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ADNOC GROUP PROJECTS AND ENGINEERING

SYNCHRONOUS MOTOR SPECIFICATION

Specification

AGES-SP-02-002

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

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

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INTER-RELATIONSHIPS AND STAKEHOLDERS

- a) The following are inter-relationships for implementation of this Specification:
- ADNOC Upstream and ADNOC Downstream Directorates and
 - 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 Synchronous Motor 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 synchronous motors.

2. SCOPE

- a) The specification applies to
 - i. Synchronous motors
 - ii. Associated excitation system and the excitation control panel.
 - iii. Purge and pressurising panel for EXp motors
- b) For ADNOC applications the synchronous motor rating is not likely to be less than 15 MW
- c) For 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	
AC	Alternating Current
ASD	Adjustable Speed Drive
AVR	Automatic Voltage Regulator
BOD	Basis of Design
CT	Current Transformer
CT	Current Transformer
DC	Direct Current
DEP	Shell Design and Engineering Practice
EMC	Electromagnetic compatibility
FAT	Factory Acceptance Test
GOOSE	Generic Object Oriented Substation Events
GRP	Glass Reinforced Plastic
HFCT	High Frequency Current Transformer
HV	High Voltage (above 1kV)
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMS	Integrated Management System
ISO	International Organization for Standardization
ITP	Inspection and Test Plan
kV	Kilo Volts

kW	Kilo Watt
LED	Light Emitting Diode
LV	Low Voltage ($\leq 1000V$)
MCB	Miniature Circuit Breaker
MCS	Maximum Continuous Speed
NEMA	National Electrical Manufacturers Association
PSR	Process Safety Requirement
RCCB	Residual Current Circuit Breaker
RACI	Responsibility assignment matrix
RTD	Resistance Temperature Detector
SDRS	Supplier Document Register and Schedule
THD	Total Harmonic Distortion
VFD	Variable Frequency Drive
VPI	Vacuum Pressure Impregnation
VT	Voltage Transformer

References

See reference documents

4. NORMATIVE REFERENCES

4.1 INTERNATIONAL CODES AND STANDARDS

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

American Petroleum Industry

API Standard 617

API Standard 670

Axial and Centrifugal Compressors and Expander-compressors

Machinery Protection Systems

API Standard 671

Special Purpose Couplings for Petroleum, Chemical and Gas Industry Services

International Electrotechnical Commission (IEC)

IEC 60034-1	Rotating electrical machines. Rating and performance
IEC 60034-2	Rotating electrical machines. Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)
IEC 60034-4-1	Rotating electrical machines. Methods for determining electrically excited synchronous machine quantities from tests
IEC 60034-5	Rotating electrical machines. Degrees of protection provided by the integral design of rotating electrical machines (IP code). Classification
IEC 60034 6	Rotating electrical machines - Part 6: Methods of cooling (IC Code).
IEC 60034 7	Rotating electrical machines - Part 7: Classification of types of construction, mounting arrangements and terminal box position (IM Code).
IEC 60034 14	Rotating electrical machines - Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher - Measurement, evaluation and limits of vibration severity.
IEC 60034 15	Rotating electrical machines - Part 15: Impulse voltage withstand levels of form-wound stator coils for rotating AC machines.
IEC 60034-29	Rotating electrical machines. Equivalent loading and superposition techniques. Indirect testing to determine temperature rise
IEC 60060 2	High-voltage test techniques - Part 2: Measuring systems.
IEC 60079	Explosive atmospheres - All Parts.
IEC 60255 1	Measuring relays and protection equipment Part 1: Common requirements.
IEC 60529	Degrees of protection provided by enclosures (IP Code).
IEC 60617-DB	Graphical symbols for diagrams.
IEC 60751	Industrial platinum resistance thermometers and platinum temperature sensors
IEC 60894	Guide for a test procedure for the measurement of loss tangent of coils and bars for motor windings.
IEC 61000-2-4	Electromagnetic compatibility (EMC). Environment. Compatibility levels in industrial plants for low frequency conducted disturbances
IEC 61000-6-2	Electromagnetic compatibility (EMC) Generic standards Immunity for industrial environments.
IEC 61000-6-4	Electromagnetic compatibility (EMC) Generic standards Emissions for industrial environments.
IEC 61850-3	Communication networks and systems in substations Part 3: General requirements.

IECEX 02	IEC System for Certification to Standards Relating to Equipment for use in Explosive Atmospheres (IECEX System)
ANSI C-37.2	Electrical power system device function numbers
International Organization for Standardization	
ISO 12944-2	Paints and varnishes. Corrosion protection of steel structures by protective paint systems. Classification of environments, Part 2: Classification of environments
ISO 12944-5	Paints and varnishes - Corrosion protection of steel structures by protective paint systems, Part 5: Protective paint systems
ISO 21940-11	Mechanical vibration. Rotor balancing. Procedures and tolerances for rotors with rigid behaviour
ISO 21940-12	Mechanical vibration. Rotor balancing. Procedures and tolerances for rotors with flexible behaviour
National Electrical Manufacturers Association (NEMA)	
ANSI/NEMA MG 1-2016, SUPPLEMENT-2018 American National Standard for Motors and Generators	
Institute of Electrical and Electronics Engineers (IEEE)	
IEEE 421.2	Guide for Identification, Testing, and Evaluation of the Dynamic Performance of Excitation Control Systems

SECTION A

5. REFERENCE DOCUMENTS

5.1 ADNOC REFERENCE DOCUMENTS

AGES-SP-02-007	HV and LV Induction Motors Specification
AGES-SP-02-001	Power Transformers Specification.
AGES-SP-02-004	Electrical Adjustable Speed Drive System Specification
AGES-SP-02-008	ECMS (Electrical Control & Monitoring System) Specification.
LATER	ADNOC tagging and numbering procedure
LATER	ADNOC painting, preservation and shipment specification

5.2 STANDARD DRAWINGS

To be advised later

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.

