

NORSOK STANDARD

COMMON REQUIREMENTS
ELECTRICAL SYSTEMS

E-CR-001
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1. FOREWORD

This standard has been developed by the NORSOK Standardisation Work Group.

Annex A is normative.

2. SCOPE

This standard is applicable to the design of the electrical systems for offshore installations.

3. NORMATIVE REFERENCES

CENELEC	European Committee for Electrotechnical Standardization.
IEC	International Electrotechnical Commission.
NEK	"Norsk Elektroteknisk Komite."
ET	"Elektrisitetstilsynet." "Retningslinjer for jording i maritime anlegg."
IFEA	"Industriens Forening for Elektroteknikk og Automatisering." "Industrielle varmekabelanlegg."
IFEA	"Industriens Forening for Elektroteknikk og Automatisering." Guidelines for the documentation of selectivity (discrimination) in a.c. systems.
NEK 606	Cables for offshore installation. Halogen free and mud resistant.
-	"Selskapet for lyskultur." "Publications: "Luxtabell" and "Nødlysanlegg".

System of units

The International System of units (SI) as set out in ISO 31 shall be used.

4. DEFINITIONS AND ABBREVIATIONS

4.1 Definitions

All terms and phrases within the scope of this standard shall be regarded as defined in the regulations and international codes and standards referred to in this document.

4.2 Abbreviations

EPS	Emergency Power Supply
SAS	Safety and Automation Systems
FEA	Industri Varmekabelanlegg
ISO	International Organization for Standardization
HVAC	Heating, Ventilation and Air Conditioning
MCC	Motor Control Center
PABX	Private Automatic Branch Exchanger Panel (telephone panel)
PLC	Programmable Logic Controller
RTD	Resistor Temperature Detector
UPS	Uninterruptible Power Supply

5. DESIGN CRITERIA

5.1 General

Necessary redundancy to obtain the required availability shall be provided to maintain the power supply during normal maintenance operations and service interruption of critical power distribution equipment.

Equipment with identical functions should be directly interchangeable.

5.2 Studies and Calculations

5.2.1 *Electrical Load Study*

An electrical load list shall be prepared to establish the electrical power requirements throughout the unit. Load estimates shall be carried out for all operational states of the unit, e.g.

- Drilling
- Maximum power consumption
- Life support
- Emergency
- Minimum load for full production with low priority loads disconnected.

An electrical load profile shall be prepared for normal operations over the entire lifetime of the unit.

Separate load studies shall be carried out to establish the temporary load requirements during pre production phases, e.g.

- Onshore commissioning and testing
- Float out
- Deck mating
- Inshore hookup and commissioning
- Tow out
- Offshore hookup and commissioning.

An allowance and contingency multiplication factor shall be applied to the estimated load to select the rating of generators and transformers.

The following factors should be used:

- | | |
|-----------------------|------------|
| • Feasibility study: | 1,5 |
| • Conceptual study: | 1,35 - 1,4 |
| • Pre-engineering: | 1,25 |
| • Detail engineering: | 1,10 |

Note:

If the electrical load data at different stages are well defined, lower factors may be used.

5.2.2 Load Flow Calculations

Steady state load flow calculations shall be carried out for the following operational states:

- Peak load with the major components in normal operation.
- Peak load with one feeder circuit of the major duplicate systems out of operation.
- Minimum load with the major components in normal operation.

The following data shall be computed:

- Magnitude and phase angle of the busbar voltages.
- Active and reactive power production and load at the busbars.
- Active and reactive power flow in cables and transformers.
- Power losses.
- Recommended setting of the transformers tapplings.

5.2.3 Short Circuit Calculations

Short circuit calculation shall be carried out for the following fault conditions:

- 3-phase symmetrical fault
- Single-phase to earth fault
- Phase to phase fault
- Phase to phase to earth fault

The maximum symmetrical r.m.s. value of the sub transient fault current shall not exceed the following values:

11 / 6,6 kV	:	40 kA rms/1sec.
690 V	:	50 kA rms/1sec.
400/230 V	:	30 kA rms/1sec.

5.2.4 Power System Dynamic Calculations

A stability analysis of the electrical power system shall be carried out and shall comprise simulations of the system transient behavior following disturbances during relevant operational modes of the unit.

