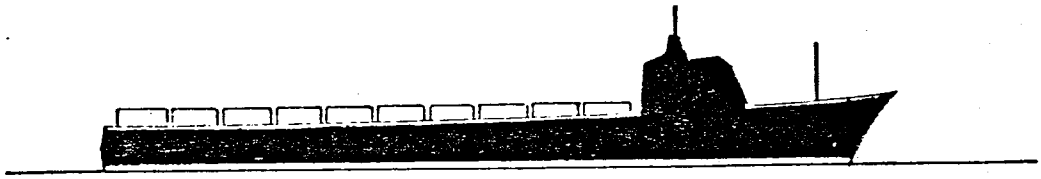

# SPECIFICATION

FOR

# CONSTRUCTION, OUTFIT, MACHINERY AND TRIALS

OF A

# TWIN SCREW, FAST CONTAINER SHIP

FOR

# TIGER LINE



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PROJECT NUMBER 483

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PART 2 MACHINERY

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# PART 2 MACHINERY

## 2.1.1 CLASSIFICATION

The design, construction, installation and testing of all main and auxiliary machinery shall be such as to satisfy the Society's requirements for the descriptive notation  (Maltese Cross) 1A1 EO.

## 2.1.2 BASIC DESCRIPTION

The Vessel is to be propelled by 2 diesel engines, each driving a controllable pitch propeller through a single input, single output, reduction gearbox.

The engines, gearboxes and propellers are to be provided with all necessary auxiliary devices including lubricating oil and cooling water pumps, fuel pumps, heat exchangers, propeller pitch control arrangements and pumps, exhaust pipes and silencers, starting air compressors, receivers, control valves and fittings.

Electrical power is to be provided for ship's services by the installation of two (2) diesel engined generator sets, similarly complete with all necessary auxiliary devices.

Emergency electrical generating capacity and emergency bilge pumping and fire fighting capabilities are to be provided for by the installation of a diesel engine driven generator complete with a clutch-coupled fire and bilge pump. This machine shall be self-contained, installed outside the main Engineroom.

Complete control of all normal and emergency functions of the main and auxiliary machinery is to be possible at all

times from the main control position in the Wheelhouse. Local controls are to be provided in the Engineroom.

2.1.3 REFERENCE CONDITIONS AND RATINGS

All main and auxiliary diesel engines shall be designed, manufactured and installed so as to provide the specified powers continuously (i.e. 24 hours per day) under the following rating conditions:

| | |
|---|---|
| Ambient air temperature | 30°C |
| Engineroom air temperature | 45°C |
| Sea water temperature | 32°C |
| Barometric pressure | 1000 mbar |
| Exhaust gas back pressure | 300mm water gauge maximum |
| Intake pressure loss | 150mm water gauge maximum |

The power of the main engines is to be the maximum continuous rating (M.C.R.) as defined by I.S.O. 3046/1.

2.1.4 FUEL AND LUBRICATING OIL

The main propulsion engines specified herein are designed to operate on marine diesel fuel or marine gas oil. However, to increase the time between fuel system services and to obtain compatibility with the main and emergency generator fuel requirements, the main engines shall be arranged to burn a suitable grade of distillate.

Lubricating oils shall be straight mineral oils, all engines, gearboxes and other oils excluding those in the hydraulic systems shall be to the same specifications and having the same viscosity rating. All oils used in the hydraulic systems shall be to the same specifications and have the same viscosity rating.

### 2.1.5 DIRECTION OF ROTATION AND INSTALLATION, SEATINGS

Both main engines are to have the manufacturer's standard rotation, i.e. counterclockwise when viewed from the output coupling end. The propellers are to have inward turning rotation, which requirement will necessitate the installation of one engine ahead of its gearbox and the other engine behind its gearbox, thereby avoiding the fitting of an idler pinion in one gearbox.

All rotating machines shall be installed with the main shaft axis fore and aft.

The main engines are to be installed on the flexible mountings supplied as standard equipment. The gearboxes are to be rigidly mounted to accept the propeller thrust. The generators are to be flexibly mounted.

Seatings for main and auxiliary machines of all sizes and for static equipment such as switchboards shall be strongly constructed of steel.

### 2.1.6 ENVIRONMENTAL CONSIDERATIONS

The ports between which the Vessel will operate have sensitive environments. Every effort shall be made during the installation of machinery to provide arrangements which will avoid the discharge overboard of oil and the emission of smoke and excessive noise.

## 2.2 MAIN PROPULSION ENGINES

### 2.2.1 BASIC ENGINE

The main propulsion engines are to be two (2) only MTU Model Number 20 V 1163 TB 62, manufactured by Motoren- und Turbinen-Union Friedrichshafen GmbH, West Germany.

These engines are direct injection, 60 degree Vee form 20 cylinder, turbo charged and intercooled diesel engines, having bore and stroke of 230mm and 280mm respectively. The total swept volume of each engine is 232.7 litres.

The maximum continuous rating (M.C.R.) of each at the reference conditions shall be 3675kW at 1100 R.P.M.

2.2.2 ENGINE AUXILIARIES

The engines shall be supplied with the manufacturer's standard equipment for fuel injection, lubricating oil pumping, air supply and salt and fresh water cooling. Two (2) exhaust turbochargers and two (2) intercoolers shall be supplied with each engine.

The engines are to be supplied with flexible mountings. The engine seatings built into the ship shall be arranged to suit the number and position of these mountings.

All necessary monitoring requirements for EO notation shall be met and as required for compliance with this Specification.

2.2.3 ENGINE STARTING

Engine starting shall be by compressed air admitted to engine cylinders. Engine preheating arrangements as manufactured by MTU shall be provided and installed.

2.2.4 TORSIONAL VIBRATION CALCULATIONS

Torsional vibration calculations shall be prepared by the engine manufacturer after receipt of the necessary particulars from the suppliers of gearboxes, shafting and propellers. These calculations shall be submitted to the Society for approval.

The torsional characteristics of the complete system shall be such that there are no barred speed ranges between the low idle speed of the engines and 1100 R.P.M.

2.2.5 ENGINE TESTING

Before leaving the manufacturer's works, the engines shall be test run in accordance with standardised engine test procedures to prove their ability to produce the specified power at the reference conditions and 1100 R.P.M. The tests shall be witnessed by the Surveyor and the Engineer.

The fuel consumption shall be measured. It shall be in the range 218-224 grams/kW hour using the specified fuel.

2.2.6 COMBINATOR CONTROLS

In association with the controllable pitch propeller manufacturer, the engine builder shall supply combinator controls for engine speed and propeller pitch.

2.2.7 ENGINE REMOVAL

A large hatch shall be provided in the main deck above each main engine to permit ready removal and replacement.

All piping, electrical wiring and other connections of whatever kind but particularly in the exhaust piping shall have plug-in or quick acting disconnect/connect arrangements in the shortest possible time, but not exceeding 5 hours.

