

**New Polar Research Vessel (NPRV)
Statement of Requirements (SoR) Section 6**

Formula to apply to a storage location where ventilation may be taken into account to allow for gradual release

$$C_t = L \div (V \times n)$$

Where:

C_t = % gas concentration,

V = room volume (with height above 2m discounted),

n = air changes per hour and

L = gas release (m³ per hour)

Worked example for gradual release

A room 5m long x 4m wide x 2.5m high located at ground level with one air change per hour (ie very poorly ventilated) houses a large 200 litre pressurised dewar containing liquid nitrogen. The dewar manufacturer quotes an evaporation rate of 4 litres per 24 hours. As the manufacturer's quoted evaporation is for a new dewar and insulation deteriorates over time, this evaporation rate is multiplied by two.

$$L = \frac{8 \times 683}{24 \times 1000} = 0.228 \text{ m}^3 \text{ hour}$$

Volume of room = 5 x 4 x 2 = 40 m³ (note: height used in calculation is 2m not actual room height of 2.5m) and no of air changes is 1

$$C_t = \frac{0.228}{40 \times 1} = 0.0057 = 0.57\%$$

This means the room O₂ concentration shall be 21 - 0.57 ≈ 20.4% which is not a problem.

Formula to apply to a location where loss during filling operations needs to be taken into account

It is normally assumed that up to 10% of the fill may be lost during filling.

$$V_o = 0.21 \times (V_R - \frac{0.1 \times V_D \times f_g}{1000})$$

Where:

V_o = volume of oxygen in the room in m³

V_R = volume of room in m³

V_D = capacity of dewar in litres

f_g = expansion factor

Worked example for loss during filling:

Volume of dewar is 30 litres, cryogenic liquid is nitrogen, volume of room (up to 2m height) is 40 m³ :

$$V_o = 0.21 \times (40 - \frac{0.1 \times 30 \times 683}{1000})$$

$$= 7.97 \text{ m}^3$$

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The concentration of oxygen in the room immediately after filling would be

$(7.97 \div 40) \times 100 \approx 20\%$ which means there would be no problem.

This formula can be modified to take into account the effect of loss during filling followed by a 100% spill. In this case the 0.1 multiplier applied to represent a 10% loss of fill (in the worked example 3 litres) is increased to take account of the full volume of the dewar i.e. becomes 1.1 (30 litres total volume of dewar + 10% loss during filling).

APPENDIX 6

ENVIRONMENT AGENCY GUIDELINES TO INSPECTORS: LABORATORY DESIGN FOR RADIOCHEMICAL LABORATORIES

http://www.nottingham.ac.uk/safety/RA_EA_GuidelinesLabDesign.htm

The Environment Agency has produced guidance applicable to laboratories in teaching and research establishments and this is reproduced below. This guidance shall be borne in mind when designing new facilities. The main criteria to be met is that:

- the floor, ceiling, walls, furniture and fittings in any part of the premises where a registered substance is used are maintained in such a condition that they can be easily cleaned.

This requirement for surface finishes which can be easily cleaned is now stipulated in the regulations for the use of other hazardous substances as well. Surfaces shall be impervious to water and offer resistance to acids, alkalis, solvents and disinfectants.

Some aspects of laboratory design have not been fully covered in the EA Guidance, or alternatives are to be recommended, and these are summarised as follows: -

Floor coverings - shall have minimum number of joins, full coving is recommended for higher grade areas but coved skirting which seals the gap between floor and wall may be adequate and more economical for many areas.

Walls and ceilings - painting with vinyl emulsion is not recommended. Acrylic emulsion provides a much harder more durable surface and for higher-grade labs oil-based paints, either in eggshell or gloss give a hard surface that is easily cleaned without surface damage.

Wash-hand basin - taps shall be of a type that can be operated without being touched by hand (e.g. knee operated ones or ones utilising optical sensors).

Changing facilities - as a minimum, somewhere to hang lab coats shall be provided near the entrance to the laboratory. It is usual to provide a lobby/changing area for higher-grade laboratories.

Fume cupboards - if a fume cupboard shall be used for containment when working with substantial quantities of a hard gamma emitter then the plinth will need to support a considerable amount of lead shielding (possibly up to 1,000 kg).

Seating - stools and chairs shall either be non-upholstered or upholstered in non-absorbent material.

Environment Agency - Guidance on standards for radiochemical laboratories - in non-nuclear premises.

1. Introduction

1.1 This Note provides guidance to Inspectors on the key considerations, from the Agency's perspective, for laboratory facilities on premises where "open" radioactive sources are kept and used.

1.2 This Note focuses on radioactive waste management implications. It does not specifically cover radiation safety and the protection of workers on premises, which may give rise to additional requirements such as radiation shielding. However, nothing in this Note shall conflict with occupational radiation safety considerations, e.g. those in the Ionising Radiations Regulations. As the matters dealt with in this note are of common interest to the Agency and HSE, Inspectors shall consider liaising with colleagues in HSE on specific cases.

1.3 By its very nature, any use of open sources is dispersive to some extent, and there will inevitably be arisings of radioactive wastes that will need to be managed. There is a requirement to ensure that any radioactive waste that is generated is of such a type and quantity that it can be disposed of by an available route, and to prevent any disposal of radioactive waste by an unauthorised route. Additionally, in accordance with Government policy on waste minimisation, the Certificates of Registration issued by the Agency under the Radioactive Substances Act 1993 require that, so far as is reasonably practicable:

- the amounts of radioactive waste that do arise are minimised; and
- all relevant parts of the premises are constructed, maintained and used in such a manner that they do not readily become contaminated, and that any contamination which does occur can easily be removed.

1.4 The purpose of this Note shall expand on those requirements so as to provide guidance on the standards which users are expected to apply. This is neither prescriptive nor exclusive, and there may be other appropriate means of compliance in specific circumstances. Clearly this Note is not a detailed design guide, and users shall be expected to consult relevant publications on laboratory design and to take advice before constructing a new radiochemical laboratory.

1.5 The benchmark for the standards given in this Note is a new radiochemical laboratory. Inspectors shall always have regard to the criterion of reasonable practicability; therefore it may not be appropriate to impose these standards where any of the following are involved:

- existing facilities
- holdings only of the less-radiotoxic nuclides such as tritium or carbon-14
- or minor usage, such as a few radioimmunoassay kits;
- or "one-off" (as opposed to continuing) uses

1.6 Specific guidance has been produced by the National Radiological Protection Board on the categorisation and designation of radiochemical laboratories (Ref 1). It shall be noted that the categories and associated facilities are based on occupational radiation exposures, rather than waste minimisation principles, and a proposal involving the facilities indicated by NRPB Categories IV and V may need particular scrutiny from the Agency's perspective. Nevertheless they are a useful indication of what may be expected at various levels of work.

The Association of the British Pharmaceutical Industry has also published specific guidelines for that industry (Ref 2).

1.7 In the following sections, extensive use has been made of points contributed by user organisations (Refs 3, 4) which are acknowledged with thanks.

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2. Floors

2.1 The floor shall be covered with an impervious surface such as a **continuous** sheet of PVC or linoleum at least 2.5 mm thick. The covering shall be covered to the walls to a height of about 15 cm contiguous with the floor surface. All edges at the walls shall be sealed or welded to prevent seepage of spilled materials.

2.2 Joints between sheets are not recommended, but may be permitted if the joints are welded and inspected to ensure the absence of a seepage path for contamination.

2.3 Any non-slip sealant material used to facilitate cleaning may be applied provided that spilled materials can be easily removed during the decontamination procedure. Generally, epoxy resin coatings are easily decontaminated.

2.4 As an alternative to a sheet material covering (such as PVC), an epoxy resin coating may provide an acceptable finish on smooth concrete.

3. Walls and Ceilings

3.1 The walls and ceilings shall generally be smooth and painted with a hard gloss or high quality waterproof vinyl emulsion to facilitate cleaning. (B S 4247 Part 2). The use of stippled surfaces or a paint finish applied to un-plastered concrete blocks, may be undesirable.

3.2 A note of caution: many paints undergo chemical or physical reactions with certain radio-nuclides. A more important criterion may therefore be the ease with which the paint can be stripped off again rather than its cleaning properties. A known problem occurs with chloride ions, which may bind irremovably with painted surfaces.

3.3 Suspended ceilings may potentially cause problems due to penetration of contamination.

3.4 Joints shall be sealed or filled with silicone type materials to facilitate cleaning (or removal in the event that decontamination cannot be achieved). Service penetrations in walls and ceilings shall be sealed and coved.

4. Doors and Windows

4.1 Wooden surfaces shall be covered with plastic laminate material or painted with a good quality polyurethane gloss paint or varnish. See 3.1 and 3.2 above.

4.2 Security of keeping radioactive materials is essential and therefore doors shall usually be lockable to ensure safekeeping or to restrict access in the event of major spillage of the materials. Doors leading off public places and which are frequently opened may additionally be secured by use of a keypad lock. For some sites, for example in the pharmaceutical industry, the user may provide a high level of security for a building and/or an entire site, rather than for an individual laboratory within a building.

4.3 Where opening windows are fitted, care shall be taken that no persons shall be affected by any release of radioactivity immediately outside. Open windows shall not be used as intentional discharge routes.

5. Benches

5.1 Working surfaces shall be smooth, hard and non-absorbent and have necessary heat and chemical resistant properties. All gaps and joints shall be sealed with a silicone type material. Depending on the type and quantity of radioactive materials used, account may need to be taken of the problems involved in decontaminating certain materials used for bench surfaces.

For example:

"Corian" apparently locks onto iodine (e.g. I-125) in several chemical forms;

Melamine fixes sodium ions (e.g. Na-22) under some conditions;

Stainless steels may bind phosphate (e.g. P-32) or chromium (e.g. Cr-51) firmly and may be very difficult to decontaminate (Ref 4).