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

- UAE Statutory Requirements
- ADNOC Codes of Practice
- Equipment Data Sheets and Drawings
- Project Specification 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 manufacturer 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 manufacturer 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

8.1 DESIGN BASIS

- (a) Motor, including excitation systems and all accessories shall:
 - (i) Have an expected lifetime of at least 30 years at rated output under the service conditions specified and maintained according to manufacturer's recommendation.
 - (ii) Be suitable for 6 years continuous uninterrupted operation.
- (b) Motor, controlgear assemblies and sub-components with less than 6 years proven operational service shall only be used if approved by COMPANY.
- (c) VENDOR shall state and include in the proposal the necessary motor monitoring and maintenance requirements to ensure continued reliable operation. As a minimum the following monitoring shall be included.
 - (i) Lube oil quality sampling
 - (ii) Winding partial discharge activity trending.

8.2 DESIGN PARAMETERS

Refer to Data Sheet

8.3 ENVIRONMENTAL / SITE DATA

- (a) Motors shall be suitable for installation in an outdoor location:

- (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:
 - 1. C5-I for onshore facilities.
 - 2. C5-M for offshore facilities.

(b) Outdoor site conditions shall be as stated in Table 1

Table 1 Outdoor ambient air temperature and humidity

Site condition	Onshore facilities	Offshore facilities
Maximum ambient air temperature	54 °C	48 °C
Minimum ambient air temperature	5°C	5°C
Maximum relative humidity	97% at 43°C	97% at 43°C

(c) Indoor site conditions shall be as stated in Table 2.

Table 2 Indoor ambient air temperature and humidity

Site condition	Onshore and offshore facilities
Maximum ambient air temperature	40 °C
Minimum ambient air temperature	5°C
Maximum relative humidity	97% at 43°C

(d) Cooling water and lube oil site conditions shall be as stated in Table 3.

Table 3 Cooling water and lube oil temperatures

Site condition	Onshore facilities	Offshore facilities
Maximum water coolant output temperature	See site specific data sheet	

Maximum temperature rise of water coolant	See site specific data sheet
Cooling water velocity range in tubes	1 to 2.5 m/s
Fouling resistance	0.52x10 ⁻³ m ² K/W (unless otherwise specified)
Permissible lube oil temperature rise	25°C for motor rated speed < 5000 rpm 33°C for motor rated speed ≥ 5000 rpm

8.4 AREA CLASSIFICATION

- (a) Motors and motor terminal boxes located in gas and vapour hazardous classified areas shall be provided with protection using the following methods:
 - (i) Ex “pzc” or EX “pxb” and Ex “ec” for zone 2 classified areas (dual certification)
 - (ii) Ex “pxb” and terminal box can be Ex “eb” for zone 1 classified areas.
- (b) Motors located in zone 1 classified areas shall be configured to trip on loss of pressurisation and shall not continue to operate on Ex “ec” protection.
- (c) Pressurisation pipework and valves shall be fabricated using SS 316L.
- (d) Air filter shall be duplex type.
- (e) Motor shall be suitable for operation in the gas group IIB and temperature class T3 unless more arduous requirements are specified on the data sheets.
- (f) Motor rating and temperature class shall be independent of the purging system.
- (g) If required on the project supplementary information, motors located in dust hazardous areas shall also be provided with level of protection for the dust group in conformance with IEC 60079-31.
- (h) Certification shall be provided by either:
 - (i) An approved IEC Ex Certification Body
 - (ii) An approved Notified Body if permitted by Company.
- (i) Self-certified equipment shall not be permitted.
- (j) Certification shall not be invalidated by additional features such as:
 - (i) Drain holes

- (ii) Protective systems
 - (iii) Noise abatement measures
- (k) Auxiliary devices mounted on the motor for protective, alarm or other purposes shall comply with the requirements of the appropriate type of protection for electrical equipment used in hazardous atmospheres.

SECTION B

9. TECHNICAL REQUIREMENTS

9.1 BASE STANDARDS

The synchronous motor shall comply with the following standards:

- (i) IEC 60034-1
- (ii) IEC 60034-14
- (iii) Associated standards referenced in the above standards

9.2 AMENDMENTS AND SUPPLEMENTS TO IEC 60034-1

1 Scope

- 1 This specification is applicable to HV rotating synchronous motors.

4.1 Duty

- 1 Unless otherwise specified, the motor shall be designed for duty type S1: continuous running duty as defined in IEC 60034-1

5.7 Co-ordination of voltages and outputs

- 1 Unless otherwise specified in the data sheet COMPANY power supply voltage shall be 11 kV

6 Site conditions

- 1 See section 9.2 and 9.3 of this specification for modifications to IEC 60034-1 clauses 6.3 to 6.5

6.6 Standstill, storage and transport

- 1 Motor, including excitation systems and all accessories shall be suitable for periods of standstill for up to 6 months within the 6 years continuous operation.
- 2 Following a period of standstill, the motor shall, without requirement for additional inspection, be suitable for another running period.
- 3 Bearings shall be protected against corrosion during transport and storage.
- 4 Products used for protection shall not require mechanical or manual cleaning of the bearings prior to commissioning of the motor.
- 5 Rotors shall be secured during transport to avoid damage caused by axial or radial movement of the rotor.

7.2 Form and symmetry of voltages and currents

7.2.1 AC motors

- 1 Equipment shall be suitable for operation on a network supply with harmonic voltage THD up to 8% unless a more arduous duty is specified on the data sheets.
- 2 Individual harmonic distortion shall not exceed the limits of class 2 as defined in IEC 61000-2-4.
- 3 For variable speed driven motors, VENDOR shall provide a co-ordinated insulation design that will be suitable for operation

7.3 Voltage and frequency variations during operation

- 1 The motors shall operate within Zone A unless otherwise specified in the data sheet.

7.4 Three phase AC motors operating on unearthed supply

- 1 Motors shall be suitable for operation on an unearthed system with an earth fault on one phase for periods for:
 - a) Up to 8 hours for a single earth fault.
 - b) A total operating time of 125 hours in one year.