## 2.3 GEARBOXES AND COUPLINGS

### 2.3.1 BASIC GEARBOX

Each gearbox shall be a marine type reduction gearbox with single helical gearing. The input pinion shall have hardened and ground teeth while the bull wheel should be heat treated, at least.

One (1) gearbox shall have the input and output on the same side, while the other shall have the input and output on opposite sides. The casings shall, however, be identical as far as possible.

The gearboxes shall have a horizontal offset between the input and output shafts to permit the engines to be located below the removal hatches. The horizontal offset should be at least 1100mm to allow adequate clearance between the propeller shaft and the engine on that gearbox having input and output on the same side.

The reduction ratio shall be 4.4 to 1 to provide 250 R.P.M. of the propeller shaft when the engine R.P.M. is 1100. Each gearbox shall be provided with a standard thrust bearing to accept the full propeller thrust.

The gearboxes shall be rigidly bolted to the seatings provided. Synthetic resin chocking to the approval of the Society shall be used.

### 2.3.2 COUPLINGS

Highly elastic couplings as, for example, Lohman & Stolterfoht "Spiroflex" type, shall be fitted between the engine output couplings and the gearbox input shafts.

The couplings should be of a type permitting rapid disconnection when engine removal is necessary. The input to the gearboxes

shall be via a quill shaft arrangement to allow for the flexibility of these couplings and the engine mountings.

2.3.3 CLUTCHES

Each gearbox shall have an externally mounted, air operated, friction clutch to allow disconnection of the engine from the gear.

2.3.4 TURNING GEAR

An electrically driven turning gear shall be provided on each gearbox. This gear should be capable of turning the gearbox, shafting, propeller and engine at approximately 2 R.P.M.

2.3.5 OIL PUMPS

Two (2) electrically dirven lubricating oil pumps shall be provided for each gearbox. One (1) pump for each gear shall be arranged as a stand-by pump.

The oil used in the gearboxes shall be to the same specification as the main engine lubricating oil.

An oil cooler shall be provided for each gearbox.

All bearings, both journal and thrust, shall be provided with temperature sensors. Low oil pressure and high oil temperature sensors shall be fitted together with all Society requirements for EO notation.

## 2.4 PROPELLERS AND SHAFTING

### 2.4.1 GENERAL

The shafting, couplings, stern gear, stern tubes, bearings, glands and propellers shall be manufactyred and supplied in accordance with the requirements of the Society, Drawing No. 483-24 "Arrangement of Shafting" and a Society approved drawing of the propellers to be supplied by the propeller manufacturer.

### 2.4.2 SHAFTING

The propeller and intermediate shafts shall be manufactured from fully killed mild steel in accordance with the requirements of the Rules, Chapter X. The shafts shall be machined all over with a fine finish in way of the bearings, glands and couplings.

The steel shall have a minimum ultimate tensile strength of 430 $N/mm^2$.

Shaft diameters of 335mm for the hollow tailshafts and 270mm for the solid intermediate shafts are to be confirmed after approval by the Society of the torsional vibration calculations submitted by the engine builders.

### 2.4.3 SHAFT COUPLINGS

Shaft couplings are to be provided and fitted as follows:

(a) at the forward end of the intermediate shafts: flanged couplings of Society approved material and dimensions with fitted steel bolts locked in approved fashion. The coupling shall be taper bored and provided with a fitted steel key to suit the forward end of the shaft.

(b) join of intermediate shafts: SKF manufacture or equal hydraulic injection couplings are to be supplied and fitted.

(c) at the aft end of the intermediate shafts: as for (a) above.

(d) at the forward end of the hollow tail shaft: to be supplied by controllable pitch propeller manufacturer and similar to (b) above.

The couplings, their fits on the shafts and the method of mounting them are to be approved by the Surveyor. The location of the couplings is shown on Drawing No. 483-24.

2.4.4 GLANDS AND SEALS

A split cast iron watertight bulkhead gland is to be fitted on the bulkhead at Frame 60 as shown on Drawing No. 483-24 for each intermediate shaft. Each gland is to be bolted to a thick pad welded into the bulkhead. The forward face of this pad is to be carefully machined truly square to the centreline of the intermediate shaft.

Stern tube seals are to be provided at the forward end of the stern tube at the bulkhead at Frame 27 and at the aft end of the stern tube behind the 'A' bracket, as shown on Drawing No. 483-24.

2.4.5 STERN TUBES

Two (2) thick walled stern tubes of approximately 500mm outside diameter are to be supplied and installed where shown on the shafting drawings. Each stern tube is to be oil filled and is to be suitably secured to the bossing and 'A' bracket to the satisfaction of the Surveyor.

## 2.4.6 SHAFT BRACKETS

The tail shafts are to be supported at their after ends just forward of the propellers by fabricated steel 'A' brackets. These brackets are to have double streamlined arms welded to fully machined bosses.

The brackets are to be fabricated from Society approved and tested material and the bottom structure of the vessel is to be reinforced by the fitting of insert plates as shown on the shell expansion drawings and as directed by the Surveyor. All welding between the bracket arms and the shell plating externally is to be ground smooth and tested by an approved process, for example X-ray or dye penetration, for cracks, and is to be approved by the Society's Surveyor.

## 2.4.7 PROPELLERS

Two (2) opposite rotation controllable pitch propellers are to be supplied and fitted to the propeller shafts. They are to have the following characteristics:

| | |
|---|---|
| Diameter: | 3000mm |
| Pitch: | 3225 (Controllable) |
| Developed Area Ratio: | 0.65 |
| No. of Blades: | 4 |
| Material: | Nickel aluminium bronze having mechanical properties and chemical composition approved by the Society |

The propellers are to be carefully designed to avoid cavitation and singing and shall be statically balanced to the satisfaction of the Surveyor. The propellers shall comply in all respects with the requirements of ISO Recommendation R 484 "Ship Screw Propellers - Manufacturing Tolerances for Casting and Finishing", Class S, High Precision.

2.4.8 PROPELLER NUTS

The propeller nuts shall be of steel of the same quality as the shafts. The nuts shall be locked by a method approved by the Surveyor. The Builder shall supply a special spanner of mild steel for the tightening and removal of these nuts.