5.2 The bench tops shall be coved (upstand) at the rear against walls. Gaps shall be sealed with a silicone type material. Bench tops may also have rounded front edges (lipped) so as to give fewer entry points for contamination - although some users feel this increases the likelihood of spills on to the floor, as the operator may misjudge where the flat surface of the bench finishes. Some bench top designs have a raised front lip, which can help prevent a spillage running off the bench on to the floor.

5.3 Exposed wood, including under benches and under bench cupboards, shall be painted with a good quality hard gloss paint or polyurethane varnish or laminated. The use of wood surfaces shall be avoided on all new laboratory designs.

5.4 Users shall carry out inspections to ensure that cracked surfaces are repaired or painted as appropriate.

5.5 Dedicated areas of bench shall be set aside for radioactive work and be clearly delineated. It is good working practice to work in plastic or metal trays on bench tops - and, especially, in dispensing / preparation cabinets where larger quantities of activity are involved - to minimise spills and spread of contamination. Disposable absorbent coverings such as "Benchkote" may similarly be useful - but as a supplement to, rather than instead of, proper bench surfaces: these coverings may therefore best be used inside trays.

6. Waste Disposal Sinks and Drainage Pipes

6.1 Sinks for the disposal of radioactively contaminated aqueous liquid waste shall be constructed of suitable material: for most applications, stainless steel is preferred. Where possible, combined sinks and draining boards shall be used, with rounded front edges and coved (upstand) at the rear against walls. Ideally an easily decontaminatable rear splash plate shall extend a reasonable distance up the wall behind the sink. Side splashguards may also be useful.

6.2 As noted in 5.1 above, phosphate ions may bind strongly on to stainless steel, and this may cause problems in laboratories where P-32 is used in quantity. (Similar problems may arise where old-fashioned sinks have been sealed with putty or in hard water areas where a calcium phosphate layer may be precipitated in the sink). Borosilicate glass sanitary ware may be appropriate in some circumstances.

6.3 Small diameter U-shaped or bottle traps shall be used, instead of large traps or catch pots, so as to avoid accumulations of radioactive sediments.

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6.4 The drain shall be connected as directly as possible to the main foul water sewer leaving the premises. Holding tanks are generally undesirable in terms of sedimentation, but may be used by some industries for other reasons - such as confirming compliance with chemical discharge consent conditions. The discharge route shall be mapped and recorded for future reference in case of maintenance on the system. Drainage system materials shall take into account the possible build up of contamination on surfaces. **NB.** All drainpipe materials may retain specific radionuclides. The most generally useful type - "vulcathene" fixes iodine very strongly - which may be significant where the radio-iodines have to be disposed of through drains of this material.

6.5 Drainage pipes for radioactive effluent shall be labelled with the ionising radiation symbol up to a point at which their contents are diluted substantially with frequently - flowing, non-radioactive effluents. This shall alert maintenance staff and thus prevent unauthorised disposal of any contaminated pipes removed during maintenance work. Pipes shall be well-supported along a suspended run, shall be down-sloped to prevent accumulations of radioactivity, and, where reasonably practicable, shall be made accessible - for example by the use of demountable panels - and subject to periodic inspection so as to assure their integrity.

7. Ventilation and Containment

7.1 Dispensing or preparation of radioactive materials that may cause airborne contamination shall be carried out under conditions to prevent dispersal of the substances. In particular, volatile radioactive materials shall never be used in the open laboratory, only in appropriate containment such as a fume cupboard. Recirculating ventilation systems may be inappropriate for volatile radioactive materials.

7.2 General dilution ventilation (air circulation) shall be provided in all radioactive laboratories. Where small quantities of radioactive materials are used, this may be provided using an extractor fan mounted in a window or a wall.

7.3 Where larger quantities of radioactive materials are used, a guiding principle for effective control of contamination is that air movement shall be maintained from less-contaminated areas to more-contaminated areas. This may be achieved for example by extracting from a general laboratory area through a fume cupboard to a discharge stack.

7.4 Inspectors shall note that the balancing of an extract ventilation system having a number of ducts, dampers and inlet points, so as to achieve design airflow rates, requires considerable skill and expertise. Alterations to damper settings by unskilled operators are therefore generally to be deprecated.

7.5 A contained workstation (Class I - III microbiological safety cabinet or fume cupboard) shall be used for dispensing or manipulation of large quantities of radioactive materials. Adequate ventilation by continuous movement of air into the workstation shall be checked regularly, preferably by measurement with an anemometer. Airflow criteria for fume cupboards are specified in BS 7258.

7.6 Internal and external surfaces shall be smooth, hard and non-absorbent and have the necessary heat and chemical resistant properties.

8. Radioactive Storage Facilities (Including Waste)

8.1 Adequate storage space shall be available to keep essential equipment in order to minimise the cluttering of equipment near working areas, and reduce the risk of spreading contamination. It may be desirable to have an area set aside for the storage of equipment awaiting decontamination.

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8.2 All refrigerators / freezers, and radioactive materials within them, shall be easily identified (labelled) and shall be lockable and shall be kept locked unless they are under surveillance, especially in large general laboratories. Refrigerators / freezers shall be regularly defrosted. It shall be noted that volatile radio-nuclides, in particular tritium, might accumulate in the ice: it is good practice for the user to check this periodically.

8.3 Waste disposal bins in the laboratory (used for storing solid waste awaiting disposal) shall be constructed of a material that is robust, and preferably shall be foot-operated. The lid shall be closed when not in use and the contents in the bag sealed or secured before removing them from the bin. All sharps, bottles, tubes, etc shall be placed in sharps containers to ensure safe handling of the, materials. Bins located outside the control of the user must be secure to prevent misuse of the contents.

8.4 Adequate storage space (e.g. a bunker or storeroom) shall be available for radioactive waste either inside or outside the laboratory. The storage space must be kept locked and may need to be under surveillance.

9. Other Facilities

9.1 Adequate **decontamination facilities**, including decontamination solutions, shall be available. "Decon" (and "Radiacwash", "Countoff" etc.) is principally useful where heavy metal contamination is present, as its special properties are in solubilising poorly soluble metals. In other circumstances, its performance may be similar to other phosphate free detergents. For most labs only the ordinary detergent used for washing up and liquid soap for hand washing shall be needed, although certain other more specialist cleaning agents may be used for special purposes. It is important that some of the old-fashioned laboratory cleaning agents such as chromic acid and permanganic acid are never used in radioactive areas (risks of fire, explosion and volatilisation of radioactive materials). More aggressive decontamination agents shall normally be held centrally, as they require specialised knowledge to use them properly and safely.

9.2 A **contamination monitor** shall be available and it must be appropriate for the type of radionuclides used in the laboratory. Indirect monitoring (by liquid scintillation counting of swabs taken from surfaces) may be needed for soft beta emitters such as carbon- 14 and (almost always) tritium. Records demonstrating that instruments are checked before use and are calibrated are required. A logbook shall be available to show that the laboratory is regularly monitored (benches, sinks, floors, drainage traps and equipment), that the results are recorded, and that any necessary decontamination is carried out.

9.3 **Tacky mats** may usefully be installed in laboratory doorways, to prevent the spread of contamination. Monitoring of these mats may give early warning of a contamination problem.

9.4 A designated **hand wash basin** shall be provided: it must never be used for the disposal of radioactive substances (other than traces from the washing of hands).

9.5 **Warning signs**, clearly and legibly marked with the word "Radioactive", with the Ionising Radiation symbol conforming with BS3510: 1968 or ISO 36 1, and any other information necessary (contact person, telephone number, etc), shall be placed on doors, cupboards, equipment, refrigerators, working areas, drainage pipes, sinks, storage facilities, sewers, exhausts as appropriate. An indication of the maximum holdings in the laboratory may usefully be included on the sign placed on the door. Warning signs shall only be used when there is a real possibility of contamination: in particular, indiscriminate use of "radioactive" warning tape shall be avoided. Generally, ancillary items such as pens and books shall not be used where there is a possibility of contamination and therefore shall not require warning signs.

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9.6 Adequate **lighting** shall be provided throughout the laboratory, particularly to enable operators to see spillages easily.

9.7 Particular considerations apply to users who handle **tritium in quantity**. Although this is a rather specialised field affecting relatively few users, nevertheless Inspectors may find it useful to be aware that tritium may be readily converted to tritiated water, which when allowed into the working environment moves with atmospheric water vapour. It is taken up by most common materials - wood, paper, clothing - and this can make them impossible to decontaminate. It is the usual practice for a facility handling large amounts of tritium to be separate from other buildings to prevent the spread of radioactivity beyond the controlled area and to allow any escape to be diluted by the outside atmosphere.

References

1. *A P Hudson and J Shaw, 1993. Categorisation and Designation of Working Areas in which unsealed Radioactive Materials are Used. National Radiological Protection Board Memorandum NRPB - M443.*
2. *Association of the British Pharmaceutical Industry, 1996. Guidelines on the Control of Radioactive Substances in the Pharmaceutical Industry. Published by the ABPI, 12 Whitehall, London SW1A 2DY.*
3. *South Birmingham Area Health Authority, Personal Communication.*
4. *D Walland, University of Bristol, Personal Communication.*

6.3 OPEN DECKS

6.3.1 Aft Working Deck

R6.128 The working decks shall be designed with as much clear area as possible.

The area shall be clear of all obstructions as far as is possible. Ventilators, air pipes, services, etc. shall be built into and recessed into the bulwarks and superstructure boundaries where appropriate.