7.5 VOLTAGE (PEAK AND GRADIENT) WITHSTAND LEVELS

- 1 Stator windings shall be able to withstand the voltage (peak and gradient) withstand levels specified in IEC 60034-15.

8.1 Thermal class

- 1 Insulation system for both stator, rotor and exciter windings shall be class F in accordance with IEC 60085.
- 2 Stator temperature rise when operating at rated with maximum cooling medium and site coolant and ambient temperatures:
 - a) Shall not exceed Class B rise when operating in zone A.
 - b) Shall not exceed Class F rise when operating in zone B.
- 3 Exciter temperature rise shall not exceed Class B rise.

9 Other performance and tests

Refer to section 15 for routine and type tests.

9.4 Momentary excess torque for motors

9.4.2 Polyphase synchronous motors

- 1 Pull-out torque shall be in excess of the following:
 - a) 135% of the rated torque for cylindrical rotor motors.
 - b) 150% of the rated torque for salient pole motors.
- 2 Transient Air-gap Torque
 - a) Bracing of all motor end windings shall be designed to withstand a three-phase short circuit at the motor terminals.
 - b) The shaft and active iron core systems shall withstand two-phase short circuits.
- 3 VENDOR shall state the maximum transient air-gap torques during:
 - a) Asynchronous start;
 - b) Two and three phase short-circuit at the motor terminals;
 - c) Reconnection after power interruption.

10.2 Marking

- 1 Add to the list.
 - (a) COMPANY's purchase order number
 - (b) COMPANY's TAG number
 - (c) Efficiency at full load
 - (d) Sub-transient reactance (not applicable to exciter)
 - (e) Transient reactance (not applicable to exciter)
 - (f) Insulation and temperature rise class
 - (g) Rated exciter field current
 - (h) Locked rotor current at rated voltage and frequency
 - (i) Locked rotor torque at rated voltage and frequency
 - (j) Allowable running-up time at rated voltage and 80 % rated voltage
 - (k) Maximum and minimum speed of the ASDs
- 2 Values provided shall be the measured values at normal operating conditions.
- 3 If the rating plate is not easily accessible, manufacturer shall supply a second plate to be mounted on the equipment in an accessible location.
- 4 Bearing information shall be provided on a separate rating plate and include the following:
 - (a) Bearing type

- (b) Size
- (c) Clearance
- (d) Shaft and housing fit for driving end and non-driving end.
- (e) Lubricant
- (f) Re-lubrication interval.
- (g) Minimum and maximum allowable quantity of lubricant for the driving end and non-driving end bearings.
- (h) Oil pressure required, for force lubricated bearings.

- 5 An asset number plate shall be fixed on a non-removable part of the motor frame. Characters shall be 6mm high, followed by a blank space of 15 x 65mm. Marking plates shall be stainless steel.

12 Tolerances

12.2 Tolerances on values of quantities

Modify clause.

- 1 Unless stated otherwise, tolerances on declared values shall be as specified in Table 21 of IEC 60034-1 with the modifications noted in the Table 12.1.

Table 12.1 Acceptable Tolerances:

	ITEM	TOLERANCE
1)	Efficiency	$\eta = \text{guaranteed value} - 5\% \text{ of } (1 - \eta)$
13)	Locked rotor current of synchronous motors	+ 0% of guaranteed value, no lower limit
N/A	pull-in torque for synchronous motors	+ or - 10% of guaranteed value
N/A	moment of inertia	+ or - 10% of guaranteed value
N/A	vibration	+ 0%, no lower limit
N/A	winding temperature rise	+ 0%, no lower limit
N/A	bearing temperature rise	+ 0%, no lower limit
N/A	noise level	+ 0%, no lower limit

N/A	total mass	+ 10%, no lower limit
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13 EMC

13.1 General

Motors shall be suitable for installation in an industrial environment as defined by IEC 61000-6-4.

13.2 IMMUNITY

Motors shall be suitable for installation in an industrial environment as defined by IEC 61000-6-2.

9.3 AMENDMENTS AND SUPPLEMENTS TO IEC 60034-14

8 Limits of bearing housing vibration

8.1 Limits of vibration magnitude

Unless more arduous requirements are specified on the data sheets motors shall comply with the requirements of vibration grade A.

Maximum allowable vibration levels shall apply to:

- (i) All operating temperatures of the motor
- (ii) All operating conditions between no-load and full load.

The vibration severity of the motor frame, including main terminal boxes, (excluding bearings) shall not exceed 4.5 mm/s (rms).

10. ADDITIONAL SPECIFIC REQUIREMENTS

In addition to the IEC Standards' requirements, the synchronous motor shall comply with the following requirements:

10.1 STARTING

- (a) Motors shall be designed for:
 - (i) Starting against load torque with the voltage at the motor terminals stated on the data sheets.
 - (ii) If no voltage is stated on the data sheets a value of 80% voltage at the motor terminals shall be used.

- (iii) Motors shall be capable of resynchronizing and re-acceleration under full load conditions following a power interruption not exceeding 0.2 s. A quadratic torque-speed characteristic for the driven equipment can be assumed
- (iv) If the re-acceleration requirement above cannot be met, and for other driven equipment torque-speed characteristics, VENDOR shall provide detailed information regarding the re-acceleration ability of the motor
- (v) 3 consecutive starts with rated load inertia and the motor initially at maximum ambient temperature
- (vi) 2 hot consecutive starts with the motor initially at full load operating temperature.
- (vii) 1000 starts per year.
- (b) A further 2 consecutive starts shall be possible after a cooling period of 30 minutes at standstill.
- (c) Motor may be assumed to decelerate under operating conditions to standstill between consecutive starts.
- (d) Motor starting current shall not be greater than 6 times the motor full load current with no positive tolerance unless a lower limit is specified on the data sheet.
- (e) Acceleration and pull-in torque shall be a minimum of 10% in excess of the load torque throughout the speed range from standstill to synchronous speed.
- (f) VENDOR shall state with quotation the following information with 80% and 100% rated voltage applied at motor terminals:
 - (i) Run-up time at rated and 80% voltage.
 - (ii) Maximum allowable run-up time.
 - (iii) "Hot" and "cold" maximum allowable stalling time.