The simulations shall include:

- Direct on line starting of the largest motors.
- Short-circuited feeders with clearance of the fault after set time delay of the protective relays.
- Generator short circuit with clearance of the fault and generator trip after the set time delay of the protective relays. Based on the analysis, load shedding shall be applied when required.
- Generator trip. Based on analysis, load shedding shall be applied when required.

The analysis shall be carried out for the worst case conditions with respect to system stability, which shall be determined separately by each project.

The analysis shall prove that the system will restabilize following the specified disturbances, and that the transient voltage and frequency variations, motor slip and start up times are within acceptable limits.

5.2.5 Protective Relay Coordination and Discrimination Study

A relay coordination study shall be carried out to determine the setting of the protective relays and direct acting circuit breakers.

Series connected overcurrent relays, direct acting circuit breakers and fuses shall be coordinated to achieve correct discrimination during fault conditions. Correct discrimination shall be maintained for the minimum and maximum prospective fault currents, while the

thermal effect of the fault current shall not exceed the thermal withstand capability of any circuit component. The relay coordination study shall be carried out according to the requirements of the IFEA "Guidelines for the documentation of selectivity (discrimination) in a.c. systems."

5.2.6 *Calculation of Harmonic Currents and Voltages*

The content of harmonics in the power system shall be examined when large converters are connected.

The magnitude of the harmonics and the total voltage distortion shall be computed for all main busbars.

On high voltage busbars the total harmonic distortion should not exceed 5% and no single harmonic should exceed 3%.

On low voltage busbars the total harmonic distortion should not exceed 8% and no single harmonic should exceed 5%.

Note: It may be necessary to feed sensitive equipment from an UPS system.

5.2.7 *Cable selection and Sizing criteria*

Electric cables shall comply with NEK606 "Cables for offshore installation. Halogen free and mud resistant."

Cables used in current transformer secondary circuits shall have a minimum conductor size of 2.5 mm².

For circuits feeding fluorescent luminaries with electronic ballast, a voltage drop of maximum 10% at the utmost luminary is permitted.

6. SYSTEM REQUIREMENTS

6.1 System Voltage and Frequency

The following voltage levels and frequency shall be used:

11 kV, 3-phase:	Generation and distribution voltage. Should be used when total installed generator capacity exceeds 20 MW. Should be used for motors from 400 kW and above.
6.6 kV, 3-phase:	Generation and distribution voltage. Should be used when total installed generator capacity is between 4-20 MW. Should be used for motors from 300 kW and above.

690 V, 3-phase:	Generation and distribution voltage. Should be used when total installed generator capacity is below 4 MW. Should be used for motors below 400 kW. Primary voltage for converters for drilling motors.
400/230 V, 3-phase + N:	TN-C-S / TN-S system shall be used as distribution voltage for lighting and small power, and for low power heating, including heat tracing. The system shall be symmetrically loaded.
UPS 230 V, single phase:	Shall be used as distribution voltages for instrumentation, control, telecommunication and safety systems.
Frequency:	50 Hz.
750 V d.c.:	Shall be used for d.c. drilling motors. "Note - Other power supply systems may be used for drilling equipment."
UPS 48 V d.c.:	Shall only be used as distribution voltage for telecommunication systems.

Only one high voltage level should be employed.

6.2 Power Supply

6.2.1 Main Power Supply

The main power supply shall serve all electrical functions during normal operation.

The main power supply may be arranged with subsea cables from a neighbouring unit, from shore, or with local power generation, or with a combination of the alternatives.

Depending on the regularity requirements of the unit the generators should be dimensioned to allow any one of them to be taken out of service any time, without reducing the oil/gas production or interrupting the stability of the electrical system, caused by start of large motors, short circuits, etc.

When local power generation is provided, the generators shall be grouped in a central power plant. The unit rating and number of generating sets shall be adapted to the load profile of the systems served over the entire lifetime of the unit.

The auxiliary switchboards for the main power generators shall be provided with two incomers, one from main and one from the emergency system with change over.

6.2.2 *Emergency Power Supply*

The emergency power supply system shall serve vital safety equipment.

