أدنـوك
ADNOC

ADNOC GROUP PROJECTS AND ENGINEERING

ELECTRICAL ADJUSTABLE SPEED DRIVE SYSTEM

Specification

AGES-SP-02-004

ص ب 898، أبوظبي، الإمارات العربية المتحدة
PO Box 898, Abu Dhabi, UAE
adnoc.ae

GROUP PROJECTS & ENGINEERING / PT&CS DIRECTORATE

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

Group Projects & Engineering is the owner of this Specification and responsible for its custody, maintenance and periodic update.

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, ADNOG 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 Electrical Adjustable Speed Drive System.

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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 AC adjustable speed drive systems (ASD) based on IEC Standards.

2 SCOPE

a) This specification applies to both low voltage and high voltage adjustable speed drives (ASD) as defined in IEC 61800-2 and IEC 61800-4 respectively. Each specification clause applies to both HV and LV ASDs unless otherwise stated.

b) ASD will comprise of the converter with its control and protection equipment and, where specified, heat exchangers, chillers, input and output transformers, harmonic filters, and the motor. For detailed requirements of transformers and motors refer to the following specifications.

i. AGES-SP-02-001 for Transformers

ii. AGES-SP-02-008 for HV & LV Induction Motors

iii. AGES-SP-02-002 for Synchronous Motors

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
ADCO	Abu Dhabi Company for Onshore Petroleum Operations Ltd.
AFE	Active Front End
ANSI	American National Standards Institute
API	American Petroleum Institute
ASD	Adjustable Speed Drive
BDM	Basic Drive Module
CDM	Complete Drive Module
CT	Current Transformer
DC	Direct Current
DCS	Distributed Control System (Process Controls)
DEP	Shell Design and Engineering Practice
DFE	Diode Front End
ECMS	Electrical Control and Monitoring System
EMC	Electromagnetic compatibility
EPC	Engineering, Procurement and Construction
EPD	Environmental Product Declaration
FAT	Factory Acceptance Test
GRP	Glass Reinforced Plastic
HMI	Human Machine Interface
HV	High Voltage (above 1kV)
HVAC	Heating, Ventilation and Air-Conditioning

IAC	Internal Arc Classification
IEC	International Electro technical Commission
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronics Engineers
IGBT	Insulated-gate Bipolar Transistor
IOC	International Oil Companies
IOGP	International Association of Oil and Gas Producers
IPC	Institute for Interconnecting and Packaging Electronic Circuits
ISO	International Organization for Standardization
ITP	Inspection and Test Plan
kV	Kilo Volts
kW	Kilo Watt
LCD	Liquid Crystal Display
LCI	Load Commutated Inverter
LED	Light Emitting Diode
LV	Low Voltage (≤ 1000V)
MCB	Miniature Circuit Breaker
MCCB	Moulded Case Circuit Breaker
MTBF	Mean Time Between Failure
MTTR	Mean Time to Repair
PCB	Printed Circuit Board
PCC	Point of Common Coupling
PDS	Power Drive System
PRP	Parallel Redundancy Protocol

PSR	Process Safety Requirement
PSSC	Power System Study Consultant
RCCB	Residual Current Circuit Breaker
PWM	Pulse Width Modulation
RACI	Responsibility assignment matrix
ROM	Read-only Memory
SCMS	Substation Control and Monitoring System
SIL	Safety Integrity Level
STO	Safe Torque Off
TCS	Trip Circuit Supervision
TFTP	Trivial File Transfer Protocol
UCP	Unit Control Panel
UPS	Uninterruptible Power Supply
USB	Universal Serial Bus
VSI	Voltage Source Inverter
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 60076-1	Power transformers - Part 1: General
IEC 60076-6	Power transformers – Part 6: Reactors
IEC 60079-2	Explosive atmospheres - Part 2: Equipment protection by pressurized enclosure "p"
IEC 60146-1-3	Semiconductor converters - Part 2: Self-commutated semiconductor converters including direct d.c. converters

IEC 61000-2-4	Electromagnetic compatibility (EMC) - Part 2-4: Environment - Compatibility levels in industrial plants for low-frequency conducted disturbances
IEC 61378	Converter transformers - Part 1: Transformers for industrial applications
IEC 61800	Adjustable Speed Electrical Power Drive Systems - All Parts.
IEC 61800-2	Adjustable speed electrical power drive systems — Part 4: General requirements — Rating specifications for low voltage adjustable speed a.c. power drive systems
IEC 61800-3	Adjustable speed electrical power drive systems Part 3: EMC requirements and specific test methods
IEC 61800-4	Adjustable speed electrical power drive systems — Part 4: General requirements — Rating specifications for a.c. power drive systems above 1 000 V a.c. and not exceeding 35 kV
IEC 61800-5-1	Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - electrical, thermal and energy
IEC 61800-5-2	Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional
IEC 60204-1	Safety of machinery - Electrical equipment of machines - Part 1: General requirements
IEC 60204-11	Safety of machinery. Electrical equipment of machines - Part 11: Requirements for equipment for voltages above 1000V AC or 1500V DC and not exceeding 36kV
IEC 60255	Measuring relays and protection equipment - All Parts
IEC 60332	Tests on electric and optical fibre cables under fire conditions.
IEC 60364	Low-voltage electrical installations - All Parts.
IEC 60445	Basic and safety principles for man-machine interface, marking and identification. Identification of equipment terminals, conductor terminations and conductors
IEC 60529	Degrees of protection provided by enclosures (IP Code).
IEC 60617-DB	Graphical symbols for diagrams.
IEC 60721-3-3	Classification of environmental conditions - Part 3-3: Classification of groups of environmental parameters and their severities - Stationary use at weather-protected locations
IEC 60870	Tele-control equipment and system

IEC 61034-2	Measurement of smoke density of cables burning under defined conditions - Part 2: Test procedure and requirements.
IEC 61131-2	Programmable controllers - Part 2: Equipment requirements and tests
IEC 61439-1	Low-voltage switchgear and controlgear assemblies - Part 1: General rules
IEC 61511-1	Functional safety – safety instrumented systems for the process industry sector – Part 1: Framework, definitions, system, hardware and application programming requirements
IEC 61850	Communication networks and systems for power utility automation - All Parts
IEC 60445	Basic and safety principles for man-machine interface, marking and identification. Identification of equipment terminals, conductor terminations and conductors
IEC TR 61641	Enclosed low-voltage switchgear and controlgear assemblies - Guide for testing under conditions of arcing due to internal fault
IEC 61869-1	Instrument transformers. General requirements
IEC 61869-2	Instrument transformers. Additional requirements for current transformers
IEC 61869-3	Instrument transformers. Additional requirements for inductive voltage transformers
IEC 61892	Electrical equipment in mobile and fixed offshore units
IEC 62271-200	High voltage switchgear and controlgear – Part 200: AC metal enclosed switchgear and controlgear for rated voltages above 1kV and up to 52kV.
IEC TS 62271-304	High-voltage switchgear and controlgear - Part 304: Classification of indoor enclosed switchgear and controlgear for rated voltages above 1 kV up to and including 52 kV related to the use in special service conditions with respect to condensation and pollution
IEC 62351	Power systems management and associated information exchange.
IEC 62402	Obsolescence management
IEC 62443	Industrial communication networks – Network and system security (DRAFT)
IEC 62477-2	Safety requirements for power electronic converter systems and equipment
IECEx 02	IEC system for certification to standards relating to equipment for use in explosive atmospheres (IECEx System)

IEEE 519	Recommended practice and requirements for harmonic control in electrical power systems
ANSI C-37.2	Electrical power system device function numbers
EN 50598-3	Eco-design for power drive systems, motor starters, power electronics and their driven applications -- Part 3: Quantitative eco design approach through life cycle assessment including product category rules and the content of environmental declarations

Where the ASD is defined in the data sheet for service on an offshore installation, the equipment shall also conform to the requirements for such equipment defined the following standards.