10.2 UNIT TRANSFORMER

- (a) If a unit transformers is specified it shall be:
 - (i) Supplied in conformance with transformers specification KBR-10-SPE-0003.
 - (ii) Thermally and mechanically designed to withstand:
 1. The number and frequency of motor starts required by this specification and associated data sheets.
 2. Re-acceleration duty, if required.
- (b) Transformer secondary shall be resistance earthed.

10.3 EXCITATION SYSTEM

- (a) VENDOR shall provide the excitation system.
- (b) Excitation system shall
 - (i) Be rated for operating with a leading power factor of 0.9 at rated output and a voltage applied at the motor terminals between 90% and 110% of the rated voltage.
 - (ii) When specified for motors, the exciter field shall be supplied from a constant voltage transformer, a phase controlled rectifier, or other approved means to maintain 95 % of rated voltage or better for at least two seconds when the primary supply voltage drops to as low as 50 % of normal voltage
 - (iii) For ASD fed motors the excitation system shall be suppressed as soon as a trip is triggered by the ASD.
 - (iv) Include the following equipment:
 - 1. Brushless exciter
 - 2. Rotating diode rectifier assembly
- (c) Excitation control panel shall be installed in a remote substation building.
- (d) Excitation control panel shall:
 - (i) Maintain the set power factor via automatic power factor controller within a margin of +2.5% to -2.5%.
 - (ii) Include the following features:
 - 1. Manual power factor adjustment
 - 2. Door mounted multifunction digital control panel for exciter control.
 - (iii) Include the following protection functions.
 - 1. Out of step
 - 2. Rotating diode failure
 - 3. Loss of excitation
 - 4. Rotor earth fault
 - (iv) Excitation control panel wiring shall be in conformance with the requirements of Annexure 1.
- (e) Exciter rotating diode semiconductors shall have a minimum rating of:
 - (i) 200% of the maximum continuous excitation current if series connected.
 - (ii) 220% of the maximum continuous excitation current if connected in parallel.

- (iii) Reverse blocking voltage rating of 200% of the maximum peak voltage generated by the main exciter.
- (iv) The rotating exciter diodes shall be of hermetically sealed silicon type protected against abnormal transient conditions by surge protector

10.4 EFFICIENCY

- (a) Motor efficiency at rated power and power factor shall not be less than:
 - (i) 98% for 2 pole motors.
 - (ii) 97.5% for 4 pole motors.
- (b) Motor efficiency shall include losses associated with the following systems:
 - (i) Excitation
 - (ii) Lubrication
 - (iii) Cooling
- (c) Unless stated otherwise on the data sheets rated power factor shall be 0.9p.u. Leading.

10.5 STATOR

- (a) Stator windings shall be:
 - (i) Form wound insulated coils
 - (ii) Star connected
 - (iii) Provided with anti-corona protection
 - (iv) Supported, braced and blocked over the full slot length to provide sufficient rigidity and to limit end winding vibration and subsequent cracking of the winding insulation.
 - (v) Able to withstand the dynamic forces, resulting from frequent starting, and starting against full opposite residual voltage.
- (b) Inter-coil packing blocks shall:
 - (i) Be positively secured to the coils by binding with cord or tape.
 - (ii) Not rely on varnish or tight initial wedging for holding the blocks in place.
- (c) Magnetic slot wedges shall only be used if VENDOR:
 - (i) Demonstrates at least 5 years of continuous operation on past installations with sufficient supply records.
 - (ii) Guarantees against failure of wedges for at least 5 years after commissioning of the machine

- (d) Motors with rated voltage > 6kV shall:
 - (i) Use mica insulation material
 - (ii) Be provided with stress grading and anti-corona protection.
- (e) Final insulation process shall be completed by use of one of the following methods
 - (i) Full VPI method.
 - (ii) Individual forming and curing of the slot parts of the windings with subsequent impregnation of the complete stator according to the VPI method.
 - (iii) Resin rich method only with approval of COMPANY.

10.6 ROTOR AND EXCITER WINDING:

- (a) The rotor windings exceeding 2 kV shall have anti-corona protection and stress grading.
- (b) The field windings shall be made of copper protected from corrosion with either resin or varnish.
- (c) The field coils shall withstand all normal transient conditions occurring during a balanced or unbalanced short circuit.

10.7 ROTOR SHAFT

- (a) Salient pole rotor shaft shall be machined from a single heat treated rotor forging. Welding on finished shafts is not allowed. Shafts and spiders subjected to welding shall be post-weld heat-treated.
- (b) Pole faces of salient pole motors may be bolted to the rotor if design has 3 years of proven continuous operation.
- (c) The shaft end shall be permanently marked with the indication 'H' to identify a half-key fitted in the keyway when balanced.
- (d) Surface finish of the machined shaft at the location where the non-contacting eddy current proximity probes are fitted shall be 0.8 μm maximum as specified in API 670.
- (e) Rotor float allowed by the bearings shall be at least ± 3 mm and maximum ± 6 mm from the magnetic centre.
- (f) Magnetic centre together with the limits of the maximum permissible axial float shall be indelibly indicated on the motor.
- (g) It shall be possible to observe the rotor position relative to the magnetic centre mark at all times.
- (h) Rigid rotor designs shall:
 - (i) Be balanced in conformance with procedure in ISO 21940-11.
 - (ii) Conform to balance quality G2.5.

