NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

SHIP ELECTRIC SYSTEMS

Graduation Project
EE-400

Student: H.Erdem Saygı (970575)

Supervisor: Özgür Cemal Özerdem

Lefkoşa-2002

ACKNOWLEDGEMENTS

First of all, I would like to thank my parents espectially my father for his huge knowledge and for his endless help. I also wish to thank to Electrical and Electronic Engineering Department Assistants Mr.Cemal Kavalcıoğlu for his helps.

I want to thanks seperately first to my supervisor Mr. Özgür C. Özerdem for shearing his experianse with me , to my instructors that during my education they support me the Dean of Engineering Faculty and Vice-President Prof. Dr. Fakhreddin MAMEDOV, and everytime from near to me, my dear instructors Chairman of Electrical and Electronic Department Assoc.Prof.Dr. Adnan Khasman, , Vice Chairman of Electrical and Electronic Engineering Department Assist. Prof. Dr. Kadri BÜRÜNCÜK, Vice-President of University Prof.Dr. Şenol BEKTAŞ, Prof.Haldun GÜRMEN, Mr. Mehrdad KHALEDİ, Assist. Prof. Dr. Doğan HAKTANIR.

I would like to express my gratitude to the Companies GESAN Ship Electrics Systems, Group Schneider and, Sanmar Shiping Co. that they gave to me informations and datas about Ship Electrics Systems.

Finally, I want to thanks everybody who helped and supported me come today's and graduated from a University.

ABSTRACT

One of the most important transportation style is ship transportation. It is the cheapest way of transporting objects one point to another point. Also the huge amout of cargo can carryied with this transportation style. But of course there are some rules which must be agreeds when doing this job. All the countries has their own rules, also it has a international rules because ships are visiting foreigner countries and these countries rule's can be different from our's, at these conditions international rules are valid.

The main thing of these rules mention about safety, because no bady can help you easly while you are sailling. The second important thing of ship is sea suitability. We are interesting electrical systems of ships and protection system and devices. Because even small devices can couse big problems.

In the ships, all the systems must be work in harmoniously, for example fire alarm system can be control some parts of main electric system, it can be stop the fans or aircondition etc... or thing about 24 V DC system, it is using accumulator batteries but batteries are charging with main electric system (generator). These are only small example.

Vessels produce their own electrical power, this can be produce by different kind of machines (or technics), the general they use diesel-electric generators and shaft generators. The number of generator and power of generator is change according to ship's diemensions. Some ships can use these generators in parallel operation.

The shaft generators are preferable for big and going far distance vessels. Because the primary mover of this machine is main engine, and for using shaft generator revolution of main engine must be stable. We can only get this rpm (rount per minute) rate while going far distaces or this system is better for picth control ships, to this system main engine is allways rotating same rpm but propeller's angle is changing.

The energy is disributed with main switchboard, also motors, ligthing system, air condition etc.. can be able to control from here. Also there is some measurement device in it like voltmeter, ampermeter, frequency meter, KW meter, we can display some information with these.

INTRODUCTION

This project was talked about rules which must be agreed while constructing the electrical systems and also safety systems, how the electrical power produce, how the electrical power distribute.

The tests must be done for equipment, which must be done for all the system. While doing these tests, period and values must be known, next chapters are talking about those things.

This project is 6 chapters and they are explained at the following.

Chapter 1- General Provision; It is talking about short explanation of next chapters, the capacities of generators, which plans must be submitted, the data's equipments in the plan, and shortly explanation of basic requirements.

Chapter 2- System Design; this chapter was mentioned about how many generators will be used and their capacities, shaft generators and their conditions in stable and variable speed, how will we placing the generators, furthermore emergency source of electrical power which will operate after failure of other systems.

Chapter 3- Electrical Equipment; this chapter was talked about, the using equipment in each unity, and giving information of their characteristics.

Chapter 4- Ship Board Installation; this chapter was mentioned about which equipment must be place where and test of these equipments, furthermore it is giving information about cables and how can we spread them.

Chapter 5- Special Ships; this chapter was mentioned about special ships, giving information about these ships, high voltage systems using in the ship and the other systems.

Chapter 6- Explanation of Example Project; with using these information, analysis the sample ship, which the information was mentioned above chapters, cost analysis of this ship and some calculations.

The conclusion presents what kind of ship forming at the end of using these systems, the desires of ship-owners, and future plans for improving these systems.

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CHAPTER 1

GENERAL PROVISIONS

1.1 Organization of Requirements for Electrical Systems

Requirements for electrical systems are organized shown in Figure 1.Chapter 1 deals with general issues and provides, for example, the required submittals and definitions for terms used throughout the electrical systems sections. Chapter 2, Chapter 3 and Chapter 4 provide for system design, equipment design and tests, and shipboard installation and tests. Chapter 5 provides special requirements for system design, equipment and installation of high voltage systems and electric propulsion systems.

1.2 Applications

Electrical systems and equipment of unrestricted ocean-going vessels are to be designed, constructed, installed and tested in accordance with applicable requirements of Chapter 1, Chapter 2, Chapter 3 and Chapter 4. Additional requirements for special systems, namely, high voltage systems (see definition in 1/1.4.3) and electric propulsion systems are provided in Chapter 5.

For vessels of less than 90 m (297 ft) in length or where the installed aggregate generator capacity is 75 kW (100 hp) or less, the requirements in Rules for Building and Classing Steel Vessels under 90 m in Length may be applied. Where generators are not arranged for parallel operation, the capacity of the largest generator may be taken as the 'aggregate generator capacity'.

Arrangements and details that can be shown to comply with other recognized standards that are not less effective than the Rules may be considered.

1.3 Plans and Data to be submitted

1.3.1 System Plans

Three copies of the following plans and data are to be submitted.

1.3.1.1 One Line Diagram

One line diagram of main and emergency power distribution systems, to show:

- Generators: kW rating, voltage, rated current, frequency, number of phases, power factor.
- Motors: kW or hp rating, voltage and current rating.
- Motor controllers: type (direct-on-line, star-delta, etc.), disconnect devices,

overload and under-voltage protections, remote stops, as applicable.

- Transformers: kVA rating rated voltage and current, winding connection.
- Circuits: designations, type and size of cables, trip setting and rating of circuit protective devices, rated load of each branch circuit, emergency tripping and preferential tripping features.
- Batteries: type, voltage, rated capacity, conductor protection, charging and discharging panel.

1.3.1.2 Schematic Diagrams

Schematic diagrams for the following systems are to be submitted. Each circuit in the diagrams is to indicate type and size of cable, trip setting and rating of circuit protective device, and rated capacity of the connected load.

-General lighting, normal and emergency

-Navigation lights

-Interior communications

-General emergency alarm

-Intrinsically safe systems

-Emergency generator starting

-Steering gear system

-Fire detection and alarm system

1.3.1.3 Shot-circuit Data

Maximum calculated short-circuit current values, both symmetrical and asymmetrical values, available at the main and emergency switchboards and the down stream distribution boards.

Rated breaking and making capacities of the protective devices.

Reference may be made to IEC Publication 60363 Short-circuit Current Evaluation with Special Regard to Rated Short-circuit Capacity of Circuit Breakers in Installations in Ships.

1.3.1.4 Protective Device Coordination Study

This is to be an organized time-current study of all protective devices, taken in series, from the utilization equipment to the source, under various conditions of short circuit. The time-current study is to indicate settings of long-time delay tripping, short-time delay tripping, and instantaneous tripping, as applicable. Where an over-current relay is provided in series and adjacent to the circuit protective devices, the operating and time-current characteristics of the relay are to be considered for coordination. Typical thermal withstanding capacity curves of the generators are to be included as appropriate.

1.3.1.5 Load Analysis

Electric-plant load analysis is to cover all operating conditions of the vessel, such as conditions in normal sea going, cargo handling, harbor maneuver, and emergency operations.

1.3.1.6 Other Information

A description of the power management system, including equipment fined with preferential trips, schedule of sequential start of motors, etc. as applicable.

-Voltage-drop for the longest run of cable of each size.

1.3.2 Installation Plans

The following plans and data as applicable are to be submitted in triplicate for approval before proceeding with the work.

1.3.2.1 Booklet of Standard Wiring Practice

This is to contain standard wiring practices and installation details. They are to include, but not limited to, cable supports and retention, typical radii of cable bends, bulkhead and deck penetrations, cable joints and sealing, cable splicing, earthing details, watertight and certified safe connections, eating and bonding connections, cable tray and bunch configurations showing clearance and segregation of cables. For cable penetrations though watertight, gastight and fire-rated bulkheads and decks, evidence of penetration design approval is to be submitted. For watertight and gastight cable penetrations, certificates issued by a competent independent testing laboratory would be acceptable. For fire-rated cable penetrations, certificates issued by an Administration signatory to SOLAS 1974 as amended would be acceptable.

1.3.2.2 Hazardous Area Plan and Equipment Data

The plan is to show hazardous area delineation, along with a list of certified safe electrical equipment and their locations in the hazardous areas. Particulars of the equipment are to include manufacturer's names, model designations, rating as to the type of flammable atmosphere and surface temperature, the degree of protection, any restrictions in their use, and document of certification. A copy of the list of equipment, as installed and approved, is to be maintained on board.

1.3.2.3 Special Hull Penetrations

Details of hull penetrations for installations such as echo sounder, speed log, and impressed current cathodic protection system.

1.3.2.4 Arrangements of Electrical Equipment

Arrangement plans showing the locations of the following equipment and systems:

-Generators, main switchboard, motor control centers, transformers/converters

-Batteries and battery charging and discharging panels

-Emergency source of power, emergency lights

-Interior communication systems

-Emergency alarm system, public addresses system, fire detection and alarm system

-Locations of cable splices and cable junction boxes

1.3.3 Equipment Plans

The following plans and data as applicable are to be submitted in triplicate for approval before proceeding with the work.

1.3.3.1 Essential Rotating Machines of 100 kW (135 hp) and Over

Plans showing assembly, seating arrangements, terminal arrangements, shafts, coupling, coupling bolts, stator and rotor details together with data of complete rating, class of insulation, designed ambient temperature and temperature rise, degree of protection fir enclosures, weights and speeds of rotating parts.

1.3.3.2 Essential Rotating Machines of Less Than 100 kW (135 hp)

Complete rating, class of insulation, designed ambient temperature and temperature rise, and degree of protection for enclosures.

1.3.3.3 Switchboards, Distribution Boards

Plans showing arrangements and details as indicated below are to be submitted for main and emergency switchboards, battery charging and discharging boards for emergency or transitional source of power:

-Front view

-Schematic diagram

-Protective device rating and setting

-Emergency tripping and preferential tripping features

-Internal power for control and instrumentation

-Type and size of internal control and instrumentation wiring

-Size, spacing, bracing arrangements, rated current carrying capacity and rated short circuit current of bus bars and bus bar disconnecting device.

-Written description of automated functions and operations of the electrical plant.

1.3.3.4 Motor Controllers

For motor controllers of 100 kW (135 hp) and over for essential services, plans showing the following particulars are to he submitted: front view, degree of protection for enclosure schematic diagram, current rating of running protection of motor, and type and size of internal wiring.

1.3.3.5 Motor Control Centers

For motor control centers with aggregate loads of 100 kW (135 hp) and over for essential services, plans showing the following particulars are to be submitted: front view, degree of protection for enclosure, schematic diagram, current rating of naming protection of motor, and type and size of internal wiring.

1.4 Definitions

1.4.1 General

The definitions of terms used are in agreement with SOLAS 1974, as amended, and IEC Publication 60092-101, paragraph 1.5, except as provided in 1/4.2.

1.4.2 Specific

The following terms are specifically defined for the purposes of electrical systems

1.4.2.1 Low Voltage

Low voltage in these Rules refers to voltages up to and including 1000 V AC; and 1200 V DC.

1.4.2.2 High Voltage

High voltage in these Rules refers to voltages above 1000 V up to and including 11 kV AC.

1.4.2.3 Essential Services

Essential services are those considered necessary for:

-Navigation, propulsion and maneuvering of the vessel;

-Emergency services as described in 2/3.3;

-Maintaining a minimum level of safety, such as providing for lighting, ventilation of propulsion machinery space, interior and radio communications, manually operated alarms, fire safety systems, bilge and ballast services; and

-Maintaining a minimum level of safety with regard to the cargoes carried, for instance, the inert gas system of an oil carrier, the ventilation of ro-ro space, etc.

1.4.2.4 Minimum Comfortable Condition of Habitability

A condition in which at least services such as cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water are adequately provided.

1.4.2.5 Cascade Protection

The application of protective devices in which the device nearest to the source of power has short circuit ratings equal to or in excess of the maximum prospective short circuit current, while devices in succeeding steps further from the source have lower short circuit ratings.

1.5 Basic Requirements

The requirements of electrical systems, as a whole are intended to assure the satisfactory operation of electrical systems on board a vessel through:

- The provision of sufficient number of generators to allow for at least one standby;
- The provision of an emergency source of power and its supply to services needed in an emergency;
- The continuity of supply in the event of an equipment fault or an overload by means of coordinated & tripping of protective devices, automatic shedding of non-essential loads, etc;
- Observation of electrical safety; such as proper sizing and protection of electrical cables, fire retarding properties of insulation materials, appropriate enclosure of equipment, proper installation and tests, etc.; with a view to minimizing the risks of fire and hazard to personnel.
- Design assessment, testing and certification of critical equipment in the systems; and providing judicious attention to the hazards of the cargoes carried and their implications or electrical equipment and system design.

CHAPTER 2

SYSTEM DESIGN

2.1 Applications

The provisions of this section apply to shipboard electrical power generation and distribution systems. High voltage systems and electric propulsion systems are subject additionally to the provisions of chapter 5.For DC systems, unless specifically stated in this chapter, and chapter 5/4, see IEC Publications 60092-201, 60092-202 and 60092-301.

2.2 Main Source of Electrical Power

2.2.1 Number and Capacity of Generators

2.2.1.1 General

The number and capacity of generating sets is to be sufficient, under normal sea-going conditions with any one generator in reserve, to carry those electrical loads for essential services and for minimum comfortable conditions of habitability. See definitions in chapter 1/4.

2.2.1.2 Consideration for Motor Starting Current

In selecting the capacity of a generating set, particular attention is to be given to the starting current of motors forming part of the system. With any one generator held in reserve as a standby, the remaining generator sets, operating in parallel and initially carrying the loads in chapter 2/2.1.1, are to have sufficient capacity with respect to the largest idle essential motor on the vessel so that the motor can be started and the voltage drop occasioned by its starting current will not cause any already running motor to stall or control equipment to drop out. The limits of transient voltage variation under suddenly applied loads are to be in accordance with chapter 3/2.7.2(c).

For vessels fitted with electric motor driven athwart ship thrusters to assist maneuvering, the starting and running of this motor may be supported by all the installed generators, provided arrangements are made such that its starting is conditional upon the requisite generators being available and that it will not cause inadvertent load shedding.

2.2.1.3 Starting from Dead Ship Condition

Dead ship condition is the condition under which the main propulsion plant, boiler and auxiliaries are not in operation due to the absence of power. The electrical power generating plant is to be sized such that with any one generator or its primary source of power out of operation, the remaining generating set(s) are capable of providing the electrical services necessary to start the main propulsion plant from a dead ship condition. The emergency source of electrical power may also be used for this purpose provided its capacity either alone or combined with other source of electrical power is sufficient to provide at the same time those services required to be supplied by chapter 2/3.3.1 to 2/3.3.8. Where electrical power is necessary to restore propulsion, the capacity is to be sufficient to restore propulsion to the ship in conjunction with other machinery, as appropriate, from a dead ship condition within thirty minutes after blackout. See also 2/2.6 and 2/2.7 below.

2.2.2 Power Supplied by Propulsion Generators

For vessels propelled by electric power and having two or more constant voltage propulsion generating sets, the vessel's service electric power may be derived from this source. See chapter 5/3.3.1.

2.2.3 Shaft Generators

2.2.3.1 Constant Speed Drive

A generator driven by propulsion machinery capable of operating continuously at a constant speed, e.g. those fitted with controllable-pitch propellers, may be considered one of the generators required by chapter 2/2.1, provided that speed and voltage variations in accordance with 3/2.7 are met even in the case of severe weather condition.

2.2.3.2 Variable Speed Drive

A generator driven by propulsion machinery not capable of operating continuously at a constant speed may be fitted in addition to the generators required by chapter 2/2.1. Arrangements are to be made such that a source of electrical power can be brought on line automatically within 45 seconds whenever the voltage or frequency of the shaft generator deviates, for any reason, beyond the prescribed limits. This shaft generator will not be counted as one of the required generators.

2.2.4 Transformers and Converters

Where transformers and/or converters form a part of the vessel's electrical system supplying to essential services and services necessary for minimum comfortable conditions of habitability, the number and capacity of the transformers and/or converters is to be such that, with any one transformer or converter, or any one single phase of a transformer, out of service, the remaining transformers and/or converters or remaining phases of the transformer are capable of supplying power to these loads under normal seagoing conditions.

Each of these transformers or converters is to be located as a separate unit with separate enclosure or equivalent, and is to be served by separate circuits on the primary and secondary sides; each primary circuit is to be provided with switchgear protective devices in each phase. Each of the secondary circuits is to be provided with a multipole isolating switch.

2.2.5 Location of Generators

At least one generating station (one or more generators sufficient to supply to essential services) is to be placed in the same space as the main switchboard (and transformers, as applicable) so that, as far as practicable, the occurrence of a fire, flooding or similar casualty in not more than one space can completely disrupt the normal electrical supply. An environmental enclosure for the main switchboard such as may he provided by a centralized control room situated within the main boundaries of the space, is not to be considered as separating the switchboard from the generators.

2.2.6 System Arrangement

Where the main source of electrical power is necessary for propulsion of the vessel, the system is to be so arranged that, in the event of the loss of any one of the generators in service, the electrical supply to equipment necessary for propulsion and steering and to ensure safety of the vessel will be maintained or restored in no more than 45 seconds. Load shedding or other arrangements are to be provided to protect the generators against sustained overload, see also 2/5.5.

2.2.7 Main Switchboard

Where the main source of electrical power is necessary for propulsion of the vessel, the main bus bar is to be subdivided into at least two parts which are normally to be connected by circuit breakers or other approved means; so far as is practicable, the connection of generator sets and other duplicated equipment are to be equally divided between the parts.

2.3 Emergency Source of Electrical Power

2.3.1 General

2.3.1.1 Basic Requirement

A self-contained emergency source of electrical power is to be provided so that in the event of the failure of the main source of electrical power, the emergency source of power will become available to supply power to services that are essential for safety in an emergency.

2.3.1.2 Scope of Provision

A self-contained emergency source of electrical power includes prime mover and its starting equipment, generator, fuel tank, emergency switchboard, associated transforming equipment, if any, transitional source of emergency power, if applicable, and emergency lighting distribution board and associated transformers, if applicable.

2.3.1.3 Requirements by the Governmental Authority

Attention is directed to the requirements of governmental authority of the country, whose flag the vessel flies, for emergency services and accumulator batteries required in various types of vessels.

2.3.2 Location

2.3.2.1 General

The self-contained emergency source of electrical power is to be located above the uppermost continuous deck, outside the machinery casing, and is to be readily accessible from the open deck. It is not to be located forward of the collision bulkhead.

2.3.2.2 Separation from Machinery Space of Category A

The location of the self-contained emergency source of electrical power in relation to the main source of electrical power is to be such that a fire or other casualty in the space containing the main source of electrical power or in any machinery space of category A will not interfere with the supply, control and distribution of emergency electrical power.

The space containing the self-contained emergency source of electrical power including trunks to such spaces are not to be contiguous to the boundaries of machinery spaces of category A or those spaces containing the main source of electrical power.

Where it can be shown that the arrangements of the spaces containing the self-contained emergency source of power in relation to machinery space of category A are in compliance with the requirements of the governmental authority of the country whose flag the vessel flies, either of the following may be considered.

i) Contiguous boundaries insulated to A-60 with the insulation extending at least 450mm (18 in.) beyond the boundary of the space containing the self-contained emergency source of power.

*ii)*Separation by a cofferdam having dimensions as required for ready access and extending at least 150 mm (6 in.) beyond the boundaries of the space containing the self-contained emergency source of power. Except for cables feeding services located in the machinery space, emergency electric cables are not to be installed in such cofferdams unless the cofferdam is insulated to A-60.

2.3.2.3 Separation from Other Spaces

Spaces containing the emergency sources of electrical power are to be separated from spaces other than machinery space of category A by fire rated bulkheads and decks.

2.3.3 Emergency Services

The emergency source of electrical power is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously. Due regard will be given to equipment not required to draw its rated load in actual service, provided supporting details are submitted.

The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for the period specified hereafter.

2.3.3.1 Emergency Lighting for Survival Craft

For a period of 3 hours, emergency lighting:

i) At every muster and embarkation station and over the sides for preparation and launching the survival craft, and its launching appliance.

ii) For the area of water into which the survival craft is to be launched.

2.3.3.2 Other Emergency Lighting

For a period of 18 hours, emergency lighting:

i) In all service and accommodation alleyways, stairways and exits, personnel lift cars and personnel lift trunks;

ii) In the machinery spaces and main generating stations including their control positions;

iii) In all control stations, machinery control rooms, and at each main and emergency switchboard;

iv) At all stowage positions for fireman's outfits;

v) At the steering gear; and

vi) At the emergency fire pump, at the sprinkler pump, and at the emergency bilge pump, and at the starting positions of their motors.

2.3.3.3 Navigation Lights

For period of 18 hours, the navigation lights and other lights required by the International Regulation for Preventing Collisions at Sea.

2.3.3.4 Radio Communication

For a period of 18 hours; the radio equipment as required by Chapter IV of SOLAS.

2.3.3.5 Internal Communication

For a period of 18 hours, all internal communication equipment as required in an emergency, this includes those required by 2/6.3.

2.3.3.6 Navigation Aids

For a period of 18 hours, the navigational aids as below.

i) Magnetic compass

ii) Gyro compass

iii) Radar

iv) Echo-sounder

v) Rudder angle indicator

vi) Propeller revolution counters

*vii)*Rate of turn indicator, if fitted

2.3.3.7 Fire Detection and Alarm System

For a period of 18 hours, the fire detection and alarm system.

2.3.3.8 Emergency Signals

For a period of 18 hours, intermittent operation of the daylight signaling lamp, the vessel's whistle, the manually operated call points, and all internal signals that are required in an emergency, which includes those in 2/6.4.

2.3.3.9 Fire Pump

For period of 18 hours, one of the fire pumps required and fixed pressure water spray system pump required. If dependent upon the emergency generator for its source of power.

2.3.3.10 Steering Gear

Steering gear which is required to comply with under this paragraph, for a period of 30 minutes continuous operation on vessels of 10,000 gross tonnage and upwards, and 10 minutes continuous operation on vessels of less than 10,000 gross tonnage, unless an independent source of power is provided in the steering gear compartment.

(Emergency Power Supply for Steering Gears: Where the required stock diameter is over 230 mm (9 inc.), an alternative power supply- sufficient at least to supply one steering gear power unit and also its associated control system and rudder angle indicator , is to be provided automatically, within 45 seconds, either from the emergency source of electrical power or from an independent source of power located in the steering gear compartment. This independent source of power is to be used only for this purpose.

The steering gear power unit under alternative power supply is to be capable of moving the rudder from 15° on one side to 15° on the other side in not more than 60 seconds with the vessel at the summer draft while running at one half the maximum speed ahead or 7 knots, whichever is the greater.

In every vessel of 10,000 gross tonnage and upwards, the alternative power supply is to have a capacity for at least 30 minutes of continuous operation and other vessel for at least 10 minutes.)

2.3.3.11 Remote Propulsion Control and Monitoring System for ACC and ACCU Notations

For 30 minutes, the remote propulsion control and monitoring system for machinery spaces intended for centralized control or unattended operation as required.

2.3.4 Vessels on Short Duration Voyages

In a vessel engaged regularly in voyages of short duration and an adequate standard of safety is attained, a lesser period than the 18 hour period specified in 2/3.3 but not less than 12 hours may be accepted.

2.3.5 Power Source

Emergency source of electrical power may be a generator, an accumulator battery, or a combination of these.

2.3.5.1 Generator

Where the emergency source of electrical power is a generator, it is to be:

i) Driven by a prime mover with an independent supply of fuel, having a flash point (closed cup test) of not less than 43°C (110^{0}F); -

ii) Started automatically upon failure of the main source of electrical power supply; and

iii) Automatically connected to the emergency switchboard supplying those services referred to in chapter 2/3.3 in not more than 45 seconds.

Where the emergency generator as specified above is not provided with automatic starting, a transitional source of emergency electrical power as specified in section 2/3.6 is to be fitted.

2.3.5.2 Accumulator Battery

Where the emergency source of electrical power is an accumulator battery it is to be capable of:

i) Automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power;

ii) immediately supplying at least those services specified in chapter 2/3.6; and

iii) Carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage.

2.3.6 Transitional Source of Power

The transitional source of emergency electrical power where required by chapter 2/3.5.1 is to consist of an accumulator battery which is to operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage and be of sufficient capacity and is to be so arranged as to supply automatically in the event of failure of either the main or the emergency source of electrical power for half an hour at least the following services if they depend upon an electrical source for their operation:

i) The lighting required by chapter 2/3.3.1, 2/3.3.2, and 2/3.3.3. For this transitional phase, the required emergency electric lighting, in respect of the machinery space and accommodation and service spaces may be provided by permanently fixed, individual, automatically charged, relay operated accumulator lamps; and

ii) All services required by chapter 2/3.3.4, 2/3.3.5, 2/3.3.7, and 2/3.3.8 unless such services have an independent supply for the period specified from an accumulator battery suitably located for use in an emergency.

2.3.7 Emergency Switchboard

2.3.7.1 Location of Emergency Switchboard

The emergency switchboard is to be installed as near as is practicable to the emergency source of electrical power.

Where the emergency source of electrical power is a generator, the emergency switchboard is to be located in the same space unless the operation of the emergency switchboard would thereby be impaired.

No accumulator battery fitted in accordance with chapter 2/3.5.2 or chapter 2/3.6 is to be installed in the same space as the emergency switchboard. An indicator is to be mounted on the main switchboard or in the machinery control room to indicate when these batteries are being discharged.

2.3.7.2 Interconnector Feeder between Emergency and Main Switchboards

The emergency switchboard is to be supplied during normal operation from the main switchboard by an interconnector feeder which is to be protected at the main switchboard against overload and short circuit and which is to be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power.

2.3.7.3 Feedback Operation

Where the emergency switchboard is arranged for feedback operation, the interconnector feeder is also to be protected at the emergency switchboard at least against short circuit, which is to be coordinated with the emergency generator circuit breaker.

In addition, this interconnector feeder protective device is to trip to prevent overloading of the emergency generator which might be caused by the feedback operation.

2.3.7.4 Non-emergency Services and Circuits

The emergency generator may be used, exceptionally, and for short periods, for services, such as routine testing (to check its proper operation), deadship start-up, blackout situations, provided that measures are taken to safeguard the independent emergency operation as required in chapter 2/3.5.1.

For ready availability of the emergency source of electrical power, arrangements are to be made where necessary to disconnect automatically non-emergency circuits from the emergency generator to ensure that electrical power is available automatically to the emergency circuits upon main power failure.

2.3.7.5 Arrangements for Periodic Testing

Provision is to be made for the periodic testing of the complete emergency system and is to include the testing of automatic starting system.

2.3.8 Starting Arrangements for Emergency Generator Sets

2.3.8.1 General

The emergency generator is to be capable of being readily started in their cold condition at a temperature of 0^0C (32^0F). If this is impracticable or if lower temperatures are likely to be encountered, heating arrangements are to be fitted.