IEC 60092-101	Electrical installations in ships. 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-02-008	Electrical control and monitoring system specification.
LATER	ADNOC tagging and numbering procedure
LATER	ADNOC painting, preservation and shipment specification
AGES-SP-02-001	ADNOC specification for transformers
AGES-SP-02-007	ADNOC specification for HV & LV induction motors
AGES-SP-02-002	ADNOC specification for synchronous motors

5.2 STANDARD DRAWINGS

To be advised

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

IOGP Specification: S-620 Supplementary specification to IEC 62271-200 High-voltage switchgear and controlgear

Shell DEPs

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 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 and 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

8.1.1 Design Life

a) The ASD shall have a minimum design life of 25 years when operating at rated conditions and maintained according to the manufacturer's recommendations.

b) The expected lifetime of electronic components may be less than 25 years. The manufacturer shall list and state the expected lifetime of these components.

c) The ASD shall be capable of continuous operation at full load for a minimum of 50,000 hours without the need for routine maintenance involving de-energisation of the ASD.

8.1.2 Availability and Reliability

a) The ASD including all individual components forming part of the system shall have an availability of minimum 0.997.

b) The manufacturer shall submit MTBF and MTTR figures for all major components of the ASD.

8.1.3 Obsolescence

The manufacturer shall submit a statement along with the bid, in accordance with IEC 62402, on any planned or predicted obsolescence of equipment or components over this design life and advise what provisions are made to allow ease of future upgrading of any switchgear purchased.

8.1.4 Cooling

Unless otherwise specified the cooling method for ASDs shall be as below.

a) Offshore
   i. Air cooled: up to 4.5 MW
   ii. Water cooled: > 4.5 MW
b) Onshore
   i. Air cooled: up to 1.5 MW
   ii. Water cooled: > 1.5 MW

8.2 DESIGN PARAMETERS

Refer to data sheet

8.3 ENVIRONMENTAL AND SITE DATA

8.3.1 Equipment Installed Indoor

a) Unless otherwise specified in the data sheet the equipment shall be installed indoors in an air-conditioned environment.

b) The climatic conditions specified in IEC 60721-3-3 for class 3K22 shall apply. This includes the following.

c) Ambient temperature range:

+5 °C to +40 °C

+30 °C daily average, air

+25 °C yearly average, air

8.3.2 Equipment Installed Outdoor

a) Where equipment is installed outdoor, the site conditions shall be as stated in the Table 1 below.

Table 1 - Outdoor Equipment Site Conditions

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

b) For offshore applications the environmental conditions as described in IEC 61892-3 clause 4.1.4 shall be applied, unless more stringent environmental service conditions are specified in the data sheet.
c) Unless otherwise stated in the data sheet the environmental conditions with respect to condensation and pollution shall be Class 0 as per the IEC TS 62271-304.

8.3.3 Component Rating

All components shall have the user defined ratings after de-rating factors (if any) for the specified service conditions.

8.3.4 Heat Exchanger Cooling Water

Cooling water site conditions shall be as stated in Table 2 below unless specified otherwise in data sheets.

Table 2 - Cooling water site conditions

Site condition	Onshore facilities	Offshore facilities
Minimum water coolant temperature	+5°C unless otherwise specified	
Maximum water coolant temperature	+30°C unless otherwise specified. Where necessary Chillers shall be provided to limit the cooling water temperature below 30°C.	
Cooling water velocity range in tubes	1 to 2.5 m/s	
Fouling resistance	0.52x10-3 m2K/W	
Maximum static water pressure	6 bar (ga)	
Minimum static water pressure	3 bar (ga)	

8.4 AREA CLASSIFICATION

8.4.1 Unless otherwise specified, the ASD shall be suitable for location in a non-hazardous area.

8.4.2 For motors located in the hazardous area refer to the relevant motor specification.

8.4.3 Equipment installed in hazardous area shall conformance to IEC 60079.

8.4.4 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 ASD shall comply with:

IEC 61800-4 (HV ASDs)

IEC 61800-2 (LV ASDs)

Associated standards referenced above are added to, amended, or complimented in the clauses below

9.2 ADDITIONS AND AMENDMENTS RELATING TO IEC 61800-4:

IEC Clause 4.1 Topologies classification

Topologies

1. The following converter topologies shall be acceptable unless otherwise agreed:
    a) VSI topology shall be used for induction motor.
    b) VSI or LCI topology shall be used for synchronous motors.
    c) Active Front End (AFE) drives using VSI technology are not acceptable for HV ASDs.
    d) Converters shall employ PWM technology with 12, 18, 24 pulse inverter.
2. Converters rectifier topology shall be:
    a) For LCI: 12-pulse maximum.
    b) For VSI:
        i. 12-pulse minimum for drives ≤ 1 MW.
        ii. 24-pulse minimum for drives > 1 MW.
3. AFE regenerative rectifiers with PWM inverter and EMC and sine filter can be used where necessary and approved by COMPANY.
4. Where VENDOR is offering topology other than Annex A of IEC 61800-4, VENDOR shall submit the reference list of ASDs supplied using such topology for a minimum of past five years for COMPANY approval

IEC Clause 5.1.1.3 Repetitive and non-repetitive transients

1. ASD system shall include surge arrestors to protect input transformer and converters against voltage surges.

IEC Clause 5.2 Transportation

COMPANY packing, transportation and preservation requirements and procedures shall also be followed.

IEC Clause 6.1.4 PDS efficiency and losses

Overall full load full speed efficiency of the PDS shall be not less than 95%.

IEC Clause 6.1.5 Overload Capacity

1. IEC 61136-1mentioned in the IEC clause is inactive.

IEC Clause 6 Ratings, 6.3 Transformers

Refer to transformer specification AGES-SP-02-001 for additional requirements.

IEC Clause 6 Ratings, 6.4 Motors

Refer to the following specifications for additional requirements.

1. Synchronous motor specification AGES-SP-02-002
2. Induction motor specification AGES-SP-02-007

IEC Clause 7.3.2 to 7.3.5 Analog and Digital input/output performance

Unless otherwise specified the input/output signal performance shall comply with IEC 61131-2

IEC Clause 9.3 Protection interface

Protection function shall be provided

1. As per this IEC unless otherwise stated in the data sheet, and diagrams.
2. For the synchronous motor exciter.
3. For Exp rated pressurized motors in accordance with IEC 60079-2

IEC Clause 10 Tests

1. As a minimum, routine tests shall be carried out in accordance with the recommended IEC procedure.

2. Any special or specific additional tests shall be subject to agreement between the VENDOR and the COMPANY at the time of order.