- (i) Motors with flexible, over-critical rotor bearing systems, balancing shall be carried out at nominal speed in conformance with one of the methods outlined in ISO 21940-12.
- (j) (Flexible) Rotor balance acceptance criteria shall be agreed with manufacturer prior to award of purchase order.
- (k) After the over speed test, the rotor balance condition shall be verified to be still within the agreed limits

10.8 CRITICAL SPEEDS

- (a) Manufacturer of driven equipment shall perform a torsional vibration analysis of the complete train.
- (b) Motor manufacturer shall provide:
 - (i) The physical data required for the torsional analysis.
 - (ii) Lateral analysis.
- (c) When motor is fed by ASD, the motor manufacturer shall liaise with ASD supplier and driven machine supplier to take into account as part of torsional vibration analysis, the axial, radial and torsional stresses produced as a result of ASD voltage and current power supply.
- (d) 4 pole single speed motors
 - (i) Motors shall have a rigid, under-critical rotor-bearing system.
 - (ii) First rotor bending critical speed shall not be lower than 125% of the synchronous speed or maximum speed for ASD motors.
- (e) 2 pole single speed motors
 - (i) Motors may have a flexible, over-critical rotor-bearing system if permitted by COMPANY.
 - (ii) First critical speed shall be below 80% of the rated synchronous speed.
 - (iii) Second critical speed shall not be lower than 125% of the rated synchronous speed.
- (f) ASD driven motors should have a rigid, under-critical rotor bearing system with the first critical speed over 125% of the maximum operational speed of the ASDs.
- (g) ASD driven motors with flexible, over-critical rotor bearing system shall have:
 - (i) First critical speed below 80% of the minimum operational speed of the ASD
 - (ii) Second critical speed over 125% of the maximum operational speed of the ASDs.
- (h) High speed ASD driven motors shall meet the "Dynamics" requirements specified in API 617.
- (i) Analysis of high speed motor critical speeds shall be
 - (i) Submitted to the COMPANY for approval.
 - (ii) Confirmed during FAT.

10.9 COOLING

- (a) Unless otherwise specified, cooler assemblies for critical motors shall be provided with 2 off 50% coolers that permit operation at:
 - (i) 70% loading within class B temperature rise limits.
 - (ii) 100% loading within class F temperature rise limits.
- (b) Tubes and filters shall be accessible for cleaning.
- (c) Cooler assemblies shall be designed such that the natural frequency of vibration of the tubes is not excited by the motor's running frequency or its harmonics.
- (d) Motors with air to water heat exchangers (IC8A1W to IEC 60034-6) shall be provided with the following:
 - (i) Single tube copper nickel design if cooled by treated water.
 - (ii) Double tube titanium design if cooled by sea water.
 - (iii) Collection trays to prevent water leaking onto stator or terminations.
 - (iv) Cooler isolation valves.
 - (v) Drain and vent valves.
 - (vi) Leak detection
 - (vii) Have a 20 % surplus number of tubes to allow for plugging of leaking tubes
 - (viii) The water box or header construction of heat exchangers shall be such that leaking tubes can be readily plugged and all tubes are accessible for cleaning.
- (ix) Where more than one heat exchanger is installed and one of the heat exchangers can be out of operation, VENDOR shall confirm that the machine will not develop hot spots because of changed internal air temperature and circulation
- (e) Motors with air to air heat exchangers (IC6A1A1 or IC6A1A6 to IEC 60034-6) motors
 - (i) Cooling air inlets shall be protected by a corrosion resistant mesh screen. Mesh wire of galvanized steel is not acceptable.
 - (ii) Surfaces of heat exchanger shall be provided with corrosion protection.
 - (iii) IC6A1A6 motors shall be equipped with N+1 motor driven fans.

10.10 EXTERNAL FANS

- (a) The external fan, and if applicable the separately mounted internal fan(s), shall be individually balanced.
- (b) External fans shall be
 - (i) Keyed onto the shaft.
 - (ii) Of non-corroding material or shall be treated with a corrosion resistant coating.
- (c) External fan covers shall be made of:
 - (i) Metallic material and treated with a corrosion resistant coating.
 - (ii) Non-metallic material if approved by the COMPANY.
 - (iii) Aluminium or Aluminium alloys shall not be used
- (d) External fan flow of cooling air shall be in the direction of the driven equipment.
- (e) Unidirectional fans shall be provided with an engraved arrow permanently indicating the direction of rotation.
- (f) Indication by means of a painted or adhesive arrow is not acceptable.

10.11 ENCLOSURE

- (a) Degree of protection shall be:
 - (i) IP55 for the motor in conformance with IEC 60034-5.
 - (ii) IP55 for auxiliary junction boxes in conformance with IEC 60529.
- (b) Enclosure and terminal box fixing bolts shall be stainless steel.

10.12 MOTOR HOUSING

- (a) Motor shall have jacking bolts or facilities to lift the machine with the aid of a mechanical jacking device to facilitate alignment of the machine with the mechanical equipment.

10.13 STATOR FRAME

- (a) The frames shall have machined feet. If the foot is hollow, the machined feet shall have supporting surfaces at four sides of each foot.
- (b) Corresponding mounting surfaces for horizontal machines shall be in the same plane and within a tolerance of 0.15 mm per meter distance between surfaces after machining.

10.14 NOISE LIMITS

- (a) Motors should preferably meet the maximum allowable noise limits by design and not by corrective measures.
- (b) If machines cannot meet the maximum allowable noise limits by design, the Manufacturer/Supplier proposed corrective measures shall be subject to approval by the COMPANY.
- (c) The sound pressure level of the loaded machine shall not exceed 82dBA measured in accordance with ISO 1680 when fed with sinusoidal voltage. In addition, 85dBA shall be the maximum value for motors fed by an ASD.
- (d) In package configuration, VENDOR and the package leader shall liaise to ensure that the electric motor will be designed in such a manner that the overall package noise level, as defined in each individual electric motor driven equipment package specification, is not exceeded

10.15 TERMINAL BOX

- (a) Main terminal arrangement may use one of the following methods:
 - (i) Phase insulated
 - (ii) Phase segregated
 - (iii) Phase separated
 - (iv) Elastimold terminations
- (b) Terminal box shall be:
 - (i) Air insulated,
 - (ii) Fabricated from steel.
 - (iii) Provided with the following:
 1. Space for installation of star point differential protection CT's and partial discharge sensors. Details of CT's shall be provided at placement of purchase order.
 2. Pre-drilled and threaded gland plate.
 3. Certified anti-condensation breather.
 4. Pressure relief vent.
 5. Synthetic resin type bushings
- (c) Short circuit rating of terminal box, bushings and terminations shall:
 - (i) Be in excess of the short circuit value stated on the data sheet.
 - (ii) Be rated for a minimum of 1s.
- (d) Discharge of exhaust products of an electrical breakdown from relief vent shall be away from personnel.
- (e) Unless otherwise stated on the data sheets, main terminal box shall be located on the side of the machine.