2.3.8.2 Number of Starts

Each emergency generator arranged to be automatically started is to be equipped with starting devices with a stored energy capability of at least three consecutive starts. The source of stored energy is to be protected to preclude critical depletion (i.e. not to be depleted beyond a level where starting by manual intervention is still possible) by the automatic starting system, unless a second independent means of starting is provided. In addition, another source of energy is to be provided for an additional three starts within thirty minutes unless manual starting can be demonstrated to be effective.

2.3.8.3 Stored Energy for Starting

The stored energy for starting the emergency generator set is to he maintained at all times, as follows:

i) Electrical and hydraulic starting systems are to be maintained from the emergency switchboard.

ii) Compressed air starting systems may be maintained by the main or auxiliary compressed air receivers through a suitable non-return valve or by an emergency air compressor which, if electrically driven, is supplied from the emergency switchboard.

iii) All of these starting, charging and energy storing devices are to be located in the emergency generator space; these devices are not to be used for any purpose other than the operation of the emergency generating set. This does not preclude the supply to the air receiver of the emergency generating set from the main or auxiliary compressed air system through the non-return valve fitted in the emergency generator space.

2.3.8.4 Manual Starting

Where automatic starting of the emergency generator in accordance with chapter 2/3.5.1 is not required, manual starting is permissible, such as manual cranking, inertia starters, manually charged hydraulic accumulators, or power charge cartridges, where they can be demonstrated as being effective.

When manual starting is not practicable, the requirements of chapter 2/3.8.2 and chapter 2/3.8.3 above, shall be complied with except that starting may be manually initiated.

2.4 Distribution System

2.4.1 General

The following are recognized as standard systems of distribution. Distribution systems other than these will be considered.

- Two-wire direct current
- Two-wire single-phase alternating current
- Three-wire three-phase alternating current
- Four-wire three-phase alternating current

2.4.2 Hull Return Systems

2.4.2.1 General

A hull return system is not to be used, with the exception as stated below:

- Impressed current cathodic protection systems;
- Limited locally earthed system, provided that any possible resulting current does not flow through any hazardous locations;
- Insulation level monitoring devices, provided the circulation current does not exceed 30mA under all possible conditions.

2.4.2.2 Final Subcircuits and Earth Wires

Where the hull return system is used, all final subcircuits, i.e., all circuits fitted after the last protective device, are to consist of two insulated wires, the hull return being achieved by connecting to the hull one of the busbars of the distribution board from which they originate. The earth wires are to be in accessible locations to permit their ready examination and to enable their disconnection for testing of insulation.

2.4.3 Earthed AC Distribution System

2.4.3.1 General Earthing Arrangement

For earthed distribution systems, regardless of the number of power source, the neutral of each power source, including that of the emergency generator where applicable, is to be connected in parallel and earthed at a single point. Reference should be made to manufacturer-specified allowable circulating currents for neutral-earthed generators.

2.4.3.2 System Earthing Conductor

System earthing conductors are to be independent of conductors used for earthing of non-current carrying parts of electrical equipment. See chapter 4/12.2 for installation details and earth conductor sizing. Four-wire three-phase AC systems having an earthed neutral are not to have protective devices fitted in the neutral conductors. Multipole switches or circuit breakers which simultaneously open all conductors, including neutral, are allowed. In multiple-generator installations, each generator's neutral connection to earth is to be provided with a disconnecting link for maintenance purpose.

2.4.4 Cable Sizing

This Paragraph applies to cables conforming to IEC Publication 60092-353 or IEC Publication 60092-3. Cables conforming to other standards are to be sized in accordance with corresponding provisions of that standard. For marine cable standards acceptable to the Bureau, see chapter 3/5.1.

2.4.4.1 Cable's Current Carrying Capacity

2.4.4.1(a) General. Cable conductor size is to be selected based on the current to be carried such that the conductor temperature, under normal operating conditions including any overload condition that may he expected, does not exceed the maximum rated temperature of the cable insulation material. The selected cable type is to have a maximum rated temperature at least 10^0C (l8^0F) higher than the maximum ambient temperature likely to exist at the location where the cable is installed.

2.4.4.1(b,) Current carrying capacities. The maximum current carrying capacities of cables are to be obtained from Table 18. These values are applicable, without correction factors for cables installed either in single- or double-layer in cable tray, or in a bunch in cable trays, cable conduits or cable pipes where the number of cables in the bunch does not exceed six. The ambient temperature is to be 45^0C (I 3^0F) or less.

2.4.4.1(c) Current carrying capacity correction. Where more than six cables which may be expected to operate simultaneously are laid close together in a bunch in such a way that there is an absence of free air circulation around them a reduction factor is to be applied to the current carrying capacity of the cables; this reduction factor is to be 0.85 for seven to twelve cables in one bunch. The correction factor for cable bunches of more than twelve cables each is to be specially considered in each case based on cable type and service duty.

2.4.4.1(d) Voltage drop. Voltage drop is to be taken in to account in determining cable size. The voltage drop in the conductors while carrying the maximum current under normal steady condition is not to exceed 6% of the nominal voltage at any point of the installation. For cables connected to batteries with a voltage not exceeding 50 V this figure may be increased to 10%.

2.4.4.1(e) Minimum conductor sizes. Conductor size is not to be less than those given in the table1 for each application as shown:

2.4.4.2 Generator Cable

Generator cable is to have a current carrying capacity of not less than the rated current or the rated continuous overload current of the generator.

2.4.4.3 Transformer Cable

Cables provided for primary and secondary circuits of transformers are to have current carrying capacities not less than the rated primary and secondary currents respectively.

2.4.4.4 Motor Control Center Feeder

Feeder cables supplying to motor control centers are to have a continuous current-carrying capacity not less than 100% of the sum of the rated current of all motors connected to the motor control center.

2.4.4.5 Distribution Panel Feeder

Feeder cables supplying to distribution panels or to any sub-distribution panels are to have current-carrying capacity of not less than 100% of the sum of the rated currents of all connected consumers. Where connected consumers are not operated simultaneously, feeder cables of lesser current capacity are permitted provided that they are protected in accordance with chapter 2/5 below.

2.4.4.6 Motor Branch Circuit

A separate circuit is to be provided for each motor having a full-load current of 6 A or more. The cables are to have a carrying capacity of not less than 100% of the motor full-load current rating. Branch circuit conductor for each motor is not to be less than *1.5* mm^2.

2.4.4.7 Lighting Circuits

Cable for branch lighting circuit is to have current carrying capacity of not less than the sum of the full load currents of the connected lighting fixtures. Where connected lighting fixtures are not operated simultaneously, feeder cables of lesser current capacity are permitted provided that they are protected in accordance with chapter 2/5 below.

2.4.4.8 Protection of Feeder Size Reduction

The size of feeder conductors is normally to be uniform for the total length, but may be reduced beyond any intermediate distribution board, provided that the reduced size section of the feeder is protected by the overload device at the board at which the feeder size is reduced.

2.4.5 Segregation of Power Circuits

Separate feeders are to be provided for normal vessels service loads and emergency service loads.

2.4.6 Steering Gear Power Supply Feeders

Each electric or electrohydraulic steering gear is to be served by at least two feeders fed directly from the main switchboard; however, one of the feeders may be supplied through the emergency switchboard. In the event that the steering gear operates a rudder with required upper rudder stock diameter of 230mm (9 in.) or more (see chapter 4/6.5), one of these feeders must be supplied through the emergency switchboard.

An electric or electrohydraulic steering gear fitted with duplicated power units is to have each of these units served by one of the feeders supplying this steering gear. The feeders supplying an electric or electrohydraulic steering gear are to have adequate rating for supplying all motors, control systems and instrumentation which are normally connected to them and operated simultaneously.

The feeders are to be separated throughout their length as widely as is practicable.

2.4.7 Lighting System

2.4.7.1 Main Lighting System

A main electric lighting system served by the main source of electric power is to be provided. This lighting system is to provide illumination throughout the vessel.

2.4.7.2 System Arrangement

The main lighting system is not to render inoperative the lighting system served by the emergency source of power (see chapter 2/3.3.1 and 2/3.3.2) in the event of a fire or other casualty occurring in the space containing the main source of electrical power and its associated distribution equipment. Conversely, a fire or other casualty occurring in the space containing the self-contained emergency source of electrical power, including the emergency lighting switchboard (see chapter 2/3.1), is not to render inoperative the main lighting system.

2.4.8 Ventilation System Circuits

Ventilation fans for cargo spaces are to have feeders separate from those for accommodations and machinery spaces. In general, power ventilation is to be capable of being stopped from a location outside the space ventilated as indicated in chapter 2/6.5.

See also, chapter 4/7.2.

2.4.9 Cargo Space Circuits

All lighting and power circuits for cargo space are to be controlled by multiple-pole switches situated outside the space. Light indicator or other means is to be provided on the multipole-linked switch to show whether the circuit is live.

2.4.10 Electric Space Heater Circuits

Each heater is to be connected to a separate final branch circuit. However, a group of up to 10 heaters with aggregate current not exceeding 16 A may be connected to a single final branch circuit.

2.5 System Protection

2.5.1 General

Each electrical system is to be protected against overload and short circuit by automatic protective devices, so that in the event of an overload or a short circuit the device will operate to isolate it from the systems:

- To maintain continuity of power supply to remaining essential circuits; and
- To minimize the possibility of tire hazards and damage to the electrical system.

These automatic protective devices are to protect each non-earthed phase conductors (e.g. multipole circuit breakers or fuses in each phase).

In addition, where possibility exists for generators to be overloaded, load-shedding arrangements are to be provided to safeguard continuity of supply to essential services

The following are exceptions:

- Where it is impracticable to do so, such as engine starting battery circuits.
- Where, by design, the installation is incapable of developing overload, in which case, it may be protected against short circuit only.
- Steering circuits; see chapter 2/5.9.5.

2.5.2 Protection Against Short-circuit

2.5.2.1 General

Protection against short-circuit is to be provided for each non-earthed conductor (multipole protection) by means of circuit breakers, fuses or other protective devices.

2.5.2.2 Short Circuit Data

In order to establish that protective devices throughout the electrical system (e.g. on the main and emergency switchboards and sub-distribution panels) have sufficient short circuit breaking and making capacities, short circuit data as per chapter 1/3.1.3 are to be submitted.

2.5.2.3 Rated Breaking Capacity

The rated breaking capacity of every protective device is not to be less than the maximum prospective short circuit current value at the point of installation. For alternating current (AC), the rated breaking capacity is not to be less than the root mean square (rms) values of the prospective short-circuit current at the point of installation. The circuit breaker is to be capable of breaking any current having an AC component not exceeding its rated breaking capacity, whatever the inherent direct current (DC) component may be at the beginning of the interruption.

2.5.2.4 Rated Making Capacity

The rated making capacity of every circuit breaker which may be closed on short circuit is to be adequate for the maximum peak value of the prospective short-circuit current at the point of installation. The circuit breaker is to be capable of closing onto a current corresponding to its making capacity without opening within a time corresponding to the maximum time delay required.

2.5.2.5 Backup Fuse Arrangements

Circuit breakers having breaking and/or making capacities less than the prospective short circuit current at the point of application will be permitted provided that such circuit breakers are backed up by fuses which have sufficient short circuit capacity for that application. Current-limiting fuses for short circuit protection may be without limitation on current rating, see chapter 2/5.3.

2.5.2.6 Cascade Protection

Cascade protection will be permitted where the combination of circuit protective devices has sufficient short circuit capacity at the point of application. Where used in circuits of essential services, such services are to be duplicated and provided with means of automatic transfer.

2.5.3 Protection Against Overload

Circuit breakers and fuses for overload protection are to have tripping characteristics (over-current trip time) which adequately protects all elements in the system during normal and overload conditions having regard to overload capacity of each of these elements.

Fuses of greater than 320 A are not to be used for overload protection. However, current-limiting fuses may be used for short circuit protection without current rating limitation.

The rating or setting of the overload protective device for each circuit is to be permanently indicated on or at the location of the protective device.

For earthed AC distribution system, see chapter 2/4.3.2.

2.5.4 Coordination of Protective Devices

2.5.4.1 General Requirements

Protective devices are to be selected such that, where considered in series, their tripping characteristics will allow, in the event of a fault (overload or short circuit), the protective device nearest to the fault to open first, thus eliminating the faulted portion from the system.

Protective devices upstream of the fault are to be capable of carrying for the necessary duration the short circuit current and the overload current, without opening, to allow the device nearest to the fault to open.

Coordination is to be provided for the following:

- Between generator protective device, bus tie, bus feeder protective device, and feeder protective devices;
- Between feeder and branch circuit protective devices for essential services except for cascade protection in chapter 2/5.2.6; and
- Between protective devices of emergency generator, emergency feeders and branch circuits.

For main and emergency generators, the circuit breakers are to open to prevent the generators from damage by thermal stress due to the fault current.

2.5.4.2 Coordination Studies

For verification of compliance with the above, a protective device coordination study in accordance with chapter 1/3.1.4 is to be submitted for review.

2.5.5 Load Shedding Arrangements

In association with the provision of chapter 2/2.6, and in order to safeguard continuity of electrical power supply, automatic load-shedding arrangements are to be provided:

i) where only one generating set is normally used to supply the required load, and a possibility exists that due to the switching on of additional loads, whether manually or automatically initiated, the total load exceeds the rated capacity of the running generator, or

ii) where upon the failure of one of the parallel running generators, the total connected load exceeds the total capacity of the remaining generator(s).

Automatic load-shedding arrangements are not to automatically disconnect:

- Services that, when disconnect, will cause immediate disruption to navigation, propulsion and maneuvering of the vessel, or

- Services that will be required or necessary to monitor and control emergency situations (such as fire, flooding, etc.).

2.5.6 Protection of Generators

2.5.6.1 Overload Protection

Generators are to be protected by circuit breakers providing long-time delay over-current protection not exceeding 15% above either the full-load rating of continuous-rated machines or the overload rating of special-rated machines. Alternatively generators of less than *25* kW *(33.5* hp) not arranged for parallel operation may be protected by fuses.

2.5.6.2 Short Circuit Protection

Generators are to be protected for short circuit by circuit breakers provided with short-time delay trips. For coordination with feeder circuit breakers, the short-time delay trips are to be set at a suitable current and time which will coordinate with the trip settings of feeder circuit breakers.

Where two or more AC generators are arranged for parallel operation, each generator's circuit breaker is, in addition, to be provided with instantaneous trip set in excess of the maximum short-circuit contribution of the individual generator.

For generators of less than 200 kW driven by diesel engines or gas turbines which operate independently of the electrical system, consideration may be given to omission of the short-time delay trip if instantaneous and long-time trips are provided.

2.5.6.3 Thermal Damage Protection

Generator circuit breakers at the main and emergency switchboard are to have tripping characteristics and to be set such that they will open before the generator sustains thermal damages due to the fault current. chapter 2/5.4.

2.5.6.4 Reverse Power Protection

A reverse power protection device is to be provided for each generator arranged for parallel operation. The setting of the protective devices is to be in the range 2 % to 6 % of the rated power for turbines and in the range 8 % to 15 % of the rated power for diesel engines.

2.5.6.5 Prime Mover Shutdown

The shutting down of the prime mover is to cause the tripping of the generator circuit breaker.

2.5.6.6 Undervoltage Protection

Generators arranged for parallel operation are to be provided with means to prevent the generator circuit breaker from closing if the generator is not generating, and to open the same when the generator voltage collapses.

In the case of an undervoltage release provided for this purpose, the operation is to be instantaneous when preventing closure of the breaker, but is to be delayed for discrimination purposes when tripping a breaker.

2.5.7 Protection of Feeder Cables

Each feeder conductor is to be protected by a circuit breaker, or fuse with disconnecting switchgear, from short circuit and overload at the supply end.

Fuse ratings and rating of time-delay trip elements of circuit breakers are not to exceed the rated current capacity of the feeder cables except as otherwise permitted for motor and transformer circuits where starting in-rush current need to be taken into account.

If the standard rating or setting of the overload protective device does not correspond to the current rating of the feeder cable, the next higher standard rating or selling may be used provided it does not exceed 150% of the allowable current carrying capacity of the feeder cable.

2.5.8 Protection for Accumulator Batteries

Accumulator batteries, other than engine starting batteries, are to be protected against overload and short circuits by devices placed as near as practicable to the batteries. Fuses may be used for the protection of batteries for emergency lighting instead of circuit breakers up to and including 320 A rating. The charging equipment, except rectifiers, for all batteries is to be provided with reverse current protection.

2.5.9 Protection of Motor Circuits

Overload and short circuit protection is to be provided for each motor circuit in accordance with the following requirements.

2.5.9.1 Motor Branch Circuit Protection

2.5.9.1(a) General. Motor branch circuits are to be protected with circuit breakers or fuses having both instantaneous and long-time delay trips or with fuses. The setting is to be such that it will permit the passage of starting currents without tripping. Normally, the protective device is to be set in excess of the motors full load current but not to be more than the limitations given in the table 2. If that rating or setting is not available, the next higher available rating or setting may be used. In cases where the motor branch circuit cable has allowable current capacity in excess of the motor full load current, the protective device setting may exceed the applicable limitation, but not to exceed that given in chapter 2/5.7.

When fuses are used to protect polyphase motor circuits, they are to be arranged to protect against single-phasing.

2.5.9.1(b) Short circuit protection only. Where the motor branch circuit is protected with circuit breaker fitted with instantaneous trip only (e.g. chapter 2/5.7.5), the motor controller is to have short circuit rating matching at least that of the circuit breaker instantaneous trip setting, and the motor overload protection (see chapter 2/5.9.2) is to be arranged to open all conductors.

2.5.9.2 Motor Overload Protection

The overload protective devices of motor are to be compatible with the motor overload thermal characteristics, and are to be set at 100% of the motor rated current for continuous rated motor. If this is not practicable, the selling may be increased to, but in no case exceeding, 125% of the motor current. This overload protective device may also be considered the overload protect of the motor branch circuit cable.

2.5.9.3 Under-voltage Protection

Under-voltage protection is to be provided for motors over *0.5* kW (0.7 hp).

2.5.9.4Under-voltage Release Protection

For motors of essential and emergency services under-voltage release is to be protected unless the automatic restart upon restoration of the normal voltage will cause hazardous conditions. Special attention is to be paid to the starting currents due to a group of motors with under-voltage-release controllers being restarted automatically upon voltage resumption after a power blackout. Means such as sequential starting is to be provided to limit excessive starting current, where necessary.

2.5.9.5 Protection of Steering Gear Circuits

2.5.9.5(a) AC motors. The steering gear feeder is to be provided with short-circuit protection only, which is to be located at the main or emergency switchboard. However, overload protection may be permitted if it is set at a value not less than 200% of the full load current of the motor (or of all the loads on the feeder), and is to be arranged to permit the passage of the starting current.

2.5.9.5(b) DC motors. The feeder circuit breaker on t4e main switchboard is to be set to trip instantaneously between 300% and *375%* of the rated full-load current of the steering-gear motor. The feeder circuit breaker on the emergency switchboard may be set to trip instantaneously between 200% and 375%.

2.5.9.5(c) Fuses. The use of fuses for steering gear motor circuits is not permitted.

2.5.10 Protection of Transformer Circuits

2.5.10.1 Protection at Primary Side Only

Each power and lighting transformer along with its feeder is to be provided with short circuit and overload protection. The protective device is to be installed on the primary side of the transformer and is to be set at 100% of the rated primary currents of the transformer. If this setting is not practicable, it may be increased to, but in no case exceeding 125% of the rated primary current.

The instantaneous trip setting of the protective device is not to be activated by the in-rush current of the transformer when switching into service.

2.5.10.2 Protection at Both Primary and Secondary Sides

Where the secondary side of the transformer is fitted with a protective device set at not more than 125% of the rated secondary current, the transformer primary side protective device may be set at va1ue less than 250% of the rated primary current.

2.5.10.3 Parallel Operation

When the transformers are arranged for parallel operation, means are to be provided to disconnect the transformer from the secondary circuit. Where power can be fed into secondary windings, short-circuit protection (i.e., short-time delay trips) is to be provided in the secondary connection.

2.5.11 Protection for Branch Lighting Circuits

Branch lighting circuits are to be protected against overload and short circuit. In general, overload protective devices are to be rated or set at not more than 30 A. The connected load is not to exceed the lesser of the rated current carrying capacity of the conductor or 80% of the overload protective device rating or setting.

2.6 Specific Systems

2.6.1 Shore Connection

Where arrangements are made for the supply of electricity from a source on shore or other external source the following requirements apply.

2.6.1.1. Connection Box and Cable

A shore connection box is to be provided on the vessel for the reception of the flexible cable from an external source, fixed cables of adequate rating are to be provided between the shore connection box and the main or emergency switchboard. The cable is to be protected by fuses or a circuit breaker located at the connection box. Where fuses are used, a disconnecting means is also to be provided. Trailing cable is to be appropriately fixed to avoid its imposing excessive stress on cable terminal.

2.6.1.2 Interlock Arrangements

An interlocking arrangement is to be provided between all generators, including the emergency generator, and shore power supply to prevent the shore power from being inadvertently paralleled with the shipboard power.

2.6.1.3 Instrumentation

An indicator light is to be provided at main or emergency switchboard to which shore power is connected to show energized status of the cable. Means are to be provided for checking the polarity (for DC) or the phase sequence (for three-phase AC) of the incoming supply in relation to the ship's system.

2.6.1.4 Earth Connection

An earth terminal is to be provided for connecting the hull to an external earth.

2.6.1.5 Information Plate

An information plate is to be provided at or near the connection box giving full information on the system of supply and the nominal voltage (and frequency if AC) of the ship's system and the recommended procedure for carrying out the connection.

2.6.2 Navigation Light System

2.6.2.1 Feeder

Navigation lights (mast head, side and stern lights) are to be fed by its own exclusive distribution board located on the navigating bridge. The distribution board is to be supplied from the main as well as from the emergency source of power (see chapter 2/3.3.3). A means to transfer the power source is to be fitted on the navigating bridge.

2.6.2.2 Branch Circuit

Each navigation light is to have its own branch circuit and each branch circuit is to be fitted with a protective device.

2.6.2.3 Duplicate Lamp

Each navigation light is to be fitted with duplicate lamps.

2.6.2.4 Control and Indication Panel

A control and indication panel for the navigation lights is to be provided on the navigating bridge. The panel is to be fitted with the following functions:

- A means to disconnect each navigation light.
- An indicator for each navigation light.
- Automatic visual and audible warning in the event of failure navigation tight. If

a visual signal device is connected in series with the navigation light, the failure of this device is not to cause the extinction of the navigation light. The audible device is to be connected to a separate power supply so that audible alarm may still be activated in the event of power or circuit failure to the navigation tights.

2.6.3 Interior Communication Systems

2.6.3.1 General

Means of communication are to be provided between the navigating bridge and the following interior locations:

i) Radio room, if separated from the navigating bridge.

ii) Centralized propulsion machinery control station, if fitted.

iii) Propulsion machinery local control position.

iv) Engineers' accommodation, where propulsion machinery space is to be periodically unattended.

v) Steering gear compartment

vi) Any other positions where the speed and direction of thrust of the propellers may be controlled, if fitted.

2.6.3.2 Engine Order Telegraph

An engine order telegraph system which provides visual indication of the orders and responses both in the machinery, space (the centralized control station, if fitted, otherwise propulsion machinery local control position) and on the navigating bridge is to be provided.

A means of communication is to be provided between the centralized propulsion machinery control station, if fitted, and the propulsion machinery local control position. This can, be a common talking means of voice communication and calling or an engine order telegraph repeater at the propulsion machinery local control position

2.6.3.3 Voice Communication

Means Of voice communication are to be provided as follows. A common system capable of serving all the following will be acceptable.

i) A common talking means of voice communication and calling is to be provided among the navigating bridge, centralized control station if fitted (otherwise the propulsion machinery local control position) and any other position where the speed and direction Of thrust of the propellers may be controlled., Simultaneous talking among these positions is to be possible at all times and the calling to these positions is to be always possible even if the line is busy.

*ii)*A means of voice communication is to be provided between the navigating bridge and the steering gear compartment.

iii) For vessels intended to be operated with unattended propulsion machinery space, the engineers' accommodation is to be included in the communication system in i).

2.6.3.4 Public Address System

A public address system is to be provided to supplement the general emergency alarm system in section 2/6.4.1, unless other suitable means of communication is provided. The system is to comply with the following requirements:

i) The system is to have loudspeakers 'to broadcast messages to muster stations and to all spaces where crews are normally present.

ii) The system is to be designed fir broadcasting from the navigating bridge and at least one other emergency alarm control station situated in.at least one other location for use when the navigating bridge is rendered inaccessible due to the emergency (see 2/6.4.1 ii). The broadcasting stations are to be provided with an override function so that emergency messages can be broadcast even if any loudspeaker has been switched oft its volume has been turned down, or the public address system is used for other purposes.

iii) With the ship underway, the minimum sound pressure level for broadcasting messages in interior spaces is to be 75dB(A) and at least 20dB(A) above the corresponding speech interference level, which is' to be maintained without action from addressees.

iv) The system is to be protected against unauthorized use.

2.6.3.5 Power Supply

The above communication systems are to be supplied with power (not applicable to sound powered telephones) from the emergency switchboard. The final power supply branch circuits to these systems are to be independent of other electrical systems.

2.6.4 Manually Operated Alarms

2.6.4.1 General Emergency Alarm System

A general emergency alarm system for purpose of summoning crew to the muster stations is to be provided. The system is to be supplemented by a public address system in chapter 2/6.3.4 or other suitable means of communication. Any entertainment sound system is to be automatically turned off when the general alarm system is activated. The system is to comply with the following requirements:

i) The system is to be capable of, sounding the general emergency alarm signal consisting of seven or more short blasts followed by one long blast on the vessel's whistle or siren and additionally on an electrically operated bell or klaxon or other equivalent system, which is to be powered from the vessel's main supply and the emergency source of power. The system is to be audible throughout all the accommodation and normal crew working spaces. The alarm is to continue to function after it has been triggered until it is manually turned off or is temporarily interrupted by a message on the public address system.

ii)(2001) The system is to be capable of operation from the navigating bridge and, except for the vessel's whistle, also from at least one other strategic location from which emergency situations are intended to be controlled. Fire control station, muster station, or cargo control station, etc. are examples of spaces that may be regarded as strategic locations; provided they we fitted with the means of operating the genera alarm system. Attention is drawn to the Flag Administration, which may require additional stations.

iii) The minimum sound pressure level for the emergency alarm tone in interior spaces is to be 80dB (A) and 10dB (A) above ambient noise level existing during normal equipment operation with the ship underway in moderate weather. In cabins without a loudspeaker, an electric alarm transducer is to be installed.

iv) The sound pressure level at the sleeping position in cabins and in cabin bathrooms is to be at least 75 dB(A) god at least 10 dB(A) above ambient noise level.

Reference is to be made to IMO Resolutions A.830 (1 *9) Codes on Alarms and Indicators.*

2.6.4.2 Engineers' Alarm

An engineer's alarm operable at the centralized propulsion machinery control station or the propulsion machinery local control position is to be provided. It is to be clearly audible in the engineers' accommodations.

2.6.4.3 Refrigerated Space Alarm

Each refrigerated space is to be fitted with means to activate an alarm in a normally manned control station operable from within such spaces for the protection of personnel.

2.6.4.4 Elevator's Alarm

Each elevator car is to be fitted with means to activate an alarm in a normally manned control station or with means of voice communication with that station.

2.6.4.5 Power Supply

The alarm systems in 2/6.4.2, 2/6.4.3 and 2/6.4.4 are to be supplied with power from the emergency switchboard. The final power supply branch circuits to the alarm systems in 2/6.4.1 and 2/6.4.2 are to be independent of other electrical systems.