3. Unless otherwise specified string tests of complete or partial drive train components shall be carried after installation at site, and not as FAT at manufacturers' works.

9.3 ADDITIONS AND AMENDMENTS RELATING TO IEC 61800-2

IEC Clause 4.2.3 Basic topology for BDM/CDM/PDS's

1. Voltage source converter shall be used on supply side.

2. Pulse width modulated (PMW) inverter shall be used to supply AC power to the motor.

IEC Clause 4.4.2 Fault Supervision

Any additional fault supervision requirements will be defined in the data sheet.

IEC Clause 4.10 Load Duty Profile

The required Load Duty Profile will be defined in the data sheet.

IEC Clause 5.0 Test

For inspection and testing requirements refer to Section 14 of this specification.

10 ADDITIONAL SPECIFIC REQUIREMENTS

10.1 GENERAL

In addition to the IEC Standards' requirements, the ASD shall comply with the following clauses.

10.2 ELECTRICAL SERVICE CONDITIONS

10.2.1 Normal Service Conditions:

a) Power supply data will be included in the data sheet.

b) Power system earthing details will be included in the data sheet. Unless otherwise specified, LV ASD shall be operated on a TN-S supply system.

c) Unless otherwise specified, the ASD shall be designed to operate under the electrical service conditions as specified in

   i. Table 2 of IEC 61800-4 for HV ASDs and

   ii. Clause 4.3.2 of IEC 61800-2 for LV ASDs.

d) The short circuit current ratio as defined in IEC 61800-4 clause 5.1.1.2 shall be specified in the data sheet if outside the range of 20 to 100.

10.2.2 Harmonics

a) For low voltage ASDs the immunity and emission levels of harmonic distortion shall be within the limits specified for Category C3 in the IEC 61800-3.

b) For high voltage ASDs the immunity level of harmonic distortion at the Point of Common Coupling (PCC) shall be limited to that of IEC 61000-2-4 class 2.

c) Harmonics at the PCC shall be restricted within the maximum allowable limits of current and voltage distortion as per recommendations in the latest edition of the following, whichever is more onerous.

   i. IEEE-519

   ii. TRANSCO standard entitled 'Engineering Recommendation No.1 of the Electricity Distribution Code '
   'Limits for Harmonics in the Electricity Supply System '
   Version 1.0.

d) Harmonic studies shall be conducted for maximum and minimum system fault level at PCC based on the data given by power system study consultant (PSSC) appointed by EPC CONTRACTOR during the EPC phase. The studies shall consider all operating points and shall determine the harmonic mitigation requirements and identify any resonant frequencies.

e) ASD VENDOR shall consider the following design topologies to mitigate excessive harmonics:

   i. AC line reactor or DC choke

   ii. Multi-pulse ASD

iii. Inline passive filter

iv. ASD with Active Front-end

f) ASD VENDOR shall demonstrate that ASD harmonics contributions at the PCC shall be within the specified limits.

g) Torsional Analysis: Torsional analysis shall be carried out by driven equipment supplier. The ASD supplier shall provide calculations of all harmonic air-gap torques. The torsion analysis shall identify any excitation of torsion resonances across the drive speed range resulting from current and voltage harmonics.

h) The ASD shall allow programming to skip frequency bandwidth in order to avoid continuous operation at a resonance frequency.

10.2.3 EMC

a) The ASD design shall meet the immunity levels of IEC 61800-3 acceptance criterion A.

b) The LV ASD for rated current up to 400 A shall be designed to operate in the second environment and meet the emission requirements of IEC 61800-3 Category C3.

c) The emission requirements of HV ASDs, and LV ASDs with rated current greater than 400A shall be as per IEC 61800-3 Category 4. The COMPANY/CONTRACTOR and the VENDOR shall agree on an EMC plan to meet the EMC requirements.

d) Installation details of the ASD components and associated cabling shall be given by the supplier to comply with the EMC requirements.

10.3 RATING, AND OPERATING PERFORMANCE

10.3.1 General

a) Where scope of supply includes the complete power drive system (PDS), the VENDOR will size the ASD based on the driven equipment data given in the data sheet.

b) Where scope of supply includes the complete drive module (CDM), the VENDOR will size the ASD based on the driven equipment and motor data given in the data sheet.

c) Where scope of supply includes only the basic drive module (BDM), the VENDOR will select the ASD based on the driven equipment and motor data given in the data sheet.

d) All components shall have the user defined ratings after de-rating factors (if any) for the specified service conditions.

e) The current from the inverter to the motor shall not exceed 1000 A per phase up to ratings of 20 MW.

10.3.2 Operating speed range:

Unless otherwise stated in the data sheet, the operational speed range shall be between 30 % and 100 % of the maximum operating speed.

10.3.3 Operating quadrant

Unless otherwise stated in the data sheet, the ASD shall be suitable for one quadrant operation.

10.3.4 ASD efficiency and losses

a) The efficiency evaluation shall include
   i. Input and output transformers,
   ii. Input supply harmonic filter and power factor correction equipment.
   iii. ASD converter.
   iv. Output filters.
   v. Auxiliary controls, such as internal ASD control boards, cooling fans or pumps.

b) Overall full load full speed efficiency of the PDS shall be not less than 95%.

10.3.5 Overload Capacity

The ASD overload capacity shall be:

a) 110% or 125% for a stated time period say 60 Sec for adjustable torque applications
b) 150% of rated motor current for one minute out of any ten minutes for constant-torque applications.

10.3.6 ASD shall be able to operate on both V/Hz (Open Loop) control mode and Closed Loop control (Field-Oriented control mode)

10.3.7 ASD shall contain an energy optimiser function that automatically regulates output voltage in order to reduce motor current and to optimise the ASD to the driven load.

10.3.8 ASD shall be designed to operate in one or more of the following operating modes to match the driven equipment requirements.

a) Variable torque changing as a function of speed.
b) Constant torque over a specified speed range.
c) Constant power over a specified speed range.

10.3.9 Torque:

ASD shall be capable of developing the following torques as a minimum.

a) The maximum torques according to the maximum rated torque curve.
b) During starting and restarting;

i. 150% maximum rated torque for 10 seconds for constant torque drives

ii. 120% maximum rated torque for 10 seconds for all other drives

c) After starting and restarting and during reacceleration.

I. 120% maximum rated torque for 60 seconds for constant torque drives

i. 110% maximum rated torque for 60 seconds for all other drives.

10.3.10 Pulsating Torques:

Current torque pulsations over the entire operating speed range shall be less than 2% of nominal torque.

10.3.11 Braking:

Where specified, ASDs shall have dynamic, regenerative, or dc injection braking.