2.4.9 PROPELLER SHAFT ALIGNMENT

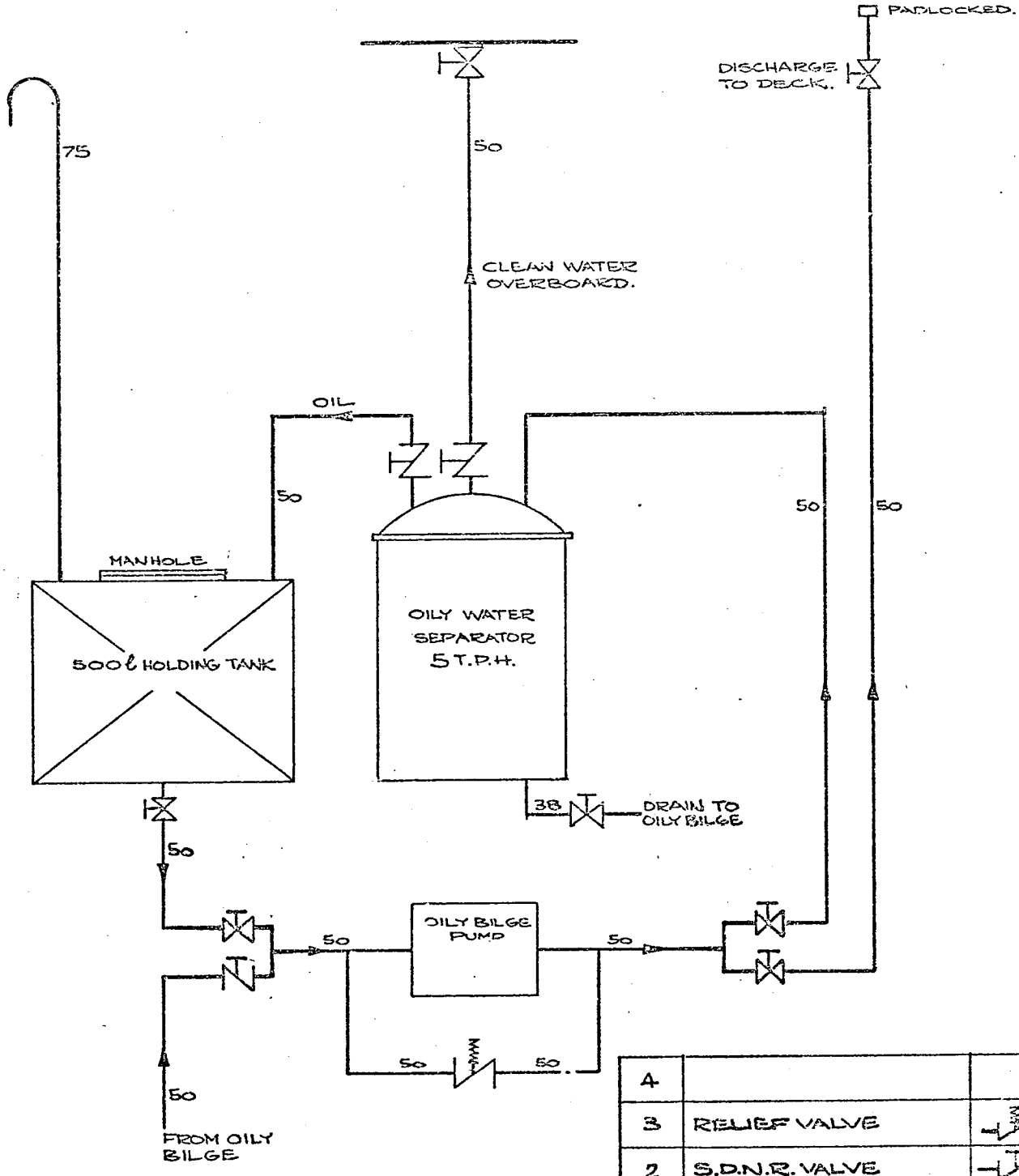
The gearbox couplings and those at the forward end of the intermediate shafts shall not be finally bolted together until the Vessel has been launched and is complete.

By testing with suitable gauges, the gearbox coupling shall be found to be parallel to the intermediate shaft forward coupling, the malalignment being less than 0.005mm per centimetre of flange outside diameter. The centreline of the shaft and the centreline of the gearbox coupling shall be concentric.

2.4.10 BEARINGS

The tailshaft bearings located at the forward and aft ends of the stern tubes shall be of the split type, white metal and oil lubricated, suitably secured to the housings to the satisfaction of the Surveyor. These bearings shall be supplied with lubricating oil from gravity tanks as covered in section 2.10.2 of this Specification.

The intermediate shafting shall be supported by pedestal mounting type split roller bearings located as shown on Drawing No. 483-24. These pedestal bearings shall be bolted with fitted bolts to fabricated mild steel stools.




| ITEM | DESCRIPTION | SYMBOL |
|---|---|---|
| 4 | | |
| 3 | RELIEF VALVE | |
| 2 | S.D.N.R. VALVE | |
| 1 | S.D.S.L. VALVE | |

WARWICK J. HOOD NAVAL ARCHITECT + 41 McLAREN ST, NORTH SYDNEY, AUST.

IPEC TIGER LINE FAST CONTAINER SHIP
OILY BILGE SYSTEM DIAGRAMMATIC

| | |
|---|---|
| DRAWN BY | J.D.T. |
| CHECKED BY | |
| TRACED BY | |

DRAWING Nº 483/264

## 2.5 DIESEL ENGINE DRIVEN GENERATORS

### 2.5.1 GENERAL

The main electrical power supply is to be 3 phase, 50 cycle alternating current of 415 volts.

This power supply is to be provided by two diesel engine driven generator sets installed in the Engineroom while a third set, for emergency power generation, is to be installed on the main deck forward in a separate enclosed space.

The main generators are to be used alternatively, i.e. they are not to be used together in parallel.

All generator sets are to be provided with certification by the society.

### 2.5.2 MAIN GENERATOR SETS

a) General Arrangement

Two (2) only sets are to be provided and installed in the Engineroom.

Each set is to consist of a turbo-charged, heat exchanger cooled, marine, diesel engine coupled to a generator having a continuous output of 320KVA at 0.8 power factor under the following conditions:

$45^{o}$ ambient air temperature
$32^{o}$ sea water temperature
1500 Engine R.P.M.

The engines are to be arranged for compressed air (motor) start and are to be capable of remote operation from the Wheelhouse.

Each engine and its generator are to be mounted on a fabricated steel base plate. A strong foundation built into the vessel's structure is to be provided for each generator set.

Each engine shall be provided with a muffler to suit. A flexible compensator shall be provided in each exhaust pipe and this shall be attached directly to the exhaust outlet on the engine. The exhaust piping shall be supported on insulated brackets from the vessel's structure so that no weight is taken on the manifolds.

The exhaust piping and mufflers shall be insulated with a suitable mineral insulation material and finally covered with asbestos fabric which is to be painted with heat-resisting paint. Sufficient insulation is to be provided so that the surface temperature does not exceed 40$^{o}$C after the engines have been running on load for two hours.

Solenoid operated automatic shut down of the generator sets is to be provided in the event of low lubricating oil pressure or high fresh water cooling temperature. Automatic shut down must be preceded by an audible and visible alarm located in the Wheelhouse. The devices shall be arranged to allow testing while the engine is running.

The engines must be capable of operating for extensive periods lightly loaded (at 20 to 30% of full load) without being damaged and without coking up.

b) Generator and Exciter

The generator and exciter shall conform to the characteristic requirements of Specification AS 1359 and be of the rotating field type capable of delivering the rated load at 0.8 lagging power factor over the range of operating conditions specified. Each generator shall be of the self excited brushless type, suitable for marine duty and enclosed, ventilated and drip proof.