2.6.5 Emergency Shutdown Systems

2.6.5.1 Ventilation Systems

2.6.5.1 (a) Machinery spaces. Electrical ventilation systems installed in machinery spaces are to be *fitted,* with means for stopping the ventilation fan motors in the event of fire. This stopping means is to be located in the passageway leading to but outside the space or at the fire fighting station if filled.

2.6.5.1(b) Cargo spaces. Electrical ventilation systems installed in cargo spaces are to be fitted with remote means of control so that the ventilation fan motors can be stopped in the event of a fire in the cargo space. These means are to be outside the cargo spaces and in a location not likely to be cut off in the event of a tire in the cargo spaces.

2.6.5.1(c) Other than machinery and cargo spaces. A control station for all other ventilation ,systems is to be located on the navigating bridge, in fire fighting station if fitted, or in an accessible position leading to but outside the space ventilated.

2.6.5.2 Fuel Oil and Thermal Oil Systems

Fuel oil transfer pumps, fuel oil unit pumps and similar fuel pumps and thermal oil circulating pumps are to be fitted with remote means of stopping. These means are to be located outside the space where these pumps are installed or at the fire fighting station if filled, so that they may be stopped in the event of a fire arising in that space.

2.6.5.3 Forced-draft Fans

Forced- or induced-draft fans for boilers incinerators, thermal oil heaters, and similar fired equipment are to be fitted with remote means of stopping. These means are to be located onside The space in which this equipment is located or at the fire fighting station if fitted, so that the flails may be stopped manually in the event of a fire arising in That space.

2.6.5.4 Unattended Machinery Spaces

For vessels intended to be operated with unattended propulsion machinery space, the emergency shutdowns of equipment in 2/6.5.1 through 2/6.5.3 associated with the propulsion machinery space are to be located in The fire-fighting station as required by 4/11.2.

2.6.6 Battery Stating Systems

2.6.6.1 Propulsion Engine

Where the propulsion engine is ranged for electric starting, at least two separate batteries (or separate set of batteries) are to he fitted. The arrangement is to be such that the batteries (or set of batteries) cannot be connected simultaneously in parallel and cacti battery (or set) is to be capable of starting the main engine. The combined capacity of the batteries is to be sufficient without recharging to provide within 30 minutes the number of starts of propulsion engines required Cot the starting in *5/5.3.1* and if arranged also to supply starting for auxiliary engine, file number of starts require in 2/6.6.2.

2.6.6.2 Auxiliary Engines

Electric staling arrangements for auxiliary engines arc to have at least two separate batteries (or separate set of batteries) or may be supplied by separate circuits from the propulsion engine batteries when such are provided. Where one auxiliary engine is arranged for electric starting, one battery (or set) may be accepted in lieu of two separate batteries (or sets). The capacity of the batteries for starting the auxiliary engines is to be sufficient for at least three starts for each engine.

2.6.6.3 Miscellaneous Requirements

The starting batteries (or set of batteries) arc to be used for starting and for engine's own control and monitoring purpose only. When the starting batteries are used for engines own control and monitoring purpose, the aggregate capacity of the batteries is to be sufficient for continued operation of such system in addition to the required number of starting capacity. Provisions are to be made to maintain continuously the stored energy at all times. Battery systems for engine starting may be of the one-wire type and the earth lead is to be carried to the engine flame.

CHAPTER 3

ELECTRICAL EQUIPMENTS

3.1 General

3.1.1 Application

Provisions of this section apply to all equipment in general. Additional requirements applicable to high voltage systems and electric propulsion systems are given in chapter 5. For DC systems, unless specifically stated in this chapter and chapter 5/4, see IEC Publications 60092-201, 60092-202 and 60092-301.

3.1.2 Standard of Compliance

In general, electrical equipment is to be designed, constructed and tested to a national, international or other recognized standard and in accordance with requirements of this section.

3.1.3 Certification of Equipment

The electrical equipment indicated below are required to be certified by the Bureau for complying with the appropriate provisions of this section (see also Table 24):

- Generators and motors of 100 kW (135 hp) and over for essential services (see definition in chapter *1/4.3)*. See chapter 3/2.
- Main, propulsion and emergency switchboards. See chapter 3/3.
- Motor controllers of 100 kW (135 hp) and over for essential services See chapter 3/3.4.
- Motor control centers with aggregate load of 100 kW (135 hr and over for essential services. See chapter 3/3.4.
- Battery charging and discharging boards for emergence and transitional source of power. See chapter 3/3.5.
- Propulsion controls, propulsion semiconductors and propulsion cables. See chapter 3/5 and 5/3.6.3, chapter 5/3.9.9b. and 5/3.9.12,

Other items are to be designed, constructed and tested in accordance with established industrial practices, manufacturer's specifications and applicable requirements in this chapter. Acceptance will be based on manufacturer's documentation, which is to be made available upon request and on satisfactory performance after installation. Mass produced items may, at the discretion of the manufacturers, be certified under the Type Approval Program, and Table 24.

3.1.4 Materials and Design

Electrical equipment is to be constructed of durable, flame-retardant, moisture resistant, materials, which are not subject to deterioration in the marine environment and at the temperatures to which it is likely to be exposed.

Electrical equipment is to be designed such that current-carrying parts with potential to earth are protected against accidental contact.

3.1.5 Voltage and Frequency Characteristics

The electrical characteristics of electrical equipment supplied from the main or emergency systems, other than battery supplies, are to be capable of being operated satisfactorily under normally occurring variations in voltage and frequency. Unless otherwise specified, the following variations from rated value are to be assumed in table3.

3.1.6 Enclosures

Electrical equipment is to have a degree of enclosure for protection against the intrusion of foreign objects and liquids appropriate for the location in which it is installed. The minimum degree of protection is to be in accordance with Table 14.

For the purpose of defining protection levels used in Table 14, the following conventions apply. The degree of protection by an enclosure with respect to the intrusion of foreign particles and water is defined by the designation 'IP' followed by two digits: the first digit signifies the protection degree against particles, and the second digit signifies the protection degree against water. For complete details, see Table 12 and Table 13. These designations are identical to that specified in JEC Publication 60529.

3.1.7 Accessibility

Electrical equipment is to be designed and arranged with a view to provide accessibility to parts requiring inspection or adjustment.

3.1.8 Insulation Material

Insulating materials are to be classified by their maximum continuous operating temperatures in accordance with the table 4:

Materials or combination of materials which by experience or accepted tests can be shown to be capable of satisfactory$_7$operation at temperature over 180^0C (356^0F) will also be considered. In this regard, supporting background information, reports, tests conducted, etc. ascertaining their suitability for the intended application and operating temperature are to be submitted for review.

3.1.9 Ambient Temperatures

For purposes of equipment rating, a maximum ambient temperature of 45'C (I 13^{0}F) is to be assumed for boiler and engine rooms; while *40'C* (104^{0}F) may be assumed for all other locations. However, for rating of electrical rotating machines, a maximum ambient temperature of 501 (122^{0}F) is to be assumed for boiler and engine rooms. Where ambient temperatures in excess of these values are expected, the total rated temperature of the equipment is not to be exceeded. Equipment which has been rated based on maximum ambient temperatures less than these specified value may be permitted provided the total rated temperature of the equipment is not exceeded.

3.2 Rotating Machines

3.2.1 *Application*

All generators and motors of 100 kW (135 hp) and over for essential services are to be designed, constructed and tested in accordance with the requirements of chapter 3/2.

All other rotating electrical machines are to be designed, constructed and tested in accordance with established industrial practices and manufacturer's specifications. Manufacturer's tests are to be in accordance with chapter 3/2.8 and test certificates are to be made available when requested by the Surveyor. Acceptance of machines will be based on satisfactory performance after installation.

3.2.2 Definitions

3.2.2.1 Periodic Duty Rating

The periodic duty rating of a rotating machine is the rated kW load at which the machine can

operate repeatedly, for specified period (N) at the rated load followed by a specified period (R) of rest and de-energized state, without exceeding the temperature rise given in Table 16; where N+R=10 minutes, and cyclic duty factor is given by N/(N+R) %.

3.2.2.2 Short Time Rating

The short time rating of a rotating electrical machine is the rated kW load at which the machine can operate for a specified time period without exceeding the temperature rise given in Table 16. A rest and de-energized period sufficient to re-establish the machine temperature to within 2^{0}C (3.6^{0}F) of the coolant prior to the next operation is to be allowed. At the beginning of the measurement the temperature of the machine is to be within 51 (9^{0}F) of the coolant.

3.2.2.3 Non-periodic Duty Rating

The non-periodic duty rating of a rotating electrical machine is the kW loads which the machine can operate continuously, for a specific period of time, or intermittently under the designed variations of the load and speed within the permissible operating range, respectively; and the temperature rise, measured when the machine has been run until it reaches a steady temperature condition, is not to exceed these given in Table 16.

3.2.2.4 Continuous Rating

The continuous rating of a rotating electrical machine is the rated kW load at which the machine can continuously operate without exceeding the steady state temperature rise given in Table 16.

3.2.3 Rating

Generators are to be of continuous rating. Motors are to be of continuous rating unless utilized on an application which definitely imposes an intermittent duty on the motor.

Ratings of rotating electrical machines are to be based on the maximum expected ambient temperature to which they are subjected; this temperature is not to be less than 50^0C (122^0F) for boiler and engine rooms and 45^0C (1 13^0F) for other locations (see 3/1.9).

3.2.4 Overload/Over-current Capability

Overload/over-current capabilities for AC and DC generators and motors are to be in accordance with IEC Publication 60034-1. For convenience, the following requirements for AC generators and motors are provided.

3.2.4.1 AC Generators

AC generators are to be capable of withstanding a current equal to 1.5 times the rated current for not less than 30 seconds.

3.2.4.2 AC Motors

3.2.4.2(a) Over-current capacity. Three phase induction motors having rated output not exceeding 315 kW (422 hp) and rated voltage not exceeding 1 kV are to be capable of withstanding a current equal to 1.5 times the rated current for not less than 2 minutes. For three phase induction motors having rated outputs above 315 kW (422 lip) the over-current capacity is to be in accordance with the manufacturer's specification.

3.2.4.2(b) Overload capacity for induction motors. Three phase induction motors, regardless of duty, are to be capable of withstanding for 15 seconds without stalling, or abrupt change in speed, an excess torque of 60% above the rated torque; the voltage and frequency being maintained at the rated values.

3.2.4.2(c) Overload capacity for synchronous motors. Three phase synchronous motors, regardless of duty, are to be capable of withstanding an excess torque as specified below for 15 seconds without falling out of synchronism; the excitation being maintained at the value corresponding to the rated load:

- ✓ Synchronous (wound rotor) induction motors: *35%* excess torque
- ✓ Synchronous (cylindrical rotor) motors: 35% excess torque.
- ✓ Synchronous (salient pole) motors: 50% excess torque.

Synchronous motors fitted with automatic excitation are to meet the same excess torque values with the excitation equipment operating under normal conditions.

3.2.5 Short Circuit Capability

Short circuit capabilities of generators are to be in accordance with IEC Publication 60034-1. Under short circuit conditions, generators are to he capable of withstanding the mechanical and thermal stresses induced by short circuit current of at least three times the full load current for at least 2 seconds.

3.2.6 Construction

3.2.6.1 Shafting

The design of rotating shaft, hollow shaft, and coupling flange with bolts are to comply with the following:

Rotor shaft:	chapter 4/3.2.1 and 4/3.2.2
Hollow shaft:	chapter 2/3.2
Key:	chapter 2/3.4
Coupling flanges and bolts:	chapter 2/3.10

3.2.6.2 Shaft Circulating Current

Means are to be provided to prevent circulating currents from passing between the journals and the bearings, where the design and arrangement of the machine is such that damaging current may be expected, due to the unbalance of magnetic fields.

3.2.6.3 Lubrication

Rotating machine's shaft bearings are to have the required lubrication at all rated operating conditions. Where forced lubrication is employed, generators are to be fitted with means to shut down their prime movers automatically upon failure of the generator's lubricating system. Each self-lubricating sleeve bearing is to be fitted with a means for visual indication of oil level.

3.2.6.4 Cooling

Where water cooling is used, the cooler is to be so arranged to avoid entry of water into the machine, whether through leakage or condensation in the heat exchanger.

3.2.6.5 Moisture Condensation Prevention

When the weight of generator and propulsion motor, excluding the shaft, is over 455 kg (1000 lb), means are to be provided to prevent moisture condensation in the machine when idle.

3.2.6.6 Stator Temperature Detection

AC propulsion generators and motors rated above 500 kW (670 hp) are to be provided with means of obtaining the temperatures at each phase of the stationary windings.

3.2.6.7 Enclosure and Terminal Box

Cable terminal boxes are to be fined with means to secure the cables. Enclosures of rotating machines including the cable terminal boxes are to be such as to eliminate mechanical injury and the risk of damage from water. oil and shipboard atmosphere. The minimum degree of protection is to be in accordance with Table 14.

3.2.6.8 Nameplate Data

Nameplates of corrosion-resistant material are to be provided and are to indicate at least the following, as applicable:

The manufacturer's serial number (or identification mark)

Type of machine

Rating

The rated voltage

The manufacturer's name

The year of manufacture

Degree of protection by IP code

The rated output

The rated current

The rated speed

The class of insulation

The rated ambient

Number of phase

temperature

The rated power factor

The rated frequency

Rated exciter voltage

Type of winding connections

Rated exciter current

3.2.7 Generator Control

3.2.7.1 Operating Governors

An operating governor is to be fitted to each prime mover driving main or emergency generator and is to be capable of automatically maintaining the speed within the following limits.

3.2.7.1 (a) Steam or gas turbine prime movers:

i)The momentary speed variations when running at full load (equal to rated output) is to be within 10% of the rated speed when:

-the full load of the generator is suddenly thrown off;

-50% of the full load of the generator is suddenly thrown on, and

-followed by the remaining 50% after an interval sufficient to restore the speed to steady state.

In all three cases, the speed is to return to within 1% of the final steady state speed in no more than *5* seconds.

ii)The steady state speed variation is to be within 5% of the rated speed at any load between no load and the full load.

iii)For emergency generators, the requirements of chapter 3/2.7.l(a)i) and 3/2.7.1(a)ii) above are to be met. However, for purpose of 3/2.7.l(a)i), where the sum of all loads that can be automatically connected is larger than 50 % of the full load of the emergency generator, the sum of these loads is to be used.

3.2.7.1(b) Diesel engine prime mover:

i) The momentary speed variations when running at full load (equal to rated output) is to be within 10% of the rated speed when:

-the full load of the generator is suddenly thrown off;

-50% of the full load of the generator is suddenly thrown on, and

-Followed by the remaining 50% after an interval sufficient to restore the speed to steady state.

In all three cases, the speed is to return to within 1% of the final steady state speed in no more than 5 seconds.

ii) The steady speed variation is to be within *5%* of the rated speed at any load between no load and the full load.

*iii)*For emergency generators, the requirements of 3/2.7.l(b)i) and 3/2.7.l(b)ii) above are to be met. However, for purpose of 3/2.7.1(b)i), where the sum of all loads that can be automatically connected is larger than 50 % of the full load of the emergency generator, the sum of these loads is to be used.

3.2.7.2 Automatic Voltage Regulation System

The following requirements are for AC generators. For DC generators, refer to IEC Publications 60092-202 and -301.

3.2.7.2(a) General. An automatic voltage regulator is to be fitted for each generator. Excitation current for generators is to be provided by attached rotating exciters or by static exciters deriving their source of power from the machines being controlled.

3.2.7.2(b) Variation from rated voltage- steady state. The automatic voltage regulator is to be capable of maintaining the voltage under steady conditions within ±2.5% of the rated voltage for all loads between zero and rated load at rated power factor, taking the governor characteristics of generator prime movers into account. These limits may be increased to ±3.5% for generators for emergency services.

3.2.7.2(c) Variation from rated voltage- transient. Momentary voltage variations are to be within the range of —15% to +20% of the rated voltage, and the voltage is to be restored to within ±3% of the rated voltage in not more than *1.5* seconds when:

a toad equals to the starting current of the largest motor or a group of motors, but in any case, at least 60% of the rated current of the generator, and power factor of 0.4 lagging or less, is suddenly thrown on with the generator running at no load; and a load equal to the above is suddenly thrown off.

3.2.7.2(d) Short circuit condition. Under short circuit conditions, the excitation system is to be capable of maintaining a steady-state short circuit current for 2 seconds or for such magnitude and duration as required to properly actuating the electrical protective devices. See chapter 3/2.5.

3.2.7.3 Parallel Operation

3.2.7.3(a) General. When it is intended that two or more generators be operated in parallel, means are to be provided to divide the reactive power equally between the generators in proportion to the generator capacity.

3.2.7.3(b) Reactive load sharing. The reactive loads of the individual generating sets are not to differ from their proportionate share of the combined reactive load by more than 10% of the rated reactive output of the largest generator, or 25% of the smallest generator, whichever is the less.

3.2.7.3(c) kW load sharing. In the range between 20% and 100% of the sum of the rated loads of all generators, the load (kW) on any generator is not to differ more than ±15% of the rated output (kW) of the largest generator or 25% of the rated output (kW) of the individual generator, whichever is the less, from its proportionate share. The starting point for the determination of the foregoing toad-distribution requirements is to be at *75%* load with each generator carrying its proportionate share.

3.2.8 Testing

3.2.8.1 Machines to be Tested and Test Schedule

Each design of generator and motor of 100 kW (135 hp) and over intended for essential services is to be assessed by testing in accordance with the "type tests'' schedule indicated in Table 15. Each subsequent production unit of an accepted design is to be tested in accordance with the "routine tests'' schedule indicated also in Table 15.

3.2.8.2 Insulation Resistance Measurement

Immediately after the high voltage tests the insulation resistance is to be measured using a direct current insulation tester between:

i) all current carrying parts connected together and earth;

ii) all current carrying parts of different polarity or phase, where both ends of each polarity or phase are individually accessible.

The minimum values of test voltage and insulation resistance are given in the table below; the temperature at which the insulation resistance is measured is to be near the operating temperature, or an appropriate method of calculation may be used shown in table 5;

3.2.8.3 Winding Resistance Measurement

The resistance of the machine winding is to be measured and recorded using an appropriate bridge method or voltage and current method.

3.2.8.4 Verification of Voltage Regulation System

Tests are to be conducted on generators to verify that the automatic voltage regulation system is capable of achieving the performance described in 3/2.7.2

3.2.8.5 Rated Load Test and Temperature Rise Measurements

The temperature rises are to be measured after running at the output, voltage, frequency and duty for which the machine is rated. The limits of temperature rise are to be as specified in Table 16.

3.2.8.6 Overload/Over-current Tests

Tests are to be conducted on generators and motors to demonstrate that their overload/over-current capabilities are as described in chapter 3/2.4.

3.2.8.7 Short Circuit Capability Tests

Tests are to be conducted on AC generators to demonstrate that the generator and its automatic voltage regulation system are capable of sustaining without damage, under steady-state short circuit condition, a current of three times the rated current for 2 seconds. See chapter *3/2.5* and -3/2.7.2(d).

3.2.8.8 Overspeed Test

AC generators and, where specified and agree upon between purchaser and manufacturer, AC motors are to withstand without damage a test run at 1.2 times the rated speed for 2 minutes. Where specified and agreed upon between purchaser and manufacturer, DC generators and motors are to withstand without damage for the following overspeed tests for 2 minutes: it is shown in table 6.

3.2.8.9 Dielectric Strength Test

The dielectric strength of all rotating machines is to be tested with all parts assembled and in a condition equivalent to normal working condition. The test voltage is to be applied between the windings under test and the frame of the machine, with the windings not under test and the core connected to the frame.

The test voltage is to be a voltage of sinusoidal wave form and a frequency of 25 Hz to 60Hz. It is to be applied continuously for, 60 seconds. The standard test voltage for all rotating machines is twice the rated voltage plus 1000 V, with a minimum of 1500 V, except for machine parts specified in the table7.

Where temperature rise test is to be performed, such as when performing type tests, the dielectric strength test is to be carried out immediately after this test.

Test voltage for other machines arc to be in accordance with IEC Publication 60034-1, Clause17.

3.2.8.10 Running Balance Test

Motors are to be operated at no load and at rated speed while being supplied with a rated voltage and frequency; and in the case of a generator, driven by a suitable means and excited to give rated terminal voltage. The vibration of the machine and operation of the bearing lubrication system, where applicable, are to be checked and found satisfactory.

3.2.8.11 Bearings

Upon completion of tests in section3/2.8.10, machines having sleeve bearings are to be opened to establish that the shaft is properly seated in the bearings.

3.2.9 Certification

Each generator and motor of 100 kW (135 hp) and over intended for essential services is to be certified based on design review and type and routine tests performed in accordance with Table 15 in the presence of a Surveyor.

At the option of the manufacturer, each machine design or type may be maintained on record as design-assessed product in accordance with the provisions. In which case, each production unit of the type may be certified based only on routine test carried out to the satisfaction of a Surveyor at the manufacturer's facilities.

Further, at the option of the manufacturer, the quality assurance system of the manufacturing facilities may also be assessed. In which case, and along with approval of the design, the machine may be deemed type approved, and each production unit may be certified based on an audit, by a Surveyor, of the quality records maintained by the manufacturer. The machine may also be listed in the Bureau's publication *List of Type Approved Equipment*.

3.3 Switchboards, Motor Controllers, etc.

3.3.1 Application

Main and emergency switchboards, power and lighting distribution boards, motor control centers and motor controllers, and battery charging panels are to be designed, constructed and tested in accordance with the provisions of this Subsection.

3.3.2 Construction, Assembly and Components

3.3.2.1 Enclosures

Enclosures and assemblies are to be constructed of steel or other suitable incombustible. moisture-resistant materials and reinforced as necessary to withstand the mechanical, electromagnetic and thermal stresses which may be encountered under both normal and short circuit fault conditions.

Enclosures arc to be of the closed type. The degree of the protection is to be in accordance with Table 14.

All wearing parts are to be accessible for inspection and be readily renewable.

3.3.2.2 Bus Bars

3.3.2.2(a) General. Bus bars are to be copper; bus bars of other materials will require special consideration. Bus bars are to be sized and arranged such that the temperature rise will not affect the normal operation of electrical devices mounted in the switchboard. The design maximum ambient temperature is to be in accordance with chapter 3/1.9.

3.3.2.2 (b) Bracing of bus bars, Bus bars and circuit breakers are to be mounted, braced and located so as to withstand thermal effects and magnetic forces resulting from the maximum prospective short circuit current.

3.3.2.2 (c) Bolted connections. Bolted bus bar connections are to be suitably treated (e.g. silver plating) to avoid deterioration of electrical conductivity over time. Nuts are to be fitted with means to prevent loosening.

3.3.2.2 (d) Cable connections. Soldered connections are not to be used for connecting or terminating any cable of 2.5 mm^2 or greater. These connections are to be made by the use of crimp lugs or equivalent.

3.3.2.2 (e) Clearance and creepage. Minimum clearances and creepage distances between live parts of different potential, i.e., between phases and between phase and the ground, are to be in accordance with the table 8.

3.3.2.3 Circuit Breakers

3.3.2.3(a) Compliance with a standard. Circuit breakers are to be designed, constructed, and tested to IEC Publication 60947-2 or other recognized standard. The certificates of tests are to be submitted upon request by the Bureau.

3.3.2.3(b) Short circuit capacity. Circuit breakers are to have sufficient breaking and making capacities as specified in chapter *2/5.2.*

3.3.2.3 (c) Removable mounting. Circuit breakers arc to be mounted or arranged in such a manner that the breakers may be removed from the front of the switchboard, without first dc-energizing the bus bars to which the breakers connect. Draw-out or plug-in type circuit breakers are acceptable for this purpose. Alternatively, an isolation switch may be fitted upstream (line or supply side) of the breaker. Consideration will be given to arrangements where portions may be isolated to allow circuit breaker removal, provided that this will not interrupt services for propulsion and safety of the vessel.

3.3.2.4 Fuses

Fuses are to be designed, constructed and tested in accordance with IEC Publication 60269 or other recognized standard. The certificates of tests are to be submitted upon request from the Bureau.

The requirements of chapter 3/3.2.3(b) and 3/3.2.3(c) are to be complied with. Where disconnecting means are fitted they are to be on the line or supply side. Where voltage to earth or between poles does not exceed 50V DC or 50V AC rms, fuses may be provided without switches. All fuses, except for instrument and control circuits are to be mounted on or accessible from the front of switchboard.

3.3.2.5 Disconnecting Device

The rating of the disconnecting devices is to be equal to or be higher than the voltage and current ratings of connected load. The device is to have indicator for its open or closed position.

3.3.2.6 Internal Wiring

3.3.2.6(a) Wires. Internal instrumentation and control wiring is to be of the stranded type and is to have flame-retarding insulation. They are to be in compliance with a recognized standard.

3.3.2.6(b) Protection. In general, internal instrumentation and control wiring is to be protected by fuse or circuit breaker with the following exception:

generator voltage regulator circuits;

generator circuit breaker tripping control circuits; and

secondary circuit of current transformer.

These circuits, however, except that of the current transformer, may be fitted with short circuit protection.

3.3.2.6(c) Terminals. Terminals or terminal rows for systems of different voltages are to be clearly separated from each other and the rated voltage is to be clearly marked. Each terminal is to have a nameplate indicating the circuit designation.

3.3.2.7 Circuit Identification

Identification plates for feeders and branch circuits are to be provided and are to indicate the circuit designation and the rating or settings of the fuse or circuit breaker of the circuit.

3.3.3 Main and Emergency Switchboards

In addition to the foregoing requirements, main and emergency switchboards are to be complied with the following requirements.

3.3.3.1 Bus Bars

Generator bus bars are to be designed to meet the maximum generator rating based on ambient temperature of *45"C* (I 13^0F). Main bus bars are to be sized to the combined rated generator current that can flow through. Distribution bus bars and bus-bar connections are to be designed for at least 75% of the combined full-load rated currents of all loads they supply, or the combined current of the generators that can supply to that part of the bus, whichever is less. When a distribution bus bar supplies to one unit or one group of units in simultaneous operation, it is to be designed for full load.

3.3.3.2 Subdivision of Bus Bars

Where the main source of electrical power is necessary for propulsion, the maid bus bars are to be subdivided into at least two pails which are normally to be connected by circuit breakers or other approved means. As far as practicable, the connection of generating sets and any other duplicated equipment is to he equally divided between the pads.

3.3.3.3 Hand Rails

Insulated handrail or insulated handles are to be provided for each front panel of the switchboard. Where access to the rear is required, insulated handrails or insulated handles are to be fitted to the rear of the switchboard also.

3.3.3.4 Instrumentation

Equipment and instrumentation are to be provided in accordance with Table 17.

3.3.4 Motor Controllers

In addition to the applicable requirements in chapter 3/3.2, motor controllers are to comply with the following.

3.3.4.1 Overload and Under-voltage Protection

Overload protection and under-voltage protection where provided in the motor controllers are to be in accordance with chapter 2/5.9.2 and chapter 2/5.9.3.

3.3.4.2 Disconnecting Means

A circuit-disconnecting device is to be provided for each branch circuit of motor rated 0.5 kW or above so that the motor and the controller may be isolated from the power supply for main- tenance purposes. However for pre-assembled or ski-mounted unit having two or more motors (e.g. fuel oil blender) a single disconnecting device in its feeder may be accepted in lieu of individual disconnecting devices for the motors, provided that the full load current of each motor is less than 6 A. The circuit-disconnecting device is to be operable externally. See also chapter 4/5.2.