10.3.12 Mains Power Failure:

The ASD shall be configurable for the following operations.

a) Ride through the mains loss

i. For short term voltage dips up to 20% without a controller trip.

ii. If specified, an extended ride through of up to 10 s for high inertia loads for high inertia loads for voltage dips up to 20%.

iii. PDS including auxiliaries shall be able to automatically restart for voltage dips over 20% or power interruptions for less than 4 s with recovery of the line voltage to 90% of its nominal value. PDS shall have the facility to block this feature, if required.

iv. Upon automatic restart, PDS shall synchronise onto a rotating motor and develop full accelerating torque within 10 s.

v. If a fast recovery of process flow is critical under transient conditions, the VENDOR shall establish the minimum tolerable speed and acceleration to ensure a successful ride through.

b) Freewheel or coast the load

c) Fast Stop the Load

10.3.13 Critical Speed:

a) The ASD control system equipment shall include programming facilities to run rapidly through and prevent permanent operation at any of the critical speeds identified for the complete rotating equipment train i.e. motor and the driven load.

b) The VENDOR shall provide guaranteed values of the critical speeds of the ASD at the bid stage.

10.3.14 Run up time:

The estimated run-up time of the ASD shall be stated by the manufacturer at tender stage. The manufacturer shall recalculate the running up time of the ASD when the final values of inertia and data from test results are known.

10.4 ASD CONSTRUCTION AND CONFIGURATION

10.4.1 Converter and Associated Controls

a) In general, each converter shall comprise:

i. Isolation switch (lockable in 'off' position).

ii. Harmonic filter and power factor correction equipment and related switching devices (Circuit breaker/contactor) and earth switch

iii. Control and auxiliary equipment supply and distribution system.

iv. Control, triggering and system control equipment.

v. Protection, supervision and alarm equipment and measuring/testing facilities.

vi. Rectifier.

vii. DC link.

viii. Invertor.

ix. Earthing switches at both input and output of HV converters.

x. Cooling equipment.

xi. Details regarding application related requirements shall be stated in the requisition.

b) Any power distribution bus bar shall be hard drawn high conductivity copper and shall be fully insulated unless otherwise stated in the data sheet.

c) Bus bars shall be braced and supported to withstand all dynamic and thermal forces and dielectric stresses during normal operation or a short circuit. Covers providing access to bus bars shall carry a "caution, risk of electric shock" symbol.

10.4.2 Mechanical Installation:

a) ASD enclosure shall be self-supporting floor mounted suitable for installation indoors unless otherwise stated in the data sheet.

b) ASD enclosure vibration limits shall be as per IEC unless otherwise stated in the data sheet.

10.4.3 Degree of Protection:

Unless otherwise given in the data sheet the minimum degree of protection shall be as below:

a) Compartments for incoming supply and power semi-conductors shall be IP 3X

b) LV compartments requiring access during normal operation shall be IP 2X with doors open.

c) Heat exchanger openings shall be IP 21

d) For MCC integrated LV ASD assemblies the minimum degree of protection shall be IP 21.

10.4.4 Bypass and Redundant Configurations:

a) By-pass and redundancy requirements shall be stated in the data sheet.

b) ASD shall be programmed to automatically select bypass control when ASD is tripped on internal fault.

c) It shall be possible to select bypass or ASD control mode from a remote location.

d) N+1 semiconductor modules per phase shall be provided where power semiconductor modules are connected in series.

e) ASDs shall be capable of operation at full load upon failure of one semiconductor module.

10.4.5 Internal Arc Classification (IAC)

a) HV ASD cabinets shall be internal arc classified as below as a minimum.

Table 10.1 Internal Arc Classification

Cabinet Type	Applicable Standard	IAC Type Designation	Arc Current	Duration
Does not contains power electronic converters	IEC 62271-200	IAC- A FLR	Supply rated short circuit current	500 msec
Contains power electronic converters	IEC 62477-2	IAC- 3a FLR	Supply rated short circuit current	500 msec

b) VENDOR calculations will be acceptable to verify the arc fault classification.

c) For converter arc-protection relying on external fuses, the rated arc fault duration shall be not less than the time required for the external fuses to clear the fault.

d) LV ASDs shall be designed to withstand an internal arc fault (refer to standard IEC TR 61641 - Enclosed low-voltage switchgear and controlgear assemblies – Guide for testing under conditions of arcing due to internal fault.

10.4.6 Interlocking

a) Key interlocking systems with upstream High Voltage Circuit breaker shall be provided.

b) Mechanical key interlocks shall be provided on all doors. Interlocking shall be fully coordinated to prevent access when line power is applied.

c) Measures shall be taken to ensure HV compartments including transformer and terminal boxes cannot be opened unless all components in the compartments are electrically dead and earthed.

d) Tripping Circuit:

i. Interlocking shall be provided to inhibit closing when a trip condition exists.

ii. Electrical interlocking shall be provided such that the shunt tripping coil cannot be energised unless the circuit breaker is closed.

iii. Failure of tripping circuit shall inhibit closing of the circuit breaker

10.4.7 Padlocking

Padlocking or key operating facilities shall be provided for the following:

a) All isolators in the “OFF” position only. It shall not be possible to padlock any switching device in its closed position, except for switches used for earthing.

b) High voltage compartments doors closed position.

c) Selector switches such as Local/remote, auto/manual selector switches in all positions.

d) Power switching devices in open position

10.4.8 Accessibility

a) Converter compartments requiring access during operation of the drive for local control and monitoring or inspection and maintenance shall be

i. Accessible from front.

ii. Separate from compartments for incoming supply and compartments housing power semi-conductors.

iii. With degree of protection IP3XD (or IP4X).

b) Design shall allow for equipment and machinery over 25 kg in weight to be removed and reinstalled using lifting points.

10.5 ASD COMPONENTS

10.5.1 Converter

Converter Insulation Requirements: The maximum voltage (crest voltage plus spike) supplied by the converter to the motor shall be less than 2 times the crest value of the rated motor voltage. The voltage spikes of current source converters shall not exceed the crest value of the motor voltage and for voltage source converters the nominal RMS value of the motor voltage.

10.5.2 Transformer

a) ASD supplier shall be responsible for sizing the transformer and shall determine its rating and winding configuration.

b) Transformer impedance shall be selected such as to limit the harmonic emissions and short circuit current within acceptable limits.

c) This section on transformer applies to input reactors also.

d) Transformer Windings: For dry-type transformers, an earthed screen shall be installed between the primary and secondary windings to mitigate the effects of radio frequency interference.

e) Transformer Integration: Where the power supply cannot tolerate transformer energisation inrush current, pre-magnetising of the input transformer shall be achieved by means of auxiliary transformer or by pre-insertion of resistance.

f) For further details refer to transformer specification AGES-SP-02-001

10.5.3 Motors

a) Any motor provided shall comply with the COMPANY Induction and synchronous motor specifications.

b) ASD topology and technology shall be selected so as to optimise the effect on motor insulation.

c) Typical voltage stress capability with motors of unusual design:

i. The ASD topology and technology shall be selected such as to optimise the effect on motor insulation.

ii. Unless otherwise agreed, suitable switching frequency, cable length and output dv/dt filters shall be selected in order to obviate the need for motors and cables with enhanced insulation.

iii. Where the drive is operated in braking mode for prolonged periods, the motor can supply voltage level of 120% of its rated voltage. Suitable motor insulation shall be provided to withstand this voltage stress.

iv. For drives with PWM active front ends (regenerative and/or unity power factor), the effective supply voltage is increased by around 15% and this should be taken into consideration

d) For further details refer to motor specifications:

i. HV & LV Motors AGES-SP-02-007

ii. Synchronous Motors AG-SP-02-002

10.5.4 DC Link Reactor

a) The converter reactor(s) shall meet the requirements of IEC 60076-6:2007, IEC 60146-1-3 and IEC 61378

b) Converter reactor(s) shall be suitable for operation with the non-sinusoidal current wave shapes and DC components under all operational conditions of the ASD without exceeding its temperature or other limits under the conditions of this specification.

c) Dry type reactors shall be equipped with 2 embedded temperature detectors.

d) Oil filled reactors shall have high oil temp alarm and trip. An over pressure relay shall be installed on the reactor.

e) Reactors should be installed inside the converter enclosure. If air-cored reactors are offered, the extent of the iron-free zone and personnel exclusion zone around the reactor(s) shall be stated in the tender for initial layout purposes.

