including specifications to his sub-vendors and sub-contractors.

It is the VENDOR'S responsibility to enforce all Purchase Order and Specification requirements on his sub-vendors and sub-contractors.

The VENDOR shall submit all relevant sub-vendor and sub-contractor drawings and engineering data to the CONTRACTOR.

The VENDOR shall obtain and transmit all sub-vendor and sub-contractors warranties to the CONTRACTOR/COMPANY, in addition to the system warranty.

13. MATERIAL & CERTIFICATIONS

Not Applicable

14. INSPECTION & TESTING REQUIREMENTS

14.1 GENERAL

- a) Before leaving the VENDOR'S works, each item of equipment shall be inspected and tested in accordance with the relevant IEC Standards as listed in Section A of this specification.
- b) The VENDOR shall provide an Inspection and Testing Plan (ITP) at least 8 weeks' notice prior to the testing date.
- c) The ITP shall be submitted for review and acceptance by the COMPANY and include Witness and Hold points in the programme for VENDOR, CONTRACTOR, and the COMPANY.
- d) The COMPANY/CONTRACTOR or his nominee shall inspect the equipment and witness the required tests indicated in the Requisition at the time the equipment is offered for final inspection.
- e) A detailed test procedure of factory tests shall be submitted at least 3 months in advance of any testing, detailing the proposed inspection, testing and witness testing programme throughout the design and build of the equipment.
- f) Test certificates for each switchgear shall be submitted prior to delivery for approval.

14.2 TESTS REPORTS

A test report form shall be submitted to COMPANY which shall include:

- i. The design values
- ii. The tolerance values
- iii. The real values as measured, including, if any, the intermediate values causing provisional refusal.

Finally, VENDOR shall compile the complete records of the inspection and tests (type, special, routine, FAT, site) in one inspection document to be included in the contractual technical documentation.

14.3 TYPE TESTS

- a) Vendor shall submit the type test certificates for each item of equipment for tests as required in the applicable IEC standards, including the following additional tests.
 - i. Tests to evaluate the insulation of the equipment by the measurement of partial discharges.
- b) Type test certificates shall be submitted with the bid.
- c) Test certificates shall be from an internationally recognised, independent testing authority, and shall be subject to Company acceptance.
- d) Table 13.1 gives the type tests listed in IEC 60076-1 and IEC 6076-11.

Table 13.1 Type Tests

IEC 60076-1 Clause Reference	Test
11.1.3 a)	Temperature Rise type test
11.1.3 b)	Dielectric type test
11.1.3 c)	Determination of sound level

11.1.3 d)	Determination of power taken by the fan and liquid pump motors
11.1.3 e)	Measurement of no-load loss and current at 90% and 110% of rated voltage
IEC 60076-11 Clause Reference	Test (Dry Type Transformers)
14.3.1	Full Wave Lightning Impulse Test (LI)
14.3.2	Temperature Rise Test
IEC 60214-1 Clause Reference	Test (Tap Changers)
5.2.1	Temperature Rise of Contacts
5.2.1	Switching Tests
5.2.1	Short-circuit Current Test
5.2.1	Transition Impedance Test
5.2.1	Mechanical Tests
5.2.1	Tightness Test
5.2.1	Dielectric Tests

14.4 ROUTINE TESTS

- a) Routine tests shall include but not be limited to the following.
- b) Routine tests shall be carried out in accordance with the IEC 60076-1, IEC 60076-11, IEC 60214-1 as per table below.