The emergency power supply systems shall comprise a combination of UPS systems, and if necessary an engine generation system.

The emergency generators shall be arranged for parallel operation with the main power grid for regular testing and maintenance of the sets.

The emergency power supply system shall be independent of the main supply systems. Equipment shall be located in separate rooms.

The generators shall start automatically and operate directly on the emergency busbars in case of failure of main system.

6.2.3 *Drilling Backup Power Supply*

The backup power supply for drilling shall secure well and equipment in case of main power failure. The system can be part of the permanent power supply system. For removable drilling facilities the backup power supply shall be part of the drilling package.

6.2.4 *Subsea Power Supply*

Hold.

6.3 Uninterruptible Power Supply (UPS) System

UPS systems shall be provided for emergency services and non emergency services requiring continuous a.c. or d.c. power supply in case of failure of the main power supply, and for services that will malfunction upon occurrence of normally expected voltage transients.

UPS power shall be provided for the following services:

- Safety systems (emergency consumers).
- Control systems required for operation and monitoring of safety auxiliary systems.
- Vital telecommunication systems.
- Control systems required for restarting of the drilling and production systems.
- Control equipment liable to fail or malfunction upon occurrence of normally expected voltage transients, e.g., on starting of large induction motors.

- Nav. Aid System.

The UPS systems shall be designed for distribution of uninterrupted power at 230 V, 50 Hz, with the exception of the dedicated UPS systems for telecommunication services which may be d.c. units.

Analysis shall be carried out to demonstrate the availability and reliability of the UPS system, and sufficiency of the battery capacities.

Backup time for public address systems shall be min. 2 hrs.

Backup time for PABX/radio systems shall be min. 8 hrs.

Redundant UPS units shall not contain common mode failure elements.

6.4 Power Distribution System

6.4.1 Main Power Distribution System

The electrical power distribution system should be provided with duplicate incomers and a bus-section circuit breaker for all major switchboards. The bus-section circuit breaker shall be normally open, the incoming circuit breakers normally closed. Duplicate equipment shall be supplied from different busbar sections.

The configuration of the main power distribution system shall depend on the regularity requirements of the unit.

6.4.2 Emergency Distribution System

In normal operation the emergency switchboard shall be fed from the main power system. After loss of main power the switchboard shall be fed from the emergency generator(s).

The busbar sectionalizing arrangement shall be adapted to the emergency generator configuration.

Electrical equipment classified as emergency equipment shall be connected to the emergency switchboard. Equipment requiring continuous operation according to statutory regulations shall be connected to UPS systems, fed from the emergency switchboard. Self-contained emergency equipment with battery units shall be fed from the emergency switchboard.

6.4.3 Electrical System Control and Supervision

The control and supervision of the power generation and distribution system, and the control of electrical motors and heaters shall be performed by a distributed control system, being a part of, or interfaced to the SAS system.

The status of the main circuit breakers and the electrical system fault annunciation shall be available on a Video Display Unit (VDU) in the central control room.

The three circuit breakers (two incomers and one bus tie) of major switchboards shall be interlocked so that only two breakers can be closed at the same time, except for make before break power transfer operation using quick switching. A manual transfer facility shall be provided to enable either feeder to be manually disconnected for maintenance purposes.

In the case of failure of one of the feeders during normal operation, the faulty part of the system shall automatically be disconnected and the bus-section breaker must be manually closed.

6.5 Earthing

Earthing systems shall comply with ET “Elektrisitetstilsynet” “Retningslinjer for jording i maritime anlegg”.

6.5.1 *System Earthing*

The system earthing methods for the different voltage levels are shown in Table 1. For system with the neutral point earthed across a resistor, the resistive current component shall be greater than the capacitive current component, but limited to the maximum values given in Table 1.