10.5.5 Capacitors

Capacitor(s) shall be:

a) Suitable for HV ASD utilization with design, manufacture and test in accordance with IEC 60871-1.

b) Suitable for continuous operation at 110% of the network rated voltage.

c) Suitable for ASD utilization with design, manufacture and test in accordance with IEC 61071 – power electronics capacitors

d) Provided with discharge circuits to ensure that all residual stored charge is reduced to less than 50V DC within 60 seconds after isolation of AC voltage – output filter capacitors. Output filter shall be an integral part of the ASD and be included in the enclosure.

10.5.6 Harmonic Filters:

a) Harmonic filters and power factor correction equipment shall be in accordance with Specification for Harmonic filter / power factor equipment, ADNOC document number (The document number will be added later)

b) Where required ASD shall be supplied complete with harmonic filters, as a packaged solution.

c) The harmonic filter shall be sized by the Supplier to provide an optimum solution for mitigating the effect of system harmonics.

d) The harmonic filter shall be of the passive type

e) Filters shall have an adequately rated switching device to enable on/off control of the filter from ASD

f) Unless otherwise specified, the filtering equipment shall be suitable for bottom cable entry.

g) Filters shall be tested as defined in Section 7 of the IEC 61800-4 and Section 14 of this specification.

10.5.7 Cooling General:

a) Converter cooling shall be by natural convection when practicable.

b) Larger cooling requirements and/or special environmental considerations may dictate use of forced air or liquid-cooled designs.

c) Acceptable cooling methods will be stated in the data sheet.

10.5.8 Air Cooling

a) Forced Air Cooling: Where required forced air-cooling system shall be provided to maintain electronic components within their operating limits.

b) Air filtering:

i. Air filters shall be provided if cooling air contains particles that could be damaging to cooling path.

ii. Cooling fan air inlets shall use standard filters accessible from outside the enclosure.

iii. Filter elements shall be replaceable without opening cabinet.

iv. Air inlets and exhaust openings shall be protected with expanded metal guards.

c) Cooling Fans:

i. Air-cooled ASD that are supplying critical plant motors shall have n+1 redundant fans and automatic switchover in the event of a fan failure.

ii. Periodical cycling between active and stand-by fans shall be initiated automatically.

iii. ASD shall monitor fan operation and shall indicate non-operational fans.

iv. ASD shall indicate operational run time of the cooling fans.

v. Means for easy replacement of fans shall be provided without the removal of the VFD from its current mounting arrangement or removal of circuit boards.

10.5.9 Liquid Cooling

Liquid-cooled ASDs shall:

a) Be provided with N+1 redundant pumps and automatic switchover in the event of a pump failure.

b) Be designed so that a failed pump can be safely isolated and repaired while the ASD system remains in service.

c) Be provided with pump motors having an L10 bearing life of at least 50,000h. Quick disconnect fittings shall be provided at each connection between the header and the supply hose.

d) Avoid use of dissimilar metals in liquid cooling piping and fittings.

e) Maintain system coolant temperature within a safe minimum and a safe maximum temperature to avoid thermal shock and/or condensation.

f) Have 2 out of 3 redundant conductivity measurement and monitoring system where specified on the data sheet.

g) Use de- ionised water in closed loop for cooling.

h) Have chiller unit type as recommended by the VENDOR based on his requirements and experience. Full details and references shall be submitted with the proposal for COMPANY approval.

10.5.10 Equipotential Bonding of Main Components

a) All converter cubicles shall be equipped with an earthing bar of high conductivity copper. The earthing bar shall be of adequate cross sectional area and mechanical strength to carry the prospective short circuit current for 1sec.

b) All major metal parts of the converter which may become energized during fault conditions shall be connected to the earthing bar.

c) Manufacturer shall advise COMPANY of the need of any special earthing requirements for any item of the drive system where normal substation earthing practice would not be adequate.

10.5.11 Power Cables

a) VENDOR shall provide the cable specification data taking into consideration the following.

i. Power cable insulation level based on the calculated stresses of the drive system.

ii. The use of screens for motor feed cables shall be as recommended by the manufacturer.

b) Unless otherwise agreed, suitable switching frequency, cable length and output dv/dt filters shall be selected in order to obviate the need for motors and cables with enhanced insulation.

c) The type and size of the cables will be advised by the COMPANY/CONTRACTOR as defined in the circuit schedule.

d) Cable Termination:

i. The VENDOR shall size the terminals and shall determine the size of terminating compartment.

ii. Where three phase cables are to be terminated the dimension of the cable compartment shall enable adequate clearances for crossing of cable cores.

iii. Unless otherwise specified the cable screen and the armouring shall be bonded to earth at both ends of the cable.

iv. Separate compartment for high and low voltage cables shall be provided.

v. When terminating to bar conductors the bar conductors shall be pre-drilled by the switchgear supplier.

vi. Pre-drilled gland plates shall be supplied as stated in the data sheet. Gland plates for single core cables shall be of non-ferrous material.

vii. All cables entering the enclosure shall be bottom entry unless otherwise stated on the data sheet.

10.6 PROTECTION AND CONTROL SYSTEM

10.6.1 General

The ASD shall be equipped with integrated digital protection and control devices which shall include the protection, automation, measurement, counting, monitoring, diagnosis, and communication functions for the entire drive system and its auxiliary equipment.

10.6.1 Protection functions:

a) Unless otherwise specified in the data sheet the following alarms ant trips shall be provided as per the IEC requirements, Section 4.4.2 of IEC 61800-2 and Table 8 of IEC 61800-4.