3.3.4.3 Resistor for Control Apparatus

Resistors are to be protected against corrosion either by rust-proofing or embedding in a protective material. Where fitted, the enclosure is to be well-ventilated and so arranged that other electrical equipment and wiring within will not be exposed to a temperature in excess of that for which they are designed.

3.3.5 Battery Charging Panels

In addition to the applicable requirements in chapter 3/3.2, battery chargers are to comply with the following.

3.3.5.1 Battery Charger

Except when a different charging rate is necessary and is specified for a particular application, the charging facilities are to be such that the completely discharged battery can be recharged to 80% capacity in not more than 10 hours.

3.3.5.2 Reversal of Charging Current

An acceptable means, such as reverse current protection, for preventing a failed battery charger component from discharging the batter', is to he fitted.

3.3.5.3 Instrumentation

The following are to be provided;

i) disconnect switch for power supply to the charge:

ii) indicator light connected to the down stream side of the disconnect switch in a);

iii) means for adjusting the voltage for charging;

iv) voltmeter to indicate the charging voltage;

v) ammeter to indicate the charging current.

vi) current limiting constant vo ltage device.

3.3.6 Testing and Certification

3.3.6.1 Certification

3.3.6.1(a) Essential and emergency services. Switchboards and associated motor control centers and distribution board, motor controllers of 100 KW and over, and battery charging panels, where required for essential services and for distribution of emergency source of power, are to be inspected by, tested in the presence of, and certified by the Surveyor, preferably at the plant of the manufacturer. Distribution boards required for similar services may be treated as in chapter 3/3.6.1(b). .

3.3.6.1(b) Other services. Switchboards, distribution boards, motor controllers, etc., where required for services other than essential or emergency, may be tested by the manufacturers. Test certificates are to be submitted upon request by the Bureau.

3.3.6.2 Insulation Resistance Measurement

The insulation resistance between current-carrying parts and earth and between current-carrying parts of opposite polarity is to be measured at a DC voltage of not less than 500 V before and after the dielectric strength tests. The insulation resistance is not to be less than 1MΩ.

3.3.6.3 Dielectric Strength Test

The dielectric strength of the insulation is to be tested for 60 seconds by an AC voltage applied, in accordance with the voltage values given in the table 9 , between each electric circuit, and all other electric circuits and metal parts earthed.

Equipment and apparatus produced in large quantities for which the standard test voltage is 2500V or less, may be tested for one second with a test voltage 20% higher than the 60-second test voltage.

3.3.6.4 Operational Tests

Operational tests are to be carried out including but not limited to the testing of protective devices (over current, under-voltage, and preferential trippings, etc.), electrical interlocks, synchronization of generators, earth detection, alarms. and measurement of bus bar temperature rise (see chapter 3/3.2.2 (a)).

3.4 Transformers and Converters

3.4.1 Enclosures

Transformers and converters are to be provided with enclosures with a minimum degree of protection as specified in Table 14.

3.4.2 Transformers for Essential Services

Transformers for essential services and for emergency source f power are to be constructed in accordance with the following requirements. Other transformers, including auto-transformers for starting motors and isolation transformers may be constructed in accordance with good commercial practice.

3.4.2.1 Rating

Transformers are to be continuously rated based the maximum expected ambient temperature to which they are subjected, but not less than 45^0C (1 13^0F) for boiler and engine rooms and 40^0C (104^0F) for other locations.

3.4.2.2 Temperature Rise

The design temperature rise of insulated windings based on an ambient temperature of 40C is not to exceed that in the table 10:

If the ambient temperature exceeds 40^0C (1 04^0F), the transformer is to be derated so that the total temperatures based on the table are not exceeded.

3.4.2.3 Cooling Medium

Transformers are to be of the dry and air cooled type. The use of liquid immersed type transformers will be subject to special consideration. Where forced circulation of cooling medium is employed, high temperature condition is to be alarmed.

3.4.2.4 Testing

Single-phase transformers rated 1 kVA and above and three-phase transformers rated 5 kVA and above intended for essential or emergency services are to be tested by the manufacturer whose certificate of tests will be acceptable and are to be submitted upon request by the Bureau. The tests are to include at least the following:

- ✓ Measurement of winding resistance, voltage ratio, impedance voltage, short circuit impedance, insulation resistance, load loss, no load loss and excitation current, phase relation and polarity.
- ✓ Dielectric strength.
- ✓ Temperature rise (required for transformer of each size and type).

3.4.2.5 Nameplate

Nameplates of corrosion-resistant material are to be provided in an accessible position of the transformer and are to indicate at least the following information:

- ✓ The manufacturer's name
- ✓ The manufacturer's serial number (or identification mark)
- ✓ The year of manufacture
- ✓ The number of phases
- ✓ The rated power
- ✓ The rated frequency
- ✓ The rated voltage in primary and secondary sides
- ✓ The rated current in primary and secondary sides
- ✓ The class of insulation or permissible temperature rise
- ✓ The ambient temperature

3.4.3 Semiconductor Converters

3.4.3.1 General

The requirements in this Paragraph are applicable to static converters for essential and emergency services using semiconductor rectifying elements such as diodes, reverse blocking triodes, thyristors, etc. The tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from the Bureau. All semiconductor converters will be accepted subject to a satisfactory performance test conducted to the satisfaction of the Surveyor after installation.

3.4.3.2 Cooling Arrangements

Semiconductor converters are preferably to be of a dry and air cooled type. Where semiconductor converters are of a liquid-immersed type, a liquid over-temperature alarm and gas over-pressure protection devices are to be provided. If provision is made for breathing, a dehydrator is to be provided. Where arrangement for the forced cooling is provided, the circuit is to be designed that power cannot be applied to, or retained, on converter stacks unless effective cooling is maintained.

3.4.3.3 Accessibility

Semiconductor converter stacks or semiconductor components are to be mounted in such a manner that they can be removed from equipment without dismantling the complete unit.

3.4.3.4 Nameplate

A nameplate or identification is to be provided or semiconductor converter and is to indicate at least the manufacturer's name and the identification number of the equipment.

3.5 Cables

3.5.1 Standard of Compliance

Electric cables constructed of stranded copper conductors, thermoplastic, elastomeric or other insulation, moisture-resistant jackets, and, where applicable, armoring and outer-sheathing are to be in accordance with IEC Publication 60092-353, IEEE Std-45 or other marine standards acceptable to the Bureau.

3.5.2 Current Carrying Capacity

Maximum current carrying capacities of cables conforming to LEC Publications 60092-353 are to be in accordance with the values given in Table 18. These values are applicable for cables installed double-banked on cable trays, in cable conduits or cable pipes. The values, however, are to be reduced for installations where there is an absence of free air circulation around the cables. See chapter *2/4.4.1* and Note 4 of Table 18.

3.5.3 Flame Retardant Standard

Electric cables are to be flame retardant and complying with any of the following:

*i)*Depending on the intended installation, cables constructed to IEC Publication 60092 standards are to comply with the flammability criteria of LEC Publication 60332-3, Category A/F or A/F/R, or

*ii)*Cables constructed to IEEE Std 45 are to comply with the flammability criteria contained therein.

*iii)*Cables constructed to other standards, where accepted by the Bureau, are to comply with the flammability criteria of IEC Publication 60332-3, category A/F or A/F/R (depending on the intended installation), or other acceptable standards.

Flame retardant marine cables which have not passed the bunched cable flammability criteria as per IEC Publication 60332-3 may be considered provided that the cable is treated with approved flame retardant material or the installation is provided with approved fire stop arrangements.

Consideration will be also given to the special types of cables such as radio frequency cable, which do not comply with the above requirements.

3.5.4 Fire Resistant Standard

Where electric cables are required to be fire resistant, they are to comply with the requirements of IEC Publication 60331 See also chapter 4/1.5 and chapter 4/11.9.

3.5.5 Insulation Temperature Rating

All electrical cables for power and lighting circuits are to have insulation suitable for a conductor temperature of not less than 60^0C (140^0F).

***3.5.6* Armor for Single Core Cables**

The armor is to be non-magnetic for single-conductor alternating-current cables. See also 4/11.4 for installation arrangements of single conductor cables.

3.5.7 Fiber Optic Cables

Fiber optic cables are to comply with a standard acceptable to the Bureau. The flame-retardant standard for electrical cables is applicable to fiber optic cables also.

3.5.8 Mineral-insulated Metal-sheathed Cables

Mineral-insulated cable provided with approved fittings for terminating and connecting to boxes, outlets and other equipment may be used for any service up to 600 V.

3.5.9 Test and Codification

Electric cables are to be tested by the manufacturers in accordance with the standards of compliance. Records of test are to be maintained and are to be submitted upon request by the Bureau. Preferably, electric cables are to be type approved. For propulsion cables, see chapter 5/3.9.12.

3.5.10 Cable Splices

Cable splice is to be made of fife resistant replacement insulation equivalent in electrical and thermal properties to the original insulation. The replacement jacket is to be at least equivalent to the original impervious sheath and is to assure a watertight splice. Splices are to be made using the splice kit, which is to contain the following:

- Connector of correct size and number
- Replacement insulation
- Replacement jacket
- Instructions for use

All cable splices are to be type- tested and approved.

3.5.11 Cable Junction Boxes

Junction box is to be constructed of material as described in chapter 3/1.4. Live parts within the box are to be provided with suitable clearances and creepage distances, or with shielding by flame retarding insulation material. Junction boxes having compartments for different voltage levels are to have each compartment appropriately identified as to its rated voltage. Cables within the junction boxes are to be well supported so as not to put stress on the cable contacts. In general, junction boxes are to comply with a recognized standard or type approved.

3.6 Non-sparking Fans

3.6.1 Design

3.6.1.1 Air Gap

The air gap between the impeller and the casing is to be not less than 10% of the shaft diameter in way of the impeller bearing but, in any case, not to be less than 2 mm (0.08 in). It need not be more than 13 mm (0.5 in.).

3.6.1.2 Protection Screen

Protection screens of not more than 13 mm *(0.5* in) square mesh are to be fitted in the inlet and outlet of ventilation ducts to prevent the entrance of object into the fan casing.

3.6.2 Materials

3.6.2.1 Impeller and its Housing

Except as indicated in chapter 3/6.2.3, the impeller and the housing in way of the impeller are to be made of alloys which, by means of appropriate test procedures, are deemed spark-proof

3.6.2.2 Electrostatic Charges

Electrostatic charges both in the rotating body and the casing are to be prevented by the use of anti-static materials. Furthermore, the installation of the ventilation fan is to ensue its bonding to the hull.

3.6.2.3 Acceptable Combination of Materials

Type tests indicated in chapter 3/6.3 will not be required for fans constructed of the following combinations of materials:

i) impellers and/or housings of nonmetallic material, due regard being paid to the elimination of static electricity;

ii) impellers and housings of non-ferrous materials;

iii) impellers of aluminum alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous materials is fitted in way of the impeller;

iv) any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm (0.5 in.) tip design clearance.

3.6.2.4 Unacceptable Combination of Materials

The following impellers and housings are considered as spark-producing and are not permitted:

i) impellers of an aluminum alloy or magnesium alloy and a ferrous housing, regardless of tip clearance;

ii) housing made of an aluminum alloy or a magnesium alloy and a ferrous impeller, regardless of tip clearance;

iii) any combination of ferrous impellers and housings with less than 13 mm (0.5 in.) design tip clearance.

3.6.3 Type Test

Each model of fan is also to be evaluated based on a type test which is to be performed in accordance with an acceptable national or international standard. Preferably, non-sparking fans are to be type approved.

3.7 Certified Safe Equipment

3.7.1 General

Certified safe equipment is equipment intended for installation in hazardous areas where flammable or explosive gases, vapors, or dust are normally or likely to be present. The equipment is to be type-tested and certified by a competent, independent testing laboratory for complying with IEC Publication 60079 or equivalent standard, and rated according to its enclosure and the types of flammable atmosphere in which it is safe to install. If desired, the manufacturer may have such equipment type approved.

3.7.2 Acceptable Types of Certified Safe Equipment

The following type of electrical equipment, expressed in IEC Publication 60079 nomenclature, will be acceptable for installation in hazardous areas identified in the Rules. Other types as well as equipment complying with an equivalent standard will also be considered.

3.7.2.1 Intrinsically Safe Equipment— 'Ex ia and 'Ex ib

An intrinsically safe equipment is one which is supplied by a tow energy circuit which when sparking, produced normally by breaking or making the circuit or produced accidentally (i.e., by short-circuit or earth-fault), is incapable under prescribed test conditions of causing ignition of a prescribed gas or vapor.

3.7.2.2 Flameproof (Explosion-proof) Equipment — 'Ex d'

Flameproof equipment is one which possesses an enclosure capable of withstanding, without damage, an explosion of a prescribed flammable gas or vapor within the enclosure and prevent the transmission of flame or sparks which would ignite the external prescribed flammable gas or vapor for which it is designed, and which normally operates at an external temperature that will not ignite the external prescribed flammable gas or vapor. A flameproof enclosure may not necessarily or ordinarily be weatherproof or dustproof.

3.7.2.3 Increased Safety Equipment — 'Ex e'

Increased safety equipment is designed with a method of protection in which measures additional to those adopted on ordinary industrial practice are applied, so as to give increased security against the possibility of excessive temperatures and the occurrence of areas or sparks in electrical apparatus which does not produce arcs or sparks in normal service.

3.7.2.4 Pressurized or Purged Equipment — 'Ex p

Pressured equipment is designed with an enclosure in which the entry of flammable gases or vapors is prevented by maintaining the air (or other non-flammable gas) within the enclosure at a specified pressure above that of the external atmosphere. Purged equipment is designed with an enclosure in which a sufficient flow of fresh air or inert gas is maintained through the enclosure to prevent the entry of any flammable gas or vapor which may be present in the ambient atmosphere.

3.7.3 Flammable Gas Groups and Temperature Classes

Certified safe equipment is to be rated for the flammable atmosphere in which it is safe to install, Each flammable atmosphere is to be identified with respect to the flammable gas, vapor or dust and its self ignition temperature; the latter is used to limit the maximum permissible external surface temperature of the equipment. The tables 11 show the typical flammable gas groups and the temperature classes as in IEC Publication 60079-20:

CHAPTER 4

SHIPBOARD INSTALLATION AND TESTS

4.1 General

4.1.1 Application

Provisions of this section apply to all electrical installations on board vessels. Additional requirements applicable to high voltage systems and electric propulsion systems are given in chapter 5. Requirements applicable to specific vessel types, particularly with regard to installations in hazardous areas,

4.1.2 Degree of Enclosure

Electrical equipment is to be protected from the intrusion of foreign mailer during service. For this purpose the degree of enclosure of electrical equipment is to be adequate for its location of installation. The minimum degrees of enclosure required for typical locations on board vessels are given in Table 14 and are to be complied with.

4.1.3 Hazardous Areas

Areas where flammable or explosive gases, vapors, or dust are normally or likely to be present are known as hazardous areas. Electrical equipment intended for installation in hazardous areas are to have suitable enclosures or arc to be of the low energy type. see chapter 4/14.

4.1.4 Inclination

Electrical equipment is to be installed such that its inclination, in both the longitudinal and athwartship directions, and in static and dynamic operating conditions, will not exceed that to which it is designed, and in any case, is to operate satisfactorily up to the inclinations defined as(Machinery installation are to be designed such as to ensure proper operation under the conditions as shown in Table 25).

4.1.5 Services Required to be Operable Under a Fire Condition *(2001)*

For the purpose of chapter 4/11.9.2, services required to be operable under a fire condition include, but not limited thereto, are the following:

- *i)* Fire and general alarm system
- *ii)* Fire extinguishing system including fire extinguishing medium release alarms
- *iii)* Fire detection system
- *iv)* Control and power systems for all power operated fire doors and their

indicating systems

v) Control and power systems for all power operated watertight doors and their indicating systems

vi) Emergency lighting

vii) Public address system

4.2 Generators and Motors

Generators, motors and other rotating machines are to be installed preferably with their shafts in a fore-and-aft direction of the vessel. Arrangements are to be made to protect generator and motors from bilge water. Precautions are also to be taken to preclude any oil which may escape under pressure from entering machine windings.

4.3 Accumulator Batteries

4.3.1 General

4.3.1.1 Application

These requirements are applicable to batteries which emit hydrogen while in use. Installation design of other battery types is to be submitted for consideration in each case along with operational hazards of the batteries.

4.3.1.2 Battery Cells

Battery cells are to be so constructed as to prevent spillage of electrolyte due to motions of the vessel at sea. Batteries are to be secured to their frays or shelves to prevent their movement.

4.3.1.3 Nameplate

Nameplates of corrosion-resistant material are to be provided in an accessible position of the transformer and are to indicate at least the following information:

- The manufacturer's name
- The type designation
- The rated voltage
- The ampere-hour rating at a specific rate of discharge
- The specific gravity of the electrolyte

(in the case of a lead-acid battery, the specific gravity when the battery is fully charged).

4.3.1.4 Referenced Requirements

The following requirements are also applicable to battery installations:

- Accumulator batteries as emergency source of electrical power, chapter 2/3.5.2
- Accumulator batteries as transitional source of electrical power, chapter 2/3.6

- Protection of accumulator batteries, chapter 2/5.8
- Battery starting systems, chapter 2/6.6.

4.3.2 Lead-acid or Alkaline Battery Storage Locations

4.3.2.1 Battery Room

4.3.2.1(a) General. Where a group of accumulator batteries is connected to charging devices with total output of more than 2 kW, it is to be installed in a battery room dedicated to batteries only. No other electrical equipment is to be installed in the battery room except that necessary for operational purposes. Each of such equipment is to be of a certified safe type for battery room atmosphere.

4.3.2.1(b) Ventilation of battery room. Battery room is to be ventilated to avoid accumulation of flammable gas. Natural ventilation may be employed if ducts can be led directly from the top of the battery room to the open air above, with an opening for air inlet near the floor.

If natural ventilation is impractical, mechanical exhaust ventilation is to be provided with fan intake at the top of the room. Fan motor is to be of certified safe type, and fan is to be of non-sparking construction (see chapter 3/6). The fan is to be capable of completely changing the air in the battery room in not more than two minutes. An alternative fan capacity may be provided if it is able to maintain the flammable gases within the battery room to a level below the lower explosive limit (L.E.L.) at the maximum battery charging current. Where the ventilation capacity is based on low-hydrogen emission type batteries (see also chapter 4/3.3), a warning notice to this effect is to be displayed in a visible place in the battery room.

4.3.2.1(c) Corrosion protection in battery room. Interior of the battery room including structural members, shelves, ventilation inlets and outlets are to be coated with paint resistant to the electrolyte used in the batteries. Shelves for lead acid batteries are to have watertight lining of sheet lead not less than 1.6 mm (1/s in) thick, and carried up not less than 75 mm (3 in.) on all sides; and that for alkaline batteries of sheet steel not less than 0.8 mm (1/16 in.) thick. Alternatively, the entire battery room may be fitted with watertight lead pan (or steel for alkaline batteries), over the entire deck, carried up not less than 150 mm (6 in) on all sides.

4.3.2.1(d) Battery trays. For purposes of heat dissipation during equalizing charge, appropriate air spaces are to be provided around each battery. Where placed in trays, batteries are to be chocked with wood strips or equivalent to prevent movement and each battery is to be supported in the tray with nonabsorbent insulator on the bottom and at the sides or with equivalent provision to secure air-circulation space all around each fray.

4.3.2.2 Deck Boxes

4.3.2.2(a) General. Where a group of accumulator batteries is connected to a charging devices with a total output of 0.2 kW up to and including 2kw, they may be installed in battery room, or alternatively in deck boxes. Deck boxes may be located in machinery spaces, or other well ventilated locations.

4.3.2.2(b) Ventilation of deck boxes. Deck boxes are to be provided with a duct from the top of the box, terminating with a means to prevent entrance of water such as goose-neck or mushroom head. At least two air inlets are to be provided at the lower part and opposite sides of the deck box. Louvers or equivalent are to be fitted at the air inlets at the lower part of the box. Where located in the weather, deck boxes including openings for ventilation are to be weathertight.

4.3.2.2(c) Corrosion protection in deck boxes. Deck boxes are to be fitted with watertight trays with coaming heights not less than 150mm (6 in.) as in chapter 4/3.2.1(c).

4.3.2.3 Small Battery Boxes

Batteries not covered in chapter 4/3.2.1 and *4/3.2.2* are to be installed in battery boxes and may be located as desired, except they are not to be located in sleeping quarters unless hermetically sealed. Small battery boxes require no ventilation other than openings near the top to allow escape of gas. For corrosion protection, the boxes are to be lined to a depth of 75mm (3 in.) consistent with the method in chapter 4/3.2.1(c).

4.3.2.4 Batteries for Engine Starting

Engine starting batteries are to be installed in the same space where the engine is installed and are to be located close to the engine.

4.3.2.5 Batteries of Different Electrolyte

Where batteries of different types, for which different electrolyte are used, are installed in the same room, they are to be segregated and effectively identified.

4.3.3 Low-hydrogen-emission Battery Storage Locations

A battery is considered low-hydrogen-emission (LHE) if it does not emit more hydrogen under similar charging condition than a standard lead-acid battery. LHE batteries connected to charging devices with total output of more than 2 kW may be installed as in chapter 4/3.2.2 provided calculations are submitted demonstrating that under similar charging condition hydrogen emission does not exceed that of standard lead-acid batteries connected to a 2 kW charging device. Similarly, LHE batteries connected to charging device with total output of 2 kW or less may be installed as in chapter *4/3.2.3* provided calculations are submitted demonstrating that under similar charging condition hydrogen emission does not exceed that of standard lead-acid batteries connected to charging device of 0.2 kW.

For such installations, a warning-notice is to be displayed to notify maintenance personnel that additional batteries are not to be installed and any replacement battery is to be the LHE type.

4.4 Switchboard and Distribution Boards

Switchboards are to be located in a dry place, Clear working space of at least 900 mm (35 in) at the front of the, switchboard and a clearance of at least 600 nun (24 in) at the rear are to be provided. The clearance at the rear may be reduced in way of stiffeners or frames so long as they do not impair the operability and serviceability of the switchboards. For switchboards enclosed at the rear and fully serviceable from the front, clearances at the rear will not be required except that necessary for cooling.

Non-conducting mats or gratings are to be provided at the front and the rear of switchboards where operations or maintenance are expected.

Distribution boards are to be installed in accessible locations, but not in such spaces as bunkers, storerooms, cargo holds or passengers' spaces.

Pipes are not to be routed in the vicinity of switchboards. Where this cannot be avoided, such piping is to be of all welded joints or means are to be provided to prevent any joint leakage under pressure to impinge on the switchboard.

4.5 Motor Controllers and Motor Control Centers

4.5.1 Location

Motor control centers are to be located in a dry place. Clear working space is to be provided around motor control centers to enable doors to be fully opened and equipment removed for maintenance and replacement.

4.5.2 Disconnecting Arrangements

4.5.2.1 General

A circuit-disconnecting device is to be provided for each branch circuit of motor rated *0.5* kW or above so that the motor and the controller may be isolated from the power supply for maintenance purposes. However for pre-assembled or skid-mounted unit having two or more motors (e.g. fuel oil blender) a single disconnecting device in its feeder may be accepted in lieu of individual disconnecting devices for the motors, provided that the full load current of each motor is less than 6A. See also chapter 3/3.6.2.

4.5.2.2 Location of the Disconnecting Device

The disconnecting device may be in the same enclosure with the controller, in which case it is to be externally operable. The branch-circuit switch or circuit breaker on the power-distribution panel or switchboard may serve as the disconnect device if it is located in the same compartment as the controller. In any case, if the disconnecting device is not within sight of both the motor and the controller, or if it is more than 15 m (50 ft) from either, it is to be arranged for locking in the open position. The disconnect switch, if not adjacent to the controller, is to be provided with an identification plate.

4.5.2.3 Open/Close Indication

The disconnect device is to be provided with indication of whether it is open or close.

4.5.2.4 Supply Voltage of Indicating Light Circuit

Where indicating light is fitted to a motor controller to indicate the availability of the power supply, and if the required disconnecting device does not de-energize the indicating light circuits, the voltage of indicating light circuits is not to exceed 150 V.

4.5.2.5 Supply Voltage of Indicating Light Circuit

Where indicating light is fitted to a motor controller to indicate the availability of the power supply, and if the required disconnecting device does not de-energize the indicating light circuits, the voltage of indicating light circuits is not to exceed 150 V.

4.5.3 Resistors for Control Apparatus

Controllers fitted with resistors are to be located in well-ventilated compartments and are to be mounted with ample clearances (about 300 mm (12 in.)) from vessel structures and unprotected combustible materials.

4.6 Lighting Systems

4.6.1 General

4.6.1.1 Hot Surfaces

Lighting fixtures are be so installed as to prevent their hot surfaces from damaging cables and wiring, and from igniting surrounding materials.

4.6.1.2 Referenced Requirements

The following referenced requirements are applicable:

Emergency lighting, chapter 3/3.3.1 and 3/3.3.2

Lighting system arrangement,	chapter 2/4.7
Cable for branch lighting circuit,	chapter 2/4.4.7
Protection of branch lighting circuit,	chapter 2/5.11

4.6.2 Lighting Installation in Cargo Spaces

Fixed lighting circuits in cargo spaces are to be controlled by multipole-linked switches situated outside the cargo spaces.

4.7 Ventilating and Heating Equipment -

4.7.1 Electric Radiators

Electric radiators, if used, are to be fixed in position and be so constructed as to reduce fire risks to a minimum. Electric radiators of the exposed-element type are not to be used.

4.7.2 Power Ventilation

Power ventilation of accommodation spaces, service spaces, cargo spaces, control stations and machinery spaces is to be capable of being stopped from an easily accessible position outside the spaces served. This position is not to be readily cut off in the event of a fire in the spaces served. The means for stopping the power ventilation of machinery spaces are to be entirely separate from the means provided for stopping ventilation of other spaces. See section 2/6.5 for details of the requirements.

4.8 Magnetic Compasses

Precautions are to be taken in connection with apparatus and wiring in the vicinity of the magnetic compass to prevent disturbance of the needle from external magnetic fields.

4.9 Portable Equipment and Outlets

Portables apparatus served by a flexible cord is not to be used in car go oil pump rooms or other hazardous areas.

4.10 Power Receptacles

Receptacles and plugs of different voltage systems are not to be interchangeable, e.g., receptacles for 230 V system are to be of a type which will not permit attaching 115 V equipment.

4.11 Cable Installation

4.11.1 General Requirements

4.11.1.1 Continuity

Electric cables are to be installed, as far as practicable in continuous lengths between termination points. Where necessary, the use of cable junction boxes will be permitted;

see chapter 4/11.13. Cable splices (see chapter 4/11.12) will be permitted during construction for joining cables between modules, or when extending or truncating the lengths of cables during repair or alteration.

4.11.1.2 Restricted Locations

Cables are to be located with a view to avoiding, as far as practicable, spaces where excessive heat and flammable gases may be encountered, and also spaces where they may be exposed to mechanical damage. Where this cannot be avoided, special measures are to be made for effective protection of cables. See also chapter 4/11.8.

4.11.1.3 Choice of Insulation

The rated operating temperature of the insulating material is to be at least 1 0^0C higher than the maximum ambient temperature in the space where the cable is installed.

4.11.1.4 High Voltage Cable

Cables serving systems above 1kV are not to be bunched with cables serving systems of 1 kV and below.

4.11.1.5 Signal Cables

Except for fiber optic cables, non-shielded signal cables for control, monitoring and safety systems essential for propulsion and maneuvering of the vessel which may be affected by electromagnetic interference are not to be run in the same bunch with power or lighting cables.