The following features are required:

- Arrangements for loading / discharging loads of up to 50t.
- Arrangements for loading/discharging portable science laboratories and equipment and repositioning them anywhere on the working deck.
- Timber sheathing over the areas used for science working deck.
- Clear height generally not less than 5.5m, open in way of the core handling area.
- Opening sections of bulwark in way of overboard deployment locations, between the "A" Frame legs on the stern and starboard side. Those sections which shall be opened manually. These sections are to have rounded smooth tops to allow nets to come in over the top and avoid the need to harness up during operations to remove the stanchions.
- At least three overside tow positions.
- Good scupper arrangements to drain surface water plus raised gratings where required to allow mud to wash away.
- Hatches are generally to have adequate coaming, dogging arrangement and hydraulic operation for hatches greater in size than required for personnel access.
- Ease in method of transferring equipment from hangar gantry and between deployment positions on the aft deck and on the starboard working deck.
- Flush decks (Aft Working Deck, Starboard side, including access to the Science Hangar) to allow movement of box-core trolley and pallet trucks.
- Enough space to deploy WASP (Wide-Angle Seabed Photography) safely from the starboard gantry.
- Capability to use camera systems (e.g. SHRIMP - Seabed High Resolution Imaging Platform) to 6500m using fibre optic/electrical conducting wires (preferably capable of 3-phase conducting).
- Ability to deploy Landers, mooring and ocean bottom packages (to include laboratory components) [side recovery / 4m clear deck / access to hangar from side].
- Winch / cable / system capable of deploying vertical nets (e.g. WP2) to a depth of 500m from a midship position.

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- Mid-water and surface trawl using equipment such as RMT (Rectangular Mid-water Nets) nets.
- Acquisition of benthic samples of the ocean bottom at depths up to 9000m.
- Separate deployment position from starboard gantry.
- Facility to embark Seismic Compressors (4) on deck - power, cooling, drainage and HP air distribution only.
- CCTV surveillance to be provided to all areas, especially where lone working required.
- All external deck working areas to be covered by at least two cameras.
- Multi-screen displays to be used for winch operating stations, being fully selectable
- Distributed Deck Hydraulics System.
- Supply of power to the decks to support a variety of portable winch systems.
- Air supply - uncontaminated air intake, low pressure to various science spaces.
- Capability to accommodate the deployment and recovery of existing equipment (variable nets, CTDs, ROV).
- Large radius transition between the deck and transom between the legs of the stern "A" Frame. Minimum radius of the transition to be 1m.
- Trip hazards shall be avoided.

The gross area of the Working Deck shall be 650m², of which 500m² shall be available for science equipment.

Conflict between cargo handling and stowage and science equipment and portable laboratories shall be avoided. Each shall have designated areas. Cargo handling, including opening cargo hold hatches shall be possible without moving science equipment mobilised onboard or portable laboratories. Deck cargo is therefore expected to be stowed on the cargo hold hatches. Cargo stowed on deck shall not obstruct access for science activities or safe operation of the ship.

It shall be fitted with substantial solid bulwarks.

Three hydraulically operated bulwark gates shall be provided on the starboard side, each 4m wide. The gates shall be of similar construction to the bulwarks. They shall be hinged to the fixed bulwarks and held closed by cross bolts and bolts into the deck. In the open position they shall be kept open by bolts into the deck. Locations are as indicated on the Concept General Arrangement Drawing.

Substantial bolted sections of bulwark shall be provided in way of known temporary over-side equipment positions e.g. ROV LARS. These removable sections shall be fitted with lifting eyes for handling by the ship's cranes. Similar removable sections shall be provided to port and starboard outboard of the Stern "A" frame.

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The deck is to be fitted with container Twistlock sockets and tie down arrangements ISO standard 20' containers, see section 6.3.15

The Aft Working Deck shall be arranged with recessed flush fitting container twistlock pockets to secure a mix of cargo, portable laboratories and science equipment, as indicated on the Concept General Arrangement drawing.

Cargo containers shall be stacked transversely, two high, with a stack weight of 40t. Portable science containers or containerised equipment may be assumed to have a gross weight of up to 20t.

The design and construction of the deck plating and its supporting structure shall be carefully undertaken so as to resist the formation of hollows where water could gather and form a slip hazard in very low temperatures.

6.3.2 'A' Frame & Science Crane Pedestals on the Aft Deck

R6.129 Integral structural pedestals shall support the Stern "A" Frame and Science Cranes.

They shall also provide ventilation and access to the spaces below (and emergency escapes from the aft end); carry power, data and air services for deck equipment, and communications equipment.

Handrails shall be provided on the inboard side of the pedestals for safety and the attachment of safety harnesses.

Eight lashing cleats (400mm) shall be fitted on the inner side of the pedestals.

6.3.3 Starboard Side Working Deck

R6.130 The area shall be clear of all obstructions as far as is possible.

Ventilators, air pipes and deck service hydraulic and electrical connections shall be built into or recessed into the bulwarks or superstructures.

It shall have a minimum general width of 4m in way of the over the side handling area, unobstructed by support structures for over the side handling systems.

It shall be fitted with a bolting down matrix at 500mm spacing. The outboard line of bolting points should not be more than 200mm from the ship side.

It shall be fitted with substantial solid bulwarks, free of snags to light lines used in conjunction with equipment over the side.

6.3.4 Starboard Side CTD Handling

R6.131 The CTD Rosette shall be deployable over the starboard side and the moonpool. The metal free CTD shall be deployed over the starboard side only.

6.3.5 Coring Capability, Temporary Installation

R6.132 Space and services for coring capability is required on the following basis:

- Capability – up to 42m long cores (125mm dia) recoverable from 6000m and 25m long cores recoverable from upto 7500m.
- Chilled storage area for limited number of sediment cores (50 nos. 1.5 m lengths). Storage for other types of samples, i.e. multi-core tubes, box core sub-cores, sample bags to be considered when designing racking. Freezer space for frozen samples. A purpose modified chilled storage container shall also be required for dedicated coring cruises (up to 500 nos. 1.5 m split core halves).

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- Ability to wash mud from the coring deck without flooding the deck by installation of removable threshold on deck using the bolting matrix.

A clear area of deck encompassing the handling areas of the over-side lifting appliances of at least 45m in length and 4m width is required for piston coring.

Piston coring equipment must accommodate loads of 2 tons + coring head + 42m conventional piston corer + 7000m wire + pull-out load that can be generated when coring in deep water. NOTE: Coring equipment is not part of the required scope of supply.

Consideration to be given to the movement of delicate core samples from the starboard deck to the Wet Laboratory such that walking through airlocks and “clean” alleyways is minimised.

6.3.6 Starboard Side Access & General Working Deck Bulwark Arrangements

R6.133 On the starboard side clear access over the bulwarks with no obstruction over bulwark height shall be provided for a distance forward of a minimum 55m from the corner of the transom. This shall facilitate handling of various long and heavy items of equipment including large piston corers.

On the port side clear access over the bulwarks with no obstruction over bulwark height shall be provided for a distance forward of a minimum 13m from the corner of the transom.

The bulwark top rail shall be constructed using a tube section over which wires and ropes can be deployed and to which items of equipment can be attached.

Bulwark stanchions shall be fitted with lashing cleats, 400mm size, at a spacing no more than 2.4m throughout.

The deck edges shall be fitted with 75mm up-stands to contain any spillages on deck.

Freeing ports shall be incorporated wherever possible. To ensure proper and rapid drainage of the working decks large diameter scuppers shall be provided. Each scupper shall be fitted with a grid and emergency plugs shall be provided for each one in case of oil spillages.

Overboard drains should be carefully arranged not to discharge above windows or portlights.

6.3.7 Other Accommodation Open Decks

R6.134 Gangway boarding positions shall be arranged at the Main Deck port and starboard. These entry positions shall be arranged with security camera arrangements providing clear unambiguous imagery.

Adequate external deck areas shall be allocated for recreational purposes. Subject to the location wind screens shall be provided.

All open decks shall be fitted with large diameter and sufficient numbers of scupper drains. Upper deck drains shall be led downwards to lower decks with their discharge points plumbed into or discharging very close to the lower deck drains. Deck drains accumulating water from decks above shall be increased in diameter accordingly to ensure proper drainage. Any accumulations of drain water on decks, including ponding, found during tests and trials shall be required to be dealt with before vessel acceptance.

Since the vessel may operate at any time with a permanent small list or trim and particularly so when in port mobilising or demobilising, care must be taken in the design to avoid areas of deck where water can gather and not drain away.

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Overboard drains should be carefully arranged not to discharge above windows or portlights.

6.3.8 Access to Lifeboats, Liferafts & Rescue Boats

R6.135 Lifeboats, Liferafts and Rescue Boats shall be located as indicated on the Concept General Arrangement Drawing. As far as practical the stowage positions shall be protected and semi enclosed. Ship side enclosure shall be affected using soft fabric curtains which are intended to maintain some environmental protection. These curtains shall be easily opened in case of emergency. In case of difficulty in opening the curtain the deployment system is not to be impeded.

Evacuation egress positions shall be provided with steps, ladders and walkways necessary for the safe evacuation of the vessel, in addition to routine exercise, inspection and maintenance.

6.3.9 Deck Coverings, and Coating

R6.136 The Science Working Deck, Science Hangar shall be timber deck sheathed.

In each case the deck shall be thoroughly cleaned and degreased and shot blasted. It is then to be hot metal sprayed with a suitable anti-corrosive material. The whole area shall be protected from wind and rain during the process and the atmosphere temperature controlled where necessary.

The timber shall be a minimum of 65 mm thick and shall be of properly prepared close grained hardwood, equivalent or better, well-seasoned, free from sap, shakes, warps and other defects and shall be reasonably free from knots. All wood shall be impregnated with anti-pest and anti-rot composition.