Table 10.2 Protection Functions

Description	Alarm	Trip
Line-side supply		
Outage, phase loss	X	X
Line over-voltages	X	X
Line under-voltages	X	X
Line voltage unbalance	X	X

Description	Alarm	Trip
Line feeder		
Over-current		X
Overload	X	X
Transformer	X	X
Gas relay (Buchholz) -oil-type only	X	X
Over-temperature (oil and winding)	X	X
Loss of cooling media	X	X
Low oil level - oil-type only	X	
Converter		
Overcurrent - commutation failure, short circuit, etc.	X	X
Overload - thermal	X	X
Overvoltage	X	X
Ground fault	X	X
Loss of cooling	X	X
Over-temperature	X	X
Loss of auxiliary supply	X	X
Loss of communication to process control	X	X
Loss of speed feedback	X	
Motor		
Motor over/under-voltage	X	X
Motor overcurrent	X	X
Overload -thermal	X	X
Over-speed	X	X
Winding over-temperature	X	X
Bearing over-temperature	X	X
High vibrations	X	X
Loss of cooling	X	X
Loss of lubrication	X	X

b) Further protection functions shall be provided as specified in the applicable equipment specifications, data sheets and SLDs for the associated equipment such as the motors, transformers, and harmonic filters.

c) The ASD shall have short circuit detection and fast cut off capability within few micro seconds at the semiconductor level.

10.6.2 Protection Relays:

a) Protection relays where provided shall be microprocessor based multifunction type, with digital display and serial communications facility to enable integration into the electrical control and data gathering system.

b) Test blocks shall be provided for testing protection relays and CT/VT circuits. Necessary test plugs shall be supplied along with the switchgear.

c) For detailed protection relay requirements refer to the Annexure 2 of this specification

10.6.3 Backup Protection:

a) For essential protection functions of the ASD, a separate backup protection shall be provided to accommodate for a failure of the electronic protection system.

b) For small LV ASD the backup protection can be a standard MCCB protection.

c) For large LV and HV ASD this should be an independent protection relay.

10.7 CONTROL AND MONITORING

10.7.1 Speed Control

a) ASD speed and torque control shall be full vector control with encoder feedback.

b) Where encoder feedback is not available the ASD speed and torque control shall be sensor-less direct vector control.

c) Speed reference signal shall be 4-20 mA.

d) Where specified feedback signal shall be 4-20 mA.

e) Input impedance of the ASDs shall be less than 600 Ohm.

f) Speed regulation shall be ±0.5% without encoder or tachometer feedback

g) The relationship between the speed, torque or power and the reference signal within the operational speed shall be linear.

h) The difference in speed between the set point value and the measured value shall be less than 2% of the set point value.

i) If the difference is more than 5% of the set point value, a 20-second time-delayed alarm shall be raised.

j) A power or torque controlled ASD shall, if the speed exceeds 102% of the maximum operational speed, reduce its power or torque until the maximum operational speed is reached.

k) The ASD shall trip if the speed exceeds 105% of the maximum operational speed.

10.7.2 Start / Stop:

a) Start and stop signals shall be hardwired potential free contacts.

b) External 'ready to start' signal will be potential-free contact.

c) Package emergency shutdown: This shall be a potential free contact signal given by an emergency condition of the driven equipment or the process. The function of this signal will be identical to an internal ASD trip.

d) Emergency shutdown interface relays shall be safety integrity level (SIL) rated in accordance with IEC 61511-1 to the SIL level defined in the circuit schedule.

e) Emergency stop: The stop signal given from the stop button located near the motor shall trip the supply contactor/circuit breaker directly. For a multi-motor ASD this signal shall trip the individual motor contactor.

f) The ASD shall be capable of receiving a hardwired fast acting load shedding signal, such that the ASD unit can be tripped quickly and safely.

g) The power removal function for package emergency shutdown, emergency stop, and load shedding shall comply with the definition of IEC 61800-5-2 for both stop functions, Safe Torque Off (“STO”) and Safe Stop 1 (“SS1”). (PSR)

h) Switching of the input transformer as part of the start/stop sequence shall be prevented to avoid the undue stress on the transformer windings.

10.7.3 Operation on Loss of Reference Signal:

a) The ASD shall be capable of continuing operating upon loss of the 4-20mA reference signal.

b) The ASD shall either

i. revert to a pre-set speed, torque, or power

ii. or, the ASD shall maintain constant speed, torque, or power at the same level as prior to loss of the signal depending on the process.

c) The parameters at which the ASD need to run on signal failure shall be specified by the COMPANY. Operator shall be able to pre-set the value of this parameter.

10.7.4 Control Supplies:

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) Close, trip, and spring charge auxiliary circuits shall have independent overcurrent protection.

c) Trip Circuit Supervision:

i. Shunt trip circuits shall have trip circuit supervision (TCS).

ii. TCS shall detect loss of tripping supply voltage, open circuit trip coil, and trip circuit wiring failure.

iii. Trip circuit supervision shall be effective whether circuit breaker is closed or open.

iv. A manual trip with guard to prevent inadvertent tripping shall be provided

v. Trip circuit supervision shall not operate when circuit breaker is isolated.

10.7.5 Control and Monitoring Functions

Unless otherwise stated in the data sheet the following control and monitoring functions shall be included as a minimum.

a) Control

i. Start / stop
ii. Speed control (raise / lower)
iii. Forward / Reverse (as applicable)
iv. Auto / Manual mode
v. Local / remote
vi. Emergency stop (Red, Non-Returnable Push Button)
vii. Trip-Remote Breaker

b) Indications:

i. Motor running
ii. Motor stopped
iii. ASD System Fault
iv. System ready to start
v. AC mains ON
vi. Motor over speed
vii. Rectifier output ON
viii. Motor zero speed
ix. Remote breaker trip
x. Potential free contacts of items 1 & 4 shall be wired separately for indications in DCS system.

c) Metering

i. Input AC voltage
ii. Input AC Current
iii. Input AC frequency
iv. Output voltage
v. Output current ASD
vi. Output frequency
vii. Motor thermal state
viii. Drive thermal state
ix. Motor speed
x. Motor energy meter
xi. DC Link voltage
xii. Hour Run

d) Annunciations

Potential free contacts shall be wired to up to the ASD output terminals for receiving the signals for following annunciations.

i. General Alarm- Transformer
ii. General Alarm- Motor
iii. General Alarm- Filter
iv. General Alarm- Switchgear
v. General Alarm- ASD
vi. General Alarm- Auxiliaries

10.7.6 Control System Equipment

The ASD control system equipment shall be provided with following functionality.

a) Self-check facilities.

b) Watch dog signalling features. Watchdog failure shall result in alarm and not unit trip.

c) Memory function to retain program, software parameters, and alarms in case of power supply failure.

d) Restarting of the control system after power failure (either main line or auxiliary line)

e) Measuring and test points shall be front-accessible as well.

f) The ASD control system shall have a memory function to retain program, software parameters and alarm/fault in case of power failure.

g) Loss of the 4 to 20 mA reference signal shall normally result in an alarm and continue running as described above in the section ‘Operation on Loss of Reference Signal’ of this specification.

h) Component failures which are covered by redundancy shall result in alarms and not unit trip.

i) It shall be possible to configure alarms and trips to be self-resetting.

10.7.7 Operator Interface

a) The ASD shall be equipped with a front mounted operator control panel consisting of the following.

i. A back-lit LCD display.

ii. Configurable digital display shall present parameter values, show bar graphs and meters, and diagnostic messages.

iii. Keypad with keys for control, reset, menu navigation, parameter selection.

b) All service adjustments required in the field shall be possible from the front of the panel.