4.11.2 Cable current Carrying Capacity

Cables sized in accordance with the current carrying capacities of Table 18, where installed on cable trays, are not to exceed double-banked. Cables sized iii accordance with the current carrying capacities of Table 18 are to be installed in such a manner as to provide sufficient air space around each cable to allow for heat dissipation

4.11.3 Cable Voltage Drop

Voltage drop at any point of the electrical installation is not to exceed 6% of the nominal voltage. For supplies from batteries with a voltage not .exceeding 50 V this figure may be increased to 10%. Where the length of the cable installed is such that, while the conductors are carrying the maximum current under steady state condition of service, this voltage drop limit is exceeded, the cable size is to be increased appropriately reduce the voltage drop. See also chapter *2/4.4.1.*

4.11.4 Single Conductor Cables

As far as possible, twin or multi-conductor cables are to be used in AC power distribution systems. However, where it is necessary to use single-conductor cables in circuits rated more than 20 A, arrangements arc to be made to account for the harmful effect of electro-magnetic induction as follows:

i) the cable is to be supported on non-fragile insulators;

ii) the cable armoring (to be non-magnetic, see chapter 3/5.6) or any metallic protection (non-magnetic) is to be earthed at mid span or supply end only;

iii) there is to be no magnetic circuits around individual cables and no magnetic materials between cables installed as a group; and

iv) as far as practicable, cables for thee-phase distribution are to be installed in groups, each group is to comprise cables of the three phases (360 electrical degrees). Cables with runs of 30 m (100 ft) or longer and having cross-sectional area of 185 mm^2 (365,005 circ. mils) or more are to be transposed throughout the length at intervals of not exceeding 15 m (50 ft) in order to equalize to some degree the impedance of the three phase circuits. Alternatively such cables are to be installed in trefoil formation.

4.11.5 Cable Support

4.11.5.1 General

Cables are to be installed and supported in ways to avoid chafing and undue stress in the cable. Cable supports and associated accessories are to be robust and are to be of materials that are corrosion-resistant or suitably treated to resist corrosion.

4.11.5.2 Spacing for Cable Support

The distance between cable supports are to be suitably chosen according to the type of cable and the degree of vibration the installation is likely to be subjected to. In general, cables are to be supported and fixed at an interval not to exceed 400 mm (16 in.). For horizontal runs where cables are laid on. tray plates, individual support brackets or hanger ladders, the distance between the fixing points may be up to 900 nm (36 in.), provided that there are supports with maximum spacing as specified above. This relaxation however does not apply to cable runs on weather decks where forces from sea water washing over the deck is expected.

4.11.5.3 Clips, Saddles, Straps

4.11.5.3 (a) Size. Clips, saddles and straps are to have surface area so wide and shaped that the cables are fixed tight without their covering being damaged.

4.11.5.3(b) Non-metallic materials. Cable clips, saddles or straps made from approved materials other than metal (such as polyamide, PVC) may be used provided that they are flame-retardant in accordance with IIEC Publication 60092-101. Where used for cables not laid on top of horizontal cable trays or similar, suitable metal clips or straps are to be added at regular intervals not exceeding 2 m (6.5 ft) in order to prevent the release of cables during a fire. This requirement however need not be apply to one or up to a few small diameter cables connecting to lights, alarm transducers, etc.

4.11.5.4 Non-metallic Conduits

Non-metallic conduits, pipes, ducts, cable frays, etc. are to be flame-retardant in accordance with JEC Publication 60092-101. Where used, they are to be installed and fixed as in chapter 4/11.5.3(b).

4.11.6 Cable Bending Radii

Cable bending radii may adhere to manufacturer's recommendations or the cable construction standard. Not withstanding that, the bending radii are to be in accordance with the table 19.

4.11.7 Deck and Bulkhead Penetrations

4.11.7.1 General

Where cables pass through watertight or tire-rated bulkheads or decks, the penetrations are to be made through the use of approved stuffing tubes, transit devices, or pourable materials which will maintain the watertight or firetight integrity of the bulkheads or decks. These devices or materials are not to cause damage to the cable.

Where cable conduit pipe of equivalent is carried through decks or bulkheads, arrangements are to be made to maintain the integrity of the water or gas tightness of the structure

4.11.7.2 Structural Insulation

Cables are not to be installed behind, or imbedded in, structural insulation. They may, however, pass through such insulation at approximately right angle. The penetration design is to preserve the insulation rating. Cable conduit or recess integral with B or C class fire-walls may be used for installing cables for accommodation purposes subject to the following conditions:

i) such fire-walls are of an approved type (e.g. by an Administration for meeting SOLAS), and

ii) arrangements are made to prevent the propagation of smoke through the conduit.

4.11.7.3 Non-watertight Penetrations

When cables pass though non-watertight bulkheads, decks or structural members, the length of the bearing surface for the cable is to be at least 6.4 mm (0.25 in.). All burrs and sharp edges are to be removed in way of the penetration.

4.11.7.4 Collision Bulkhead

No cable is allowed to penetrate the collision bulkhead.

4.11.7.5 Refrigerated Spaces

For penetration through insulated refrigerated space bulkheads, cables are to be installed in phenolic pipes or similar heat-insulating material. The pipe may be inserted through the bulkhead stuffing tube or joined directly to the bulkhead penetration piece.

4.11.8 Mechanical Protection for Cables

4.11.8.1 General

Electric cables exposed to risk of mechanical damage during normal operation of the vessel are to be of the type provided with metallic armor or otherwise be suitably protected from mechanical injury.

4.11.8.2 Additional Protection

Cables installed in locations such as within cargo holds, in way of cargo hatch openings, open decks subjected to seas, etc., even of the armored type, are to be protected by substantial metal shields, structural shapes, pipe or other equivalent means, which are to be of sufficient strength to provide effective protection to the cables. Metallic protections are to be electrically continuous and earthed to the hull. Non-metallic protections are to be flame retardant. Expansion bellows or similar where fitted are to be accessible for maintenance.

4.11.8.3 Drainage

Cable protective casings, pipes, and similar fixtures are to be provided with drainage.

4.11.9 High Fire Risk Areas *(2001)*

4.11.9.1 Emergency Feeders

Cables emanating from the emergency switchboard and supplying power to equipment located outside machinery space of category A are not to pass through machinery space of category A so as to maintain their functionality in the event of fire or other casualty causing the main source of electrical power in the machinery space of category A to be unavailable. As far as practicable, such cables, including those for internal communications and emergency signals, are also to be routed clear of galleys, laundries, the external boundaries of machinery space of category A and other high fire risk areas.

4.11.9.2 Services Necessary under a Fire Condition

4.11.9.2(a) Cables and apparatus for those services required to be operable under a fire condition (see chapter 4/1.5) including those for their power supplies are to be arranged so as to minimize the possibility of loss of services due to any localized fire.

4.11.9.2(b) Where cables for such services cannot be routed clear of high fire risk areas or zones, they are to be fire resistant in accordance with chapter 3/5.4 where they pass through high fire risk areas or zones other than those which they serve, unless exempted by 11.9.2 (c).

4.11.9.2(c) Cables used in systems that are self monitoring, fail safe or duplicated with cable runs separated as widely as is practicable, may be exempted from the fire resistant requirement provided the functionality of the system is maintained.

4.11.9.2(d) The fire resistant cables are to extend from the control/monitoring panel, or for power supply cables from the distribution point within the space containing the emergency source of electrical power, to the nearest local distribution: panel serving the relevant area/zone. In all instances, the run of cables is to be as straight as is practicable.

4.11.9.2(e) This paragraph does not alleviate the requirements for emergency feeders in 4.11.9.1.

4.11.10Mineral Insulated Cables

At all points where a mineral-insulated metal-sheathed cable terminates an approval seal is to be provided immediately after stripping to prevent entrance of moisture into the mineral insulation and, in addition, the conductors extending beyond the sheath are to be insulated With an approved insulating material. When a mineral-insulated cable is connected to boxes or equipment, the fittings are to be approved for the conditions of service. The connections are to be in accordance with the manufacturers installation recommendation.

4.11.11 Fiber Optic Cables

The installation of fiber optic cables is to be in accordance with the manufacturer's recommendations to prevent sharp bends where the fiber optic cables enter the equipment enclosure. Consideration is to be given to the use of angled stuffing tubes. The cables are to be installed so as to avoid abrading, crushing, twisting, kinking or pulling around sharp edges

4.11.12 Installation of Cable Splices

All splices are to be made with approved splice kit, see chapter 3/5.10. No splice is permitted in hazardous areas, except for cables of intrinsically safe circuits. Neither is splice permitted in propulsion cables. Where permitted, the following installation details are to be complied with:

i) All splices are to be made after the cables are in place and are to be in locations accessible for inspection.

ii) The conductor splice is to be made using a pressure type buff connector by means of an one-cycle compression tool.

iii) Armored cables having splices are not required to have the armor replaced provided that the armor is made electrically continuous.

iv) Splices are to be so arranged that mechanical stresses are not carried by the splice. Splicing of fiber optic cables is to be by means of mechanical or fusion methods as recommended by the manufacturer.

4.11.13 Installation of Cable Junction Boxes

Junction boxes may be employed to connect cables provided they are of approved design, see section 3/5.11. Junction boxes are not to be used in propulsion cables, however. Where permitted the following installation details are to be complied with:

i) The junction box enclosures are to be suitable for the locations of installation.

ii) Junction boxes are to be in locations accessible for inspection.

iii) For low voltage systems (50 V, 110 V, etc. up to 1 kV AC, see chapter 1/4), each voltage level is to be provided with its own junction box or separated by physical barriers within the same junction box. For high voltage systems (> 1kV) a separate junction box is to be used for each of the voltage levels.

iv) Emergency circuits and normal circuits are not to share the same junction box.

v) Armored *cables are to have their armoring made electrically continuous.*

vi) Cables arranged for connection at a junction box are to be well-supported and fastened so that conductor contacts are not subjected to undue stress.

4.11.14 Cable Termination

Cables stripped of moisture-resistant insulation are to be sealed against the admission of moisture by methods such as taping in combination with insulating compound or sealing devices. Cable *conductors for* connection to *terminals* are to be *fitted with* crimp lugs of corresponding current rating, or equivalent. Soldered lugs are permitted for conductors up to *2.5* mm^2 only. Cables are to be secured to the terminal box or other sturdy structure in such a manner that stresses are not transmitted to the terminal. Cable's moisture resistant jacket is to extend through the outermost cable clamp of the terminal box. Where applicable, other properties of the cable, e.g. flame retarding, fire resistant, etc. are to be retained through to the terminal box.

4.12 Equipment Earthing

4.12.1 General Requirements

4.12.1.1 Equipment

For protection against electrical shock, exposed metal parts of electrical machine or equipment which are not intended to be live but which are liable under fault conditions to become live are to be earthed unless the machine or equipment is:

i) supplied at a voltage not exceeding 50 V (DC or AC rms) between conductors (auto-transformers are not to be used for the purpose of achieving this voltage); or

ii) supplied at a voltage not exceeding 250 V (AC) by safety isolating transformers supplying only one consuming device; or

iii) Constructed in accordance with the principle of double insulation.

4.12.1.2 Cables

Metallic armor of cables and metallic sheath of mineral-insulated metal-sheathed cables are to be electrically continuous and are to be earthed to the metal hull at each end of the run except that final sub-circuits may be earthed at the supply end only.

4.12.1.3 Receptacles

Receptacles operating at more than 50 V are to have an earthing pole. Attachment plugs for non-permanently fitted equipment operating at more than 50 V are to have an earthing pole and an earthing conductor in the portable cord to earth the dead metal parts of the equipment.

4.12.2 Earthing Methods

The metal frames or enclosure of permanently installed electrical equipment may be earthed through metallic contact with the vessel's structure where the arrangement and method of installation assure positive earthing. Otherwise, they are to be connected to the hull by a separate conductor as follows:

i) Earthing conductor is to be of copper or other corrosion resistant material.

ii) The nominal cross-sectional area of every copper earthing conductor is to be not less than that required by Table 20.

iii) Connection of an earthing conductor to the hull is to be made in an accessible location, protected from mechanical damage, and secured by a screw of corrosion-resistant material having cross-sectional area equivalent to the required earthing conductor but, in any case, not less than 4mm (0.16 in) in diameter.

4.13 System Earthing

System earthing is to be in accordance with chapter *2/4.3* for low voltage system, and with chapter 5/2.2.3 for high voltage system. Earthing method as described in chapter 4/12.2 is to be complied with.

4.14 Electrical Equipment in Hazardous Areas

4.14.1 General

Hazardous areas are spaces where flammable or explosive gases, vapors, or dust are normally present, or likely to be present. Hazardous areas are to be classified based on the likelihood of presence and the concentration and type of flammable atmosphere, as well as in terms of the extent of the space. Electrical equipment is not to be installed in hazardous areas unless it is essential for safety or for operational purposes. Where the installation of electrical equipment in such location is necessary, it is to be selected based on its suitability for the hazardous area so classified. Such equipment is to be as specified in the appropriate sections of the Rules as indicated below.

4.14.2 Hazardous Areas

4.14.2.1 General

The following spaces are, in general, to be regarded as hazardous areas:

i) Tanks containing flammable liquids having a flash point of 60^0C (140W) or below.

ii) Holds containing solid bulk cargoes liable to release flammable gases or dust.

iii) Holds or enclosed cargo spaces containing cargoes that are likely to emit flammable gases or vapors, e.g. dangerous goods, vehicles with fuel in their tanks, etc.

iv) An enclosed or semi-enclosed space:

v) having a direct access or opening into the hazardous areas defined in i), ii) or iii), through a door, a ventilation opening, etc.;

vi) immediately adjacent to the hazardous areas defined in i); or *vii)* containing pumps or piping used for conveying liquid described in i).

viii) A defined zone in open space:

ix) 3 m (10 ft) from an opening to the hazardous areas defined in i), ii), iii) or iv), such as a door, a ventilation opening, a tank vent, etc., unless as otherwise indicated in chapter 4/14.2.2 and 4/14.2.3;

x) immediately adjacent to the hazardous area define in i); or

xi) in way of pumps or piping used for conveying liquid described in i).

4.14.2.2 Specific Vessel Types

Due to the nature of the cargoes carried, or the types of operation performed at sea, hazardous areas are defined for the following vessel types in the appropriate sections of the Rules:

i) Oil carriers carrying crude oil or refined oil products having a flash point of 60^0C (140W) or below.

ii) Bulk carriers carrying coal or other dangerous cargoes in bulk.

iii) Container carriers or dry cargo vessels carrying dangerous goods or vehicles with fuel in their tanks.

iv) Roll-on/roll-off vessels carrying vehic4es with fuel in their tanks.

v) Liquefied gas carriers carrying flammable gases.

vi) Chemical carriers carrying flammable liquid having a flash point of 60^0C or below.

vii) Drilling vessels performing exploratory or production drilling of hydrocarbon deposits. See 4/1.4.2 of *Mobile Offshore Drilling Unit Rules.*

viii) Floating hydrocarbon production facilities. See *Guide for Floating Production, Storage and Offloading Systems.*

4.14.2.3 Miscellaneous Spaces

The following spaces are to be regarded as hazardous areas:

i) Paint stores. Within the paint store; open deck area within 1 m (3 ft) from ventilation inlet and natural ventilation outlet; and open deck area within 3 m (10 ft) from power ventilation outlet. Enclosed spaces giving access to the paint store may be considered as non-hazardous, provided that:

a)The door to the paint store is gastight with self-closing devices without holding back arrangements.

b)The paint store is provided with an acceptable, independent, natural ventilation system ventilated from a safe area, and

c) Warning notices are fitted adjacent to the paint store entrance stating that the store contains flammable liquids.

ii) Battery rooms. Within the battery room; open deck area within lm (3 ft) from natural ventilation outlet, and open area within 3m (10 ft) from power ventilation outlet. See chapter 4 / 3.2.1

iii) Helicopter refueling facilities. Enclosed space is containing Components of the refueling pump/equipment; and open deck area within 3 m (10 fl) from ventilation outlet of enclosed space containing refueling pump/equipment, 3 m (10 ft) from tank vent outlet, and 3 m from refueling pump/equipment.

iv) Oxygen-acetylene storage rooms. Within due storage room; open deck area within 1 m (3 fl) from natural ventilation outlet, and open area within 3 m (10 ft) from power ventilation outlet.

4.14.3 Certified Safe Equipment In Hazardous Areas

4.14.3.1 General

Only electrical equipment of the following types complying with 1Ff Publication 60079, or other recognized standards, as described in chapter 3/7 is to be considered for installation in hazardous areas.

Intrinsically sale type (Ex i)

Flameproof (explosion-proof) type (Ex d)

Increased safety type (Ex e)

Pressurized or purged type (Ex p)

Consideration is to be given 10 the flammability group and the temperature class of the equipment for suitability for the intended hazardous area, see BC Publication 60079-20.

4.14.3.2 Paint Stores

Electrical equipment installed in paint stores may be any of the types indicated in chapter 4/14.3.1 and is to be at least IEC Publication 60079 group IIB class T3. In defined hazardous areas on open deck outside paint stores, electrical equipment with IP 55 enclosure or better, whose surfaces do not reach unacceptable high temperature, may also be accepted.

4.14.3.3 Battery Room

Electrical equipment installed in battery room is to be Ex i or Ex d only and is to be IEC Publication 60079 group IIC class TI.

4.14.3.4 Oxygen-acetylene Storage Room

Electrical equipment installed in oxygen-acetylene storage room is to be Ex i or Ex d only and is In be 1Ff Publication 60079 group IC class 12.

4.14.3.5 Helicopter Refueling Facilities

Electrical equipment installed in areas defined for helicopter refueling facilities may be any of the types in chapter 4/14.3.1 and is to be at least IEC Publication 60079 group IIA class T3.

4.14.3.6 Other Spaces

Electrical equipment allowable in hazardous areas defined in chapter 4/14.2.2 is given in appropriate sections in Part 5 of these Rules and Rules for Mobile Oj5cshore Drilling Units and Guide for Flowing Production Storage and Offloading Facilities.

4.14.4 Intrinsically-safe Systems

4.14.4.1 Separation from Other Electrical Systems

Intrinsically-sale systems are to be completely separated and independent of all other electric systems. Intrinsically-safe cables are to have shielded conductors or to be installed a minimum of 50 mm (2 in.) from ether electric cables and are not to occupy an enclosure (such as junction box or terminal cabinet) with non-intrinsically-safe circuits.

4.14.4.2 Arrangements of Common Enclosure

When intrinsically-safe components are located by necessity within enclosures that contain non-intrinsically-safe systems, such as control consoles and motor starters, such components are to be effectively isolated in a subcompartment by physical barriers having a cover or panel secured by bolts, locks, Allen-screws, or other approved: methods, the physical barrier is not intended to apply to the source of power for the intrinsically-safe circuit interface.

The sub-compartment is to have an identifying nameplate indicating that the equipment within is intrinsically-safe and that unauthorized modification or repairs are prohibited.

4.14.5 Cables in Hazardous Areas

Cables in hazardous areas ate to be armored or mineral-insulated metal-sheathed. Where these cables pass through boundaries or such locations, they are lobe in through gaslight fittings. No splices are allowed in hazardous areas except in intrinsically safe circuits.

4.14.6 Lighting Circuits in Hazardous Areas

All switches and protective devices for lighting fixtures in hazardous areas are to interrupt all poles or phases and are to he located in a non-hazardous area. Pie switches and protective devices for lighting fixtures are to be suitably labeled for identification purposes.

4.14.7 Permanent Notice and Booklet of Certified Safe Equipment

A booklet containing the list of certified safe equipment as installed, along with the particulars of the equipment (see chapter l/3.2.2), is to be maintained on board. Permanent notices are to be posted in the vicinity of hazardous areas in which such electrical equipment is installed to advise crew of the availability of die booklet so that it can he reference during repair or maintenance.

4.15 Shipboard Tests

4.15.1General

Upon completion of the installation, electrical systems are to be tested under working conditions to the satisfaction of the Surveyor.

4.15.2 Generators

Each generator is to be operated for a time sufficient to show satisfactory operation, individually and in parallel, arid with all possible load combinations.

4.15.3 Switchboards

Generator protective devices e.g., over load protection, reverse power protection, under voltage protection, preferential trip, and auxiliary motor sequential starting, as applicable are to be tested.

4.15.4 Motors

Each motor is to be operated for a time sufficient to show satisfactory performance at such load as can readily be obtained.

4.15.5 Interior Communications System

Satisfactory operation of the interior communications system as required by chapter 2/6.3 is to be demonstrated. Particular attention is to be paid to the voice communication system for is audibility while the vessel is underway.

4.15.6 Voltage Drop Measurement

Voltage drop along power and lighting cables is to be measured. Voltage drop at any part of the installation is not to exceed the limits specified in chapter 2/4.4.1(d).

4.15.7 Insulation Resistance Measurements

Insulation resistance of power and lighting tables is to be measured. Appliances connected to the circuits may be disconnected for this test. Each power and each lighting circuit is to have an insulation resistance between conductors and between each conductor and card, of not less than the values which shown in table 21.

4.16 Guidance for Spare Parts

While spare pals are not required for class, the spare parts listed below are for unrestricted service and are provided as a guidance to assist in ordering spare parts which may be appropriate for the intended service. The maintenance of spare parts aboard each vessel is the responsibility of the owner.

4.16.1 Spare Fans of Electrical Equipment

One complete set of bearing for each size and type of generator and motor.

4.16.2 Measuring Instrument

A 500 V insulation-resistance measuring instrument (megger).

CHAPTER 5

SPECIAL SYSTEMS

5.1 Application

This section applies to (a) high voltage systems; (b) electric propulsion systems; and (c) three-wire dual-voltage DC systems. Unless stated otherwise, the applicable requirements of chapter 1 through chapter 4 are to be complied with.

5.2 High Voltage Systems

5.2.1 Application

The following *requirements* in this Subsection are applicable to AC systems with nominal voltage (phase to phase) exceeding 1 kV and up to 11 kV. For systems with nominal voltages exceeding 11 kV a recognized relevant standard will be considered. Unless stated otherwise, the applicable requirements of chapter 1, chapter 2, chapter 3 and chapter 4 are to be complied with.

5.2.2 System Design

5.2.2.1 Standard Voltages and Frequency

The nominal standard voltages/frequencies recommended are 3.0 kV, 3.3 kV, 6.0 kV, 6.6 kV, 10 kV and 11 kV at 50 or 60 Hz. Other voltage/frequencies in accordance with a recognized national standard will be considered provided that the entire system is designed to that standard.

5.2.2.2 Distribution Systems

The following distribution systems may be used:

3 phase 3 wire with insulated neutral, or

3 phase 3 wire with earthed neutral.

Earthed neutral systems are permitted only outside hazardous areas.

5.2.2.3 Earthed Neutral Systems

5.2.2.3(a) Neutral earthing. Where a system with neutral earthed is provided, the connection to the earth is to be though a resistor or other limiting devices so that in case of an earth fault the current is not to be greater than the full load current of the largest generator on the switchboard nor less than three times the minimum current required to operate any device against an earth fault. Special consideration will be given to directly earthed neutral or other proposed earthed neutral systems.

5.2.2.3(b) Equipment. Electrical equipment is to withstand the earth fault current for the time necessary to trip the protective device.

5.2.2.3(c) Neutral disconnection. Each generator neutral is to be provided with means for disconnection for maintenance purposes.

5.2.2.3(d) Hull connection of earthing resistors. All earthing resistors are to be connected to the hull. Methods of connection ate to be considered with respect to interference to radio, radar and communication systems. Additionally, the earth resistors or devices for connection of the neutrals to the hull are to be provided for each section of the system that can be operated independently.

5.2.2.3(e) Interconnection of neutrals. Generators running in parallel may have a common neutral conductor to earth provided the third harmonic content of the wave form is 5% or less. Otherwise, individual resistors are to be provided for neutral connection to earth of each generator.

5.2.2.4 Earth Fault Detection

An earth fault is to be indicated by visual and audible means. Rapid isolation is to be provided unless the system is designed to operate continuously with an earth fault.

5.2.3 Circuit Protection

5.2.3.1 Protection of Generator

Protection against phase-to-phase fault in the cables connecting the generators to the switchboard and against inter-winding faults within the generator is to be provided. This is to trip the generator circuit breaker and dc-excite the generator.

5.2.3.2 Protection of Power Transformers

If the total connected load of all outgoing circuits of the power transformer secondary side exceeds the rated load, an overload protection or an overload alarm is to be fitted. When transformers are connected in parallel, tripping of the protective devices at the primary side is to automatically trip the switch or protective devices connected at the secondary side.

5.2.3.3 Voltage Transformers for Control and Instrumentation

Voltage transformers are to be protected against short-circuit by fuses on the primary and secondary sides. Special consideration will be given to omitting fuses on the primary side or to fitting automatic circuit breakers on the secondary side instead of fuses.

5.2.3.4 Fuses

The use of fuses for overload protection is not permitted but may be permitted for shod-circuit protection

5.2.3.5 Over Voltage Protection

Lower voltage systems supplied through transformers from high voltage systems are to be protected against over-voltages due to loss of insulation between primary and secondary windings. Direct earthing of the lower voltage system or appropriate neutral voltage limiters may be fitted. Special consideration will be given to the use of an earthed screen between the primary and secondary windings of high voltage transformers.

5.2.3.6 Coordination of Protective Devices

Regardless of the neutral arrangement, coordination of protective devices in accordance with the intent of chapter 2/5.4 is to be provided.

5.3.4 Equipment Design

5.2.4.1 Air Clearance and Creepage Distance

5.2.4.1(a) Air clearance. Phase-to-phase air clearances and phase-to-earth air clearances between non-insulated parts are to be not less than the minimum as specified shown in table 22.

Where intermediate values of nominal voltages are accepted, the next higher air clearance is to be observed. Where necessary, these distances are to be increased to allow for the electromagnetic forces involved. In the ease of smaller distances, appropriate voltage impulse test is to be applied.

5.2.4.1(b) Creepage distance. Creepage distances between live parts and between live parts and earthed metal parts are to be adequate for the nominal voltage of the system, due regard being paid to the comparative tracking index of insulating materials under moist conditions according to the IEC Publication 60112 and to the transient over-voltage developed by switching and fault conditions.

5.2.4.2 Circuit Breakers and Switches

Where electrical energy or mechanical energy is required for the operation of circuit breakers and switches, a means of storing such energy is to be provided with a capacity at least sufficient for two on/off operation cycles of all the components. However, the tripping due to overload or short-circuit, and under-voltage is to be independent of any stored electrical energy sources. This does not preclude the use of stored energy for shunt tripping.

At least one independent source of supply for auxiliary circuits of each independent section of the system is to be provided.

5.2.4.3 Rotating Machines

5.2.4.3(a) Protection. Rotating machines are to have a degree of protection as per Table 14 but not less than IP23; for terminal box, IP44; and for motors accessible to unqualified personnel, IP43.

5.2.4.3(b) Windings. Generator stator windings should have all phase ends brought out.

5.2.4.3(c) Temperature detectors. Rotating machines are to be provided with temperature detectors in their stator windings to actuate a visual and audible alarm in a normally attended position whenever the temperature exceeds the permissible limit. If embedded temperature detectors are used, means are to be provided to protect the circuit against over-voltage.

5.2.4.3(d) Cooler. Water-air heater exchangers of rotating machines are to be of the double tube type. In a normally attended position a visual and audible alarm is to be given to monitor water cooler leakage.

5.2.4.3(e) Space heater. Effective means are to be provided to prevent the accumulation of moisture and condensation within the machines when they are idle.

5.2.4.4 Switchgear and Control-gear Assemblies

Switchgear and control gear assemblies are to be constructed according to the IEC Publication 60298 and the following additional requirements:

5.2.4.4(a) Protection. Switchgear, control-gear assemblies and converters are to have a degree of protection in accordance with Table 14 but not less than IP23.