The output of the generator shall be three phase, 415 Volts between phases and a frequency of 50Hz at 1,500 r.p.m. The windings shall be suitable for star connection with the star connection brought out to a terminal in the terminal box.

The field poles shall be provided with damper windings.

The generator shall be designed to restrict the harmonic content to prevent excessive neutral currents to circulate. (i.e. Total harmonic content to be less than 3% and individual harmonic less than 2%).

The rectifier diode carrier shall be part of the rotating armature assembly and shall be easily accessible. The bridge connected diodes shall be directly connected to the generator field system.

Construction and finish of the generator, exciter and all associated equipment shall be suitable for operation under the climatic conditions specified.

The cooling arrangement shall comply with the following requirements:

i) Any fans or other ventilating device for circulation air through the machines shall be built-in as an integral part of the machine.

ii) The generator shall be designed with flanged openings in the casing and each inlet opening shall be fitted with an efficient filter to prevent the ingress of dust and the outlet opening shall be covered with a wire screen having apertures not exceeding $5mm^2$.

A 240 Volt anti-condensationheating element shall be provided if required by the manufacturer, which shall be automatically "ON" when the generator set is not in service, and "OFF" when in service.

All bearings shall be of the ball or roller type, grease lubricated and efficiently sealed against ingress of dust.

Thermistors shall be provided in the stator windings and terminals brought out to a separate terminal box.

The waveform of the generators shall be in accordance with AS 1359.40 but where a statically excited machine is offered, typical oscillograms for the equipment must be supplied at the time of tendering.

The generators shallbe capable of withstanding without any injurious effects a short circuit at the output terminals in accordance with the Rules.

c) Governor

Governing shall be of Class 1 limits as defined in Appendix H of the latest edition of AS 1501.

A manual speed regulator shall be provided on each engine control panel.

The sets shall be shut down automatically and alarms brought up in the Wheelhouse, in the event of overspeed as set out in the Rules.

d) Automatic Voltage Regulator

A static type automatic voltage regulator suitable for continuous operation shall be provided for each set and shall be capable of maintaining the voltage within 2.5% of the rated voltage.

The automatic voltage regulator shall be incorporated on the control panel and shall be adequately protected against mechanical damage and the ingress of dust.

e) Radio Interference Suppression

The whole of the set, including the motor, generator, exciter, clutch, automatic voltage regulator and electrical controls for the engine, shall be effectively suppressed against the emission of radio interference in accordance with British Standard Specification BS 833.

Details of the methods to be employed for the suppression of radio interference shall be supplied with the tender.

f) Performance of Sets

In addition to providing the continuous rating specified the generating sets and their associated governors and automatic voltage regulating equipment shall be selected to meet the following requirements:

i) When a generator is being driven at its rated speed and supplying a load approximately equal to 250KVA at 0.8 power factor and giving its rated voltage under control of its A.V.R., and a motor starting load of 150KVA is suddenly connected, the maximum voltage drop shall not exceed 15% and the voltage shall be restored to within 2.5% of the rated voltage within 0.5 seconds.

ii) When a generator is running at no-load and/or full load and the largest load on board which normally can be switched on/off is suddenly applied and/or thrown off, the instantaneous voltage drop and/or rise is not to be more then -15% and/or +20% of the rated voltage. In general, the voltage is to be restored to the normal value ($\pm$ 2.5%) within 0.5 second.

The frequency under the abovementioned conditions shall be maintained within the limits set down in the Rules.

## 2.5.3 EMERGENCY GENERATOR

### a) General Arrangement

The machine is to consist of a naturally aspirated, heat exchanger cooled, 4 stroke diesel engine coupled to a self excited two bearing brushless generator having a continuous output of 140KVA at 0.8 power factor. The generator set shall be built, tested and certified in accordance with the Rules.

The set shall be installed in the emergency generator room located on the starboard side of the main deck forward.

The engine and alternator shall be mounted together on a common steel base plate and the complete machine shall be installed as shown on the General Arrangements drawings. A steel enclosure shall be provided to guard the machine against the elements, but at the same time permitting the free flow of air for aspiration and cooling.

Automatic starting arrangements shall be provided in the event of main generator failure. Starting power shall be supplied by 24 Volt D.C. batteries charged by the ship's main power supply.

The engine is to have its own independent fuel supply from a header tank of approximately 500 litres capacity located within the compartment.

The exhaust piping system and muffler shall be arranged and efficiently insulated as for the main generator set engines.

Solenoid operated automatic shut down of the generator set is to be provided in the event of low lubricating oil pressure or high fresh water cooling temperature. Automatic shut down must be preceded by an audible and visible alarm located in the Wheelhouse. The devices shall be arranged to allow testing while the engine is running.

The engine must be capable of operating extensive periods lightly loaded (at 20 to 30% of full load) without being damaged and without coking up.

b) Generator and Exciter

The generator shall be of the self excited brushless type, suitable for marine duty and enclosed, ventilated and drip proof.

The output of the generator shall be three phase, 415 Volts between phases and a frequency of 50Hz at 1,500 r.p.m. The windings shall be suitable for star connecting with the star connection brought out to a terminal in the terminal box.

Thermistors shall be provided in the stator windings and terminals brought out to a separate terminal box.

The generator shall be capable of withstanding without any injurious effects a short circuit at the output terminals in accordance with the Rules.

All other requirements shall be similar to the main generators.

c) Governor

Governing shall be of Class 1 limits as defined in Appendix H of the latest edition of AS 1501.

A manual speed regulator shall be provided on each engine control panel.

The set shall be shut down automatically and alarms brought up in the Wheelhouse, in the event of overspeed as set out in the Rules.

d) Automatic Voltage Regulator

A static type automatic voltage regulator suitable for

continuous operation shall be provided for each set and shall be capable of maintaining the voltage with 2.5% of the rated voltage.

The automatic voltage regulator shall be incorporated on the control panel and shall be adequately protected against mechanical damage and the ingress of dust.

e) Radio Interference Suppression

As specified for main generators.

f) Performance of Set

In addition to providing the continuous rating specified the generating set and associated governor and automatic voltage regulating equipment shall be selected to meet the follwoing requirements:

i) When a generator is being driven at its rated speed and supplying a load of approximately 80KVA at 0.8 power factor and giving its rated voltage under control of its A.V.R., and a motor starting load of 85KVA is suddently connected, the maximum voltage drop shall not exceed 15% and the voltage shall be restored to within 2.5.% of the rated voltage within 0.5 second.

ii) When a generator is running at no-load and/or full load and the largest load on board which normally can be switched on/off is suddenly applied and/or thrown off, the instantaneous voltage drop and/or rise is not to be more the -15% and/or +20% fo the rated voltage. In general, the voltage is to be restored to the normal value (± 2.5%) within 0.5 second.

The frequency under the abovementioned conditions shall be maintained within the limits set down in the Rules.

g) Starting Batteries and Charger

A battery and battery charger unit shall be supplied for starting of the emergency generator system in accordance with the Rules.