Table 1. System Earthing Methods

VOLT.	POWER SOURCE	TRANSFORMER
11 kV	Generator neutral shall be high resistance earthed. Maximum earth fault current shall be limited to 20 A per generator.	Transformer neutral shall be high resistance earthed. Maximum earth fault current shall be limited to 20 A per transformer.
6.6 kV	Generator neutral shall be high resistance earthed. Maximum earth fault current shall be limited to 20 A per generator	Transformer neutral shall be high resistance earthed and connected to the main earth. Maximum earth fault shall be limited to 20 A per transformer.
750 V d.c.	Both poles isolated.	
690 V	Generator neutral shall be high resistance earthed. Maximum earth fault current shall be limited to 100A per generator.	Transformer neutral shall be high resistance earthed and connected to the main earth. Maximum earth fault current shall be limited to 100A per transformer.
400/ 230 V TN-S system		Transformer neutrals shall be solidly earthed.
230 V UPS	Isolated.	
D.C. V	Both poles isolated. 1)	

In case of only one emergency generator installed, the generator neutral shall be isolated.

Note:

1. D.C. voltages for telecommunication system, may have one pole earthed.

6.5.2 Lightning Protection

No additional installations will be required for the lightning protection, provided the unit consist of bolted and welded steelwork that will provide a continuous current path from the highest point of the unit to the main earth.

6.6 Lighting System

6.6.1 General

The following clauses govern the design and functional requirements of the general lighting system.

Other lighting systems such as navigation aids, helideck lighting, marking systems and aviation obstruction lighting shall be designed according to the requirements of statutory regulations.

For the lighting calculations a maintenance factor shall be applied, reflecting the environmental conditions and time between maintenance intervals.

6.6.2 *Lighting Equipment*

The general lighting system shall be designed with fluorescent luminaries. The fluorescent tubes shall be of the two pins, slim long life type.

Floodlights, with high pressure sodium lamp, shall be used for general lighting of open deck areas, inside big open modules where an acceptable mounting height is achievable, on cranes, flare booms, sea surface below boat and raft stations.

Incandescent luminaries shall not be used. For comfort lighting within the living quarter and office areas, low energy lighting sources like compact/mini tubes may be used.

Battery operated handlamps with battery chargers shall be provided. The handlamps with chargers shall be certified for use in zone 1.

Emergency luminaries shall be of the instant start type.

Lighting for escape routes may where applicable consist of self-contained neon guidelights along the floor and above doors. The luminaries shall meet zone 1 requirements.

6.6.3 *Lighting System Design*

The lighting system shall consist of four categories of lighting:

- Normal lighting:
Covering approximately 70% of the lighting requirements. The normal lighting shall be fed from the main distribution system.
- Emergency standby lighting:
Covering approximately 30% of the platform lighting requirements. In normal operation the emergency stand by lighting shall form part of the normal lighting system. However, in emergency modes the luminaries shall be fed from the emergency distribution system.
- Emergency escape lighting:
About 10% of the emergency stand by luminaries, covering escape ways, lifeboat stations, critical equipment etc., shall be equipped with an integral battery, charger and inverter system.
Other emergency luminaries e.g. floodlights, shall be supplied from a centralized battery system.

- Portable emergency lighting:
The battery charger for battery operated handlamps should be fed from the emergency distribution system.

Local subdistribution boards shall be provided for power distribution to the lighting system within each functional area. The distribution boards shall to the extent possible be located in nonhazardous dry areas.

Distribution boards for emergency lighting shall be equipped for common remote alarming of tripped circuit.

As a guideline for design of the emergency lighting, including safety and escape lighting, the publication "Nødlysanlegg" issued by "Selskapet for lyskultur" (The Association of Lighting Design) shall be used.

6.6.4 Normal Lighting Illuminance Levels

The illumination levels shall comply with the NORSOK Standard S-DP-002 "Working Environment".

6.6.5 Emergency Standby Lighting Illuminance Levels

In areas of high risk average horizontal illuminance on the reference plane shall be as high as the task demands and it shall be no less than 10% of normal lighting level or 15 lx, whichever is greater. It shall be free of harmful stroboscopic effect.

6.6.6 Emergency Escape Lighting Illuminance Levels

For escape routes up to 2 m in width, the horizontal illuminances on floor along the center line of an escape route shall be not less than 1 lux and the central band consisting of not less than half the width of the route shall be illuminated to a minimum of 50% of that value. Wider escape routes may be treated as a number of 2 m wide strips.

6.7 Power Outlets

6.7.1 Small Power Outlets

A small power convenience socket outlet system shall be designed such that any area can be reached with a 15 m flexible cord without passing through doors.