Table 13.2 Routine Tests

IEC 60076-1 Clause Reference	Test
11.1.2.1 a)	Measurement of winding resistance
11.1.2.1 b)	Measurement of voltage ratio and check of phase displacement
11.1.2.1 c)	Measurement of voltage ratio and check of phase displacement
11.1.2.1 d)	Measurement of no-load loss and current
11.1.2.1 e)	Dielectric routine tests
11.1.2.1 f)	Test on no-load tap-changers, where appropriate
11.1.2.1 g)	Leak test with pressure for liquid-immersed transformers
11.1.2.1 h)	Tightness test and pressure tests for tanks for gas-filled transformers
11.1.2.1 i)	Check of the ratio and polarity of built-in current transformers
11.1.2.1 j)	Check of core and frame insulation for liquid immersed transformers with core or frame insulation
IEC 60076-11 Clause Reference	Test (Dry Type Transformers)
14.2.1	Measurement of winding resistance
14.2.2	Measurement of voltage ratio and check of phase displacement
14.2.3	Measurement of voltage ratio and check of phase displacement
14.2.4	Measurement of no-load loss and current

14.2.5	Applied Voltage Test (AV)
14.2.6	Induced Voltage Withstand Test (IVW)
14.2.7	Partial Discharge Measurement
IEC 60214-1 Clause Reference	Test (Tap Changers)
5.3.1	Mechanical Test
	Sequence Test
	Auxiliary Circuits Insulation Test
	Pressure and Vacuum Tests

- c) Routine tests for reactors shall conform to IEC 60076-6.
- d) Routine tests on transformer components shall be carried out as per the relevant IEC standards.
- e) Routine tests shall also include:
 - i. Full functional tests including proving of interlocking, operating mechanisms, and ancillary devices, etc.
 - ii. Relay primary and secondary injection tests
 - iii. Conformity of tags, labels, wires, and terminals markings.
 - iv. Interface with remote panels provided by the VENDOR and third party VENDORS.
 - v. ECMS Simulation Tests: Proving of successful interfacing of all necessary communication devices between ECMS and DCS systems. This shall include full functional tests on switchgear and its feeders such as: remote control, automatic starting, automatic transfer and load shedding, etc.

14.5 ADDITIONAL TESTS

- a) Additional tests shall be carried out for transformers of U_m greater than 72.5kV, in accordance with IEC 60076-1 as per table below.

Table 13.3 Additional Tests

IEC 60076-1 Clause Reference	Test
11.1.2.2 a)	Determination of capacitances windings-to-earth and between windings
11.1.2.2 b)	Measurement of d.c. insulation resistance between each winding to earth and between windings
11.1.2.2 c)	Measurement of dissipation factor (tan delta) of the insulation system capacitances
11.1.2.2 d)	Measurement of dissolved gases in dielectric liquid from each separate oil compartment, except diverter switch compartment
11.1.2.2 e)	Measurement of no-load loss and current at 90% and 110% of rated voltage

- b) Sealed tank transformers shall be filled with liquid and subject to a leak test of 1 bar(g) without loss of pressure for 24 h.
- c) Conservator type transformers shall be subjected to a leak test of 0,3 bar(g) without loss of pressure for 24 h.
- d) Transformers not of a standard prototype design previously tested shall be impulse tested in conformance to IEC 60076.

14.6 SPECIAL TESTS

- a) Where agreed as part of the purchase order, the following special tests may be included in the scope of VENDOR testing, in accordance with IEC 60076-1.
- b) Other tests may be agreed in the purchase order for any specialised transformers included in the Vendor's scope of supply.

Table 13.4 Special Tests

IEC 60076-1 Clause Reference	Test (Dry Type Transformers)
11.1.4 a)	Dielectric special test
11.1.4 b)	Winding hot-spot temperature-rise measurements
11.1.4 c)	Determination of capacitances windings-to-earth and between windings
11.1.4 d)	Measurement of dissipation factor (tan delta) of the insulation system capacitances
11.1.4 e)	Determination of transient voltage transfer characteristics
11.1.4 f)	Measurement of zero sequence impedance(s) on three-phase transformers
11.1.4 g)	Short-circuit withstand test
11.1.4 h)	Measurement of d.c. insulation resistance between each winding to earth and between windings
11.1.4 i)	Vacuum deflection test on liquid immersed transformers
11.1.4 j)	Pressure deflection test on liquid immersed transformers
11.1.4 k)	Vacuum tightness test on site on liquid immersed transformers
11.1.4 l)	Measurement of frequency response
11.1.4 m)	Check of external coating
11.1.4 n)	Measurement of dissolved gases in dielectric liquid
11.1.4 o)	Mechanical test or assessment of tank for suitability for transport
11.1.4 p)	Determination of weight with transformer arranged for transport (for transformers up to 1600kVA)