The unit shall be 24 Volts with capacity to perform 12 separate starting attempts of minimum 10 seconds duration.

The unit shall be supplied in a cubicle which shall be dustproof, of sheet metal construction minimum 2 mm thick, suitably braced with angle iron where necessary, and arranged for floor mounting on a 75mm x 50mm galvanised mounting base.

The unit shall comprise of two sections, the top and bottom sections respectively, housing (a) the full wave silicon rectifier and control equipment and (b) the battery in a ventilated compartment behind a hinged lockable door.

The battery unit shall consist of suitable sealed lead acid cells. The DC supply shall be insulated from earth. The unit shall be complete with all necessary intercell connections. The cells shall be despatched in a fully charged state.

An adequately rated test resistor shall be incorporated in the test circuit to provide a drain of 100 amps on the battery when the test switch is operated.

An automatic constant potential charger, designed to automatically charge the cells, shall be provided. The charger shall be capable of maintaining full charge on the battery. The charger shall be supplied by a double wound transformer and shall be fitted with a rheostat charge rate control.

The charger shall be suitable for operation from a 240 Volt 50Hz single phase supply.

The following shall be incorporated in the cubicle:

a) AC switch and fuse link
b) AC mains pilot lamp
c) Charging ammeter arranged to indicate state of battery condition
d) State of charge test circuit
e) Trickle and booster resistors
f) Normal/Boost selector switch
g) Off/Test selector switch
h) Charger failure relay connected to an alarm light shall be provided to monitor the output of the charger. This relay shall be initiated in the event of an appreciable drop in either the boost charge or the float charge. A spare set of alarm contacts to be wired to a set of terminals for connection to a remote alarm unit.

The following ancilliary equipment shall be provided for each unit:

a) Terminal spanner
b) Hydrometer depth tester
c) Topping up bottle and 4.5 litres of distilled water
d) Full schematic diagram for the control system
e) Operation and maintenance instruction book.

## 2.6 AIR COMPRESSORS AND SYSTEMS

### 2.6.1 STARTING AIR SYSTEM

Two (2) electrically driven 2-stage water cooled air compressors with separate receivers are to be installed in the Engineroom. One of the compressors is to be connected to both the main and emergency power supplies and shall be the cold start compressor. The second compressor is to be connected to the main power supply only.

The compressors are to be capable of charging a receiver via an oil/water separator in less than 1 hour. Each receiver is to be sufficient for six starts of one main engine and one auxiliary engine without recharge. The air is to be piped from the receivers to:

(a) the main engines for direct injection starting as shown on the engine builder's piping diagram; and
(b) the starting motor on the diesel generator engine via a suitable reducing relief valve.

### 2.6.2 CONTROL AIR SYSTEM

The pneumatic remote bridge control system requires a supply of clean and dry air at a pressure of 4 Bar. This control air is to be supplied by an electrically driven air compressor mounted on a receiver of approximately 2 cubic metres capacity. It is to be supplied complete with all necessary automatic control switches, traps and driers so as to ensure a constant supply of dry and clean air.

A standby supply is to be taken from the starting air system via a suitable reducing valve.

The compressor control pipes are to be connected to the air receivers as far away from the compressor as possible so as to prevent compressor pulsations from affecting pressure switch operation.

## 2.7 EXHAUST PIPES AND SILENCERS

The exhaust pipes and silencers shall be arranged as shown on the Engineroom arrangement drawing.

A flexible bellows connection shall be provided at each engine manifold connection. Mild steel exhaust piping shall be provided with bolted flange joints.

The exhaust piping and main engine silencers shall be effectively supported from the ship's structure by insulated brackets or hangers and no weight shall be taken by the exhaust outlet elbows on the engine's turbo-chargers.

The two exhaust outlets from each main engine are to be mated into dry type, spark-arresting silencers of the largest size to provide noise attenuation and low back pressure to the requirements of the engine manufacturer. The exhaust outlet pipes from the silencers are to discharge to atmosphere via the funnel casing.

A spark-arresting silencer is to be supplied for each generator engine and installed in the Engineroom uptake between the main and bridge decks. The exhaust outlet pipes from these engines are to discharge to atmosphere via the funnel casing.

All exhaust pipes and silencers are to be efficiently insulated so that the surface temperature of the insulation does not exceed 45$^{o}$C after the engines have been running at their rated power for at least 2 hours. The exhaust pipes are to be provided with water collecting sumps and automatic draining arrangements.

## 2.8 BOW TRANSVERSE THRUSTER

One (1) bow transverse thruster shall be supplied and installed where shown on the General Arrangement drawing.

The bow thruster shall provide a static thrust of approximately 3 tonnes and shall be driven via a power take-off on the Port main engine.

The bow thruster shall be equipped with a controllable pitch propeller having a diameter of approximately 1200mm.

An hydraulic pump is to be supplied by the bow thruster manufacturer.

## 2.9 RUDDERS AND STEERING GEAR

### 2.9.1 GENERAL

The rudders and steering gear are to be manufactured and installed in accordance with the Rules of the Society and the relevant parts of Drawing Number483-25. The forces produced by the action of the rudders are high, and consequently the rudders, steering gear, supporting structure and all associated items are to be strongly made and well fitted.

### 2.9.2 RUDDERS

Twin semi-balanced streamlined rudders of double plate construction are to be manufactured from mild steel plate and fully welded. The centrelines of the rudder stocks are offset inboard from the centrelines of the propeller shafts to permit withdrawal of the shafting without removal of the rudders. The rudder horns carrying the lower bearings shall be welded into the ship's structure, the main piece of each horn extending up through the bottom shell plating and into the rudder trunk supporting structure. The rudders and horns are to have a smooth finish externally and are to be air-tested for watertightness on completion. The internal surfaces of the rudders and horns shall be efficiently coated with an approved corrosion-resistant compound.

### 2.9.3 RUDDER STOCKS

The rudder stocks and pintles are to be machined from fully killed steel forgings. They are to be machined all over and provided with tapers and keyways to suit the steering gear.

The material of the stocks is to be tested and approved by the Society and is to have a minimum specified tensile strength of 430 $N/mm^2$. The nuts on the stocks and the pintles shall be suitably locked after tightening.

Cover plates over the nut recesses in the rudders are to be flush, secured with countersunk head machine screws, and watertight.

2.9.4 RUDDER BEARINGS

Bearings are to be provided to support each rudder. The pintle bearings at the bottom shall be of a phenolic resin impregnated asbestos material, "Ferobestos" or equal, machined to the manufacturer's recommended tolerances to suit water lubrication.

The main bearings in the rudder trunks for the bottom ends of the rudder stock shall be of the same material.

The top bearings immediately below the tiller bosses are to carry the weight of the rudders and the radial loads from the steering gear. They are to be of cast iron, bronze bushed, with conical working faces, the self-aligning type, for example Taylor Pallister design or equal. This bearing is to incorporate a gland and is to be greased automatically.