It shall be attached using recessed deck studs, washers and nuts and the recesses filled with wood plugs glued in place.

The whole deck shall be sanded smooth on completion of fitting and before caulking.

The timber shall be laid on a resilient waterproof sealing compound and shall be caulked and sealed with a modern resilient caulking compound (e.g. Sikaflex). Deck timbers shall be laid under totally dry conditions. The timber itself shall be maintained in a totally dry condition before laying.

The deck area and any cut-outs around deck attachments shall be fitted with steel coaming bars welded to the deck. Gutterways shall be provided as necessary particularly at the deck edges or space boundaries taking into consideration ice accretion.

Working Deck areas which are not timber clad shall be coated with a non-slip paint system coated with an epoxy based resilient, impact resistant, deck compound of minimum thickness 15mm (e.g. Trawlerdeck or equivalent).

6.3.10 Bolting Down Matrix

R6.137 The working deck areas shall be fitted with a matrix bolting down system with 1000mm x 1000mm spacing. A further allowance of 100m² shall be made where the spacing shall be specifically reduced to 500mm x 500mm.

The typical bolting point socket shall consist of a 50mm diameter round bar drilled and tapped with a blind hole of depth 50mm to take a M24 bolt.

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The round bar section shall be long enough to be integrated by welding into suitable under deck structure. The socket shall be provided with a grub screw for temporary closure when not in use. Its material shall be bronze or stainless steel and shall have a screwdriver slot or hexagonal socket (Allen key). All screwed plugs to be fitted using anti-seize compound, e.g. Copperslip.

The primary loading of the bolting matrix is shear parallel to the deck. 'Pull out' or compression loading shall be taken as 5 tonnes and Safe Working Load shall be 1 tonne..

The socket shall be arranged flush to the deck plating or the deck covering (e.g. timber) where applicable.

All sockets shall be tested to the requisite pull-out loading and a certificate supplied.

A purpose designed and substantially constructed testing device shall be provided for regular proof loading of individual matrix sockets by the ship's crew.

6.3.11 Wheelhouse / Observation Lounge Top (Open Deck)

R6.138 This shall be primarily an aerial platform for both ship systems and scientific systems. It shall have easy internal and external access.

It shall be equipped with at least 12 mounting points to which portable equipment can be securely bolted. Portable equipment shall be assumed to be of up to 100kg in weight. Means shall be provided for lifting such equipment to the required position without the use of shore cranes.

Two areas of bolting matrix using M12 sockets shall be provided totalling 10m². A further area having a bolting matrix at 1000mm spacing shall be provided on an open deck having good aerial line of sight over at least 180 degrees of continuous arc.

It must be large enough to allow careful placement of equipment to avoid interference between transmitted and received signals.

The deployment of transmitting equipment must be such as to allow safe access for personnel at all times. The Observation Lounge top outside the Crow's Nest shall be used as an observation platform for, for example, cetacean and bird life studies. Two observation posts, one port and one starboard shall be arranged. These shall be open wind 'dodger' structures with room for two persons.

Consideration needs to be given to the location of sound signalling apparatus so as not to cause a restriction to access in this area.

6.3.12 Science Hangar Top

R6.139 Open decks utilised for scientific winch wire routing are to have general access confined to prescribed routes and personnel shall be protected from injury by guard rails and protective fences where necessary.

6.3.13 Container Slots

R6.140 The aft working deck shall be arranged with recessed flush fitting container twistlock pockets to secure a mix of cargo, portable laboratories and science equipment, including the following:

- Cargo containers stacked transversely over the cargo hatches, assume 2 high, 20ft cargo containers, each 20t. (14 positions)
- Portable laboratories, based on combinations of 8ft, 10ft and 20ft containers, each up to 12t (20ft units), stacked up to two high (40 positions).
- Skid mounted science equipment, such as AUV launch and recovery systems, ROV systems.

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The Science Hangar Deck shall be arranged with recessed flush fitting container twistlock pockets to secure a mix of portable laboratories and science equipment, including the following.

Wherever possible and appropriate the containers shall be constrained by guides.

Plate and angle guides shall be fitted to assist in location of the container when loading and to protect adjacent structures and equipment from impacts (applies to Cargo Holds and Science Hangar only).

Laboratory and machinery container slots shall be provided with the necessary service modules located alongside.

Indirect access shall be provided from the Deck Laboratory to other Laboratories

Containers and Machinery / Equipment containers located within the Science Hangar. This indirect access shall be undercover and protected from the outside environment. Lobbies shall be provided into which containers can be 'plugged' and sealed in place.

The lobbies are to have all the necessary service points for connections to be made to the containers.

Where containers are or can be connected to the vessel via means of a lobby an inflatable pneumatic seal should be provided.

6.3.14 Container & Deck Services

R6.141 The Contractor shall install comprehensive service points for containers and deck operations.

Container servicing points shall be fitted adjacent to individual containers or groups of containers and be either in a protected environment or contained within a protective enclosure.

The following Services shall be run for containerised science equipment as follows:

General Container Laboratories (each location)

- Fresh water supply
- Clean seawater supply
- Cooling Water
- Scientific low pressure compressed air
- Ethernet and low power network connections
- 415V, 3 phase, 63A, 50 Hz
- 415V 3 phase distribution
The inlet shall be 4 pin (3p + E), IP67 rated to IEC- EN60309-2.
- 230V, single phase, 50 Hz
- 230V, single phase, 50 Hz Clean
- 110V, single phase, 60 Hz Clean
- Control and Data connections Junction Box

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- Common earth connection
- Temporary use cable trays.
- Ship's telephone system connection
- Ship's general alarm and fire detection system connection.
- Roxtec gland assembly size approx. 120 mm x 160 mm for gas pipe/cable entries.
- Drainage

Other Specific Containers which would utilise the same services as above (each)

Seismic System Containers 4 (each container)

- 415V, 3 phase 250kW, 50 Hz housed in suitable IP rated junction boxes.
- 230V 32amp single phase housed in suitable IP rated junction boxes..
- One electric motor driven two speed high pressure air compressor capable of producing 442 cu.m/hour (260 cfam/min) low speed, 663 cu.m/hour (390 cfam/min) high speed, at 200 bar pressure with a power supply of 415v, 3 phase.
- High pressure air for 4 umbilical hose winches for seismic air guns is supplied by up to four air compressor containers. No permanently fixed pipework is foreseen.

Deep CTD winch

Hydrographic winch

Radionuclide Laboratory Container

- 415V 3Phase Distribution
The inlet shall be 4 pin (3p + E), IP67 rated to IEC- EN60309-2.

Ultra Clean Chemistry Laboratory Container

Constant Temperature (Biology) Laboratory Container

Atmospheric Laboratory Container

Aquarium Container

Aquarium Transport Container

Containerised Multi-Sensor Core Logging System (GeoTek)

Biosecurity Requirements. Container

Aerosol Container

Requires 220V 3-phase power with neutral line – should be supplied from an independent transformer in order to give *“The configuration that works if supply is routed through a star configuration transformer with the star point tied to earth*

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Normally also need compressed air and a vacuum line. Ideally, we would have pumps providing these within the ship itself as they can get rather noisy. However, this means feeding 1 inch reinforced tubes around, with two tubes between the container and the pumps and an extra line between the pumps and the outside world to vent out butanol vapours”

All positions shall be protected from their respective environments by suitable enclosures

6.3.15 Container Handling & Securing Twist Locks

R6.142 A number of twist locks shall be provided, sufficient to secure the maximum specified number of containers to be stowed onboard, plus a reserve of 50% spare.

One semi-automatic 20ft container spreader shall be supplied for handling both cargo containers and portable laboratories that may be configured within a standard ISO cargo container frame and corner fittings.

6.3.16 Hydraulic Power Distribution System for Science Equipment

R6.143 The Contractor shall design, supply, and fit a dedicated hydraulic power distribution system to service scientific equipment brought on board and temporarily installed on working decks or in working spaces.

The system shall be compatible with the ‘open circuit’ hydraulic design of the equipment which will be connected to it.

An electro-hydraulic machinery space shall be provided convenient to the working decks. It shall be located and specified such that any noise must not impinge on accommodation or laboratory areas and must not contribute to the underwater noise signature.

Hydraulic power shall be distributed to 8 systems of manifolds at:

- Two positions on each side of the Aft Working Deck
- Two positions at the aft end of the hangar to service HP air containers or machinery containers in the deck slots
- One position in the forward part of the Hangar.
- One position forward on the Starboard Side Working Deck
- Crane power packs

At these positions there shall be pressure, return and drain line connections with bayonet type self-sealing quick connectors. Each system comprises the following :

- Pressure (P1 - 5) – Pressurised supply
- Return (R1 - 5) – Zero Pressure return
- Drain (D1 - 4) – Zero pressure return line to tank

Lines 1 - 4 should have a capacity of 75 litres/minute, whilst P5 should have a capacity of 150 litres/minute noting the criteria below.

The supply pumps should be arranged so that any outlet can be individually selected and pumps connected to supply that outlet in 25 litres/minute steps up to the 75 litres/minute maximum rate. The 150 litres/minute outlets also required to be individually selectable, though the supply capacity can be supplied from a single

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source pump i.e. does not require steps, though the option to vary the flow rate would be desirable.

The manifolds shall be recessed within the line of the bulwark stiffening and be suitable for prolonged exposure to a marine environment (SS316L). The piping shall be stainless steel and the deck penetrations shall be Roxtech or equivalent. Piping underdeck may be steel and painted. Connections on deck manifolds to be HyFit QR BSPP stainless steel coupling, male for return and drain lines and female for pressure lines.

The system shall allow the selection of which deck connections to put "in use", noting that in some circumstances all connections may require shall be "in use".