IEC 60076-11 Clause Reference	Test (Dry Type Transformers)
14.4.1	Partial Discharge Test for Transformers Operated under Single Phase Line-to-Line-to Earth Fault Condition
14.4.2	Measurement of Sound Level
14.4.3	Short-circuit Test
14.4.4	Climatic Tests
14.4.5	Environmental Test
14.4.6	Fire Behaviour Test
14.4.7	Seismic Test

15. SPARE PARTS

- a) The VENDOR shall propose:
 - i. A list of commissioning spare parts
 - ii. A list of 2 years operation spare parts
 - iii. A list of special tools required for erection, commissioning and maintenance
- b) Special tools required for erection, commissioning and maintenance shall be shipped together with the Switchgear.
- c) Each spare part shall be separately packed and clearly identified for storage management.

16. PAINTING, PRESERVATION & SHIPMENT

16.1 PAINTING

- a) Surface preparation and painting shall be in accordance with the COMPANY standard.
- b) Alternatively, VENDOR may propose the standard for enhanced protection against corrosion in outdoor climates. The paint system applied shall provide adequate protection against the adverse effects of the climatic conditions specified. Full details of VENDOR's painting specification shall be provided with the proposal for COMPANY approval.
- c) The equipment shall be fully tropicalized.
- d) Alternatively, VENDOR may submit his coating system for protection against external corrosion for COMPANY approval. Full details of VENDOR's painting specification shall be provided with the proposal.
- e) The finish of internal walls of tank, covers, connecting boxes and cooling systems shall effectively protect against the effects of corrosion and the influence of the oil or synthetic liquid used in the transformer.
- f) External surface preparations, prior to the overall paint finish, shall comprise at least the following:
 - i. Radiators and corrugated tanks shall be hot-dip galvanized

- ii. Tanks and other parts shall be hot-dip galvanized, or zinc sprayed if too large for the hot-dip process.
 - iii. The surface preparation of tank walls shall include blast cleaning to surface preparation SP 5 in accordance with SSPC or SA 2.5 - 3 per BS EN ISO 8503-2.
 - iv. Welded areas, such as the tank cover rims of hermetically sealed transformers, shall be painted with zinc-rich paint.
- g) The external paint finish colour shall be grey RAL 7035. Inside the main tank the colour shall be white to facilitate internal inspection.
- h) THE CONTROL PANELS SHALL BE PAINTED TO THE VENDOR'S STANDARD SPECIFICATION, IF DEMONSTRATED TO BE equal to or better than the ADNOC surface preparation specification – colour RAL 7035.

1.1 SHIPMENT

Manufacturer's standard packing shall be acceptable unless otherwise stated in the COMPANY's preservation and export packing procedure and on data sheet. Installation of impact recorders on individual packing boxes and containers shall be included.

17. COMMISSIONING

The requirements of commissioning shall be included in the requisition document.

18. TRAINING

The requirements of commissioning shall be included in the requisition document.

19. DOCUMENTATION/ VENDOR DATA RECORDS

19.1 GENERAL

- a) VENDOR shall submit the type and number of drawings and documentation for CONTRACTOR'S authorization or information as listed in the Material Requisitions and Purchase Orders.
- b) Schedule of documents and data submittal shall be as agreed in the purchase order.
- c) Comments made by CONTRACTOR on drawing submittal shall not relieve VENDOR or sub-vendors of any responsibility in meeting the requirements of the specifications. Such comments shall not be construed as permission to deviate from requirements of the Purchase Order unless specific and mutual agreement is confirmed in writing.
- d) Each drawing shall be provided with a block in the bottom right-hand corner incorporating the following information:
 - i. Official trade name of the VENDOR.
 - ii. VENDOR'S drawing number.