2.9.5 STEERING GEAR

The steering gear is to be of electro-hydraulic type, twin cylinder, with double acting pistons in each cylinder. The pistons are to be attached to the twin tillers at each end through piston rods by Rapson slide units.

The steering gear shall be, for example, Svendborg type 280 LSD, Analog, or equal having main hydraulic pumps of axial piston design, with variable yield, regulated by an electronic servo unit.

The steering gear is to be capable of turning the rudders to $40^{\circ}$ on either side of the Vessel's centreline. Under power the time from hard over to hard over when the Vessel is running full speed ahead is not to be more than 28 seconds.

The rudder speed is to be regulated as a function of the rudder command which will limit the frequency of rudder movements and the amount of rudder angle and thus reduce the resistance to propulsion.

The tillers are to be either split type or shrunk design, provided with keys to be secured to the rudder post. The two tiller assemblies are to have double tillers of cylindrical section, to accept the Rapson slide rings. Suitable arrangements are to be made to transfer the weight of the rudder and post from the tiller to a conical faced rudder carrier bearing.

Suitable bypass/relief valves are to be provided to prevent overloading of the hydraulic system when the rudders are in the hard over position, these valves being designed so as to relieve the hydraulic system of any shock loading caused by external forces acting on the rudders. The hydraulic piping shall be of seamless steel.

Rudder stops are to be built into the rudder stock unit, between the ends of the cylinders and the Rapson slide units. One of the four Rapson slide units is to have an arrangement of shims or packing to allow fine adjustment of the piston rods to accommodate any slight misalignment of the rudder posts.

Automatic pilot control of the electronic servo unit is to be so arranged that either one of the main pumps may be operated or both; when both pumps are running the time taken for the rudders to move from hard over Port to hard over Starboard is to be approximately half the time taken when one pump is running.

## 2.10 TANKS, PUMPS, PIPING AND VALVES

### 2.10.1 GENERAL

Complete and operating systems including all necessary tanks, pumps, piping, valves, fittings and accessories shall be provided for the following services:

(a) Main and auxiliary diesel engine fuel
(b) Main and auxiliary diesel engine cooling
(c) Bilge pumping and fire fighting
(d) Gearbox oil cooling
(e) Steering gear hydraulic system
(f) Stern tube and main and auxiliary engine lubrication

These systems are shown diagramatically on Drawing No. 483-26, Sheets 1, 2 and 3. All items of gear and equipment, piping, valves and fittings shall be of the lightest possible weight consistent with the requirements of serviceability and compliance with the Rules.

### 2.10.2 TANKS

Tanks are to be provided as shown on the General Arrangement and Engineroom Arrangement plans and as required by this specification. They are to be built-in or separate as specified herein. All tanks shall be tested to heads at least equal to the maximum operating head or as required by the Society.

All tanks shall be provided with filling pipes, air escape pipes, level alarms and distant reading contents gauges, manholes and handgrips for internal inspection or cleaning and drain cocks or plugs. Drain cocks on fuel tanks shall have weighted handles or other arrangements to make them positively self-closing.

The following tanks are to be fitted:

(a) Fuel Tanks - Main

Two (2) only double bottom tanks between Frames 95 and 107 built into the vessel's structure as shown on the Structure and Arrangement Drawings. The tanks are to be provided with filling and venting arrangements as shown on the diagram. The filling pipes are to have lockable caps while the vent pipes are to have goosenecks with synthetic rubber ball stoppers, cages and flame-guards. The filling and vent pipes are to extent at least 1 metre above the main deck. These pipes are to have engraved labels on them or adjacent to them indicating their functions. Distant reading contents gauges and high and low level alarms are to be provided for these tanks.

(b) Fuel Tank - Emergency Generator Set Header Tank

This tank is to be located between Frames 122 and 125 on the Starboard side as shown on the General Arrangement plan and is to have a capacity of 500 litres.

The tank is to be filled from the main fuel tank via a fuel transfer pump in the Engineroom and is to have a distant reading contents gauge and a high level alarm.

(c) Fresh Water Tank

One (1) only double bottom tank of approximately 5000 litres capacity is to be built into the vessel's structure between Frames 117 and 124. The tank is to have air escape and filling pipes and a distant reading contents gauge.

(d) Header Tanks for Main and Auxiliary Engine Lubricating Oil

Two (2) tanks are to be installed, one each Port and Starboard, under the "ramp" between Frames 95 and 100, as shown on Drawing No. 483-26, Sheet 3.

Each tank is to have a distant reading contents gauge, low level alarm, filling and sounding pipes, flow meters and regulators as shown on the Drawing.

(e) Stern Tube Lubricating Oil Tanks

Each stern tube and forward shaft seal shall be supplied with lubricating oil from gravity tanks of approximately 270 and 5 litres capacity respectively. Each tank shall be provided with distant reading contents gauges and low level alarms as shown on Drawing No. 483-26, Sheet 3.

(f) Salt Water Ballast Tanks

Ballast tanks are to be provided where shown on the Arrangement and construction drawings and shall be located as follows:

(a) One each Port and Starboard between Frames 107 and 115
(b) One each Port and Starboard between Frames 40 and 60. The shaft tunnel passes through these tanks.
(c) One each Port and Starboard on the main deck forward
(d) One each Port and Starboard on the main deck aft.

Tanks referred to in (a) and (b) above are to extend up to the main deck.

Contents gauges, air and filling pipes and alarms are to be provided as shown on Drawing No. 483-26, Sheet 1.

(g) Hydraulic Oil Tanks

Tanks for the hydraulic systems are to be located and sized to suit the manufacturer's specifications.

(h) Oily Water Tank

A holding tank of 500 litres capacity is to be provided in the Engineroom.

2.10.3 PUMPS

All pumps are to be of high grade commercial standard design for reliability and economy of operation. The fire and bilge pumps, the fuel transfer pump, the gearbox oil cooler pump and the stern tube lubrication pump shall be approved by the Society.

Electrically driven pumps shall be supplied with a marine type totally enclosed fan-cooled electric motor. Each pump and its motor shall be arranged as a close coupled unit, or alternatively the motor shall drive through a flexible coupling with both pump and motor mounted on a common base. All salt water pumps are to be constructed of corrosion-resistant materials, for example casing and cover 88-10-2 gunmetal, impeller aluminium bronze, shaft stainless steel or monel metal. Other pumps may be of standard cast iron commercial construction. All pumps shall be provided with spares as recommended by the manufacturer and as required by the Society. The following pumps are to be provided:

(a) Bilge, Ballast and Fire Fighting (Drawing No. 483-26/1)

Two (2) electrically driven, self-priming, centrifugal pumps are to be provided in the Engineeroom, each having a capacity of 110 cubic metres per hour.

Each pump is to be driven by an electric motor connected to the 415 volt 3 phase 50 cycle supply.