5.2.4.4(b) Mechanical construction. Switchgear should be of metal-enclosed type in accordance with IEC Publication 60298 or of the insulation-enclosed type in accordance with IEC Publication 60466.

5.2.4.4(c) Configuration. The main bus bars are to be subdivided into at least two parts which are to be connected by circuit breakers or other approved means. As far as practicable, the connection of generating sets and any other duplicated equipment is to be equally divided between the parts.

5.2.4.4(d) Clearance and creepage distances. For clearance and creepage distances, see section 5/2.4.1

5.2.4.4(e) Circuit breakers. Circuit breakers are to be of the withdrawable type or fitted with equivalent means or arrangements permitting safe disconnection whilst the bus bars are live.

5.2.4.4(f) Locking facilities. Withdrawable circuit breakers and switches are to be provided with mechanical locking facilities in both service and disconnected positions.

For maintenance purposes, key locking of withdrawable circuit breakers, switches and fixed disconnections are to be possible. Withdrawable circuit breakers, when in the service position, are to have no relative motion between fixed and moving parts.

5.2.4.4(g) Shutters. The fixed contacts of withdrawable circuit breakers and switches are to be so arranged that in the withdrawn position the live contacts of the bus bars are automatically covered.

5.2.4.4(h) Earthing and short-circuiting facilities. For maintenance purposes, an adequate number of earthing and short circuiting facilities is to be provided to enable equipment and cables to be earthed or short-circuited to earth before being worked upon.

5.2.4.5 Transformers

5.2.4.5(a) Protection. Transformers are to have a degree of protection in accordance with Table 14 but not less than IP44. However, when installed in spaces accessible to qualified personnel only, the degree of protection may be reduced to IP2X. For transformers not contained in enclosures, see 5/2.6.

5.2.4.5(b) Space heater. Effective means to prevent accumulation of moisture and condensation within the transformers (when de-energized) is to be provided.

5.2.4.6 Cables

5.2.4.6(a) Standards. Cables are to be constructed to IEC Publication 60092-3, 60092-354, or other equivalent standard. See also 3/5.

5.2.4.6(b) Rated voltage. In a system with insulated neutral, the rated phase to earth voltage *(U_0)* of the cables is to be not less than the nominal voltage of the system. For an earth neutral system, the rated phase to phase voltage *(Un)* is to be not less than the nominal voltage of the system. See IEC Publication 60183.

5.2.4.7 Miscellaneous Equipment

Equipment is to comply with the following IEC standards or equivalent:

i)	Circuit Breakers	IEC Publication *60056*
ii)	Switches	IEC Publication 60265
iii)	Fuses	IEC Publication 60282
iv)	Contactors	IEC Publication 60470
v)	Current Transformers	IEC Publication 60185
vi)	Voltage Transformers	IEC Publication 60186
vii)	Relay	IEC Publication 60255

5.2.5 Cable Installation

5.2.5.1 Runs of Cables

High Voltage cables are not to be run through accommodation spaces. If not practicable, special consideration will be given to such installation.

5.2.5.2 Segregation

High voltage cables are to be segregated from cables operating at lower voltages; in particular, they are not to be run either in the same cable bunch, the same ducts or pipes, or, in the same box. Other suitable equivalent arrangement may be accepted.

5.2.5.3 Installation Arrangements

High voltage cables are to be installed on cable frays or equivalent when they are provided with a continuous metallic sheath or armor which is effectively bonded to earth; otherwise they are to be installed for their entire length in metallic ducting or pipes effectively bonded to earth.

5.2.5.4 Termination and Splices

Terminations in all conductors of high voltage cables are to be, as far as practicable, effectively covered with suitable insulating material. In terminal boxes, if conductors are not insulated, phases are to be separated from earth and from each other by substantial bafflers of suitable insulating materials. Precautions are to- be taken to relieve the electrical stresses where cable insulation is terminated. Terminations and splices are to be of a type compatible with the insulation and jacket material of the cable and are to be provided with means to earth all metallic shielding components (i.e. tapes, wires, etc.)

5.2.5.5 Marking

High voltage cables are to be readily identifiable by suitable marking.

5.2.6 Equipment Installation

5.2.6.1 Voltage Segregation

Higher voltage equipment is not to be combined with lower voltage equipment in the same enclosure, unless segregation or other suitable measures are taken to ensure safe access to lower voltage equipment.

5.2.6.2 Large Equipment Enclosure

Where high voltage equipment is not contained in an enclosure but a room forms the enclosure of the equipment, the access doors are to be so interlocked that they cannot be opened until the supply is isolated and the equipment earthed down. At the entrance of such spaces, a suitable marking is to be placed which indicates danger of high voltage and the maximum voltage inside the space. For high voltage equipment installed outside these spaces, a similar marking is to be provided.

5.2.7 Shipboard Installation and Tests

5.2.7.1 Rotating Machine Tests

A high voltage test is to be carried out on the individual coils in order to demonstrate a satisfactory level of withstanding of the inter-winding turn insulation to steep fronted switching surges. This test applies to coils for rotating machines to be used for either earth or insulated systems. The peak test voltage is to be that calculated by: $Ut= 2.45$ Un, where Un is the nominal voltage of the system. Each coil is to be subject to at least five impulses. Alternative procedures recommended by the manufacturer will be considered.

5.2.7.2 Switchgear Tests

A power frequency voltage test is to be carried out on high voltage switchgear and control-gear assemblies using the following test voltages in accordance with the procedures of IEC Publication 60298 or other equivalent standards Table 23.

5.2.7.3 Cable Test after Installation

After installation, high voltage cables are to be subjected to a voltage test with a DC voltage of 4.2 Uo + 3.36 kV for cables of up to and including 3.6/6 (7.2) kV, and 4.2 Uo for cables of higher voltage, where Uo is the rated voltage in kV between conductor and earth (or metallic screen) for which the cable is designed. The voltage is to be applied for 15 minutes. Test voltage according to other recognized standard may be accepted.

5.3 Electric Propulsion Systems

5.3.1 Application

The requirements in this Subsection are applicable to electric propulsion systems. Electrical propulsion systems complying with other recognized standard will be considered.

5.3.2 Plans and Data to be Submitted

In addition to the plans and data to be submitted in accordance with chapter *1/3* as applicable, the following plans and data are to be submitted for review.

- One-line diagrams of propulsion control system for power supply, circuit protection, alarm, monitoring, safety and emergency shutdown systems including list of alarm and monitoring points.

- Plans showing the location of propulsion controls and its monitoring stations.
- Arrangements and details of the propulsion control console or panel including schematic diagram of the system therein
- Arrangements and details of electric coupling.
- Arrangements and details of the semiconductor converter enclosure for propulsion system, including data for semiconductor converter, cooling system with its interlocking arrangement.

5.3.3 Electric Power Supply Systems

5.3.3.1 Propulsion Generators

5.3.3.1(a) Power supply. The power for the propulsion equipment may be derived from a single generator. If a vessel service generator is also used for propulsion purposes, other than for boosting the propulsion power, such generator and power supply circuits to propulsion systems are also to comply with the applicable requirements in this Subsection. See also *2/2.2*.

5.3.3.1(b) Single system. If a propulsion system contains only one generator and one motor and cannot be connected to another propulsion system, more than one exciter set is to be provided for each machine. However, this is not necessary for self-exited generators or for multi-propeller propulsion ships where any additional exciter set may be common for the ship.

5.3.3.1(c) Multiple systems. Systems having two or more propulsion generators, two or more semiconductor converters, or two or more motors on one propeller shaft are to be so arranged that any unit may be taken out of service and disconnected electrically without preventing the operation of the remaining units.

5.3.3.1(d) Excitation systems. Arrangements for electric propulsion generators are to be such that propulsion can be maintained in case of failure of an excitation system or failure of a power supply for an excitation system. Propulsion may be at reduced power under such conditions where two or more propulsion generators are installed provided such reduced power is sufficient to provide for a speed of not less than 7 knots or ~'2 of the design speed whichever is the lesser.

5.3.3.1(e) Features for other services. If the propulsion generator is used for other purposes than for propulsion, such as dredging, cargo oil pumps and other special services, overload protection in the auxiliary circuit and means for making voltage adjustments are to be provided at the control board. When propulsion alternating-current generators are used for other services for operation in port, the port excitation control is to be provided with a device that is to operate just below normal idling speed of the generator to remove excitation automatically.

5.3.3.2 Propulsion Excitation

5.3.3.2(a) Excitation circuits. Every exciter set is to be supplied by a separate feeder. Excitation circuits are not to be fitted with overload circuit-interrupting devices except those intended to function in connection with the protection for the propulsion generator. In such cases the field circuit breaker is to be provided with a discharge resistor unless a permanent discharge resistor is provided.

5.3.3.2(b). Field circuits. Field circuits are to be provided with means for suppressing voltage rise when a field switch is opened. Where fuses are used for excitation circuit protection it is essential that they do not interrupt the field discharge resistor circuit upon rupturing.

5.3.3.2(c) Vessel's service generator connection. Where the excitation supply is obtained from the vessel's service generators, the connection is to be made to the generator side of the generator circuit breaker with the excitation supply passing through the overload current device of the breaker.

5.3.3.3 Semiconductor Converters

Semiconductor converter circuits are to be able to withstand the transient overcurrents to which the system is subject during maneuvering. Where semiconductor converters connected in parallel, the current for each semiconductor converters is to be equally distributed as far as practicable. If several elements are connected in parallel and a separate fan is filled for each parallel branch, arrangements are to be made for disconnecting the circa for which ventilation is not available. Where semiconductor converters are connected in series, the voltage between the semiconductor devices are to be equally distributed as hr a practicable. In case of failure of the cooling system, an alarm is to be given or the current a u be reduced automatically.

5.3.4 Circuit Protection

5.3.4.1 Setting

Overcurrent protective devices, if any, in the main circuits are to be set sufficiently high so as not to operate on overcurrents caused by maneuvering or normal operation in heavy seas or in floating broken ice.

5.3.4.2 Direct-current (DC) Propulsion Circuits

5.3.4.2(a) Circuit protection. Direct-current propulsion circuits are not to have fuses. Each circuit is to be protected by overload relays to open the field circuits or by remote-controlled main-circuit interrupting devices. Provision is to be made for closing circuit breakers promptly after opening.

5.3.4.2(b) Protection for reversal of the rotation. Where separately driven DC generators an connected electrically in series, means shall be provided to prevent reversal of the rotation of a generator upon failure of the driving power of its prime mover.

5.3.4.3 Excitation Circuits

An overload protection is not to be provided for opening of the excitation circuit.

5.3.4.4 Reduction of Magnetic Fluxes

Means are to be provided for selective tripping or rapid reduction of the magnetic fluxes of the generators and motors so that overcurrents do not reach values which may endanger the plant.

5.3.4.5 Semiconductor Converters

5.3.4.5(a) Overvoltages protection. Means are to be provided to prevent excessive overvoltages in a supply system to which converters are connected. Visual and audible alarms are to be provided at the control station for tripping of the protective fuses for these devices.

5.3.4.5(b) Overcurrent protection. Arrangements are to be made so that the permissible current of semiconductor elements cannot be exceeded during normal operation.

5.3.4.5(c) Short-circuit protection. Fuses are to be provided for protection of short-circuit of semiconductor converters. Visual and audible alarms are to be provided at the control station for tripping of these semiconductor protective fuses. In case of blown fuse, the respective part of the plants is to be taken out of operation.

5.3.4.5(d) Filter circuits. Fuses are to be provided for filter circuits. Visual and audible alarms are to be provided at the control station for tripping of the fuse.

5.3.5 Protection for Earth Leakage

5.3.5.1 Main Propulsion Circuits

Means for earth leakage detection are to be provided for the main propulsion circuit and be arranged to operate an alarm upon the occurrence of an earth fault. When the fault current flowing is liable to cause damage, arrangements for opening the main propulsion circuit are also to be provided.

5.3.5.2 Excitation Circuits

Means are to be provided for earth leakage detection in excitation circuits of propulsion machines but may be omitted in circuits of brushless excitation systems and of machines rated up to 500 kW.

5.3.5.3 Alternating-current (AC) Systems

Alternating-current propulsion circuits are to be provided with an earthing detector alarm or indicator. If the neutral is earthed for this purpose, it is to be through an arrangement which will limit the current at full-rated voltage so that it will not exceed approximately 20 A upon a fault to earth in the propulsion system. An unbalance relay is to be provided to open the generator and motor-field circuits upon the occurrence of an appreciable unbalanced fault.

5.3.5.4 Direct-current (DC) Systems

The earthing detector may consist of a voltmeter or lights. Provision is to be made for protection against severe overloads, excessive currents and electrical faults likely to result in damage to the plant. Protective equipment is to be capable of being so set as not to operate on the overloads or overcurrents experienced in a heavy seaway or when maneuvering.

5.3.6 Propulsion Control

5.3.6.1 General

Failure of a control signal is not to cause an excessive increase in propeller speed. The reference value transmitters in the control stations and the control equipment are to be so designed that any defect in the desired value transmitters or in the cables between the control station and the propulsion system will not cause a substantial increase in the propeller speed.

5.3.6.2 Automatic and Remote Control Systems

Where two or more control stations are provided outside the engine room, or where the propulsion machinery space is intended for centralized control or unattended operation, the provisions of Part 4, Chapter 9 are to be complied with.

5.3.6.3 Testing and Inspection

Controls for electric propulsion equipment are to be inspected when finished and dielectric strength tests and insulation resistance measurements made on the various circuits in the presence of the Surveyor, preferably at the plant of manufacture. The satisfactory tripping and operation of all relays, contactors and the various safety devices are also to be demonstrated.

5.3.6.4 Initiation of Control

The control of the propulsion system can be activated only when the delegated control lever is in zero position and the system is ready for operation.

5.3.6.5 Emergency Stop

Each control station shall have an emergency stop device which is independent of the control lever.

5.3.6.6 Prime Mover Control

Where required by the system of control, means are to be provided at the control assembly for controlling the prime mover speed and for mechanically tripping the throttle valve.

5.3.6.7 Control Power Failure

If failure of the power supply occurs in systems with power-aided control (e.g. with electric, pneumatic or hydraulic aid), it is to be possible to restore control in a short time.

5.3.6.8 Protection

Arrangements are to be made so that opening of the control system assemblies or compartments will not cause inadvertent or automatic loss of propulsion. Where steam and oil gauges are mounted on the main-control assembly, provision is to be made so that the steam or oil will not come in contact with the energized parts in case of leakage.

5.3.6.9 Interlocks

All levers for operating contactors, line switches, field switches and similar devices are to be interlocked to prevent their improper operation. Interlocks are to be provided with the field lever to prevent the opening of any main circuits without first reducing the field excitation to zero, except that when the generators simultaneously supply power to an auxiliary toad apart from the propulsion, the field excitation need only be reduced to a low value.

5.3.7 Instrumentation at the Control Station

5.3.7.1 Indication, Display and Alarms

The necessary instruments to indicate existing conditions at all times are to be provided and mounted on the control panel convenient to the operating levers and switches. Instruments and other devices mounted on the switchboard are to be labeled and the instruments provided with a distinguishing mark to indicate full-load conditions. Metallic cases of all permanently installed instruments are to be permanently earthed.

The following instruments, where applicable, are to be provided.

i) For AC systems: ammeter, voltmeter, indicating wattmeter and field ammeter (not required for brushless generators) for each propulsion generator and for each synchronous motor.

ii) For DC systems: an ammeter for each main circuit and one or more voltmeters with selector switches for reading voltage on each propulsion generator and motor.

iii) For electric slip couplings: an ammeter for the coupling excitation circuit.

5.3.7.2 Indication of Propulsion System Status

The control stations of the propulsion systems are to have at least the following indications for each propeller:

i) "Ready for operation": power circuits and necessary auxiliaries are in operation.

ii) "Faulty": propeller is not controllable.

iii) "Power limitation": in case of disturbance, for example, in the ventilators for propulsion motors, in the converters, cooling water supply or load limitation of the generators.

5.3.8 Equipment Installation and Arrangements

5.3.8.1 General

The arrangement of bus bars and wiring on the back of propulsion-control assemblies is to be such that all parts, including the connections, are accessible. All nuts and connections are to be fitted with locking devices to prevent loosening due to vibration. Clearance and creepage distances are to be provided between parts of opposite polarity and between live parts and earth to prevent arcing; see chapter 3/3.2.2 for low voltage systems and *3/3.4.1 for* high voltage systems.

5.3.8.2 Accessibility and Facilities for Repairs

5.3.8.2(a) Accessibility. For purposes of inspection and repair, provision is to be made for access to the stator and rotor coils, and for the withdrawal and replacement of field coils. Adequate access is to be provided to permit resurfacing of commutators and slip-rings, as well as the renewal and bedding of brushes.

5.3.8.2(b) Facility for supporting. Facilities are to be provided for supporting the shaft to permit inspection and withdrawal of bearings.

5.3.8.2(c) Slip-couplings. Slip-couplings are to be designed to permit removal as a unit without axial displacement of the driving and driven shaft, and without removing the poles.

5.3.8.3 Semiconductor Converters

Converters are to be installed away from sources of radiant energy in locations where the circulation of air is not restricted to and from the converter and where the temperature of the inlet air to air-cooled converters will not exceed that for which the converter is designed. Immersed-type converters are to use a non-flammable liquid. Where forced cooling is utilized, the circuit is to be so designed that power cannot be applied to or retained on converters unless effective cooling is maintained. Convener stacks are to have at least 1P22 protection and mounted in such a manner that they may be removed without dismantling the complete unit.

5.3.8.4 Propulsion Cables

Propulsion cables are not to have splices or joints except terminal joints and all cable terminals are to be sealed against the admission of moisture or air. Similar precautions are to be taken during installation by sealing all cable ends until the terminals are permanently attached. Cable supports are to be designed to withstand short- circuited conditions. They are to be spaced less than 900 mm (36 in.) apart and are to be arranged to prevent chafing of the cable. See chapter 4/21.9.2 for cable hangers and cable straps.

5.3.9 Equipment Requirements

5.3.9.1 Material Tests

The following materials intended for main propulsion installations are to be tested in the presence of a Surveyor: thrust shafts, line shafts, propeller shafts, shafting for propulsion generators and motors, coupling bolts, and in the case of direct-connected turbine-driven propulsion generators, fan shrouds, centering and retaining rings. Major castings or built-up parts such as frames, spiders and end shields are to be surface inspected and the welding is to be in accordance with the requirements of Part 2, Chapter 4 in ABS booklet.

5.3.9.2 Temperature Rating

When generators, motors or slip-couplings for electric propulsion are fitted with an integral fan and will be operated at speeds below the rated speed with full-load torque, full-load current, or full-load excitation, temperature rise limits according to Table 16 are not to be exceeded.

5.3.9.3 Protection Against Moisture Condensation

Means for preventing moisture condensation as specified in chapter 3/2.6.5 is applicable for rotating machines and converters regardless of the weight of the machines.

5.3.9.4 Prime Movers

5.3.9.4(a) Capability. The prime mover rated output is to have adequate overloading and build-up capacity for supplying the power which is necessary during transitional changes in operating conditions of the electrical equipment. When maneuvering from full propeller speed ahead to full propeller speed astern with the ship making full way ahead, the prime mover is to be capable of absorbing a proportion of the regenerated power without tripping due to overspeed.

5.3.9.4(b) Speed control. Prime movers of any type are to be provided with a governor capable of maintaining the pre-set steady speed within a range not exceeding 5% of the rated full-load speed for load changes from full-load to no-load.

5.3.9.4(c) Manual controls. Where the speed control of the propeller requires speed variation of the prime mover, the governor is to be provided with means for local manual control as well as for remote control. For turbines driving AC propulsion generators, where required by the system of control, the governor is to be provided with means for local hand control as well as remote adjustment from the control station.

5.3.9.4(d) Parallel operation. In case of parallel operation of generators, the governing system is to permit stable operation to be maintained over the entire operational speed range of the prime movers.

5.3.9.4(e) Protection for regenerated power. Braking resistors or ballast consumers are to be provided to absorb excess amounts of regenerated energy and to reduce the speed of rotation of the propulsion motor. These braking resistors or ballast consumers are to be located external to the mechanical and electric rotating machines. Alternatively, the amount of regenerated power may be limited by the action of the control system.

5.3.9.5 Rotating Machines for Propulsion

The following requirements are applicable to propulsion generators and propulsion motors.

5.3.9.5(a) Ventilation and protection. Electric rotating machines for propulsion are to be enclosed ventilated or be provided with substantial wire or mesh screen to prevent personnel injury or entrance of foreign matter. Dampers are to be provided in ventilating air ducts except when recirculating systems are used.

5.3.9.5(b) Fire-extinguishing systems. Electric rotating machines for propulsion which are enclosed or in which the air gap is not directly exposed are to be fitted with fire-extinguishing systems suitable for fires in electrical equipment. This will not be required where it can be established that the machinery insulation is self-extinguishing.

5.3.9.5(c) Air coolers. Air cooling systems for propulsion generators are to be in accordance with piping systems.

5.3.9.5(d) Temperature sensors. Stator windings of AC machines and interpole windings of DC machines, rated above 500 kW, are to be provided with temperature sensors.

5.3.9.6 Propulsion Generators

Excitation current for propulsion generators may be derived from attached rotating exciters, static exciters, excitation motor-generator sets, or special purpose generating units. Power for these exciters may be derived from the machine being excited or from any ship service, emergency, or special purpose generating units.

5.3.9.7 Direct-current (DC) Propulsion Motors

5.3.9.7(a) Rotors. The rotors of DC propulsion motors are to be capable of withstanding overspeeding up to the limit reached in accordance with the characteristics of the overspeed protection device at its normal operational setting.

5.3.9.7(b) Overspeed protection. An overspeed protection device is to be provided to prevent excessive overspeeding of the propulsion motors due to light loads, loss of propeller, etc.

5.3.9.8 Electric Couplings

5.3.9.8(a) General. Couplings are to be enclosed ventilated or be provided with wire or mesh screen to prevent personnel injury or the entrance of foreign material. All windings are to be specially treated to resist moisture, oil and salt air.

5.3.9.8(b) Accessibility for repairs. The coupling is to be designed to permit removal as a unit without moving the engine. See also chapter 5/3.8.2(a).

5.3.9.8(c) Temperature rating. The limits of temperature rise are to be the same as for alternating-current generators given in Table 16, except that when a squirrel-cage element is used, the temperature of this element may reach such values as are not injurious. Depending upon the cooling arrangements, the maximum temperature rise may occur at other than fill-load rating so that heat runs will require special consideration; for this purpose, when an integral fan is fitted, the coupling temperatures are not to exceed the limits in Table 16 when operated continuously at 70% of fill-load rpm, fill excitation and rated torque. Temperature rises for insulation materials above 1 SOT will be considered provided they are in accordance with a recognized standard.

5.3.9.8(d) Excitation. Excitation is to be provided as required for propulsion generators. See chapter 5/3.9.6.

5.3.9.8(e) Control equipment. Electric-coupling control equipment is to be combined with the prime mover speed and reversing control and is to include a two-pole disconnect switch, short-circuit protection only, ammeter for reading coupling current, discharge resistor and interlocking to prevent energizing the coupling when the prime mover control levers are in an inappropriate position.

5.3.9.8(f) Nameplates. Nameplates of corrosion-resistant material are to be provided in an accessible position of the electric coupling and are to contain the following typical details:

manufacturer's name, serial number and frame designation

rated output and type of rating

ambient temperature range

rated voltage, speed and temperature rise

rated exciter voltage and current

5.3.9.9 Semiconductor Converters for Propulsion

5.3.9.9 (a) General. Converter enclosures and other parts subject to corrosion are to be made of corrosion-resistant material or of a material rendered corrosion resistant. Ambient air temperature is to be in accordance with section 3/1.9. In the case of water-cooled converters, the inlet cooling water temperature is assumed to be 30^0C (86^0F), unless otherwise approved. In all cases, the temperature rise under all conditions is to be limited to such a value as will permit the converter to meet the specified performance criteria. Schematic and one-line diagrams are to be submitted for review.

5.3.9.9(b) Testing and inspection. Semiconductor converters for propulsion systems are to be tested in the presence of and inspected by the Surveyor, preferably at the plant of the manufacturer. Duplicate units of previously tested semiconductor converters are to be tested only as deemed necessary by the Surveyor to demonstrate successful operation.

5.3.9.9(c) Insulation test. The insulation of semiconductor converters is to be tested with all the parts completely assembled not withstanding previous tests carried out by the manufacturer on individual parts. The dielectric strength is to be tested by the continuous application for 60 seconds of an alternating voltage having a crest value equal to ‘12 times the specified test voltage and a frequency of 20 Hz to 60 Hz. The standard test voltage is to be twice the normal voltage of the circuit to which it is applied plus 1000 V except that where the secondary circuit operates below 60 V, the test voltage is to be 600 V rms. and where in the range of 60 ‘V to 90 V, the test voltage is to be 900 V rms. The dielectric test voltage is to be applied between each circuit and earthed metal pans. Alternative test procedures will be considered where the above requirement could result in damage to sensitive components.

5.3.9.9(d) Design data. The following limiting repetitive peak voltages, *URM,* are to be used as a base for the semiconductor device:

- when connected to a supply specifically for propeller drives:

  $URM = 1.5\ Up$;

- when connected to a common main supply:

  $URM = 1.8\ Up$;

where *Up* is the peak value of the rated voltage at the input of the semiconductor converter. If the semiconductors are connected in series, the above values may be increased by 10%.

5.3.9.9(e) Watertight enclosures. Convener units having a watertight enclosure are to meet successfully the insulation test specified in chapter 5/3.9.9(e) after being subjected to a stream of water from a nozzle not less than 25 mm (1 in) in diameter under a head of 10.5 m (35 ft), played on the enclosure for at least 15 minutes from a distance of 3 m (10 ft).

5.3.9.9(f) Terminals. The alternating current terminals are to be marked with the letters AC. The direct current terminals are to be marked with a plus (+) on the positive terminal and a minus (-) on the negative terminal.

5.3.9.9(g) Nameplates. Nameplates of corrosion-resistant material are to be provided in an accessible position of the semiconductor converter or its enclosure and are to indicate at least the following information:

manufacturer’s name and serial number

type (silicon, copper oxide, etc.)

rated AC and DC voltages and amperes

number of phases and frequency

ambient temperature range and cooling medium

5.3.9.10 Reactors and Transformers for Semiconductor Converters

5.3.9.10(a) General. Interphase reactors and transformers used with semiconductor converters are to conform with the requirements of chapter 3/4 and the following.

5.3.9.10(b) Voltage regulation. Means to regulate transformer output voltage are to be provided to take care of increase in converter forward resistance and in addition to obtain the necessary performance characteristics of the converter unit in which the transformer is used.

5.3.9.10(c) High temperature alarm. Interphase reactors and transformers used with the semiconductor converters for main and auxiliary, propulsion systems are to be provided with high temperature alarm at the switchboard or the propulsion control station. The setting value of the alarm is to be determined by their specific insulation class and is not to exceed the temperature corresponding to the limit listed in chapter 3/4.2.2.

5.3.9.11 Switches

5.3.9.11(a) General design. All switches are to be arranged for manual operation and so designed that they will not open under ordinary shock or vibration; contactors, however, may be operated pneumatically, by solenoids, or other means in addition to the manual method which is to be provided unless otherwise approved.

5.3.9.11(b) Generator and motor switches. Switches for generators and motors are preferably to be of the air-break type but for alternating-current systems, where they are to be designed to open full-load current at full voltage, oil-break switches using nonflammable liquid may be used if provided with leak-proof, nonspilling tanks.