- iii. Drawing title giving the description of contents whereby the drawing can be identified.
- iv. A symbol or letter indicating the latest issue or revision.
- v. PO number and item tag numbers.

e) Revisions

- i. Document and drawing revisions shall be identified with symbols adjacent to the alterations.
 - ii. A brief description of each revision shall be given in tabular form.
 - iii. If applicable, the authority and date of the revision shall be listed. The term "Latest Revision" shall not be used.
- f) All documents shall show the relevant order number, item tag numbers and VENDOR'S references and shall be distributed as specified in the purchasing documents.
- g) Graphic symbols for electrical diagrams shall be according to IEC 60617-DB. Device code numbers shall be as per ANSI C-37.2 -1996.
- h) All documents shall be in English
- i) Installation operating and maintenance manuals shall be arranged as follows:
- i. The front cover, spine and inside page shall state the purchase order number and VENDOR'S reference number.
 - ii. The inside front page shall carry an index listing the contents of each section of the manual.
 - iii. Individual sections shall be completed and shall refer to the equipment actually supplied.
 - iv. Published data shall also be included, including published data for bought-in items.
 - v. Full detail for installation setting up shall be included.
 - vi. Recommended test data shall be stated, covering initial and also regular testing shall be given. For example high voltage AC or DC test values.
 - vii. Items requiring regular inspection, checking, testing and maintenance shall be listed and the time scale clearly indicated.
 - viii. Important items shall be cross referenced to other part of the manual as necessary.
 - ix. Fault finding chapter shall be included.
 - x. As built panel and interconnection wiring diagrams
 - xi. CD ROM for programming protection relays
 - xii. Parts and equipment list

19.2 DELIVERABLES

Unless otherwise stated in the requisition or purchase order documents, the VENDOR shall as a minimum supply the following documents.

Table 19.1 Deliverables

Document	With Bid	Project Documentation
Transformer overall arrangement	X	X
Completed data sheet	X	X
Dielectric oil data sheets and type test certificate as per IEC 60255 35	X	X
Type test reports as per IEC 60076 – 1	X	
For transformer of similar design - Short circuit test - Lightning impulse withstand test	X	
Transformer and offline tap changer connection diagram		X
Equipment technical details	X	X
2-years spare part list	X	
Special tools if any	X	X
Painting system specification	X	
Foundation guide details if required		X
List of Electric consumers		X
Lifting and handling procedures		X
Arrangement details of auxiliary equipment		X
Layout of connection boxes and control panels		X
Wiring and termination diagrams		X
Schematic diagrams		X
Operation and maintenance manuals		X
Detailed drawings of all interface points		X
FAT procedures		X
Test reports for or type test, routine tests, special tests, and site tests		X

20. GUARANTEES & WARRANTY

The VENDOR shall guarantee, in accordance with the general conditions that the equipment shall meet the performance conditions specified in this specification, associated documents and Data Sheets.

SECTION D

21. DATA SHEETS TEMPLATES

Data sheet shall be inserted and decided by ADNOC

Data sheet (Document number to be advised later)

22. STANDARD DRAWINGS

Not applicable

SECTION –E

23. ANNEXURE 1 - AUXILIARY AND CONTROL EQUIPMENT ADDITIONAL REQUIREMENTS

1. SCOPE

This Annexure specifies the requirements for the auxiliary and control equipment such as enclosures and components, anti-condensation heaters, wiring, earthing, identification labels and markings, colour coding etc., where these are not fully covered by the main specification.