A third pump is to be provided for emergency fire fighting and bilge pumping duties. This pump is to be driven by the emergency generator diesel engine via a disconnect clutch. It is to be self-priming and have a capacity of 30 cubic metres per hour at a pressure head of 20 metres. This pump is to rotate at a speed of 1300 R.P.M. and is to be constructed of the same corrosion-resistant materials as the main fire and bilge pumps.

(b) Fuel Oil Transfer Pump

One (1) self-priming centrifugal or gear type pump is to be installed and shall have a capacity of 40 litres per minute at a pressure head of 10 metres. This pump is to rotate at a speed of 1475 R.P.M. and may be constructed of cast iron to commercial standards.

(c) Oily Bilge Pump

One (1) positive displacement pump, having a capacity of 10 cubic metres per hour at a pressure head of 15 metres, is to be supplied and installed.

(d) Fresh Water Pump

Two (2) pumps each capable of delivering approximately 50 litres per minute at a pressure head of 15 metres are to be installed. One of these pumps is to act as a standby. The pumps are to discharge into a galvanised pressure tank of approximately 150 litres capacity. The system is to include a pressure switch, air volume control, relief valve, check valve and pressure gauge.

(e) Gearbox Lubricating Oil Pumps

Three (3) electrically driven pumps of approximately 150 litres per minute capacity at a pressure head of 135 metres are to be installed. One pump is to be arranged as a standby.

(f) Main Engine Sea Water Pump

One (1) self-priming electrically driven pump is to be installed as a standby unit. It shall have a capacity of approximately 2600 litres per minute against a pressure head of 10 metres.

(g) Main Engine Lubricating Oil Pump

One (1) electrically driven pump is to be installed and is to have a capacity suitable for standby operation.

(h) Main Engine Fresh Water Cooling Pump

One (1) electrically driven pump is to be installed and is to have a capacity suitable for standby operation.

2.10.4 PIPING AND VALVES

Piping shall be lead as directly as practicable with a minimum number of bends and fittings but with sufficient joints to provide for removal, inspection, servicing and replacement as necessary. Piping shall be fitted as close as possible to deck beams and bulkhead stiffeners but no piping shall be run along the ship's sides. Piping is to be kept clear of the Engineroom deckhead in way of the hatch for engine removal and is not to be fitted over the top of the switchboard. Cutting of the ship's structure for the passage of pipes is not permitted except where it is essential to penetrate a

watertight or oiltight bulkhead, a deck or tank top, in which case an approved type of bulkhead fitting is to be used. In no case shall the plating form part of a joint or piping.

Piping of reciprocating machinery is to have approved flexible connections located as close to the machine as possible. Pipes are to be supported adjacent to the flexible connection. Oil fuel and lubricating oil piping is to be run clear of engine exhausts and electrical equipment as far as possible. Piping units are not permitted in inaccessible locations.

The piping system shall be suitably designed to allow for all stresses of thermal expansion, as well as stresses due to deflection of the hull structure.

Pipes are to have suitable thickness for each service and shall be hydraulically tested according to the requirements of the Society.

Where galvanised piping is specified, galvanising is to be carried out after the fabrication of the pipes and attachment of the flanges, as far as practicable. Where adjusting flanges, sleeve joints and short branch pieces are to be welded on board, these shall be coated with zinc solution paint.

All piping systems shall be cleaned and free from welding slag before installation, and the principal piping system shall be flushed after installation.

All valves, cocks and flanges shall be in accordance with the requirements of the Society.

Piping, valves, strainers, mud boxes and other fittings shall be provided for all services as described in the schedule on the following pages. Mud boxes and strainers may be fabricated from mild steel and galvanised after fabrication, or alternatively shall be of bronze.

One (1) main high suction and two (2) low suction sea chests shall be provided. Each suction sea chest is to be of welded steel construction and shall be fitted with sea valves of strong construction and anti-corrosive zinc. An air blow connection and an air vent pipe shall be fitted to the main sea chest. Each suction sea chest shall be fitted with a removable galvanised grating with a clear area of at least twice the area of the sea valves.

| SYSTEM | PIPE | | | FITTINGS Material | | | JOINTS |
|---|---|---|---|---|---|---|---|
| | Material | Thickness | Bore | Body | Internal | Spindle | |
| FUEL OIL | Solid Drawn Steel Black | Sch. 40 | 50 & above<br>38 & below | Cast Iron<br>G.M. | G.M.<br>G.M. | 316 S/S or R.N.B. | Slip on welded flange B.S.T.E. Approved screwed union |
| LUBE OIL | Solid Drawn Steel Black | Sch. 40 | 40 & above<br>38 & below | Cast Iron<br>G.M. | G.M.<br>G.M. | 316 S/S or R.N.B. | Slip on welded flange B.S.T.E. Approved screwed union |
| STARTING AIR | Solid Drawn Steel Black | Sch. 120 | - | C.S. | Steel | Steel or 316 S/S | Slip on welded flange B.S.T.J. |
| CONTROL AIR | Solid Drawn Copper | - | - | Bronze | G.M. | 316 S/S or steel | Approved compression fitting |
| BILGE, BALLAST & FIREMAIN | Solid Drawn Steel galvanised after fabrication | Sch. 40 | 75 & above<br>50 & below | C.I.<br>G.M. | G.M.<br>G.M. | 316 S/S or R.N.B. | Slip on welded flange B.S.T.E. |
| SEA WATER COOLING SYSTEM | Solid Drawn Steel galvanised after fabrication | Sch. 40 | 75 & above<br>50 $ below | C.I.<br>G.M. | G.M.<br>G.M. | 316 S/S or R.N.B. | Slip on welded flange B.S.T.E. |
| SOIL AND WASTE | Solid Drawn Steel galvanised after fabrication | Sch. 40 | 50 & above | C.I. | G.M. | (316 S/S<br>(<br>(or<br>(R.N.B.<br>( | Slip on welded flange |
| | Galvanised S.D.S. | Sch. 40 | 38 & below | G.M. | G.M. | | Screwed union |
| SHIP SIDE VALVES | - | - | 75 & above<br>50 & below | Cast Steel<br>G.M. | G.M.<br>G.M. | (316 S/S<br>(or<br>(R.N.B. | Flanged B.S.T.E. |

| SYSTEM | PIPE | | | FITTINGS Material | | | JOINTS |
|---|---|---|---|---|---|---|---|
| | Material | Thickness | Bore | Body | Internal | Spindle | |
| DOMESTIC FRESH WATER | Copper | - | - | Bronze | Bronze | R.N.B. | Screwed union Silver solder |
| FRESH WATER ) CIRCULATING ) ) SEA WATER ) | Solid Drawn Steel galvanised after fabrication | Sch. 40 | 50 & above | Cast Iron | G.M. | 316 S/S or | Slip on welded flange B.S.T.E. |
| CIRCULATING ) | | | 38 & below | G.M. | G.M. | R.N.B. | Approved screwed union |

## 2.11 VENTILATION AND AIR CONDITIONING

### 2.11.1 VENTILATION - ENGINEROOM

The Engineroom is to be ventilated by means of a forced supply system, supplying sufficient air to the Engineroom to meet the maximum needs of the main and auxiliary engines plus a further volume of air sufficient to provide a complete change every 5 minutes.