5.3.9.11(c) Field switches. Where necessary, field switches are to be arranged for discharge resistors unless discharge resistors are permanently connected across the field. For alternating-current systems, means are to be provided for dc-energizing the excitation circuits by the unbalance relay and earth relay.

5.3.9.12 Propulsion Cables

5.3.9.12(a). Conductors. The conductors of cables external to the components of the propulsion plant, other than cables and interconnecting wiring for computers, data loggers or other automation equipment requiring currents of very small value, are to consist of not less than seven strands and have a cross-sectional area of not less than 1.5 mm^2 (2,960 circ. mils).

5.3.9.12(b)Insulation materials. Ethylene-propylene rubber, cross-linked polyethylene, or silicone rubber insulated cables arc to be used for propulsion power cables except that polyvinyl chloride insulated cables may be used where the normal ambient temperature will not exceed 50^0C (122^0F).

5.3.9.12(c) Impervious metallic sheath. Impervious metallic sheaths will be considered but are not to be used with single-conductor alternating-current cables.

5.3.9.12(d) Inner wiring. The insulation of internal wiring in main control gear, including switchboard wiring, shall be of flame-retardant quality.

5.3.9.12(e) Testing. All propulsion cables, other than internal wiring in control gears and switchboards, are to be subjected to dielectric and insulation tests in the presence of the Surveyor.

5.3.10 Trials

Complete tests are to be carried out including duration runs and maneuvering tests which should include a reversal of the vessel from full speed ahead to full speed astern, tests for operation of all protective devices and stability tests for control. All tests necessary to demonstrate that each item of plant and the system as a whole are satisfactory for duty are to be performed. Immediately prior to trials, the insulation resistance is to be measured and recorded.

5.4 Three-wire Dual-voltage DC Systems

5.4.1 Three-wire DC Generators

Separate circuit-breaker poles are to be provided for the positive, negative, neutral and also for the equalizer leads unless protection is provided by the main poles. When equalizer poles art provided for the three-wire generators, the overload trips are to be of the algebraic type. No overload trip is to be provided for the neutral pole, but it is to operate simultaneously with the main poles. A neutral overcurrent relay and alarm system is to be provided and set to function at a current value equal to the neutral rating.

5.4.2 Neutral Earthing

5.4.2.1 Main Switchboard

The neutral of three-wire dual-voltage direct-current systems is to be solidly earthed at the generator switchboard with a zero-center ammeter in the earthing connection. The zero-center ammeter is to have a full-scale reading of 150% of the neutral...current rating of the largest generator and be marked to indicate the polarity of earth. The earth connection is to be made in such a manner that it will not prevent checking the insulation resistance of the generator to earth before the generator is connected to the bus. The neutrals of three-wire DC emergency power systems are to be earthed at all times when they are supplied from the emergency generator or storage battery. The earthed neutral conductor of a three-wire feeder is to be provided with a means for disconnecting and is to be arranged so that the earthed conductor cannot be opened without simultaneously opening the unearthed conductors.

5.4.2.2 Emergency Switchboard

No direct earth connection is to be provided at the emergency switchboard; the neutral bus or buses are to be solidly and permanently connected to the neutral bus of the main switchboard. No interrupting device is to be provided in the neutral conductor of the bus-tie feeder connecting the two switchboards.

5.4.2.3 Size of Neutral Conductor

The capacity of the neutral conductor of a dual-voltage feeder is to be 100% of the capacity of the unearthed conductors.

CHAPTER 6

EXPLAINATION OF EXAMPLE PROJECT

6.1 General

I was mention about rules of ship electric systems in chapter 1, chapter 2, chapter 3, chapter 4, and for special vessels chapter 5. These are theoretical informations, and those datas taking from the most famous company of the world. This is ABS (American Bureau of Shipping), it decide rules about sea suitablelity and safety systems.

6.2 Choosing Suitable Ship

After presenting these informations. I try to find a small ship for understanding ship electric systems more.

In this shipping project which I want to explain, I choose a small ship. Because the bigger and more detailed projects are a little bit difficult to explain, drawings are need to much space, and we haven't got to enough pages for this process.

I was mention that the rules are changing according to ships dimensions and ship type, if how much dimension is ship big, the rules are be coming more complex. It is valid for ship's function too. If ship is been how much danger (fuel oil tankers , chemical tankers, passenger ships and special cargo ships) the rules which it wants by ABS are change and be comes more difficult to construct . If example is necessary, the number of generator is change, fire system is change and sea water resistively level is change etc... I will try to explain more things about fire system in next topics.

6.3 The Ship Specialties

I want to explain a ship which is 25m length and it is not carrying cargo or passenger, it is rescue boat (tug boat) and it is constructed by ocean conditions. This tug boat is constructing in shipyard which is in Turkiye/Istanbul/Tuzla.

6.4 Dimensions

The full dimensions and power of ship is in following.

- Length overall (hull) =25,25m
- Length WL =24,0 m
- Beam (MLD) = 8,6 m
- Depth (MLD) = 4,0 m
- Draft (max) = 3,1 m

- Power = 2*1078 kW

There are three floors, machinery floor, main deck and bridge deck but there is one more floor under the machinery floor and the function of this floor is getting a balance to a ship. They are called balance tanks.

6.5 Information of Engines

If we give a little bit more information. The main engines are Caterpillar and it have two engines, every one is 1078 kW.

The generators are Stanford (74 kVA 112A 3*380 V and 50 Hz) and it have two generators and addition of generators there is a shore connection, which it have all ships. Because ships are not always travel (sailing) some time they are approach the seaports or they can be tug to the docks, at that time the working of generator be comes an expensive.

Up to here we talk about how and where to get energy to the ships. Know we start to talk about how to use this energy.

The one of the speciallity of ship is; they are producing energy for selling, they are producing energy for their needs. How much amount of energy are they need, they produce that much energy. If one generator is not enough to satisfy this power the others are connecting to line parallel.

The addition of diesel oil generator some ships which are going to far distance, they use shaft generator. It is connecting between main engine and propeller, the primary mover is main engine, at that time ship is not spend extra fuel oil.

The ship can have 24 V dc devices, also emergency lighting and fire alarm system use 24V dc. Some devices are feed by generators (by using redresser and rectifier) and some system are feed by accumulator batteries. These batteries can work independently from a general system.

The devices; motors lighting system which we must supply an energy are shown below.

(oily water pump, black water pump, Anchor windlass, compressors, air condition (in the air condition device; compressor cooling water pump, 3 heater and 3 fan motor), diesel oil transfer pump, 2 fans, fresh water hydrafore, capstain windlass and of course main lighting system.)

Air condition device, diesel oil transfer pump and two fans must have emergency stop remote control and they have to stop at the same time and externally .

Some of the electrical circuits are 380 V, some circuits use 220 V, and for this purpose we use transformers.

KW rating of the motors, lighting system and sockets in the ship show below.

- Oily water pump ------------------0,75kW 1,4 A
- Black water pump-----------------0,75kW 1,4 A
- Anchor windlass--------------------7,5kW 14 A
- Compressor 1------------------------2,2kW 4,5A
- Compressor 2------------------------2,2kW 4,5A
- Fire pump----------------------------7,5kW 14 A
- Bilge pump---------------------------7,5kW 14 A
- Air condition-----------totally----14,1kW
- Diesel oil transfer pump-----------1,7kW 3,2A
- Fan 1-------------------------------- 2,2kW 4,2A
- Fan 2---------------------------------2,2kW 4,2A
- Fresh water hydr.-------------------0,75kW 1,4A
- Capstain----------------------------11/15kW 28,5A

For illumination.

- Engine room port illum. 280W
- Engine room starboard illum. 240W
- Steering room and hold illum. 200W
- Accommodation illum. 200W
- Bed overhead lamp 160W
- Wc. illumination 140W
- Corridor illumination 120W
- Cabin sockets 900W
- Kitchen socket 900W
- Engine room socket 1200W
- Oven 3000W

We use second illumination and socket panel for bridge deck.

- Bridge deck illumination 300W
- Main deck illumination 600W
- Aft deck reflectors 1000W

- Frw. Deck reflectors 500W
- Projector 1 2000W
- Projector 2 1000W
- Clear view screen 300W
- Wheel house illumination 350W
- Nav. light reft. Supply 720W
- Window wiper 930W

6.6 Planning of Building

At first ship construction engineer is decide which kinds of equipments will they put in to the ship according to ABS rules (ship type and ship dimension), from this rules they find number of generators, capacity of pump and the other pumps, etc... Some addition can be including, for example air condition.

They send those data to the electric company. At the same time they must send the ships plans to this company. Because they constitute the allocation plan. All the plans must be harmony. For example pipe allocation plan, machinery allocation plan. If they allocate their own equipment at the same place, they can cause some confusion.

When the electric company takes those datas, they can start to process. At first electric plans are drawing, and than the allocation plans are drawing.

6.7 Main Switch Board

6.7.1 Generator Part

We are produce electricity by generators. Generator 1 and generator 2 are same also the circuit connections are exactly same. When we produce electricity we must know the quantity of current, voltage, power, and frequency. We reduce the amount of current when we measure, we use a current transformer for this job. It is 150/5 transformer. Also we must read voltages of each phase , we must put a automatic fuse for protecting a voltmeter selector switch. This device choose phase and they can read only one phase voltage at the same time. KW meter is taking taking voltage and current values and calculating power.

1MCB is the main contactor of generator 1. We can apply electricity to a system when it is on position. 1L1, 1L2 lambs are shows the position of a contactor. These lambs are feed by 220V. It is supply by 1T2 transformer and its ratio is 380/220V.

1BB is a busbar breaker. It is generally close when the circuit or devices damage between 1BB and generator 1 this is opened and devices are repair.

1K1 controls the position of lambs (1L1 and 1L2) and also we see it controls the other parts U main contactor coil.

The second part is the same of the first generator part. The main think of this ships electric system is every supply (Generator 1, Generator 2, and shore connection) worhs alone; it means they can not use parallel connection.

At the end of this drawing we see 4TR transformer and a signal lamb, it show us is there any voltage in busbar or not.

6.7.2 Distribution Part

When we analyze this plan they were use 13 motors, these are oily water pump, black water pump, Anchor windlass, compressor 1 and compressor 2,fire pump, bilge pump, air condition, diesel oil transfer pump,fan1,fan 2, fresh water hydrafore, capstain windlass. Each one of them is control by 2 contacts, one of them is in the main switch board and the other is near the device, the first one is using as afuse the second one is using as on/off shalter.(The second switches are showing as **S** in the box.)

6.7.3 Emergency Stop Remote Control

According to the ABS rules, some devices must be emergency stop externally. These are air conditions, fans and diesel oil transfer pump. For example if there is a fire in a room and air condition or fans flows air in a room and fire is grown. Same think is valid for diesel oil transfer pump. Emergency stop button must be a different place from the devices. Because fire may be near to these devices.

6.7.4 Illumination

6.7.4.1 Transformer

There is one more connection for illumination. We use a transformer for drop to voltage ratio 380/220 V and its connection style delta-delta (Δ-Δ). The advantage of this connection is no phase shift associated with it and no problems with unbalanced load harmonics.

6.7.4.2 Lighting Panel

There are 2 lighting panels. (L1, L2)

L1 panel is control engine port illumination, engine room starboard illumination, steering room and hold illumination, accommodation illumination, bed overhead lamb, Wc. illumination, corridor illumination, cabins sockets, kitchen sockets, engine room sockets, oven and one more for spare.

L2 panel is control bridge deck illumination, main deck illumination, aft deck reflectors, Frw. Deck reflector, projector 1, projector 2, clear view screen, wheel house illumination, nav. light reflector, window viper and one more spare.

For carrying cable one place to another place we use cable trays it is connecting sealing or walls. While we spread cable on the trays we must agree with the rules. The rules say that if a one tray has 10 cables, we can not put any more on it. We must spread a new tray behind first one and it must have a 10 cm distance between two trays for air circulation. Because cables can get warm when it is using.

When cables pass the steel wall if it is in below deck it must be water resistive. We can get this condition with special equipment which is shown in figure 2.

6.8 Cost Analysis

At the end of the project I'm research the prize of the equipment which we are using in the main switchboard end the other panels. They are only equipment prizes. All cost of constructing this panels including worker's pay is nearly 25,000$. This prize levels are taken from the GESAN Electric Company. They can not send us cable information, only they can say that we are using MGG type of cable inside the panels, and MCGC type of cable for lighting.

The equipment's prizes are shown in table 26, table 27, table 28, table 29 and table 30.

6.9 Calculations of Accumulator Batteries

All ships must use batteries for emergency conditions, while we are calculating the magnitude of batteries; we have to know all emergency equipment's powers. We are multiply by this value with quantity and we find total power. With using P=V*I we find can find all equipment's current's. We are multiplying this value with working time and demand factor we get the required A/h value. We are assuming the battery power factor % 55.These calculations are shown in table 31.

CONCLUSION

One of the most important problem of the ship owner's is electrical problems, when their ships are at the sailing. For decreasing those problems, the authorities have been making investigations for long years. These investigations was occurred some rules and all the ship electric firms have to attend them. These rules were improved for sailing fewer problems and the most important thing for human safety. At nowadays which the technology is improved so quickly, and the rules became more secure and more comfortable.

Certainly one of the important reason is costs. If the number of the crews becomes less, this is more economic for ship owners. Futures technology will give permeation to create ships with minimum human been or without any human been.

This project was mentioned how to follow ship's electrical system from top to end, the rules which must be attend and the necessary tests for equipment.

The sample ship's electrical system is AC, also for emergency conditions there is a 24V DC circuit. At this ship there are two caterpillar generators. Each generator is 74 KVA and 3-phase 380V. These are connected to busbar after measuring their voltage, current, frequency, and kilowatt ratings. From the busbar, it is distributed to the necessary equipments like; pumps, fans, air condition and lighting circuits.

The important thing which always have to be remembered, the cables is become hot when the current flows inside from it. For this purpose all the cables could not spread at the same point, there must be a space between them for feeder cables, but not for lighting circuit, because lighting circuits needs fewer power.

Ship electric technology is very convenient to improve. The contactors can be easily control by PLC. Of course the inputs and the outputs must be modificated for large current. Later the navigation systems can be adapted to the PLC and ships will control without human. But totally humanless ships are only dream, because when the system is failure some ones must be repair them.

REFERENCES

[1] ABS booklet for Electrical Engineers
(Rules for building and classing (STEEL VESSELS 2001))

[2] ABS home page http://www.eagle.org

[3] For electrical equipments http://www.schneider-electric.com.tr

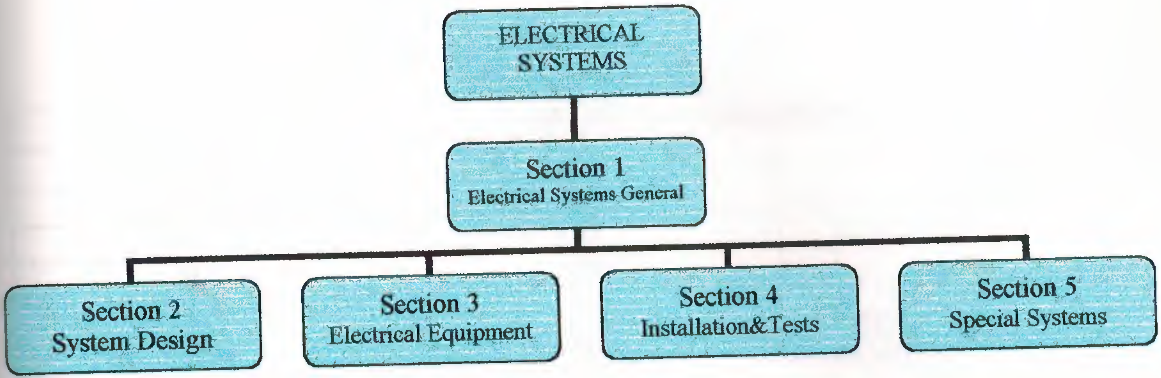

Figure -1-

Table-1-
(Minimum conductor sizes)

Size, mm²	*Application*
1.0	Power, lighting and control cables
1.5	Motor feeder cables
0.5	Signaling and communication cables for essential services, except those assembled by the equipment manufacturer
0.375	Communication cables for non-essential services, except those assembled by the equipment manufacturer

Table-2-
(Motor full-load currents)

Type of motor	*Rating or setting, % motor full-load current*
Squirrel-cage and synchronous Full-voltage, reactor- or resistor-starting	250
Autotransformer starting	200
Wound rotor	150

Table-3-
(Voltage-Frequency characteristics of main and emergency systems)

	Permanent	*Transient*
Frequency	±5%	±10%(5s)
Voltage	±6%,-10%	±20% (1.5s)

Table-4-
(Insulation Material)

Class	***Maximum continuous temperature***	
	°C	**°F**
A	105	221
E	120	248
B	130	266
F	155	311
H	180	356

Table-5-
(Minimum values of the test voltage and insulation resistance)

Rated voltage U_n (V)	***Minimum test voltage (V)***	***Minimum insulation resistance (MΩ)***
$U_n \leq 250$	$2U_n$	1
$250 < U_n \leq 1000$	500	1
$1000 < U_n \leq 7200$	1000	$U_n/1000+1$
$7200 < U_n \leq 15000$	5000	$U_n/1000+1$

Table-6-
(DC machines are to withstand without damage for these overspeed for 2 minute)

DC machine type	***Overspeed requirements***
Generators	1.2 times the rated speed
Shunt-wound and Separately excited motors	1.2 times the highest rated speed, or 1.15 times the corresponding no-load speed whichever is the greater
Compound-wounded motors having speed regulation of 35%or less	1.2 times the higher rated speed, or 1.15 times the corresponding no-load speed, whichever is the greater but not exceeding 1.5 times the highest rated speed
Compound-wound motor having speed regulation greater than 35% or and series-wounded motors	The manufacturer is to assign a maximum safe operating speed which is to be marked on the rating plate. The overspeed for these motor is to be 1.1 times the maximum safe operating speed.

Table-7-

(Machines which is not applying standard test voltages)

Machine part	***Test voltage (rms)***
Field windings of synchronous generators, synchronous motors and synchronous condensers: a) For all machines except that is b) b) For motor starter connected with field winding across resistance of more than ten times of the field winding resistance	a) Ten times the rated field voltage with a minimum of 1500 V and a maximum of 3500V b) 1000V + twice the maximum value of the voltage with a minimum of 1500V
Phase-wound rotor of induction motors: a) for non-reversing motors or motors reversible from standstill only b) For motors reversible by reversing the primary supply while running	a) 1000V + twice the open- circuit standstill secondary voltage b) 1000V+ four times the open- circuit standstill secondary voltage

Table-8-

(Minimum clearance and creepage distance)

Rated insulation voltage U_n (V)	***Minimum clearance (mm)***	***Minimum creepage distance (mm)***
$U_n \leq 2500$	15	20
$251 < U_n \leq 660$	20	30
$660 < U_n \leq 1000$	25	35

Table-9-

(Voltage Values for Dielectric Strength Test)

Rated voltage U_n (V)	***AC test voltage rms (V)***
$U_n \leq 12$	250
$15 < U_n \leq 60$	500
$60 < U_n \leq 300$	2000
$300 < U_n \leq 690$	2500
$690 < U_n \leq 800$	3000
$800 < U_n \leq 1000$	3500
$1000 < U_n \leq 1500$ (DC only)	3500

Table-10-
(Temperature Rise)

Insulation Class	***Copper temperature rise by resistance, °C (°F)***	***Hottest spot temperature rise, °C (°F)***
A	55(99)	65(117)
B	80(144)	110(198)
F	115(207)	145(261)
H	150(270)	180(324)
Note: Metallic parts in contact with or adjacent to insulation are not to attain a temperature in excess of the hottest spot temperature rise.		

Table-11-
(Typical flammable gas groups and temperature classes)

Gas group	***Representative gas***	***Temperature Class***	***Maximum surface temperature, °C***
I	Methane	T1	≤450
IIA	Propane	T2	≤300
IIB	Ethylene	T3	≤200
IIC	Hydrogen	T4	≤135
		T5	≤100
		T6	≤85

Table-12-
(Degree of Protection of Electrical Equipment (First IP Numeral))

First IP numeral	***Short description***	***Definition***
0	Non-protected	No special protection
1	Protected against solid objects greater than 50mm(2in.)	A large surface of the body, such as a hand (but no protection against deliberate access). Solid object exceeding 50nm (2 in.) in diameter.
2	Protected against solid objects greater than 50mm(2in.)	Fingers or similar objects not exceeding 80nm (3,15in.) in length. Solid objects exceeding 12mm (0,5 in.) in diameter.
3	Protected against solid objects greater than 2,5 mm (0,1 in.)	Tools, wires, etc. of diameter or thickness greater than 2,5 mm (0,1 in.). Solid objects exceeding 2,5mm (0,1 in.) in diameter.
4	Protected against solid objects greater than 1 mm (0,04 in.)	Wires or strips of thickness greater than 1 mm (0,04in.). Solid objects exceeding 1mm (0,04 in.) in diameter.
5	Dust protected	Ingress of dust is not totally prevented, but dust does not enter in sufficient quantity to interfere with satisfactory operation of the equipment.
6	Dust-tight	NO ingress of dust.

Table-13-
(Degree of Protection of Electrical Equipment (Second IP Numeral))

Second IP numeral	***Short description***	***Definition***
0	Non-protected	No special protection
1	Protected against dripping water	Dripping water (vertically falling drops) is to have no harmful effect.
2	Protected against dripping water tilted up to 15°.	Vertically dripping water is to have no harmful effect when the enclosure is tilted at any angle up to 15° . from its normal position.
3	Protected against spraying water	Water falling as spray at an angle up to 60°. from the vertical is to have no harmful effect.
4	Protected against splashing water	Water splashed against the enclosure from any direction is to have no harmful effect.
5	Protected against water jets	Water protected by a nozzle against the enclosure from any direction is to have no harmful effect.
6	Protected against heavy seas	Water from heavy seas or water protected in powerful jets is not to enter the enclosure in harmful quantities.
7	Protected against the effects of immersion	Ingress of water in a harmful quantity is not to be possible when the enclosure is immersed in water under defined conditions of pressure and time.
8	Protected against submersion	The equipment is suitable for continuous submersion in water under conditions which are to be specified by the manufacturer. ***Note*:** Normally this will mean that the equipment is hermetically sealed. However, with certain types of equipment, it can mean that water can enter but only in such a manner that it produces no harmful effects.

Table-14-
(Minimum Degree of Protection)

Example Of Location	Condition of Location	Switchboards, distribution boards, motor control center & controllers	Generators	Motors	Transformers, Converters	Lighting fixtures	Heating appliances	Accessories(2)
Dry accommodation space	Danger of touching live Parts only	IP20	-	IP20	IP20	IP20	IP20	IP20
Dry control rooms(4)		IP20	-	IP20	IP20	IP20	IP20	IP20
Control rooms	Danger of dripping liquid and/or moderate Mechanical damage	IP22	-	IP22	IP22	IP22	IP22	IP22
Machinery space above floor plates		IP22	IP22	IP22	IP22	IP22	IP22	IP44
Steering gear rooms		IP22	IP22	IP22	IP22	IP22	IP22	IP44
Retriggering machinery room		IP22	-	IP22	IP22	IP22	IP22	IP44
Emergency machinery rooms		IP22	IP22	IP22	IP22	IP22	IP22	IP44
General store rooms		IP22	-	IP22	IP22	IP22	IP22	IP22
Pantries		IP22	-	IP22	IP22	IP22	IP22	IP44
Provision rooms		IP22	-	IP22	IP22	IP22	IP22	IP22
Bathrooms &Showers	Increased danger of Liquid and/or mechanical Damage	-	-	-	-	IP34	IP44	IP55
Machinery spaces below floor plates		-	-	IP44	-	IP34	IP44	IP55 (3)
Closed fuel or lubricating oil separator rooms		IP44	-	IP44	-	IP34	IP44	IP55 (3)
Ballast pump rooms	Increased danger of Liquid and mechanical damage	IP44	-	IP44	IP44	IP34	IP44	IP55
Refrigerated rooms		-	-	IP44	-	IP34	IP44	IP55
Galleys and Laundries		IP44	-	IP44	IP44	IP34	IP44	IP44
Shaft or pipe tunnels in double bottom	Danger of liquid spray presence of cargo dust, Serious mechanical damage and/or aggressive fumes	IP55	-	IP55	IP55	IP55	IP55	IP56
Hold for general cargo		-	-	-	-	IP55	-	IP55
Open decks	Exposure to heavy seas	IP56	-	IP56	-	IP55	IP56	IP56
Bilge wells	Exposure to submersion	-	-	-	-	IPX8	-	IPX8

Notes : 1 Empty spaces shown with "-" indicate installation of electrical equipment is not recommended.
2 "Accessories" include switches, detector, junction box, etc.
3 Socket outlets are not to be installed in machinery spaces below the floor plate ,enclosed fuel and lubricating oil separator rooms or spaces requiring certified safe equipment.
4 For the purpose of this Table, the wheelhouse may be categorized as a "dry control room" and consequently , the installation of IP20 equipment would suffice therein provided that (a) the equipment is located as to preclude being exposed to steam, or dripping/spraying liquids from pipe flanges, valves, ventilation ducts and outlets, etc., installed in its vicinity, and (b) the equipment is placed to preclude the possibility of being exposed to sea or rain.

Table-15-

(Factory Test Schedule for Rotating Machines of 100kW (135hp) and Over)

Test (see chap. 3/ 2.8)	AC generators		AC motors		DC machines	
	Type test (1)	Routine test (2)	Type test (1)	Routine test (2)	Type test (1)	Routine test (2)
1 Visual inspection.	X	X	X	X	X	X
2 Insulation resistance measurement, see chap. 3/2.8.2	X	X	X	X	X	X
3 Windings resistance measurement, see chap. 3/2.8.3	X	X	X	X	X	X
4 Verification of voltage regulation system, see chap. 3/2.8.4	X	X				
5 Rated load test and temperature rise measurement, see chap. 3/2.8.5	X		X		X	
6 Overload/over-current test, see chap. 3/2.8.6	X		X		X	X
7 Verification of steady short circuit condition, see chap. 3/2.8.7 (3)	X					
8 Over-speed test, see chap. 3/2.8.8	X	X	X(4)	X(4)	X(4)	X(4)
9 Dielectric strength test, see chap. 3/2.8.9	X	X	X	X	X	X
10 Running balance test, see chap. 3/2.8.10 (5)	X	X	X	X	X	X
11 Verification of degree of protection.	X		X		X	
12 Bearing check after test.	X	X	X	X	X	X
13 Air gap measurement.	X	X			X	X
14 Commutation check.					X	

Notes:
1. Type tests applies to prototype machines or to at least the first of a batch of machines.
2. Machines to be routine tested are to have reference to the machine of the same type that has passed a type test.
3. Verification at steady short circuit condition applies to synchronous machines only.
4. Where so specified and agreed upon between purchaser and manufacturer.
5. Static balance (machine rated 500 rpm or less) or dynamic balance (over 500 rpm) will be accepted in lieu of the specified test on machines to be close-coupled to engines and supplied without shaft and/or bearing, or with incomplete set of bearings.