The power pack shall be of multiple pump type operating in cascade and delivering oil at flow rates exactly in accordance with demand.

Particular attention shall be paid to noise levels generated by the power pack and the choice of pump type must be made with this consideration in mind.

The operating pressure shall be a maximum of 200 Bar.

All pump, tanks, manifold units, controls and piping shall be resiliently mounted to prevent transmission of noise and vibration into the hull structures.

All connections to be fitted with blanking caps/covers to protect from dirt and weather when not in use.

Flushing

After assembly and during the first operation of the oil systems the lines to be flushed through, using the medium intended for the service, with exception of lubricating oil and diesel fuel oil lines.

Filters used for hot oil flushing to be:

- For hydraulic systems 100 µm
- For lubricating oil systems </- 20 µm
- Filling of the lubricating oil systems to take place through 10 µm filters.

The cleanliness of each hot oil flushed system to be in accordance with:

- Biodegradable Hydraulic Oils
- Hydraulic oil ISO 4406 15/12
- Lubricating oil ISO 4406 17/14

6.3.17 Not Used R6.144

6.3.18 High Pressure Air Piping Systems

R6.145 The Contractor shall design fit and test a high pressure compressed air system for use with our portable high pressure air compressor containers.

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A fixed distribution piping system shall be installed to service HP air compressor containers which shall be located on deck (these are shown on the Concept General Arrangement as Main Deck). There will be up to four 20' standard HP air containers of this type shall be carried.

This piping system shall provide a manifold close to the container locations nominated for the compressor containers, which will consist of a water / oil catch, a drain valve and an isolation valve to connect to containers via a caged flexible hose. All valves shall be to Hale Hamilton screw down specification, all pipework / fittings shall be Tungum / Keelering specifications.

The hard piping of the manifold shall have a Fisher Valve arrangement with suitable silencer and venting pipe work. The silencer shall be located away from any well used personnel thoroughfares and the exhaust shall point outboard with a sound deflector.

The hard piping shall then be split into two systems, one port and one starboard which are each split into two deck outlet connections on the aft deck, one located on each pedestal and one each on port and starboard bulwarks recessed within the line of the stiffening.

The test pressure of system shall be 400 Bar and the operating pressure shall be 200 Bar.

Power supplies shall be provided close to the locations nominated for the compressor containers. Each container will require power supplies of 250kW at 415V, 3 phase, 50 Hz and 230V 32amp single phase. These supplies shall be housed in suitable IP rated junction boxes.

All manifold units, controls and piping shall be resiliently mounted to prevent transmission of noise and vibration into the hull structures. All pipework shall be painted and labelled to comply with Lloyd's Register requirements.

Seismic High Pressure Air Standards

NERC will consider alternatives which, through the use of modern materials and production techniques, offer improvement with regard to robustness, durability, and cost effectiveness.

In the unlikely event that any of these standards create a conflict with the requirements of the Classification and Surveying Authorities then the requirements of the latter will generally apply. In such event however it is to be brought to the immediate attention of NERC who will discuss the issues with the Classification and Surveying Authorities directly.

High pressure air for 4 umbilical hose winches for seismic air guns is supplied by up to 4 air compressor containers.

Hard Piping

- HP Air piping to be Stainless Steel thick walled metric
- Appropriate connections with suitable re-mate able high quality couplings (Keelering) are required to be in accordance with relevant standards.
- Fisher valve arrangement, for piloted pressure regulation, with suitable venting location and piping is required along with a large effective silencer located high up on the superstructure away from personnel activity areas and pointing overboard so that noise is directed away from the ship.

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- Outlets on Aft Deck (Port side Bulwark, Port Gantry Pedestal, Starboard Gantry Pedestal, Starboard side Bulwark)
- Non return valve N52 (Hale Hamilton)
- Connections Stainless Steel JIC male, with caps.
- 3 Inlets from Containers (manifold(s) in suitable locations to allow connection by flexible hose to the compressor containers) each comprising;
 - ❖ Non return valve NRS 2 (Hale Hamilton)
 - ❖ Water/oil catcher with drain valve
 - ❖ Hale Hamilton screw down isolation valve
 - ❖ Connections JIC male, with caps.

6.4 POWER GENERATION, MACHINERY & EQUIPMENT

6.4.1 General Requirements

R6.146 All equipment shall be proven in service and come from reputable, financially sound, and recognised worldwide marine suppliers. They must not be 'first of the line' or 'last of the line', and shall be supplied with Lloyd's Register Classification for general marine use without qualification and fit for purpose in the operating environments specified in this Statement of Requirement.

The same supplier shall be responsible for the electrical power generation, distribution, propulsion and power management systems. However equipment within the scope of supply may be sub-contracted to a third party, subject to NERC's agreement.

The electrical power system shall be arranged with connection to the external communication system to allow remote access for fault diagnosis by the supplier. All machinery is to be provided with full facility manufacturer's diagnostics equipment and necessary licenses due to extremely limited opportunity/ difficulty of embarking service personnel for trouble shooting and diagnosis.

EXEMPLARS:

GE Power Conversion

Siemens

Wartsila

Spares shall be accessible worldwide and available for at least 25 years.

The choice of equipment shall be made on the basis of through-life cost, not just the initial capital value but to recognise the impact of future spares costs which are the responsibility of the NERC (held purposefully high by such foregoing suppliers in order to balance the books in the long term)

The main engines, alternators and all auxiliary machinery shall be constructed to the demands of the Classification and surveying authorities.

The machinery installation as a whole shall be suitable for continuous operation at the specified powers and outputs under the accelerations imposed by the operating environment specified at Section 4.6.

The power generation, distribution, propulsion, steering, dynamic positioning, auxiliary and domestic systems shall be designed and arranged to provide the minimum overall fuel consumption.

6.4.2 Main Engine Rooms & Propulsion Motor Rooms

R6.147 The vessel shall be arranged with redundant propulsion and steering systems and compartments, enabling full control over propulsion and steering in the event of the worst case single failure, including fire and flood of a machinery space, including Engine Rooms, Switchboard Rooms, Propulsion Motor Rooms, Shaft Tunnel and Steering Gear Rooms. It shall be possible to run both propulsion shafts with either one engine room flooded or a switchboard room on fire. For this purpose cooling water supply to shaft bearing, propulsion motor and associated VFD drives must have crossover over connection either Port or Starboard central fresh water cooling system.

There shall be cross over connection on power supply via two propulsion switchboards also for maintaining propulsion at reduced power. In such events it is accepted that performance may be degraded.

The ancillary systems required to support propulsion and steering shall also have sufficient redundancy to achieve these objectives.

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These Spaces shall also be arranged with independent safety systems, access and escapes.

Bidder to apply a PSMR* compliant system, however where the SoR stipulates more stringent requirements, then the SoR prevails.

6.4.3 Main Power Generation

General

R6.148 A diesel electric power plant (power station principle) is the required solution and power balances must be carefully considered to ensure that the most desirable mix of diesel alternator numbers and capacity are chosen to suit the varying operations. It shall be for the builder to calculate the power requirement for the different operating modes and cruise profiles of operations and demonstrate them to the purchasers.

Power generation solutions shall be submitted that can be demonstrated as having minimum through life cost, in terms of maintenance and fuel consumption. Solutions may include power generation at variable frequency.

EXEMPLAR:

*GE Power Conversion
Siemens*

In case of a variable frequency solution consideration shall be given to optimising noise and fuel efficiency to meet the criteria identified above.

A battery back-up system shall be installed as a means to operate with the minimum number of diesel alternator running to meet the electrical power demand, and avoid a blackout in case of failure of a running alternator set. Normal operation must not be affected due to fault in the battery system.

The harbour load shall be specially considered in respect of low load operation of diesel alternator sets. A harbour generator shall be installed. The harbour genset should be mechanical injection type if allowable. Alternatively electronic injection type can be considered. The harbour genset shall be supplied with enhanced range of spares and diagnostic laptop and necessary maintenance tooling.

In port load would be made up of air conditioning and ventilation, domestic, lighting and galley requirements, continuous and intermittent use of engine room machinery, intermittent use of mooring equipment and intermittent use of deck machinery.

See Section 4. Typical Cruise Profiles

6.4.4 Machinery Arrangements

R6.149 The arrangement of machinery shall be developed by the Contractor and the submitted for approval at an early date. Positions of ladders, machinery space ventilation trunks, manholes, electrical cableways and equipment handling facilities and routes shall be shown on this drawing. In general clear working spaces shall be arranged around all principal equipment at least sufficient for the maintenance of that equipment. Overhaul space, lifting arrangements and withdrawal routes shall be encompassed in the machinery space design and demonstrated during ship trials.

Removal routes for major components shall be provided for obsolete equipment required to be removed during the life of the vessel.

All large and small pieces of equipment which may require removal for maintenance such as electric motors, pumps etc. are to have lifting eyes located above and alongside so that they can be lifted and transferred to a removal route safely and easily and without the need for removal of other pieces of equipment or piping.

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System pipework that traverses the 'pipe tunnels' should be arranged that access is afforded to every pipeline without the need to remove sections from another system. Enough clearance shall be provided around these pipe systems so as not to accumulate corrosive debris over time that will compromise the steel integrity of the surrounding tanks, causing failure.

The arrangement of all machinery spaces, above and below platform decks, must provide personnel movement routes for regular inspections, operations and maintenance of all equipment and machinery with headroom clearance of at least 2.1m including the tank top areas. Easy access of valves/dampers/handles etc shall be possible during emergency situations. Guardrails and hand rails shall be provided where necessary for personnel protection against ship motions.

The ability to meet these requirements at an early stage of the design shall be demonstrated by the use of a comprehensive 3-Dimensional model of each machinery space.