10.7.8 External Interfaces.

a) The electrical system is monitored and controlled by the overall electrical control and monitoring system (ECMS) as described in ADNOC ECMS specification (document number to be advised). This system enables communication between protection relays, ASD controls, Power

Management Units and Engineering Workstations to enable remote monitoring and control of the electrical network and drives.

b) The interface signals between the ASD and the ECMS shall be as defined in the Data Sheet, Control and Indication Schedule, and any other documents referenced in this specification. The interface signals shall include control, indication, monitoring, and measurement signals.

c) Certain pre-selected data will be transmitted between the EMCS and the DCS for control and monitoring, to effect process system control of the ASD.

d) Communication facilities shall be provided for remote trouble shooting and failure analysis.

e) It shall be possible to update relay parameters from Engineering Workstations or local lap-top connections.

f) Connections for local computers (laptops) shall be physically secured. This functionality shall be password protected and the manufacturer shall provide all necessary software.

g) The ASD control system shall be able to be synchronized with ECMS in order to stamp ASD electrical alarms and faults.

10.7.9 Performance of Communications Links

a) ASD shall be able to communicate with upstream switchgear, ECMS and DCS using the standard industrial protocols, as defined in the data sheet.

b) Where proprietary software is used, the interface software shall be provided to match the protocols defined. Digital interfaces shall conform to IEC 61850.

c) Unless agreed otherwise, trips to and from the ASD shall be hard-wired.

d) The use of IEC 61850 for transfer of protection signals or measured values used for protective functions between IEDs shall be subject to agreement between the COMPANY and the VENDOR.

e) The use of IEC 61850 process bus shall be subject to agreement between the COMPANY/CONTRACTOR and the VENDOR.

f) For interlocking, blocking, protection signals, or measured values used for protective function transferred between IEDs on the same IEC 61850 Station Bus network, the following applies:

g) They shall be fully functional independently of the associated wide area communications infrastructure (servers and firewalls)

10.7.10 Fault Diagnostic:

a) The ASD shall include a comprehensive microprocessor based digital diagnostic system which shall monitor its own control functions and display faults and operating conditions.

b) Fault diagnostic and indication logic shall be equipped with a memory function to retain information regarding the cause of tripping of the ASD even after interruption of the power supply.

c) Fault log data shall be stored in non-volatile memory or be supported by a UPS sized to provide a minimum of 48 hour data retention.

d) Unless otherwise agreed in the requisition UPS supply to the system components or to the electronics for the diagnostics and its display shall be provided by the VENDOR.

e) The fault diagnosis system shall provide detailed information to troubleshoot the ASD system down to the printed circuit board or power semiconductor level.

10.8 SAFETY

a) The ASD shall comply with the electrical safety requirements of IEC 61800-5-1.

b) The ASD shall comply with the functional safety requirements of IEC 61800-5-2.

c) The interface with rotating equipment shall conform to IEC TR 62061-1 for safety of machinery and control systems, and requirements for related documents.

10.9 NOISE REQUIREMENTS

a) Unless otherwise specified, measurement methods for transformer noise emission shall be in accordance with IEC 60076-1.

b) The noise levels shall not exceed the following values:

i. Air cooled drives; less than 80dBA

ii. Water cooled drives; less than 75dBA

iii. Large air cooled drives having a noise level in excess of 80dBA may be accepted

iv. Drives with noise levels in excess of the stated values will only be permitted with approval of COMPANY Responsible engineer.

10.10 CONDITION MONITORING

Provision shall be made for the following for continuous online condition monitoring of the ASD components

a) Partial discharge monitoring sensors and analysing software for HV systems

b) Temperature monitoring devices

c) IGBT modules

d) Monitoring of internal components of ASD handled within the ASD package, with values and alarms communicated to the DCS.

10.11 CYBER SECURITY

a) A role based access control shall be incorporated

b) Cyber security for the products and external interface shall comply with IEC 62443 series of standards as applicable.

c) Communication protocols shall comply with IEC 62351.

d) VENDOR shall provide firewall and malware protection in line with COMPANY corporate cyber security policy.

10.12 ECO DESIGN

a) LV ASDs shall be capable of operating with high efficiency motors of classes IE2, IE3, and IE4.

b) Where specified, Eco design transformers, and Eco design ASD shall be used.

c) Where stated in the data sheet, the VENDOR shall provide Environmental Product Declaration (EPD) in accordance with EN 50598-3.

10.13 SECONDARY COMPONENTS AND WIRING

Refer to Annexure 1 for design and constructional requirements for secondary control panels.

10.14 EQUIPMENT TESTING

a) As a minimum, routine tests shall be carried out in accordance with the recommended IEC procedure.

b) Any special or specific additional tests shall be subject to agreement between the COMPANY/CONTRACTOR and the VENDOR at the time of order.

c) Unless otherwise specified string tests of complete or partial drive train components shall be carried after installation at site, and not as FAT at manufacturers' works.

SECTION C

11 DETAILS SCOPE OF SUPPLY

The scope of supply of shall include:

a) Detailed design

b) Studies as indicated in this specification and the requisition

c) Supply of materials

d) Factory and site inspection and testing

e) Documentation including certification

f) Installation, commissioning and start-up assistance; where specified in the requisition

g) 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 type of equipment.

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 subvendors 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 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 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 item of equipment shall be submitted prior to delivery for COMPANY acceptance.

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 TESTS:

a) For HV ASD converter and the associated control VENDOR shall perform all tests as listed in Table 10 of IEC 61800-4 and Table 13 of IEC 60146-1-1 including optional tests.

b) For LV ASD converter and the associated control VENDOR shall perform all tests as listed in Table 4 of IEC 61800-2.

c) For all other items of equipment and components forming part of the ASD, VENDOR shall perform all type tests, routine tests, sample tests, and special tests as per the relevant IEC standards.

d) Tests shall be carried out in accordance with the relevant IEC standards and as per the agreed procedures.

14.4 TYPE TESTS:

a) In addition to above VENDOR shall perform type tests to evaluate the insulation of the equipment by the measurement of partial discharges.

b) 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 for HV ASDs.

c) Type test certificates shall be submitted with the bid.

d) Test certificates shall be from an internationally recognised, independent testing authority, and shall be subject to COMPANY acceptance.

14.5 ROUTINE TESTS

a) Routine tests shall also include the following.

i. Full functional tests including proving of interlocking, operating mechanisms, and limit switches.

ii. Relay primary and secondary injection tests.

iii. Conformation of name plates, tags, labels, wire and terminal markings.

iv. Interface with remote panels provided by a third party manufacturer.

v. Check memory function of fault diagnostic and indication logic

vi. ECMS Simulation Tests: Proving of communicating devices interface with ECMS and DCS. This shall include functional tests such as remote control, automatic starting, and stopping.

14.6 SPECIAL TESTS

a) Any special or specific additional tests shall be subject to agreement between the COMPANY/CONTRACTOR and the VENDOR at the time of order.

b) Equipment for installation offshore shall be tested to confirm compliance with the requirements of IEC 61892-3.