The supply fans shall be two-speed, the fast speed to meet the above requirement, the slow speed to provide merely sufficient air for a complete change every 5 minutes, to be used when the main machinery is not running.

### 2.11.2 FANS AND SUPPLY TRUNKING TO ENGINEROOM

Two (2) axial flow, 2-speed fans, 1 metre diameter, each capable of delivering 10 $m^3$/second and 3 $m^3$/second respectively at high and low speed shall be installed. These fans are to be driven by electric motors of suitable capacity connected to the 415 volt 3 phase supply. The fans shall be installed one each Port and Starboard in mushroom ventilators mounted on the forecastle deck outboard of the exhaust trunk.

The vent casings shall be fitted with remote control fire flaps below the fans.

The air is to be supplied through ducting which is to run outboard of the line of the web frame flanges and to exit beneath each main engine as shown on the Engineroom arrangement drawing. Natural exhaust is to be provided from the Engineroom via the funnel uptake trunk. An approved fire flap is to be fitted.

Alarms and running lights are to be provided for both fans.

## 2.11.3 AIR CONDITIONING

The Wheelhouse and the crew accommodation on the forecastle deck are to be air conditioned.

The air conditioning equipment shall be designed to overcome the heat gains to the air conditioned sections of the Vessel when the outdoor temperature is 35°C, and is to maintain an internal temperature of 21°C. For winter operation, electric heating elements are to be installed which shall be housed within a heater bank box mounted downstream from the air handling evaporator unit.

## 2.11.4 AIR CONDITIONING CONDENSING UNIT

The condensing unit will comprise a refrigeration compressor, main driving motor, flexible coupling, shell and tube marine condenser/receiver and necessary controls. The condensing unit shall be fitted with a marine type shell and tube condenser with admiralty brass tubes and stainless steel tube plates, this being fitted with removable bronze water end plates for cleaning purposes. The electric motor shall be a totally enclosed, fan cooled squirrel-cage induction type, 50 cycle, operating at 1440 R.P.M. The complete condensing unit is to be mounted on a mild steel base, suitably treated for corrosion resistance and fitted with all the necessary pipes, controls, gauges, etc. ready for installation within the Vessel.

## 2.11.5 CONTROLS

The high/low pressure control shall have a manual reset on the high pressure cut-out. An oil pressure differential switch shall be incorporated on the control board to protect the compressor against oil pressure failure. A low pressure control is to be incorporated on the panel for pump down control. A gauge panel shall be provided, complete with three gauges, being high pressure gauge, compound low pressure

gauge and oil pressure gauge. A low oil level alarm switch is to be fitted.

The condensing unit assembly shall be completely piped and fitted with liquid line drier, liquid line sight glass moisture indicator, fusible plugs and necessary service valves.

## 2.12 INSULATION

For insulation, see Section 1.6.4 of Part 1 of this Specification "GENERAL INFORMATION, HULL AND OUTFIT".

## 2.13 PROVISIONS FOR AUTOMATION, REMOTE CONTROL AND DATA LOGGING/ ANNUNCIATION

### 2.13.1 GENERAL

In respect of the main and auxiliary machinery installations, the Society's Rules contained in Chapter XV relating to the Class Notation EO for periodically unmanned machinery plants shall be complied with.

All equipment shall contain facilities which will provide independent interfacing to interlocking systems, automation, remote control and data logging equipment, safety systems generally as follows.

### 2.13.2 STATUS INDICATION

Where required by the Rules, or otherwise indicated by the Engineer, equipment shall provide independent, dry auxiliary contacts (2 wire connection). Where required, auxiliary slave relays shall be supplied to provide additional dry contacts for such independent functions as follows:

(a) One set of contacts for data logging
(b) One set of contacts for feedback to remote control/ interlocking system.

### 2.13.3 ALARMS - CONTACT

Where required by the Rules or otherwise indicated by the Engineer, all alarm indications, where provided by contact closure/opening, shall be dry contacts (2 wire) connected as follows:

(a) One set of contacts for connection to remote annunciator system

(b) One set of contacts for connection to data logging system.

(c) One set of contacts for safety operation system (if required)

NOTE: Trip indication shall be addition to status, where required, and in some cases may also be employed for safety operation and initiating automatic shutdown (refer (c) above).

2.13.4 ANALOG

Where required by the Rules or otherwise indicated by the Engineer, approved transducers shall be provided, having approved signal conventions, for connection via two wires to the monitoring and alarm data logging system, as well as remote indication associated with unattended operation of machinery compartments.

2.13.5 CONTROL

Where required by the Rules, or otherwise indicated by the Engineer, all machinery shall have provision for remote control and indication. Such remote control facilities shall be either pneumatic, hydraulic or electrically actuated as required, with appropriate indication feedback to the Engineer's approval.

2.13.6 SYSTEM INTERFACE - CONTROLS AND INDICATIONS

All the control, indication, alarm and logging wiring for the above electric control and indication facilities shall be marshalled to integrally located, clearly identified tunnel type terminal strips, with inbuilt isolation and test links, segregated from all other wiring, on each major separately located machinery cubicle or panel, all to the Engineer's approval. The location of such interface terminal strips

shall be such that access can be made without disruption to normal operation or danger to service personnel. Ease of access is also required for installation purposes.

All control and indication piping for pneumatic or hydraulic control facilities shall be similarly routed to screwed unions located at a convenient point suitable for quick disconnection, all to the Engineer's approval.

All control and indication/alarm wiring, as well as pneumatic/hydraulic piping, external to machinery cubicles/panels shall be part of the automation, controls and data logging system for remote control and automation, except where interlocks, controls and specific status indications comprise part of the machinery installation and are integral to the operation of such machinery. In such cases, all interwiring or piping necessary for commissioning and operation shall be provided as part of the machinery system.

2.13.7 SEGREGATION AND ISOLATION OF POWER SUPPLIES

Generally, the following will be provided by the electrical system:

Power supplies for alarm systems and safety systems for auxiliary systems shall be completely independent.

Safety, control and remote control systems for main engines shall be completely independent with separate power supplies.

Loss of electrical supply shall not affect the position of steering gear.

Control circuits for remote operation of reversing shall be protected by separate circuit breakers.

## 2.13.8 FAILSAFE OPERATION

All contacts employed for alarm functions shall be provided as normally closed, such that failure of coil, open circuit, or power supply in addition to alarm condition will initiate an alarm (release alarm).

Interlock circuits shall similarly be arranged for failsafe operation.

Contacts employed for safety functions shall bc provided as normally open, such that inadvertent open circuit conditions do not initiate safety shutdown of equipment.

Power supplies to safety and alarm systems shall be independently monitored and alarmed in the event of failure.

## 2.14 SPARE PARTS

Spare parts shall be provided to satisfy the Rules for the class and notation required.