All personnel movement and access routes for inspection, operation and maintenance on tank tops must be fitted with either chequer plate floor plates or gratings raised at least 100mm above the tank top.

LED lighting units shall be fitted throughout machinery spaces, above and below platforms to provide high levels of illumination (minimum 300 Lux) with minimal shadowing.

6.4.5 Diesel Engines

R6.150 The engine powers and speed shall be stated by the Prospective Contractor in his Tender and confirmed by the Contractor as the vessel's design is progressed.

The diesel engines shall be 4 stroke, single turbocharger, fresh water cooled, unidirectional, in line, operating at no more than 1000 p.p.m. and all of the same type, although numbers of cylinders may be varied. Numbers of cylinders per engine shall be no more than 12.

The engines shall be supplied with one fuel injection pump per cylinder.

The engines shall not run at more than 95% M.C.R. at the full load rating of the alternators.

The permissible overload is 10% for one hour every twelve hours. The maximum fuel "rack" position shall be mechanically limited to 110% of the engine's continuous output.

They should be designed to run on Low Sulphur Marine Gas Oil (LSMGO), but capable of running on Marine Diesel Oil (MDO).

They must be designed according to the latest proven smokeless engine technology.

Engines shall be started by compressed air.

Each engine is to have a separate crankcase breather pipe routed up and out of the engine room via the exhaust uptake casing to the funnel terminating in a weatherproof exit fitted with an oil mist trap and drain to a common collection pipe leading back down to the sludge or drain oil tank. Each oil mist trap shall be clearly marked as to the engine it serves. Pipework must be suitably internally treated so as not to allow corrosion products to accumulate and then block the pipe at a bend / allow debris into the engine. Flame screens must be accessible for routine cleaning.

The engines shall be fitted with suitable governors to suit the Power Management System requirements.

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In order to assure the achievement of the required underwater noise limits the engines and alternators shall be mounted on a rafting system to isolate the diesel generator units from the ship's structures.

The diesel generator and its mounting systems shall be designed assembled and Factory Acceptance Tested by a *Manufacturer* who has a proven successful track record in producing units which have been installed in at least 3 similar vessels possessing URN signatures equal to or better than ICES 209.

Because of the criticality of these units to the achievement of the vessel's requirements particularly in respect of reliability and underwater radiated noise, the requirements relating to their choice are necessarily stringent. Units may be offered which do not fully fulfill these requirements however the proposals must be accompanied by detailed strategy evidencing how the vessel's requirements, including those for reliability and underwater radiated noise, shall be assured in an equal or improved manner.

The engines shall be cooled with treated fresh water.

Each engine shall have an independent lubricating oil system and incorporate automatic back flushing filter and centrifugal filter. An electrically driven pre-lubrication system shall be fitted to each engine.

The engines shall be capable of running 24 hours under the unattended machinery space regime.

All engine mounted control and monitoring equipment shall be suitably resiliently mounted to avoid damage from vibration.

Sufficient side and end collision chocks shall be fitted. Double bellows shall be required for exhaust, cooling water and fuel/oil connections due to large engine movements resulting from double rafting and ice-breaking.

Specific fuel consumption shall be specified for each operating mode identified herein. According to ISO 3046/1, lower calorific value 42700kJ/kg, at constant engine speed, with engine driven pumps. Tolerance +5% the fuel consumption shall be measured during the shop trial of each engine.

FAT & HAT shall be carried out on individual items of installed equipment and systems which shall then be carried forward as part of the overall acceptance of this item

6.4.6 Automation and Control

R6.151 Automation Requirements and Standards shall comply with the following:

Automation Requirements and Standards

- 1) Remote and automatic controls and instrumentation for operation with unmanned engine room shall be provided as required by the relevant rules and regulations.
- 2) Instrumentation shall be provided to enable local and manual operation of machinery and equipment in case of failure of remote or automatic control. Instrumentation shall be local to manual operating positions for the various systems. Control of the engine system parameters, e.g. Jacket Water temperature shall be possible manually if automatic control fails.
- 3) Failure modes identified in the FMEA shall be simulated on trials and alarms confirmed.
- 4) Technical details of instruments and their incorporation in their respective systems shall be provided to the NERC as part of the Plan Review process.

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- 5) Automation shall be integrated with the DP, Thruster Control System and PMS using common hardware.

Machinery Surveillance System

A machinery surveillance system shall be installed in the machinery control console to give visual indication of fault conditions arising in the main and auxiliary plant. The system is to have a downloadable memory facility able to store at least one year's data. A printer shall be provided for downloading hard copies of data if required. This system shall form part of the overall machinery control and monitoring package of equipment from one single contractor.

Alarm, Control, and Monitoring System - Ship Systems

- 1) Vessel Management System (VMS) shall be arranged with a level of automation adequate to maintain a periodically unattended engine room under normal sea going conditions, DP and Science operations. It shall be possible to stop and start thrusters and all ventilation and cooling systems in the vessel from the bridge Operator stations shall be arranged in engine control room 3 nos and wheelhouse. A alarm from all other systems shall be displayed in the VMS system.
- 2) Memory function with at least one month capacity for retrieving data shall be provided.
- 3) The system arrangement shall be such that no single fault, failure of power supply or system malfunction shall prevent effective plant control being retained. Full redundancy shall be built into the various systems and system processors to have hot backup facility.
- 4) The system must be equipped with a self-diagnostic system for easy troubleshooting and maintenance.
- 5) An alarm shall be given if the propulsion and manoeuvring system are not able to control the vessel as ordered. It shall not be possible to start any thrusters before sufficient power is available on actual bus bar. Request for power shall be send to the power management system. Failure on the system shall be monitored and general alarms shall be forwarded to the VMS system.
- 6) The VMS system shall include:
 - Essential equipment as pumps, ventilators and compressors.
 - All equipment for automatic start up after a black out
 - Duty stand-by control of electric motors.
 - Pneumatic or electric remote controlled valves for oil (See Note1), Note 2), water and ballast tanks and for bilge systems.
 - ❖ Note 1) Clean L.O., Dirty L.O., sludge tanks, incinerator F.O./Sludge tanks valves should be normal manual valves.
 - ❖ Note 2) Valves on F.O. bunker system should be remotely operated to enable loading/discharging bunkers from the MCR/nearest operating station
 - Power Management System (PMS), interface.
 - Mimic diagrams for remote controlled systems.

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- Remote Sounding of bilge water tanks, sludge tanks, F.O. overflow tank, C.W. system header tanks, Hydraulic L.O. system tanks over 1cbm & L.O. storage tanks larger than 1cbm, fuel oil bunker tanks, water ballast tanks and FW tanks.
 - Stability and heeling tanks also shall have remote sounding if fitted
 - Alarm signals from control systems for main machinery.
 - Interface to DP 2 system.
 - Distributed Control Stations (Outstations) located in engine rooms, thruster rooms and other locations of machinery and equipment.
- 7) The alarm system in Engine Control Room shall indicate incoming alarms on the VDUs and printed on the alarm printer. Adjustment of alarm set points, time-delays, blocking of alarms etc shall be possible from the workstations using password access.
- 8) All units of the system - distributed control stations as well as operator workstations and accommodation panels - have to be connected to two redundant and independent networks of high capacity and suitable for marine purpose.
- 9) The system shall automatically inhibit alarms and warnings associated with any plant except tank level alarms when the plant is not operating. Nuisance alarms shall not occur during normal start-up, stop and operation.
- 10) **Contents Gauge**
All fuel, lubricating oil and fresh water storage/service tanks shall be fitted with contents measurement system of an approved type. It must be possible to measure the contents by manual means in the event of failure. All tanks both in and out side the engine room must have a contents remote read out in the engine room.
- All liquid level alarm systems are to incorporate adjustable alarm delay relays to damp/eliminate ship motion effects.
- 11) **Bilge Alarms**
All compartments with a common boundary with the sea or where water may accumulate otherwise undetected shall be fitted with high bilge level alarms.
- 12) **Sea Surface Temperature Sensors**
Seawater temperature sensors shall be installed with one in the engine room and a second in the clean sea water pumping room with readouts in the engine room control room and in the main laboratory. Readouts must be able to access both sensors.
- 13) **Klaxons and Alarm Lights.**
Klaxons and alarm light towers indicating machinery alarm conditions shall be situated to give complete coverage throughout the machinery spaces and winch room and all klaxons are to operate with each alarm condition and shall be silenced by a common muting button on the MCR control console. Klaxons must be continuously rated and have a tone distinct from other audible warnings.

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The use of klaxons for alarms and telephones shall be especially considered for their impact on sleep patterns (24/7 hours of working) in any cabins which might be affected. Alternative means of attracting the attention of engineering staff shall be proposed.

14) Duty Engineer Alarm System

The VMS system shall provide a system comprising alarm units for installation in the accommodation and machinery spaces.

Spaces in accommodation that shall have alarm unit include Engineers' cabins, Mess Room, Officers' Lounge, Cadet Cabin and communal spaces such as Conference Room, TV lounges, Library, etc.

If Air handling rooms is not designated as a machinery space, they it shall also have an alarm panel.

15) Spare Capacity

The VMS system shall be designed with a spare capacity of at least:

- 40% memory and CPU load for each intelligent module.
- 40% Bus network load.
- 20% spare capacity for each type of I/O etc.

**6.4.7 Not Used
R6.152**

6.4.8 Torsional & Axial Vibration Calculations

R6.153 The Contractor is to guarantee that the shafting system of the diesel electric plant is free from any dangerous stresses resulting from whirling, axial and torsional vibrations. The calculated torsional stresses shall be forwarded to NERC at an early stage in the design. The Contractor is to guarantee that the shafting system from any propulsion drive motor is free from any dangerous stresses resulting from torsional, whirling and axial vibrations. Barred speed ranges shall be avoided. The calculated torsional stresses shall be forwarded to NERC at an early stage in the design.