- (f) Star point terminal box, if provided, shall be located on the opposite side to main terminal box. The star point terminal box shall have adequate space for the installation of star side differential CTs. Details of CT's shall be provided by the CONTRACTOR and made available to the manufacturer for installation in the terminal box.
- (g) Final position of terminal box shall be fixed at Purchasing Order stage.
- (h) Lowest part of the terminal box, including cable gland shall not be lower than the lowest part of the motor.
- (i) Cable gland entry thread shall be metric with the size detailed on the data sheet.
- (j) Gland plate for single core cables shall be non-magnetic material.
- (k) Clamping devices shall be provided inside the main terminal box to separate and support the cable conductors and, if applicable, the winding end-tails. This is to ensure that the ability to withstand the short-circuit current will be maintained after completion of the termination. Clamping devices material shall be non-hygroscopic.

10.16 COUPLING

- (a) Coupling shall be designed to without permanent deformation the maximum transient torques which can be expected at the coupling from:
 - (i) Two or three-phase short-circuit at the motor terminals.
 - (ii) During asynchronous connection of a synchronous motor.
- (b) Driven equipment manufacturer shall supply the coupling half for the motor manufacturer to mount.
- (c) Shaft key shall be dimensioned based on drawing supplied by the driven equipment manufacturer to avoid residual imbalance or additional machining of key.
- (d) The coupling components shall be balanced individually and the assembled coupling shall be balanced as a unit by the driven equipment manufacturer.
- (e) Coupling design shall be in accordance with API 671.
- (f) The shaft ends shall be provided with a threaded hole or holes to facilitate the assembly or removal of the coupling and bearing races.
- (g) For motors intended to drive directly, loads, which require a variable torque during each revolution, e.g., reciprocating compressors, the shaft end design and coupling shall be matched to the driven equipment.

10.17 BONDING

- (a) Machines shall be fitted with bonding straps across joints within or between the main enclosure, the bed plate and the heat exchanger.
- (b) Bonding across the main frame and terminal is necessary unless VENDOR can demonstrate the absence of circulating current defects.
- (c) Internal steel work, e.g. air guides, shall be bonded so that no sparking can occur across joints.

10.18 BEARINGS AND LUBE OIL SYSTEM

- (a) Motors and exciters shall be equipped with self-lubricated or force-lubricated hydrodynamic sleeve bearings.
- (b) Sleeve bearings shall be of the spherical seated, self-aligning type.
- (c) Radial sleeve bearings shall have replaceable liners or shells.
- (d) Sleeve bearing design shall:
 - (i) Suppress hydrodynamic instabilities and provide damping to limit rotor vibration to the maximum specified amplitudes at both operating and critical speeds.
 - (ii) Permit motor starting without the aid of jacking oil.
 - (iii) Provide protection of the rotor in the event the rotor shifts axially as a result of the axial force exerted during uncoupled operation or the imbalance of axial forces during start-up.
- (e) If jacking oil systems are required, they shall be provided by the motor manufacturer.
- (f) Sleeve bearing housing design shall permit replacement of the bearing liners without disassembly of coupling or other machine parts.
- (g) Bearings shall be equipped with an oil level or flow indicator, visible without disassembly of any machine parts or noise abatement material.
- (h) Bearings with a ring lubricating system shall allow visual inspection of the oil ring operation while the machine is running.
- (i) Replenishment of lube oil shall be possible with the motor in operation.
- (j) Disc and wiper lubricated bearings may be used if:
 - (i) Designed for an oil change interval of at least 12 months.
 - (ii) The oil change shall be possible without disassembly of any other machine parts.
- (k) Bearing shall be arranged so that there will be no:
 - (i) Ingress of oil vapour into the motor and exciter housings
 - (ii) Contamination of oil from dust or sand.

- (iii) Leaks to the outside.
- (l) Motors that drive hydrocarbon gas compressors shall not have their lube-oil systems combined with that of the driven equipment unless the compressor is fitted with:
 - (i) Dry gas seals to prevent gas entering the lube-oil
 - (ii) Means to prevent lube-oil penetrating the dry gas seals.
- (m) If combined lube-oil systems are used, the driven equipment manufacturer shall supply the common lube-oil console.
- (n) Motors shall be able to run down safely if the forced lubrication fails or is switched off without the need for battery driven emergency lube oil pumps.
- (o) Rundown tanks shall be provided.
- (p) Motor manufacturer shall confirm rundown tank required elevation and capacity.
- (q) Lube oil piping shall be flanged or welded.
- (r) Insulated bearings shall be provided.
- (s) Method of insulation shall be:
 - (i) Permanent and non-deteriorating during assembly and disassembly of the bearing.
 - (ii) Provided with a shorting facility at the drive end of 2 bearing motors.
- (t) Shorting connection shall be removable for testing.
- (u) Single pedestal bearing motors insulation system shall be of 'sandwich' construction with two separate insulating layers.
- (v) Removable earthing connection shall bridge one layer to ensure equi-potential bonding of the middle conducting block.
- (w) Insulated bearing at the non-drive end of motor or on single bearing motors shall bear a prominent warning label reading: "Caution: Bearing Must Be Kept Insulated"
- (x) VENDOR shall provide the following bearing information with quotation:
 - (i) Bearing data, e.g., type, size, clearance, maximum allowable thrust;
 - (ii) Installation instructions;
 - (iii) Bearing insulation details;
 - (iv) Minimum permissible lube oil flow;
 - (v) Normal lube oil flow;
 - (vi) Required lube oil quality.