2. NORMATIVE REFERENCES:

IEC 60204	Safety of Machinery. Electrical Equipment of Machines.
IEC 60332	Tests on electric and optical fibre cables under fire conditions.
IEC 60364	Low Voltage Electrical Installations
IEC 60445	Basic and safety principles for man-machine interface, marking and identification. Identification of equipment terminals, conductor terminations and conductors
IEC 60754-1	Test on gases evolved during combustion of materials from cables. Determination of the halogen acid gas content
IEC 61034-2	Measurement of smoke density of cables burning under defined conditions - Part 2: Test procedure and requirements.
IEC 61439	Low Voltage Switchgear and Controlgear Assemblies

In addition, the auxiliary and control equipment and components shall comply with the relevant IEC standards

3. ENCLOSURE

3.1 The auxiliary control panels shall be:

- a) Fabricated sheet steel, or GRP where specified in the data sheet.
- b) Painted and finished in accordance with the VENDOR as well as COMPANY standard for indoor or outdoor installation as applicable, whichever is more stringent.
- c) Have bottom cable entry, unless specified otherwise on the data sheets.
- d) Provided with LED type panel light, operated by a door switch, unless specified otherwise.
- e) Pad-lockable incoming supply switch where applicable.
- f) Equipped with an anti-condensation heater.

3.2 Floor mounted panels shall be rigid, self-supporting, and installed on a base frame.

- 3.3 Enclosures and doors shall be fabricated of heavy gauge steel of minimum thickness of 2mm with structural reinforcing members as 3mm minimum.
- 3.4 Wall mounted panels shall be suitable for bolting to a frame to be fixed to the wall.
- 3.5 Components mounted within the control panels shall be din rail mounted on a removable back-plate.
- 3.6 Door mounted metering, protection, and indication components shall be flush mounted.

4. WIRING AND TERMINATION

- 4.1 Wire Conductor material shall be stranded copper
- 4.2 Minimum conductor size shall be as below.
 - a) Power circuit: 2.5 sq. mm
 - b) Control circuit: 1.0 sq. mm
 - c) Data communication: Unless otherwise specified the minimum conductor size for data communication shall be as per Table 5 of IEC 60204-1.
- 4.3 Wire insulation shall be:
 - a) 450/750V grade for power circuits
 - b) 250V grade for instrumentation.
- 4.4 Wiring, including accessories and trunking shall be as below:
 - a) Flame retardant complying with IEC 60332 series standards.
 - b) Where specified on data sheet these shall be low smoke and halogen free complying with the following requirements.
 - i. Minimum light transmission value of 60%, conforming to IEC 61034-2.
 - ii. Maximum halogen gas emission of 0.5%, when tested in accordance with IEC 60754-1.
- 4.5 Cables shall be run in trunking or conduits. Separate trunking shall be provided within the panel for CONTRACTOR wiring to be completed at site, where terminal blocks are not mounted adjacent to incoming cable glands.
- 4.6 Trunking fill shall be limited to maximum 70%.
- 4.7 Gland plates shall be undrilled metallic compatible with cable armour and panel material.
- 4.8 Terminals and lugs shall be one of the following:
 - a) Crimped bootlace type lugs.
 - b) Crimped ring type copper lugs.
 - c) Screw-less push-in type terminals (if approved by Approving Authority).
- 4.9 Wires shall be identified at terminating points using printed heat-shrink sleeves.
- 4.10 20% spare terminals shall be provided in each section of terminal blocks for future use.

- 4.11 All spare I/O contacts of protection and auxiliary relays shall be wired to terminal blocks and numbered as per VENDOR documentation.
- 4.12 Unless the access to live terminals is prevented by interlocking (or otherwise), terminal and lugs at voltage above 110 V shall be shrouded.
- 4.13 Terminal Arrangement and Segregation:
 - a) Terminal blocks shall be grouped into separate terminals for internal and external connections.
 - b) Terminals carrying different voltages shall be segregated.
 - c) Only one conductor shall be terminated in one side of a terminal
- 4.14 Where necessary shorting terminals (or switch terminals) shall be used to facilitate operations and testing.
- 4.15 Terminals associated with inductive CT circuits shall be provided with shorting links mounted in an accessible position in the LV compartment.
- 4.16 Disconnection links shall be used for earthing of control supplies and CTs.
- 4.17 VTs shall be provided with isolating type terminals.
- 4.18 The VENDOR shall include in his scope of supply test plugs and connection cables for relay testing purposes