The calculations shall also be done for a mode when the one of the propulsion shaft is assumed to be trailing / freewheeling.

Torsional and axial vibrations shall be recorded during the sea trials and shaft stresses calculated. Results shall be supplied to the NERC representative for acceptance.

Natural frequencies of local structures, including support structures of main equipment shall be calculated by the Builder at the design stage and submitted for NERC review.

Noise and vibration tests shall be carried out during sea trials by an independent contractor selected by Yard with NERC's agreement.

Contractor is to provide specific guidance for trailing a shaft after trials.

6.4.9 Main Propulsion & Steering System

R6.154 The vessel shall be equipped with a main propulsion and steering system which either provide or contribute to the compliance with the requirements for:

- Ship Speed
- Propulsion shaft speed / Propeller pitch control

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- Directional control
- Manoeuvring
- Dynamic positioning
- Underwater Radiated Noise
- Taking into account the needs and requirements of;
 - ❖ The minimisation of through life costs e.g. fuel economy, survey and maintenance costs
 - ❖ The desired delivery date of the vessel
 - ❖ The Vessel capable of the full intended range of operations.

Twin controllable pitch propellers driven by variable speed propulsion motors are foreseen. The hydraulic pitch control activation system shall be designed for minimum noise transmission.

The propulsion shafting shall be completely enclosed in twin asymmetric skegs.

The propulsion tailshaft shall withdraw outboard from the stern tube.

Shaft couplings shall be hydraulically fitted taper type.

Shaft seals shall be split type capable of afloat replacement.
Stern tube lubrication shall be water lubricated or with bio-degradable oil.

Provision shall be provided to ensure continued lubrication of shaft bearings / motor bearings while any one of the shaft is trailing/freewheeling.

Propulsion shafting and drive bearings shall have lubrication systems suitable for operation at low speed (rpm).

Consideration shall be given to provide shaft brakes unless motor turning gear of sufficient strength is fitted.

The propulsion control and steering system shall be designed for infinite control throughout the operating speed range between zero and 14 knots.

It shall be required that a conventional propulsion system is proposed and the individual parts shall be of proven design and they shall be from a *Manufacturer* recognised as one of the leaders in the field.

The units proposed shall possess the necessary attributes to support success of the choice such as, but not limited to, large diameter 5 bladed Ice strengthened propellers designed for low noise arranged with large hull tip clearances (greater than 1m).

The main electric propulsion motors shall be selected, designed and installed to achieve the low underwater noise required for scientific activities as defined elsewhere in this SoR (see section 5.1.29).

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Because of the criticality of these units to the achievement of the vessel's requirements particularly in respect of reliability and underwater radiated noise, the requirements relating to their choice are necessarily stringent. Units may be offered which do not fully fulfil these requirements however the proposals must be accompanied by detailed strategy evidencing how the vessel's requirements, including those for reliability and underwater radiated noise, shall be assured in an equal or improved manner.

6.4.10 Power Management System

R6.155 The Power Management System (PMS) shall comply with the following:

- 1) The PMS system shall be integrated with the DP, VMS and Thruster Control System using common hardware
- 2) The power generating and distribution system shall normally be operated automatically (PMS mode) or in manual mode.
 - The PMS system shall include dedicated control systems for each main generator set and control for the switchgear. The PMS system shall control automatic starting and stopping of main diesel alternator sets, according to demand, operator requirements and alarm conditions.
 - Redundancy of the PMS system for redundant propulsion and DP 2 operation shall be approved by the Classification Society.
 - A failure in one switchboard shall not affect the function of another switchboard or other sections of the switchboard in which the failure has occurred.
 - Automatic synchronising of the diesel generators shall be possible over each generator breaker and over the bus ties.
 - The Emergency Generator shall not run in parallel with other generators.
- 3) The Power Management System (PMS) to provide the following functions:
 - Management of machinery to run to meet the operating demand with appropriate reserve.
 - Maintain the line frequency at rated value.
 - Share the total load between the running generators in proportion to their rated power, adjustable for routine maintenance/running-in etc.
 - Automatic de-load of generator before automatic disconnection of a generator.
 - Automatic up-load of generator after automatic connection of a generator.
 - Maintain full functionality of each section and independence of the others, when split switchboards.
 - Preferential trip of unessential load in three steps.

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The PMS system shall also show a graphical simulation of the logical steps when switching from one operating mode to another, showing start up and stopping of machinery during the process.

Care should be taken to create a highly user friendly system with adjustable power settings, password protected to Chief Engineer.

- 4) Automatic start of a diesel generator sets shall occur under the following conditions:
- Standby start request fault on a running set.
 - Operator initiated request
 - Low surplus power.
 - Start request of large electrical consumers.
 - Low line voltage or low line frequency.

It shall be possible to select a target maximum number of main engines (1, 2 or 3) with the PMS limiting the starting of additional engines when spurious demand for propulsion power is requested such as the vessel hitting a wave. However, the PMS system shall be able to override such manual limits and start additional engines if there is an electrical load demand from a large consumer for purpose other than propulsion.

- 5) Automatic stop of the diesel generator sets shall occur under the following conditions:
- High surplus power for a specific time, subject to DP2 mode status.
 - Operator request
 - Faulty running generator set after synchronising of standby generator set.
- 6) The PMS and VMS shall be provided with an interface that allows selected control of the diesel alternators in service and on standby (with selection of order of start-up) and Power Limiting feature based on a manually selectable number of engines.

6.4.11 Dynamic Positioning Thrusters & Controls

R6.156 The vessel shall be equipped with thrusters and controls which shall provide compliance with the requirements for dynamic positioning.

The Thruster Control System shall be integrated with the DP, VMS and PMS using common hardware.

The URN requirements shall not be applicable during Dynamic Positioning. However the effect of thruster operations must be considered with regard to the habitability of the vessel with particular reference to potential for both transient and steady noise and vibration effecting discomfort and sleep deprivation.

However occasionally quiet operation in DP mode is required when communicating with underwater devices.

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Any hydraulic power units employed to serve the thruster units shall be designed such that all efforts are made to reduce noise. In addition adequate cooling shall be provided for such systems to maintain proper operating temperatures even under the most arduous ambient and loading conditions as defined in the Operating Conditions

6.4.12 Manoeuvring Thrusters

R6.157 The vessel shall be equipped with thruster(s) and controls which shall provide compliance with the requirements for:

Manoeuvring

The URN requirements shall not be applicable during Dynamic Positioning. However the effect of thruster operations must be considered with regard to the habitability of the vessel with particular reference to potential for both transient and steady noise and vibration effecting discomfort and sleep deprivation.

Any hydraulic power units employed to serve the thruster units shall be designed such that all efforts are made to reduce noise. In addition adequate cooling must be provided for such systems to maintain proper operating temperatures even under the most arduous ambient and loading conditions as defined in the Operating Conditions

6.4.13 Emergency Power Generation

R6.158 A diesel engine powered alternator shall be located outside the engine room to feed the Emergency Switchboard. Its capacity shall be based upon the normal emergency requirements.

The emergency diesel powered generator shall be capable of carrying 110% full load, under the specified conditions, for a period of 1 hour.

The engine and alternator solidly coupled together shall be resiliently mounted to the deck to limit noise and vibration transmission to the structure.

The emergency generator shall be provided with two entirely independent starting systems, e.g. battery plus hydraulic or compressed air. It is essential that one of the system chosen provides a truly 'black start' facility.

The emergency generator shall start automatically and operate directly on the emergency bus bar in case of mains failures and automatically disconnect on restoration of the main power supply and run for a short time after disconnection as a cool down period.

The emergency generator prime mover shall have integral thermostatic temperature controlled radiator cooled jacket water heating.

A means by which the fuel tank can be filled from the ship's daily service tanks using the ship's fuel transfer system shall be provided.

6.4.14 Harbour Power Generation

R6.159 A diesel engine powered alternator shall be located in one engine room to provide sufficient power for hotel and service facilities. Its capacity shall be based upon the normal harbour requirements including operation of deck machinery, cranes and hatches.

The generator shall generate electrical power at constant frequency and supply the auxiliary services switchboard.

The engine and alternator solidly coupled together shall be raft mounted, the raft being resiliently mounted to the deck to limit noise and vibration transmission to the structure in accordance with the onboard noise requirements.

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The Harbour Generator shall be arranged to be selected for automatic starting in the event of electrical power failure on the Switchboard that it is connected to.

6.4.15 Winterisation Requirements

R6.160 The Winterisation requirements shall be met by a thermal plant or electrical trace heating depending on appropriate application. The heating system shall be able to supply heat tracing to the deck plating at lifeboat, liferaft stations, pilot boarding area, external stairways & ladders, heli-deck, emergency towing bracket. The thermal plant shall be able to supply heating of cargo hold space and to fan heaters serving engine rooms, thruster rooms, propulsion motor rooms and cargo holds in the ventilation intakes. It shall also be able to supply steam for manual de-icing purposes. De-icing steam jet outlets served by portable hoses shall be provided at safety critical areas prone to icing. Example heli-deck, towing bracket, lifeboat/liferaft stations, aft working deck (1 on each crane pedestal), fore deck (positions neat to winch doors).

Air Bubbling air shall be supplied from a stand-alone compressed air system fed by rotary compressors. As a back-up / enhancement to this feature, ballast tanks that are most vulnerable to freezing shall be served by steam or thermal fluid heating coils. As an example, tanks identified as vulnerable to freezing are peak ballast tank, ballast tanks below exposed part of the main deck and technical water tank. Alternative to coil heating inside ballast tank, the use of ballast water in recirculation mode for general cooling purpose shall be considered to maintain ballast water temperature above freezing point.