In control rooms, local equipment rooms and offices approximately 20% of the convenience outlets shall be fed from the local emergency subdistribution board.

Convenience socket outlets shall be rated 16 A. Circuits dedicated for socket outlets shall have no other consumers connected.

6.7.2 Power Outlets

A power socket outlet system shall be designed such that any working area can be reached with a 40 m flexible cable without passing through doors.

The sockets shall be rated 63 A, 400/230 V, 3 phases + neutral.

6.8 Temporary Work Station

Socket outlets or junction boxes for connection of 125 A, 400/230 V, 3 phase + neutral, temporary work station for turnarounds and major modification work, should be located close to container lay down areas.

6.9 Electrical Heat Tracing

6.9.1 General

Heat tracing shall be applied for frost protection, condensation prevention and process temperature maintenance.

Depending on the process requirements, heat tracing for process temperature maintenance shall be supplied from the emergency distribution system.

Design, material and installation should be according to the guidelines issued by IFEA "Industrielle Varmekabelanlegg".

6.9.2 Design

The heat tracing cables should be of the self limiting type.

Temperature control devices like RTD, thermostats etc. should not be used. For specific applications, however, where the self limiting characteristic of the heating cable is unsuitable regarding response or temperature limitations, thermostatic control shall be used. Temperature control devices shall be installed if excessive temperature will cause corrosion on pipes and tubing.

6.9.3 Power Supply

Each of the circuits shall be equipped with an automatic trip, 30 mA earth fault relay. Trip indication shall be provided for each circuit. Common alarm shall be given to a central alarm system for each subdistribution board.

Subdistribution boards shall be provided for local power distribution to the heat tracing system in each functional area. The distribution boards should be located in non-classified areas.

6.10 Navigation Aids System

All power supply and control equipment shall be located indoors, at a location suitable for maintenance activities.

The integrated power supplies shall be galvanically isolated from the mains.

6.11 Thermographic Inspection

Possibilities for thermographic on load inspection or use of thermostrips for equipment like power transformer, UPS, switchgear and motor control center, should be arranged.

6.12 Separate Electrical Rooms

Separate electrical rooms shall be used when required by statutory regulations. Otherwise, electrical equipment should be located in multidiscipline rooms.

6.13 Location of Major Electrical Equipment

In order to avoid installation of major electrical equipment in hazardous areas or in exposed environments, all major electrical equipment shall be installed inside equipment rooms with a controlled atmosphere.

6.14 Ignition Source Control

Equipment left live in an ESD situation shall be explosion protected and certified for installation in zone 1 area. Excepted is emergency equipment in living quarter and other areas subject to special considerations.

Depending on the location, small power outlets, power outlets and temporary work stations shall be automatically isolated upon detection of gas.

For emergency distribution board, Ex-protection shall be evaluated in each case depending on the location.

All emergency luminaries shall be explosion protected and suitable for installation in zone 1 area. For living quarter and other safe areas this is valid only for escape light.

7. EQUIPMENT REQUIREMENTS

7.1 High Voltage Switchboard

7.1.1 General

The switchboards and switchgear-rooms should allow for future extension to at least one end of the switchboard, according to separate flexibility requirements.

The control voltage shall be supplied from an UPS system at 230 V a.c.

Status for main circuit breakers shall be shown on the breaker front. (On, off, trip.)

7.1.2 Motor Starters

Motor starters shall be equipped with vacuum or SF₆ contactors and fuses, or circuit breakers dependent on the circuit rating. Contactors and fuses shall not be used for circuits above 250A.

Surge arrestors or other protection devices shall be used in connection with vacuum contactors.

It shall also be considered if capacitors are to be installed on the motor terminals as additional protection in connection with vacuum contactors.

7.2 Low Voltage Switchboard

7.2.1 Sparing Philosophy

Spare capacity of approximately 10% should be provided. Spare panels and compartments shall be equipped to facilitate future installation without shutting down the switchboard.

7.2.2 Feeders and Incomers

Circuit breakers shall be used on incomers, bus tie breakers and outgoing feeders for currents above 400A.

Outgoing feeders below 400A may be provided with load breaker and fuses, or moulded case circuit breakers.

The control voltage shall be supplied from an UPS system at 230 V a.c.