Table-16-
(Limit of Temperature Rise for Air Cooled Rotating Machines)

Ambient temperature = 50°C (1)

Item No.		Part of machine	Temperature measuring method	Limit of temperature fuse, °C For class of insulation				
				A	E	B	F	H
1	a)	A.C windings of machines having rated output of 5,000 kW (or kVA) or more	Resistance	50	-	70	90	115
			Embedded temp. detector	55	-	75	95	120
	b)	A.C windings of machines having rated output above 200 kW (or kVA) but less than 5,000 kW (or kVA)	Resistance	50	65	70	95	115
			Embedded temp. detector	55	-	80	100	120
	c)	A.C windings of machines having rated outputs of 200 kW (or kVA) or less (2)	Resistance	50	65	70	95	115
2		Windings of armatures having commutators	Thermometer	40	55	60	75	95
			Resistance	50	65	70	95	115
3		Field windings of A.C and D.C machines having D.C excitation, other than those in item4	Thermometer	40	55	60	75	95
			Resistance	50	65	70	95	115
4	a)	Field winding of synchronous machines with cylindrical rotor having D.C excitation winding embedded in slots, except synchronous induction motors	Resistance	-	-	80	100	125
	b)	Stationary field windings of A.C machines having more than one layer	Thermometer	40	55	60	75	95
			Resistance	50	65	70	95	115
			Embedded temp. detector	-	-	80	100	125
	c)	Low resistance field winding of A.C and D.C machines and compensating windings of D.C machines having more than one layer	Thermometer	50	65	70	90	115
			Resistance	50	65	70	90	115
	d)	Single-layer windings of A.C and D.C machines with exposed bare or varnished metal surfaces and single layer compensating windings of D.C machines(7)	Thermometer	50	70	80	100	125
			Resistance	50	70	80	100	125
5		Permanently short-circuited windings	The temperature rise of any parts is not to be detrimental to the insulating of that part or to any other part adjacent to it.					
6		Magnetic cores and all structural components, whether or not in direct contact with insulation (excluding bearings)						
7		Commutators, slip-rings and their brushes and brushing	The temperature rise of any parts is not to be detrimental to the insulating of that part or to any other part or to any other part adjacent to it. Additionally, the temperature is not to exceed that at which the combination of brush grade and commutators/slip-ring materials can handle over the entire operating range.					

Notes:

1. The limit of temperature rise in the above Table is based on an ambient temperature of 50°C in accordance with IEC Publication 60092-101. For 40°C ambient, the temperature rises may be increased by 10°C.
2. With application of the superposition test method to windings of machines rated 200 kW (or kVA) or less with insulation classes A,E,B or F, the limits of temperature rise given for the resistance method may be increased by 5°C.
3. Also includes multiple layer windings provided that the under layers are each in contact with the circulating coolant.

Table-17-

(Equipment and Instrumentation for Switchboards)

Instrumentation and Equipment	*Alternating-current (AC) Switchboard*	*Direct-current (DC) Switchboard*
1. Indicator light	An indicator light for each generator connected between generator and circuit breaker. (3)	An indicator light for each generator connected between generator and circuit breaker.
2. Generator Disconnect	A generator switch or disconnecting links in series with the generator circuit breaker which is to disconnect completely all leads of the generator and the circuit breaker from the buses except the earth lead. (1)	A generator switch, or disconnecting links, in series with the circuit breaker which will open positive, negative, neutral and equalizer leads, except that for 3-wire generators equalizer poles may be provided on the circuit breaker. For 3-wire generators the circuit breakers are to protect against a short circuit on the equalizer buses. (1)
3. Insulation Monitor and Alarm	A means for continuously monitoring the electrical insulation level t earth, and an audible or visual alarm for abnormally low insulation. (3)	A means for continuously monitor-ring the electrical insulation level to earth, and an audible or visual alarm for abnormally low insulation values. (3)
4. Ammeter	An ammeter for each generator, with a selector switches to read the current of each phase. (3)	An ammeter for each 2-wire generator. For each 3-wire generator an ammeter for each positive and negative lead and a center-zero ammeter in the earth connection at the generator switchboard. Ammeters are to be so located in the circuit as to indicate total generator current.
5. Voltmeter	A voltmeter for each generator, with a selector switch to each phase of the generator and to one phase of the bus. (3)	A voltmeter for each generator with voltmeter switch for connecting the voltmeter to indicate generator voltage and bus voltage. For each 3-wire generator , a voltmeter with voltmeter switch for connecting the voltmeter to indicate generator voltage , positive to negative, and bus voltage positive to negative, positive to neutral and neutral to negative. Where permanent provisions for shore connection are fitted, one voltmeter switch to provide also for reading shore- connection voltage, positive to negative
6. Space heater indicator light	Where electric heaters are provided for generator, a heater indicator light is to be fitted for each generator.	Where electric heater is provided for generators, a heater indicator light is to be fitted for each generator.
7. Synchroscope or Lamps	A Synchroscope or synchronizing lamps with selector switch for paralleling in any combination. (3)	Not applicable
8. Prime mover Speed Control	Control for prime mover speed for paralleling (3)	Not applicable
9. Wattmeter	Where generators are arranged for parallel operation, an indicating wattmeter is to be fitted for each generator. (3)	Not applicable
10. Frequency meter	A frequency meter with selector switch to connect to any generator. (3)	Not applicable
11. Field switch	A double-pole field switch with discharge clips and resistor for each generator. (2)	Not applicable
12. Voltage Regulator	A voltage regulator. (3)	Not applicable

continued…

Table-17(continued)-
(Equipment and Instrumentation for switchboards)

Instrumentation and Equipment	Alternating-current (AC) Switchboard	Direct-current (DC) Switchboard
13. Stator Winding Temperature Indicator	For alternating propulsion generator above 500kW, a stator winding temperature indicator is to be fitted for each generator control panel.(3)(4)	For direct current propulsion generator above 500kW and interpole winding temperature indicator is to be fitted for each generator control panel. (3)(4)

Notes:

1 The switch or links may be omitted when draw-out or plug-in mounted generator breakers are furnished.

2 for generators with variable voltage exciter or rotary rectifier exciter, each controlled by voltage-regulator unit acting on the exciter field switch and the discharge resistor and may be omitted.

3 Where vessels have centralized control systems in accordance with Part 4 Chapter 9 in ABS booklet and the generators can be paralleled from the main control station, this equipment may be mounted on the control console.

4 For high voltage systems , see also chapter 5/2.4.3.(c)

Table-18-
(Maximum Current Carrying Capacity for Cables)

Conductor Size mm²	Conductor Size 10³ circ mils	1-core V60 PVC/A	1-core V75	1-core R85 XLPE E85 EPR	1-core M95 S95	2-core V60 PVC/A	2-core V75	2-core R85 XLPE E85 EPR	2-core M95 S95	3-or 4-core V60 PVC/A	3-or 4-core V75	3-or 4-core R85 XLPE E85 EPR	3-or 4-core M95 S95
		Maximum current in amperes (see chapter 3/5.2) 45°C ambient; 750V and less, AC or DC ; see Notes											
625			755	894	1006		642	760	855		529	626	704
600			736	872	981		626	741	834		515	610	687
	1000		662	784	882		563	666	750		463	549	617
500			656	778	875		558	661	744		459	545	613
	950		641	760	854		545	646	726		449	532	598
	900		620	734	826		527	624	702		434	514	578
	850		598	709	797		508	603	677		419	496	558
	800		576	682	767		490	580	652		403	477	540
400			571	677	761		485	575	647		400	474	533
	750		553	655	737		470	557	626		387	459	516
	700		529	628	706		450	534	600		370	440	494
	650		506	599	674		430	509	573		354	419	472
	600		481	570	641		409	485	545		337	399	449
300		335	477	565	636	285	405	480	541	235	334	396	445
	550		455	540	607		387	459	516		319	378	425
	500		429	509	572		365	433	486		300	356	400
240		290	415	492	553	247	353	418	470	203	291	344	387
	450		402	476	536		342	405	456		281	333	375
	400		373	442	498		317	376	423		261	309	349
185		250	353	418	470	213	300	355	400	175	247	293	329
	350		343	407	458		292	346	389		240	285	321
	300		312	370	416		265	315	354		218	259	291
150		220	309	367	412	187	263	312	350	154	216	257	288
	250		278	330	371		236	281	315		195	231	260
120		190	269	319	359	162	229	271	305	133	188	223	251
	212		251	297	335		213	252	285		176	208	235
95		165	232	276	310	140	197	235	264	116	162	193	217
	168		217	257	289		184	218	246		152	180	202
70		135	192	228	256	115	163	194	218	95	134	160	179

continued...

Table-18(continued)-
(Maximum Current Carrying Capacity for Cables)

Conductor Size		***Maximum current in amperes (see chapter 3/5.2)*** *45°C ambient; 750V and less, AC or DC ; see Notes*											
		1-core				*2-core*				*3-or 4-core*			
mm^2	*10^3 circ mils*	*V60 PVC/A*	*V75*	*R85 XLPE E85 EPR*	*M95 S95*	*V60 PVC/A*	*V75*	*R85 XLPE E85 EPR*	*M95 S95*	*V60 PVC/A*	*V75*	*R85 XLPE E85 EPR*	*M95 S95*
	133		188	222	250		160	189	213		132	155	175
	106		163	193	217		139	164	184		114	135	152
50		105	156	184	208	89	133	156	177	74	109	129	146
	83,7		140	166	187		119	141	159		98	116	131
35		87	125	148	166	74	106	126	141	61	88	104	116
	66,4		121	144	162		103	122	138		85	101	113
	52,6		105	124	140		89	105	119		74	87	98
25		71	101	120	135	60	86	102	115	50	71	84	95
	41,7		91	108	121		77	92	103		64	76	85
	33,1		79	93	105		67	79	89		55	65	74
16		54	76	91	102	46	65	77	87	38	53	64	71
	26,3		68	81	91		58	69	77		48	57	64
	20,8		59	70	78		50	60	66		41	49	55
10		40	57	67	76	34	48	57	65	28	40	47	53
	16,5		51	60	68		43	51	58		36	42	48
6		29	41	49	55	25	35	42	47	20	29	34	39
	10,4		38	45	51		32	38	43		27	32	36
4		22	32	38	43	19	27	32	37	15	11	27	30
	6,53		28	34	38		24	29	32		20	24	27
2,5		17	24	28	32	14	20	24	27	12	17	20	22
	4,11		21	25	32		18	21	27		15	18	22
1,5		12	17	21	26	10	14	18	22	8	12	15	18
1,25			15	18	23		13	15	20		11	13	16
1,0		8	13	16	20	7	11	14	17	6	9	11	14

Notes to Table 18

(1) The nomenclature of cable insulation types used in chapter 3/ Table 18 is as follows:

Table -18(a)-

Insulation type designation		***Insulation material***	***Maximum conductor Temperature, °C***
IEC 60092-353	IEC 60092-3		
PVC/A	V60	Polyvinyl chloride-general purpose	60
-	V75	Polyvinyl chloride-heat resisting	75
XLPE	R85	Cross-linked polyethylene	85
EPR	E85	Ethylene propylene rubber	85
-	M95	Mineral (MI)	95
S95	S95	Silicone rubber	95

(2) The maximum current values given in Table 18 have been derived from IEC Publication 60092-353 and are based on ambient temperature of 45°C and on the assumption that when a group of four cables bunched together and laid in free air the conductors will attain and operate continuously at a temperature equal to the maximum rated temperature of the insulation.

(3) The maximum current values given in table 18 (and those derived there from) may be used, without correction factors, for cables installed double-banked in cable conduits or cable pipes, expect as noted in note(4).

(4) Where more than six cables expected to be operated simultaneously are laid together in a bunch in such a way that there is an absence of free air circulation around them, a correction factor of 0,85 is to be applied to the values gives in Table 18. Special consideration is necessary if the number of cables installed in this manner exceeds twelve.

(5) The maximum current values given in table 18 are applicable to both armored and unarmored cables.

(6) If ambient temperature differs from 45°C, the maximum current values in table 18 are to be multiplied by the following factors.

Table-18(b)-

Maximum conductor temperature	***Ambient correction factor***					
	40°C	***50°C***	***55°C***	***60°C***	***65°C***	***70°C***
60°C	1,15	0,82	--	--	--	--
75°C	1,08	0,91	0,82	0,71	0,58	---
80°C	1,07	0,93	0,85	0,76	0,65	0,53
85°C	1,06	0,94	0,87	0,79	0,71	0,61
95°C	1,05	0,95	0,89	0,84	0,77	0,71

(7) Where the number of conductor s in a cable exceeds 4, the maximum current value is to be corrected by factors as indicated in the following table.

Table-18(c)-

No. of Conductors	*Correction factor for 3-or 4-core values in Tbale18*
5-6	0,8
7-24	0,7
25-42	0,6
≥43	0,5

(8) When a mineral-insulated cable is installed in such a location that its copper sheath is liable to be touched when in service, the current rating is to be multiplied by the correction factor 0,80 in order that the sheath temperature does not exceed 70°C.

(9) Cables being accepted based on approved alternate standard may have current carrying capacity of that standard provided the cables are in full compliance with that standard.

Table-19-
(Cable Bending Radii)

Cable construction		Over all diameter, D	Minimum internal bending radius
Insulation	***Outer covering***		
Thermoplastic or thermosetting with conductor	Unarmored or unbraided	D≤ 25 mm (1 in.)	4 D
		D>25 mm	6 D
	Metal braid screened or armored	Any	6 D
	Metal wire or metal-tape armored or metal-sheathed	Any	6 D
	Composite polyester/metal laminate tape screened units or collective tape screening	Any	8 D
Thermoplastic or thermosetting with shaped copper conductor	Any	Any	8 D
Mineral	Hard metal-sheathed	Any	6 D

Table-20-
(Size of Earthing Conductors (Equipment and System Earthing))

Type of earthing connection		*Cross-sectional area, A, of associated current carrying conductor*	*Minimum cross-sectional area of copper earthing connection*
Earth-continuity conductor In flexible cable or flexible cord	A1	A ≤16 mm²	A
	A2	16mm² <A≤32mm²	16mm²
	A3	A >32 mm²	A/2
Earth- continuity conductor incorporated in fixed cable	For cables having an insulation earth-continuity conductor		
	B1a	A≤1.5mm²	1.5mm²
	B1b	1.5mm² <A≤16mm²	A
	B1c	16mm² <A ≤32mm²	16mm²
	B1d	A >32mm²	A/2
	For cables with earth wire in direct contact with the lead sheath		
	B2a	A≤2.5 mm²	1 mm²
	B2b	2.5mm² ≤2.5mm²	1.5 mm²
Separate fixed earthing conductor	C1a	A≤2.5mm²	Stranded earthing connection: 1.5mm² for A≤1.5mm² A for A>1.5 mm²
	C1b		Unstranded earthing connection: 2.5 mm²
	C2	2.5mm²<A≤8mm²	4mm²
	C3	8mm²<A≤120 mm²	A/2
	C4	A>120 mm²	70mm², see Note(1)
Note (1) For earthed distribution systems, the size of earthing conductor need not exceed A/2.			

Table-21-
(Insulation Resistance Measurements)

Load (A)	*Insulation Resistance (MΩ)*
≤5	2
≤10	1
≤25	0,4
≤50	0,25
≤100	0,10
≤200	0,05
>200	0,025

Table-22-
(Air Clearance and Creepage Distance)

Nominal Voltage kV	*Minimum air Clearance mm(in.)*
1-1.1	25(1.0)
3-3.3	55(2.2)
6-6.6	90(3.6)
10-11	120(4.8)

Table-23-
(Switchgear Test Voltages)

Nominal voltage (phase to phase) kV	*Test voltage kV*
1.0-3.6	10
3.6-7.2	20
7.2-11	28

Table-24-
(Certification Details-Electrical and Control Equipment)

Electrical and control Equipment(1)	Individual unit certification (2)	Type Approval Program (3)					
		Product design assessment			Quality assurance assessment		
		(a) Design review	(b) Type exam	(b) Type test	(a) Quality Std.	(b) Quality Plan	(d) Mfr.'s Documt.
1. Generator and motors for essential services ≥100kW	d,s,t	x	x	x	x	x	o
2. Generator and motors for essential services <100kW	g	x	o	x	o	o	x
3. Propulsion generators and motors	d,m,s,t	x	x	x	x	x	o
4. Switchboards (propulsion, main and emergency) (4)	d,s	-	-	-	x	x	o
5. Motor controllers for essential services ≥100kW	d,s	x	x	-	o	o	x
6. Motor control centers for essential services ≥100kW	d,s	x	x	-	o	o	x
7. Battery charging and discharging boards for emergency and transitional source of power	d,s	x	x	-	o	x	x
8. Power transformer and converters	g	o	x	x	o	o	x
9. Cables	d-1,t	x	x	x	o	x	x
10. Propulsion cables	d-1,s,t	x	x	x	x	x	o
11. Circuit breakers & fuses	g,t	-	x	x	o	o	x
12. Certified safe equipment	t	-	x	x	o	o	x
13. Governors	t	-	x	x	o	o	x
14. Control, monitoring and safety system devices, including computers, programmable logic controllers, etc., for **ACC** and **ACCU** notation	t	-	x	x	o	x	x

Notes:

1. For full certification details, see Chapter 3 and chapter 5 for electrical equipment.
2. Nations used in this column are:
   - d- Design review by ABS.
   - d-1 review by ABS.
   - m- Material tests to be witnessed by Surveyor.
   - s- Survey at the plant of manufacture including witnessing acceptance tests of production unit.
   - t- Type test, conducted on a sample or a prototype is required.
   - g- Certification by ABS not required; acceptance is based on manufacturer's guarantee.
3. For description of type Approval Program, Type Approval Program may be applied as alternative to certification of individual units. Notations used in this column are:
   - x- indicates the particular element of the program is applicable.
   - o- indicates the particular element of the program is not optional.
   - "-" indicates the particular element of the program is not applicable.
4. This equipment is generally made to custom design; but manufacturing facilities may be quality assurance approved.

Table -25-
(Design Angles of Inclination)

	Angle of inclination, degree (1)			
	Athwartship		Fore-and-aft	
Installation, components	Static	Dynamic	Static	Dynamic
Propulsion and auxiliary machinery	15	22,5	5	7,5
Safety equipment				
Emergency power installation (3)	22,5	22,5	10	10
Emergency fire pumps and their drives	22,5	22,5	10	10
Switchgear				
Electrical and electronic appliances and control systems	22,5 (2)	22,5 (2)	10	10

Notes:

1. Athwartship and fore-and-aft inclinations occur simultaneously.
2. Up to an angle of inclination of 45 degrees, switches and controls are to remain in their last set position.
3. In vessel designed for carriage of liquefied gases and of chemicals, the emergency power installation is to remain operable with the vessel flooded to its permissible athwartship inclination up to a maximum of 30 degrees.

Figure-2-
(Water Resistivity System)

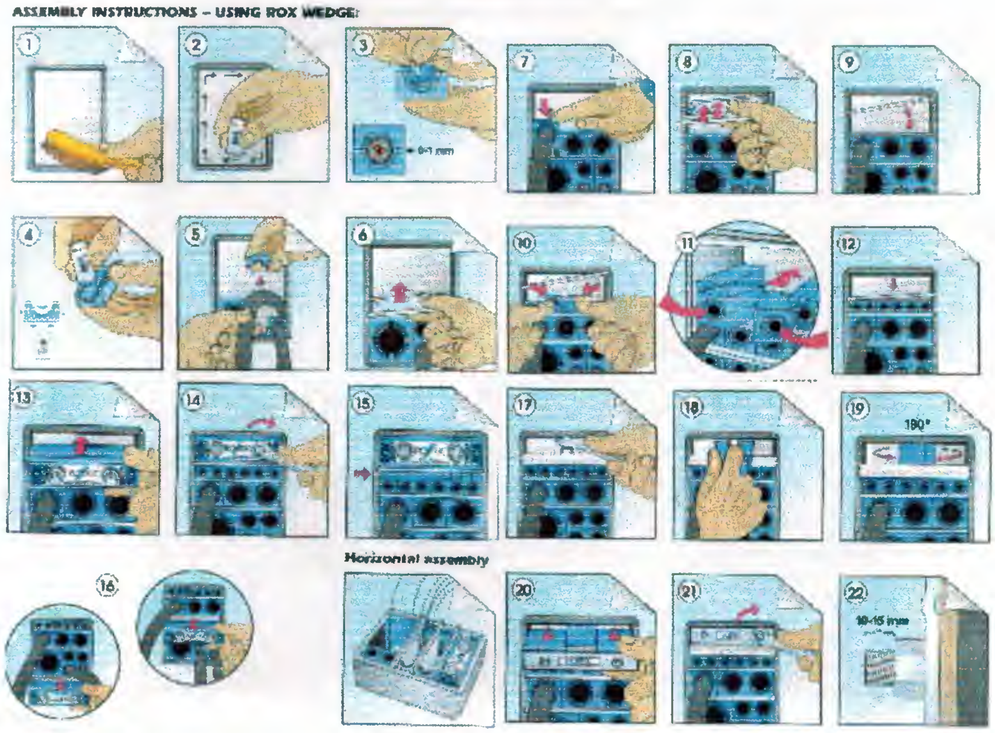

Figure-3-
(Main Switchboard Front view)

Figure-4-
(Main Switchboard Front view 2)

Figure-5-
(Main Switchboard Back View)

Figure-6-
(Cable Trayers)

Cost Analysis
Table-26-
(Main Switchboard Generator Part)

Name into the Plan	Name of equipment	Code	Single Prize *1000TL	# of equipment	Total Prize *1000TL
1BB-2BB	Bus bur breaker	IN 160T-160A	201,100	2	402200
3BB	Bus bur breaker	IN 125T-125A	143,800	1	143,800
1MCB-2MCB	Main Circuit breaker	NS 160H TM 125D 3P 100-125A 70KA	602,500	2	1,205,000
3MCB	Main Circuit breaker	NS 100H TM 80D 3P 64-80A 70KA	602,500	1	602,00
1K1-2K1-3K1	Contactors	CA2-DN22+LA1-DN22	36,500	3	109,500
1L1~3L2	Pilot Lamb	220V 2W	2,800	8	16,800
1F6~3F5	Automatic fuse	NC32N C2A	45,700	10	457,000
1TR-2TR-3TR	Transformer	380/220V 5VA	11,000	3	33,000
1F1~3F3	Automatic fuse	NC 32N C6N	37,960	6	227,760
1KW-2KW	KW meter	96*96 3*380V Hz 150/5	262,700	2	525,400
1A1~2A3	Amp. meter	96*96 150/5	24,000	6	144,000
1Hz~2Hz	Frequency meter	96*96 47-53 Hz 380V	43,300	2	86,600
1CT1~2CT3	Current Transformer	150/5 5VA	15,300	6	91,800
2VS-1VS-3VS	Voltmeter switch	A008-B16	10,100	3	30,300
1V-2V-3V	Voltmeter	96*96 0-500V	26,500	3	79,500
IM	Isolation monitor	96*96 380V	705$	1	705$
3A	Amp. meter	96*96 100/5	24,300	1	24,300
3AS	Amp. meter switch	A048-B16	19,200	1	19,200
3CT1~3CT3	Current Transformer	100/5 5VA	16,100	3	48,300
			TOTAL	705$ + 4,103,303,000TL	

Table-27-
(Main Switchboard)

Name into the Plan	Name of equipment	Code	Single Prize *1000TL	# of equipment	Total Prize *1000TL
L1~L6	Automatic Fuse	C32N 1KA U15A	10,100	6	60,600
LV	Voltmeter	96*96 0~250V	26,800	1	26,800
LAS	Amp. meter selector switch	A048-B16	15,500	1	15,500
LVS	Voltmeter selector switch	A008-B16	12,500	1	12,500
LA	Amp. meter	96*96 50/5	24,300	1	24,300
LAF2-LAF3-LAF4	Automatic Fuse	C23H U2K 10KA	?	1	?
L1-L3	Automatic Fuse	C32H U32A-3P	45,700	2	91,400
1-2-4-5-10-11-13-16	Automatic Fuse	C32H-10KA-U5A-3P	43,950	8	351,600
3-6-7-12	Automatic Fuse	C32H-10KA-U25A-3P C32H-U5A C32H-U25A C32H-U10A NS100N-25~32A C32H-U15 NS100N-20~25A	31,600 43,950 43,950 43,950 272,800 43,950 272,800	4 4 4 4 2 2 2	126,400 175,800 175,800 175,800 545,600 87,900 545,600
K	Relay of contactor	LC1 D1210	36,300	2	78,800
T	---------	2,5~4A LR2 D1310	48,000	4	192,000
--	EMC. Stop remote control contactor	--------	36,300	1	36,300
TR	Lighting transformer	3*5KVA 380/220V 1*5KVA 380/220V	1,136,000	1	1,136,000
IM	Isolation monitor	--------	705$	1	705$
IMS	Isolation monitor switch	A212-B14	22,800	1	22,800
				TOTAL	705$ + 3,545,736 TL

Table-28-
(Fire Alarm + 24V EMC.)

Name into the Plan	Name of equipment	Code	Single Prize *1000TL	# of equipment	Total Prize *1000TL
DM	Intercom	*5+1main	450$	1	450$
FP	Main		230$	1	230$
	Alarm bell		18$	2	36$
	Manual call point		25,000	3	75,000
	Ionization detector		22$	8	176$
	Heat detector 85°C		18$	1	18$
	24V emc. Light		9,600	11	105,600
			TOTAL	910$ + 180,000,000TL	

Table-29-
(220V Illumination + Sockets)

Name into the Plan	Name of equipment	Code	Single Prize *1000TL	# of equipment	Total Prize *1000TL
	Florescent	------	24,90$	29	722,1$
	Bronze Lamp	------	14,275	4	57,100
	Deck lamp	-----	18,550	11	204,050
	Bed lamb	------	6,000	4	24,000
	Sockets for rooms	-----	3,210	8	25,680
			TOTAL	722,1$ + 310,830,000TL	

Table-30-
(24V Dc panel)

Name into the Plan	Name of equipment	Code	Single Prize *1000TL	# of equipment	Total Prize *1000TL
	Rectifier	220V(AC) ≈24V (DC)	450,000	1	450,000
	Rectifier	360V(AC) ≈24V (DC)	610,000	1	610,000
	Battery	PB- 24V 800A/h	1,200,000	-	1,200,000
		NU-100A	5,400	1	5,400
		L10A	5,300	5	26,500
		L6A	6,280	12	75,360
		L16A	5,300	4	21,400
	Relay contactor	3 TA 76	59,000	1	59,000
		2 PL 6A	20,700	21	434,700
		A201-B16	7,200	11	79,200
	Lamb	24V	2,300	7	16,100
			TOTAL	2,977,660,000TL	

Table-31-
(Calculation of accumulator batteries)

Definition	Power Each W	Quantity	Total power W	Total current A	Working time T	Total A/h	Demand factor	Required A/h
Boat illumination	40	1	40	1,66	3	4,99	0,6	2,99
Fire alarm panel	30	1	30	1,25	18	22,5	1	22,5
24V Socket	30	2	60	2,5	18	45	0,2	9
VHF	60	1	60	2,6	18	45	1	45
VHF+DSC	72	1	72	3	18	54	1	54
Nautex	48	1	48	2	18	36	0,2	7,2
Control Panel	10	1	10	0,41	18	7,49	1	7,49
Echo Sounder	120	1	120	5	18	90	0,2	18
Radar	196	1	196	8,1	18	147	0,3	44
Steering Gear ind.	50	1	50	2,08	18	38	0,2	7,6
GPS	24	1	24	1	18	18	0,2	3,6
Navigation Panel	280	1	280	11,66	18	210	0,3	63
Whistle	12	1	12	0,5	18	9	0,1	0,9
Starboard Panel	50	1	50	2,08	18	37,49	0,5	18,7
Bilge alarm	50	1	50	2,08	18	37,49	0,5	18,7
Christmas Tree Panel	40	7	280	11,66	18	210	0,03	6,3
Bridge-main deck illumination	15	4	60	2,5	18	45	1	45
Below-engine room deck illumination	15	9	135	5,6	15	101	1	101
TOTAL REQUIRED A/h								476,98

Considering the Battery Power Factor of % 55
476,98 * % 55 = 262,33
476,98 + 262,33 = **739,31**