14.7 PERFORMANCE TESTS

a) Unless otherwise specified combined tests of complete or partial drive train components shall be carried out after installation at site, and not as FAT at manufacturers' works.

b) If specified in the requisition, the ASD equipment such as unit transformer, motor, converter, filters and auxiliaries shall be lined up for the combined test at VENDOR's works. The test shall be performed for one ASD system of each rating.

c) The performance test shall at least include the following tests:

I. Insulation resistance tests

II. Heat run tests at rated load, recording the following:

- Transformer temperature rise
- Motor temperature rise
- Converter temperature rise
- Bearing temperatures
- Shaft vibrations
- Current unbalance
- Noise level
- Linearity between set point and output.

III. Efficiency test at 50/75/100% load.

IV. Power factor test at 50/75/100% load.

V. Functional tests (controls, alarms, trips, etc.)

VI. Test of the converter emergency stop at full load

VII. Test of flying restart capability following a trip at full speed

VIII. Test of the earth fault protection

IX. Replacement of filter and deionizer resin bottle in operation

X. Recording of the motor voltage, current, speed and power during start-up, ramp-up and

XI. Trip at full speed

XII. Visual inspection (dimensions, protection degree, individual marking, accessibility, etc.)

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 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 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.
e.	Obsolescence statement
f	Guaranteed values of the critical speeds of the ASD at the bid stage.
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
k	Logic and loop diagrams showing the software and hardware of the trip circuits, trip circuit supervision and alarm circuits.
l	Final data sheet complete with actual design and tested values.
m	Overall description of control philosophy
n	Detail of harmonic output characteristics for each ASD
o	Heat loss of all ASDS components for HVAC sizing calculation
p	Efficiency calculations
q	Harmonic calculations
r	All the information as required by the relevant IEC standards.

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

To be advised later

SECTION –E

23 ANNEXURE 1 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 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.

4.0 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) 50/750V 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. The following colour code shall be used.

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

6.0 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.

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.

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.

24 ANNEXURE 2 PROTECTION RELAYS

1.0 SCOPE

The purpose of this Annexure is to define the technical, installation and connection requirements for protection relays and auxiliary components associated with electrical equipment covered in this specification.

2.0 NORMATIVE REFERENCES

IEC 60255	Measuring Relays and Protection Equipment - All Parts
IEC 60870	Tele-control Equipment and Systems
IEC 61850	Communication Networks and Systems for Power Utility Automation - All Parts
IEC 62271-3	High-voltage Switchgear and Controlgear. Digital Interfaces based on IEC 61850
IEC 62439	Industrial Communications Networks

3.0 FUNCTIONAL REQUIREMENTS

3.1 Protection relay design, manufacture and testing shall comply with IEC 60255.

3.2 Protection relays shall be micro-processor based multi-function type, incorporating a digital display and serial communication facilities.

3.3 The relay shall be selected to suit the protection functions and circuit configuration as applicable and shall include Event and Disturbance recording facilities.

3.4 An inbuilt Trip coil & Close coil supervision facility shall be provided for protection relays associated with circuit breaker feeders.

3.5 Where fully digital switchgear is offered, the protection relays shall be provided with the necessary Low Energy Analogue Input facilities.

3.6 Protection relays shall be located on the low voltage compartment of the switchgear panels unless otherwise specified.

3.7 Protection devices shall have an HMI on which metering, circuit monitoring and alarm/trip parameters shall be displayed.

3.8 HMI and front of panel-mounted relays shall be flush mounted and of withdrawable design. CT connections shall be automatically shorted if the device is withdrawn.

3.9 Each protection relay shall have facilities for calibration and injection testing without disconnection of secondary wiring.

3.10 Accessible test blocks, for calibration and testing of the protection relay functions, shall be located adjacent to the device to which they are connected.

3.11 The power supply to the relays shall be derived from the trip/close supply as defined in the Data Sheets. Loss of supply shall not initiate a main circuit trip.

3.12 Protection relays shall include provision for input of a number RTDs, where specified, for temperature monitoring using PT100 sensors and shall be capable of inclusion of Arc Flash detection systems.

3.13 Protection relays shall be designed to withstand the environmental conditions defined in Clause 4.3 Table 1 of IEC 60255-1.

3.14 Circuit breaker status signals into the protection relay shall be taken directly from the breaker auxiliary contacts, not via interposing relays.

4.0 DIGITAL COMMUNICATION INTERFACE

4.1 Digital communications interface shall be provided to ensure compliance with IEC 61850 (all parts) as detailed in IEC 62271-3.

4.2 Protection devices shall be provided with two ports for serial communication to enable integration into the electrical monitoring and control system (EMCS), via an EMCS interface unit in each switchboard.

4.3 A further port, located on the front panel, shall be provided for connection of an Engineering Laptop. It shall be possible to update relay parameters from the remote Engineering Workstations (part of the EMCS system) and local lap-tops.

4.4 The relay shall be capable of supporting differing communication protocols, however the communication between relays and ECMS shall be IEC 61850 with ring topology as redundancy communication

4.5 Protection relays shall be capable of time synchronizing with an external master clock, located in the ECMS, via the communication network.

4.6 The relay shall support file transfer protocol TFTP and file transfer through IEC 61850.

4.7 For fully digital switchgear options, the process bus network connections shall be fully redundant, with GOOSE (Generic Object Oriented Substation Events to IEC 61850) communication and PRP

(Parallel Redundancy Protocol to IEC 62439) protocol included to provide vertical and horizontal communication.

5.0 HMI

5.1 User interface shall provide a colour LCD front panel display, and navigation keys

5.2 The HMI display shall include the applicable Single Line representation of the circuit, with online metering, status and alarm information and control functionality

5.3 The HMI shall be capable of displaying measured values, calculated values, I/O status, device status, target messages, events, and configured relay settings

5.4 The HMI shall be capable of displaying up to 32 digital and 16 analogue data channels

5.5 The HMI shall include an event recorder, displaying an extensive listing of time-stamped events.

5.6 The HMI shall be capable of displaying fault and disturbance data to assist in diagnostics in the event of a fault trip. The recorder shall include displays of selectable analogue and digital monitoring points.

6.0 SOFTWARE AND HARDWARE

6.1 The protection relays shall have a common hardware and firmware platform that shall support each functional unit applications. The relay shall be equipped with separate processors for protection and for communication related functions.

6.2 The relay design should include self-diagnostic checking and monitoring/alarms

6.3 The relay shall store all its recorded data in non-volatile memory.

6.4 Time synchronizing and remote access parameterization for all protection relays shall be provided.

6.5 Protection relays shall have capabilities for time stamping, remote access parametrization in accordance with the selected communication protocol.

6.6 Relays shall support user defined logic to build control schemes supporting logic gates, timers, non-volatile latches.

6.7 An in-built relay configuration tool shall be provided, having embedded graphical user interface to build programmable logic.

6.8 Electronic board assemblies shall have conformal coating for harsh environments.

6.9 Microprocessor based protective relays shall employ IPC (Institute for Interconnecting and Packaging Electronic Circuits) Class 3 printed circuit boards (PCB). Specifically, IPC Class 610-3

6.10 Protection relays shall be provided with a security hierarchy, with separate password access for differing levels of use, for example, observing measured quantities, operator access for executing commands and administrator access for modifying relay configuration or protection settings.