- (y) VENDOR shall confirm if barring is required.
- (z) For ASD motors, manufacturer shall liaise with the driven equipment manufacturer to obtain information on low-speed barring requirements of the whole train.
- (aa) Bearing lubrication system shall be compatible with low speed barring requirement.

10.19 MOTOR MONITORING AND PROTECTION

- (a) Partial Discharge Monitoring
 - (i) All motors shall be provided with HFCT partial discharge sensors.
 - (ii) HFCT's shall be installed in the motor terminal box and control wiring wired to a separate terminal box on the motor housing.
 - (iii) If motor is located within a hazardous area, sensors and termination arrangement shall be certified for use in the hazardous area.
 - (iv) Capacitor couplers can be used for partial discharge measurement where necessary for large motors.
- (b) Temperature monitoring and protection
 - (i) RTD's for windings, bearings and air circuit temperature monitoring shall be:
 1. 3 wire type, PT-100 platinum resistance elements to IEC 60751
 2. Wired to transmitters located within a junction box located on the machine skid.
 3. Located to detect the highest temperature.
 - (ii) RTD temperature detector shall measure temperature of the internal cooling air entering and leaving the heat exchanger.
 - (iii) Stator winding RTD's shall be provided as follows:
 1. A minimum of 2 simplex RTD's per phase.
 2. Separate RTD's for machine protection and condition monitoring.
 3. Supplied with either:
 - Independent test confirmation that the RTD's do not require over-voltage surge arresters.
 - Over-voltage surge protection for the RTD's installed on the auxiliary terminal box.
 - (iv) Sleeve bearings shall be provided with two RTD temperature detectors.
 - (v) Bearing RTD's shall not short circuit bearing insulation.
 - (vi) Rotor temperature monitoring system shall:
 1. Use wireless technology.

2. Convert signals to 4-20 mA for use within the machine monitoring system.
- (vii) Rotor monitoring system shall be suitable for operation in the classified area by one of the following methods:
1. Independent certification for monitoring system.
 2. Covered by the motor pressurisation certification.
- (c) Vibration monitoring and protection.
- (i) Vibration monitoring and protection shall be provided for radial shaft vibration monitoring.
 - (ii) X-Y probes shall be provided for each side of the bearing.
 - (iii) Radial Vibration protection shall trip the motor if any 2 of the drive or non-drive end bearing probes detect the 'high high' trip level.
 - (iv) Logic shall consider probe "not OK" as vote to trip.
 - (v) Vibration probes shall be non-contacting eddy current proximity probes provided in conformance with API 670.
 - (vi) Type and model number of the required probes shall be subject to approval by Company responsible engineer.
 - (vii) Probes shall be located at 90° to each other and mounted in such a way that replacement is possible while the motor is running.
 - (viii) Rotors shall be checked for runout and the correct location of the probe elements shall be determined before installation in the machine housing.

10.20 ANTI-CONDENSATION HEATERS

- (a) Anti-condensation heaters shall be provided for HV motor enclosure and HV terminal box.
- (b) Heaters shall:
- (i) Be a fully insulated design and suitable for operation on the voltage stated on the data sheet.
 - (ii) Be arranged to provide uniform heating.
 - (iii) Maintain the temperature of the motor 5C above ambient temperature.
 - (iv) Be wired to terminals in a separate heater terminal box mounted on the motor frame.
 - (v) Be provided with a prominent warning label stating: "Warning - Circuit May Be Live when motor is stationary".

10.21 MAINTENANCE ACCESS

- (a) Motors shall be fitted with inspection plates and access covers.
- (b) Access covers shall be provided to facilitate:

- (i) Measurement of air gap at drive end and non-drive end.
 - (ii) Maintenance of motor and excitation equipment.
- (c) VENDOR shall submit rotor withdrawal procedure with quotation.

10.22 MOTOR PURGE AND PRESSURISING UNIT:

- (a) A motor purge and pressurising system in accordance with IEC 60078-2 shall be provided by the motor VENDOR.
- (b) The system shall ensure automatically the necessary purging cycle prior to the motor start and maintain the minimum required pressurisation during motor operation.
- (c) No external power supply shall be required. All the controls shall be performed from the instrument air supplied by others. The initiation of purging cycle shall be manual.
- (d) A 40 µm or lower air inlet filter with maintenance bypass shall be provided.
- (e) The system shall initiate following alarm and trips as a minimum.
 - (i) Loss of positive pressure alarm for Ex 'py' and Ex 'pz' protection.
 - (ii) Loss of positive pressure trip for Ex 'px' protection.
- (f) All hardware for the system shall be mounted in a control cabinet.
- (g) The control cabinet shall be suitable for outdoor mounting with degree of protection IP55 in accordance with IEC 60529.
- (h) For detailed requirements of the control cabinet refer to the Annexure 1

SECTION C

11. DETAILS SCOPE OF SUPPLY

The scope of supply of 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 subvenders and subcontractors.

It is the VENDOR'S responsibility to enforce all purchase order and specification requirements on his subvenders and subcontractors.

The VENDOR shall submit all relevant subvendor and subcontractor drawings and engineering data to the CONTRACTOR.

The VENDOR shall obtain and transmit all subvendor and subcontractor's 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 manufacturer'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 manufacturer 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 COMPANY.
- d) The COMPANY/CONTRACTOR or his nominee will inspect the transformer(s) 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 reports in accordance with the relevant IEC standards including the following shall be submitted to COMPANY.
 - i. The design values
 - ii. The tolerance values
 - iii. The real values as measured, including, if any, the intermediate values causing provisional refusal.
- b) VENDOR shall compile the records of all inspections and tests including routine tests and special tests in one document and shall submit as part of 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.