Status for main circuit breakers shall be shown on the breaker front. (On, off trip.)

7.2.3 Motor Starters

Motor and starters shall be designed for direct on-line starting.

The control voltage shall be supplied from a common control voltage transformer for each busbar section. A separate control voltage busbar shall be provided. Protection shall be provided individually for each motor starter circuit.

Special care shall be taken in cases where the length of the control voltage cable between a starter and a local control station is very long, for which capacitive effects in cable may cause problems.

Starters should be grouped into motor control centers located in switchboard rooms.

7.3 Electrical Indicating Instruments

7.3.1 General

Panel instruments should be of class 1.0.

Current transformers for measuring purposes shall have 5 A or 1 A secondary current.

Voltage transformers shall have 110 V secondary voltage. Shunts used on d.c. current metering shall be 60 mV.

Where synchronizing can take place, the following instruments shall be provided for manual synchronizing:

- Synchronoscope
- Double voltmeter
- Double frequency meter.

7.3.2 Requirements

Electrical indicating instruments shall be according to Table 2, Indicating Instruments.

Table 2. Electrical Indicating Instruments

ELECTRICAL INDICATING INSTRUMENTS								
Indicating Instruments	Generators		Motor Feeders		Transf. feeders/ outgoing circuit br. feeders	Incomers	D.C. systems	Busbar metering
	Incomers	Control panel	> 1000 kW	< 1000 kW				
Voltmeter + selector switch	X	X				X		X
1 voltmeter							X	
Ammeter + selector switch (1)	X	X			X	X		
1 ammeter			X	X			X	
Wattmeter		X	> 2MW					
VAr meter		X						
Frequency meter		X						
Synchroscope		X						
Ammeter for field current AVR		X						
Hours run meter		X	X	X				
kWh meter		X						
1 ammeter in one phase				X				

Note 1: 3 ammeters may be used.

7.4 Motors

7.4.1 General

A.C. motors should be of the squirrel cage, direct on-line start type. All stator windings shall be star-connected. Where variable speed/torque regulation is required, converter fed a.c. motors should be used. D.C. motors may be used for certain battery supplied lube oil pumps and ventilation fans.

Vibration measurement nipples for off-line condition monitoring shall be provided on all motors of frame size 180 and above.

Anticondensation heaters shall be provided for all high voltage motors, and for all low voltage standby motors exposed to severe condensation conditions.

Connections for high voltage motors shall be provided with insulated connectors.

The terminals and the earthed frame of high voltage motors shall be provided with contact bolts for application of mobile earthing apparatus.

High voltage motors shall not have random wound windings.

High voltage motors shall have insulation class F utilized to class B.

7.4.2 Motor Rating, Ex Protection and Enclosure

Motor rating and protection shall be according to Table 3.

Table 3. Motor Rating and Protection

MOTOR TYPE	NOM. VOLT.	RATED OUTPUT	Ex PROTECTION 3)	INS. CLAS	ENCLOSURE
LV	400 V a.c.	≤ 200 kW	e, n d/e (1)	F	IP55 (2)
LV	690 V a.c.	≤ 400 kW	e, n d/e (1)	F	IP55 (2)
HV	6,6 kV a.c. 11 kV a.c.	≥ 300 kW ≥ 400 kW	p d/e (1)	F	IP55 (2)

Notes:

1. Shall be used with Ex e termination.
2. IP56 shall be used on open deck.
3. If relevant.

7.5 Local Control Stations

Motors shall be manually controlled for maintenance purposes from a control station adjacent to the motor. Local emergency stop shall be connected directly to the motor starter.

Control stations shall be standardized with view to symbols, colours and lettering on pushbuttons, indication lights, selector switches, etc. throughout the unit.

8. RELAYS AND PROTECTION

8.1 General

Solid state, microprocessorbased multifunction protective relays with programmable release characteristics should be employed for protection of the electrical power generation and distribution system and electric motors.

Relays with data communication features should be employed in large, centrally controlled systems.

8.2 Main Generator Protection

Main generator protection shall be according to Table 4.