5. COLOUR CODING AND MARKING:

- 5.1 The colour and marking of actuators (push buttons) shall be in accordance with IEC 60204-1.
- 5.2 The following colour code shall be used:
- 5.3 Status signal light:
 - a) On/closed: RED
 - b) Off/Open: GREEN
 - c) Fault/Trip: YELLOW
 - d) Voltage presence: WHITE
 - e) Anti-con heater on WHITE
- 5.4 Non-illuminated push button:
 - a) On/Close/Start: GREEN
 - b) Off/Open/Stop: RED
 - c) Emergency Stop RED
 - d) Lamp test BLACK
 - e) Reset BLUE (if any)
- 5.5 Mechanical indication shall be provided for the following positions of circuit breakers, if applicable:
 - a) Close / Open position

- b) Test / Service / Withdrawn position
 - c) Spring charged / discharged condition
 - d) Earth switch position Open / Closed
- 5.6 Conductors and terminals shall be in compliance with the IEC 60445

6. EARTHING AND BONDING

- 6.1 A separate earth bar shall be provided within the panel for termination of all earth wires.
- 6.2 The earth bar shall be insulated from the back-plate but connected by one earthing conductor to the back-plate. Unless otherwise specified, this bus bar shall have a minimum cross-sectional area in accordance with clause 8.2.2 of IEC 60204-1.
- 6.3 Earthing bus bars and conductors shall be hard-drawn, high-conductivity copper.
- 6.4 A means of earthing the incoming cable glands and the enclosure to this central earthing point shall also be provided.
- 6.5 An earth stud shall be provided on all doors, with earthing straps across hinges.
- 6.6 Panels containing instrument circuits requiring instrument reference earth shall be equipped with a separate instrument earth bar insulated from the enclosure protective earth.
- 6.7 A separate IS earth bar, insulated from both the PE and the instrument earth bar, shall be provided for non-galvanic IS components located in the panel.

7. LABELS AND IDENTIFICATION

- 7.1 Equipment and components shall be tagged as per the ADNOC tagging and numbering procedure, document reference (Document number will be advised later)
- 7.2 Each equipment and component shall be labelled as per the general arrangement drawings.
- 7.3 Warning labels shall be provided with white characters on a red background for the following:
 - a) Terminals remaining live when a functional unit is isolated
 - b) Terminals associated with external sources of supply
- 7.4 Identification labels shall be laminated, engraved Traffolyte with black letters on a white background. The text shall be in the language nominated on project documentation.

8. ANTI-CONDENSATION HEATER:

- 8.1 Each assembly section of enclosures shall be equipped with anti-condensation heaters.
- 8.2 Capacity of heaters shall be sufficient to prevent the formation of possible condensation under the service conditions.
- 8.3 Anti-condensation heaters shall:
 - a) Have IP 2X protection.

- b) Be fitted with a guard.
- 8.4 Anti-condensation heaters shall be controlled by hygrostats.
- 8.5 The heater shall be energised from an external power source at 240/220VAC, single phase and neutral.
- 8.6 Each heater circuit shall be provided with a manually controlled cut off switch mounted at the control cubicle/compartment.
- 8.7 Each heater circuit shall be supplied from a residual current circuit breaker (RCCB) equipped with the following:
 - a) 30 mA earth leakage protection and
 - b) Auxiliary contacts for 'tripped' and status indication.
 - c) Padlocking facility.
- 8.8 'Heater circuit live' indication shall be provided by means of white colour LED or lamp.
- 8.9 Panel power circuits for anti-condensation heater circuits associated with external equipment, e.g. excitation systems shall be switched on automatically when the equipment is not running.