14.4 ROUTINE TESTING

- a) All motors shall be subjected to the following tests:
- i. Routine test as defined by IEC 60034-1
 - ii. Efficiency at full load and $\frac{3}{4}$ load, at rated power factor in conformance with IEC 60034-2 parts 1 and 2.
 - iii. Temperature rise test in conformance with one of the methods defined in IEC 60034-29.
 - iv. Vibration test in conformance with IEC 60034-14
 - v. Shaft voltage measurement
 - vi. Insulation resistance test on:
 - Motor and exciter windings
 - Heater(s)
 - Bearing insulation (where both bearings are insulated)
 - vii. Polarization Index test on stator windings
 - viii. Partial discharge and $\tan \delta$ measurements at both industrial frequency and 0.1 Hz (offline)
 - ix. Pressure test on water coolers
 - x. Physical inspection for compliance with this technical specification and the data sheets.
 - xi. Dimensional checks
 - xii. Polarization index of stator winding shall have a minimum value of:
 - 1.5 if insulation resistance of motor exceeds a value of $120 \times (U_n + 1)$ Megaohms
 - 2.0 for all other values of insulation resistance.
 - xiii. Determination of motor quantities in conformance with IEC 60034-4-1
 - xiv. Locked rotor current and torque
 - xv. Motor torque-speed curve
 - xvi. Overspeed test.
- b) Rotor balance shall be checked after the overspeed test for conformance with:
- i. ISO 21940-11 G2.5 limits for rigid rotor machines.
 - ii. Agreed residual vibration limits for flexible rotor machines.
- c) If the residual out of balance has increased by more than 10%, the rotor shall be rebalanced.
- d) Overspeed test and the check balance shall be repeated until the rotor is stable and conforms to the agreed limits.
- e) If specified on the data sheet the following tests shall be completed:

- i. Sample coil voltage withstand test in conformance with IEC 60034-15
 - ii. Spray stator test in conformance with NEMA MG-1 2018
 - iii. EMC tests in conformance with IEC 61000-6-4.
 - iv. AVR tests in conformance with IEEE 421.2
- f) Routine tests on motor components shall be carried out as per the relevant IEC standards.
- g) Routine tests shall also include:
 - i. Full functional tests including proving of interlocking, operating mechanisms, and limit switches, 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 a third party VENDOR
 - 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 MOTOR ROUTINE TEST IN COMBINATION WITH UNIT TRANSFORMER

- (a) Where specified in the data sheet
 - i. The motor in combination with the associated unit transformer shall be given a routine test as specified in (14.4)
 - ii. Transformer routine tests as specified in the ADNOC transformer specification AGES-SP-02-001 shall also be carried out in combination with the motor.
 - iii. The transformer shall be subjected to the following:
 - measurement of reactance and resistance;
 - calculated resistance and reactance at 20 °C;
 - noise test;
 - for motor unit transformers: Short-circuit test, IEC 60076
 - iv. If no short-circuit type test certificate for an identical transformer is available, a simulated transformer/motor on-load start test, with the transformer at its normal operating temperature, shall be performed. The test procedure shall be:
 - Measurement of reactance at normal operating temperature;

- Three tests with a current corresponding to the motor starting current. The duration of the test shall be equal to the running-up time of the motor;
- Measurement of reactance after the simulated starts. The measured value shall not deviate by more than 2% from the value prior to tests;

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) Colour shade shall be grey, RAL 7035.

16.2 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/MANUFACTURER 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 the VENDOR 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 reached and 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. Purchase order 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 manufacturer's references and shall be distributed as specified in the purchase order 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 and drawings 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, i.e., values for high voltage, AC or DC. etc., will be given.
- 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 wiring diagram
- xi. CD ROM for programming protection relays.
- xii. Parts and equipment lists.

19.2 DELIVERABLES

Unless otherwise stated in the inquiry/order documents, the VENDOR shall at least supply the following documents. The language used shall be ENGLISH.

Table 19.1 Deliverables

With Bid:	
a.	Preliminary single-line diagram.
b.	Preliminary general arrangement and floor plan drawings.
c.	Minimum clearances around the assemblies for ventilation and safety during operation and maintenance.
d.	Type Test Certificates. Test values shall be furnished with test certificates.
After placement of order:	
a.	Single-line diagram.
b.	Schematic diagrams of all different types of circuits.
c.	Final assembly arrangement drawing showing main circuits, main dimensions, foundation plan, shipping section and cable termination arrangement details.

d.	Minimum clearances around the assemblies for ventilation and safety during operation and maintenance.
e.	Total mass of the assembly and of the individual shipping sections.
f.	Transport, installation, commissioning, operation and maintenance instructions, limited and specific to the assembly and its components.
g.	List of spare parts (commissioning, insurance & two years operations)
h	Test report of the final routine testing. Test values shall be furnished with test certificates.
i	Details, catalogues and characteristics of protective relays.
j	Interface wiring diagram

20. GUARANTEES & WARRANTY

The VENDOR shall guarantee, in accordance with the general conditions of purchase, that the equipment shall meet the performance conditions specified in this specification and Data Sheet.

The warrantee shall apply for a period of two years after installation and commissioning of the equipment and shall apply to defective materials, design and workmanship.

SECTION D

21. DATA SHEETS TEMELATES

Data sheet shall be inserted and decided by ADNOC

Data sheet (Document number to be advised later)

22. STANDARD DRAWINGS (AS APPLICABLE)

Not Applicable.

SECTION –E

23. AUXILIARY AND CONTROL EQUIPMENT ADDITIONAL REQUIREMENTS

1.0 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.

2.0 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

3.0 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 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.

4.0 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.
- 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 manufacturer 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
- 5.0 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/Close

5.6 Conductors and terminals shall be in compliance with the IEC 60445

6.0 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.

7.0 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 function is isolated
 - b) Terminals associated with an external source of supply

- 7.4** Labels shall be laminated, engraved Traffolyte with black letters on a white background. The text shall be in the language nominated on project documentation.

23.1 EQUIPMENT NAME PLATE AND RATING PLATE SHALL BE STAINLESS STEEL AND ENGRAVED

8.0 ANTI-CONDENSATION HEATER:

- 8.1** Each assembly section of enclosures shall be equipped with anti-condensation heaters.
- 8.2** The 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.
 - 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 supplies for anti-condensation heater circuits associated with external equipment, e.g. excitation systems, shall be switched on automatically when the equipment is not running.