Table 4. Generator Protection

Protective function	Trip generator and excitation breaker	Local and Remote Alarm
Differential protection	X	X
Overload and shortcircuit	X	X
Earth fault	X	X
Stator RTD, temp. high		X
Stator RTD, temp. hi/hi	X	X
Rotor earth fault	X	X
Directional earth fault (1)	X	X
Overvoltage	X	X
Undervoltage	X	X
Reverse active power (1)	X	X
Excitation failure	X	X
Negative phase sequence	X	X

Note 1:

For generators in parallel operation only.

8.3 Emergency Generator Protection

Emergency generator protection shall be according to Table 5.

Table 5. Emergency Generator Protection

Protective Function	Emergency Mode		Test Mode	
	Trip generator and excitation breaker	Local and Remote Alarm	Trip generator and excitation breaker	Local and Remote Alarm
Short circuit	X	X	X	X
Earth fault				X
Stator RTD,temp.high				X
Stator RTD, temp. hi/hi				X
Directional earth fault (1)	X	X	X	X
Reverse active power (1)	X	X	X	X
Excitation failure			X	X

Note 1:

For generators in parallel operation only

8.4 Electric motor and power transformer protection

Electric motor and power transformer protection shall be according to Table 6.

Table 6. Motor and Power Transformer Protection

Protective function	Low voltage motor	High voltage motor	Power transformer	Local and Remote Alarm
Differential protection			X (4)	X
Overload	X	X		X
Shortcircuit	X	X	X (7)	X
Earth fault	X	X	X (5)	X
RTD, temp. high		X (1)	X (1)	X
RTD, temp. high high		X (2)	X	X
Stalled rotor	X (3)	X		X
No. of start attempts/thermal state		X		X
Negative sequence		X		X

Notes:

1. Alarm only.
2. Should the RTD detect overtemperature in motors driving fire water pumps, an alarm only shall be annunciated while the operation shall be continued in emergency mode.
3. Stalled rotor protection shall be provided for all submerged pump motors.
4. Differential protection shall be provided for transformers ≥ 4 MVA.
5. Earth fault protection shall be provided:
 - a) for protection of the primary winding against internal faults
 - b) for protection of the switchboard connected to the secondary winding, and internal faults when the neutral point is earthed across a neutral resistor
6. Restricted earth fault protection shall be provided for transformers with solidly earthed neutral.
7. Shall protect the primary and secondary windings, and the busbar of the switchboard connected to the secondary winding.

8.5 11 kV / 6,6 kV Busbar Relays

The following relays shall be connected to each busbar section of 11 kV / 6,6 kV switchboard:

- Undervoltage relay.
A stationary undervoltage situation shall initiate tripping of the connected motors.
- Frequency relay. Input to Load Shedding System.
A stationary low frequency situation shall initiate tripping of the connected motors.

8.6 Other Circuits

Lighting and small power transformers

- Circuit breakers with primary overcurrent/short circuit relay, moulded case circuit breakers or fuses.
- Earth fault protection.

690 V Sub-distribution feeders

- Circuit breakers with overcurrent/short circuit relay.
- Earth fault protection.

Feeders to 230 V sub-distribution boards

- Moulded case circuit breakers with overcurrent/shortcircuit relay.
- Earth fault protection.

Lighting and small power circuits

- Miniature circuit breakers.
- Earth fault protection.

Trace heating circuits

- Miniature circuit breakers.
- Earth fault protection.

8.7 Load Shedding

A load shedding system shall be considered, to prevent total "black-out" caused by the starting of large motors or loss of one of the main generators.

Tripping of selected large motors or loads shall be initiated by input from a frequency relay. A selector switch or programmable unit should be provided on each motor starter incorporated in the load shedding system to enable the selection of the loads to be disconnected. The selection should also be enabled from the central control room.

ANNEX A
EQUIPMENT DATA SHEETS
(Normative)

EDS-001	UNINTERRUPTIBLE POWER SUPPLY (UPS)
EDS-002	EG, GENERATOR
EDS-003	EH, HIGH VOLTAGE SWITCHBOARD (>1kV)
EDS-004	EM, INDUCTION MOTOR
EDS-005	EN, LOW VOLTAGE SWITCHBOARD (<1kV)
EDS-006	ER, CONVERTERS
EDS-007	ET, POWER TRANSFORMER