Air bubbling of shall be main anti-freezing technique for ballast tanks. However heating of the ballast tanks with the aid of heating coils shall be also provided as an enhancement.

Waste heat recovery shall be used as a primary source of heating requirements, with a fully redundant oil fired alternative in case the waste heat is insufficient to meet demand.

6.4.16 Auxiliary Boilers

R6.161 Steam and Hot Water

The vessel shall have two thermal plants, one steam, one hot water to support winterisation systems and general shipboard steam supply. Exhaust gas economizers shall be arranged one in each engine room casing after the SCR's, in a combined exhaust gas flow from both Main Engines in that Engine Room to recover the waste heat from generator engine exhaust. The unit shall be capable of passing the full quantity of engine exhaust gases at specified MCR. The exhaust gas economizer shall be designed to allow dry running at emergency.

In harbour during low load operating condition of the engines the thermal demand shall be served with oil firing of the main thermal plant.

Two types of thermal plant shall be considered for the vessel. The final selection shall be based on the best arrangement for the vessel and capacity determined by complete heat load calculation for all operating profile of the vessel. At harbour including low load operating condition of the engines, the thermal demand shall be served with oil firing of the main thermal plant. The selected thermal plant shall have sufficient capacity to meet winterisation requirements of the vessel outlined below. A general arrangement of both plants is described below.

Steam & Hot Water based system - A composite steam and hot water based thermal plant consisting of fired marine water tube boiler and exhaust gas boiler shall be provided. Maximum evaporation rate of the boilers shall be based on the steam demand of the vessel for the most onerous operating profile.

An oil fired hot water heater shall be installed for heating duty.

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The steam & hot water heating systems shall be arranged to meet the requirements for redundant machinery and winterisation measures.

The water from the main boiler shall be circulated through the economizer by the boiler water-circulating pump. Surplus of steam generated by the economisers shall be automatically dumped to a fresh water cooled steam condenser.

Steam tracing lines shall supply heating steam to tanks (sludge oil, waste oil, bilge holding tank etc.) The plant shall be able to supply steam for; preheating of HVAC air supply to accommodation, domestic fresh calorifier heater, fan heaters in engine room, thruster rooms, propulsion motor room and cargo holds.

Magnetic drive pumps without conventional drive shaft seals shall be used for boiler circulation pumps.

6.4.17 Cooling & Waste Heat Recovery Systems

R6.162 The vessel shall be equipped with a central cooling system primarily to service the following equipment:

- Main Engines
- Thruster motors
- Main propulsion motors
- Main alternators
- Auxiliary fresh water cooling system

Heat that normally is dissipated from the cooling water shall be recovered in a heat recovery unit, for instance a fresh water generator installed in the engine room.

Waste heat from exhaust gas shall be recovered in exhaust gas economizers.

Heat recovery wheel shall be used for energy conservation in HVAC air handling units by way of recovering the enthalpy available on the exhaust air.

6.4.18 Central Fresh Water (F.W.) Cooling System

R6.163 Generally all primary cooling shall be by treated fresh water in turn cooled by seawater via plate type coolers. Two separate central fresh cooling systems shall be provided, one for each Engine Room. Each system shall serve two generator engines, one aft thruster motor, one forward thruster motor and one main propulsion motor. A crossover F.W. cooling pipework between Engine Rooms is to be provided to allow one Engine Room system to be served by the system in the other. The cooling systems shall be arranged to suit the expected operation in low temperatures / ice and also whilst traversing the Tropics, with elevated sea water temperatures. The numbers and capacity of heat exchangers shall be determined according to the heat balance for the cooling water system. The heat balance calculation shall be submitted for owner's approval. The system shall be designed according to engine and propulsion motor manufacturer's recommendations and guidelines.

The fresh water cooling system is to be divided into a high temperature (HT) and a low temperature (LT) circuit. The HT water circulating through cylinder jackets and cylinder heads while LT water circulating through the charge air cooler and the lubricating oil cooler. Combined HT and LT heat exchangers may be considered.

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External to the engines, each fresh water cooling system shall have an electric driven preheating circulating pump, two LT FW circulating pumps (one running, one standby), two HT circulating p (standby for engine driven pump), an expansion tank, necessary number of wax type temperature controlling thermostatic mixing valves, a pre-heater, coolers and b y-pass over coolers. Each electric driven LT FW cooling pumps shall have 100% cooling capacity in the LT FW system. The pre heater shall be electric or steam heated. The temperature in the FW systems shall be regulated on the fresh water side of the coolers.

The freshwater cooling systems shall serve electrical motors, lubricating oil coolers and frequency converters associated with each thruster and propulsion motor.

The expansion tank shall be fitted with filling connections from the domestic fresh water system. The volume of expansion tanks shall be min. 10% of water volume in system. The static pressure of expansion tank shall be well inside both minimum and maximum pressure recommended by engine or equipment supplier.

Expansion header tanks shall be fitted for each system fitted with contents gauges, sight gauges, low and high level alarms and as sociated isolation valves. The expansion tanks shall also have level transmitters that are connected to the VMS system to allow for hi and low alarm points. Tanks shall be installed in accessible positions for checking contents gauges.

Corrosion inhibitor shall be used in the fresh water cooling systems. It shall be possible to inject treatment chemical into fresh water system at a location other than the expansion tank to facilitate dispersion of chemical fully through the system.

There shall be installed ball valves with blanked ends/plugs for effective air bleeding on all places where there may be trapped air pockets. Routing of pipes shall be constructed in a way that avoid air pockets as far as practical possible.

Pumps shall be of centrifugal type with housing of cast iron, impeller of bronze and 13% Chrome steel shafts and fitted with mechanical seals. Couplings shall be of the flexible buffer ring type and/or rigid type according to the manufacturer's standard design. Consideration shall be given to using magnetic drive pumps without conventional drive shaft seals.

Suction and delivery pressure gauges shall be fixed to each pump, with isolating cocks fitted on pump body.

Bottom bearings of vertical pumps shall be of internal water lubricated type.

Pumps shall be resiliently mounted onto the ships structure and have flexible connections to their connecting suction and delivery pipe work in accordance with the requirements for low external noise.

All pumps shall be located for easy access for maintenance work and/or adjustment including the removal of their drive motors. Motors should be pinned for alignment and ease of ensuring correct alignment when reassembling.

Pipes with galvanized inner surfaces are not allowed in the fresh water cooling system.

Temperature regulating valves should be multiple element Wax Thermostatic AMOT type, with external manual override.

Temperature regulating valves in cooling system which are pneumatically or hydraulically controlled should be fail "as is" type.

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Shaft bearings and thruster cooling requirements shall be met in case of failure of the system in one engine room.

6.4.19 Sea Water (S.W) Cooling System

R6.164 The cooling system serving systems that are used for vessel's station keeping shall be independent to the cooling requirements for scientific functions of the vessel.

The sea water cooling systems shall be arranged with redundancy according to DP2 Class Notation. Two separate sea water cooling systems shall be provided, one for each Engine Room. Each system shall provide cooling for the fresh water systems serving engines, propulsion motors and thruster motors in the respective compartments with cross over from others.

The sea water systems shall be cross connect with valved connections, which are normally closed.

Sea water may be used for the air conditioning chilled water system compressors to maintain acceptable margins.

Each system shall have two variable speed sea water pumps, each with a capacity of 100% of the total need. One unit shall be running and other on standby and arranged for automatic start / stop of the pump. The pumps shall also be able to be remote operated from engine control room. Both pumps shall be connected to high and low sea chest. Change over between high and low suction sea chest shall be remote operated from the ship's engine control system.

Two sea strainers shall be fitted for each engine room seawater system with differential pressure alarms to identify the onset of severe fouling and shall be possible to remove one of the two sea strainers for cleaning with the seawater cooling system in operation.

Each system shall have two sea/fresh water coolers made of titanium plate type or equal material (approved by NERC), and designed for 20 % fouling. The cooler shall be able to maintain the engine outlet temperatures at engine builders recommended levels when all the engines are developing 100% M.C.R. with a sea temperature of 35°C.

The cooler frame size shall be such as to allow additional plates if necessary to further extend its cooling capacity by 25%. The cooling system circulating pumps shall be sized in a similar manner.

Each individual heat exchanger shall be rated at 100% of the required cooling requirement.

All central coolers shall have fixed arrangement for back flushing, and shall be provided with strainers in seawater inlet. Connection for acid cleaning of seawater side shall be arranged. Gasket in the coolers, inlet and outlet valves shall be sustainable for cleaning acid.

The main seawater circulation system shall be able to re-circulate through the high and low sea chests using the keel plating as a cooler when sea chest are ingested with ice. A seawater return line to the sea bay, with isolating valve, shall be required for this mode of operation in addition to regular overboard discharge.

Special attention shall be given to the proper sizing of pipes, fittings and valves within the cooling system to avoid undue noise and erosion of piping material (e.g. reducer units which produce excessive flow speed changes). All reducer units in any event shall be specially protected.

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For sea water cooling purposes in drydock a system shall be installed whereby a shore connection can be easily fitted and a means of using the seabay tanks as a supply source for the sea water cooling with return to the relevant tank. This arrangement shall allow the Harbour Generator to be run in drydock and supply the domestic power demand. .

6.4.20 Auxiliary Fresh Water Cooling Systems

R6.165 An auxiliary fresh water cooling systems based in auxiliary machinery room shall be provided for cooling of systems like starting air compressors, provision cooling compressors, air conditioning unit (compressors and condensers), scientific winch system or any other scientific cooling system, power pack units serving mooring winches, cranes, launch and recovery systems. etc.

Deck mounted and containerised portable equipment will require cooling water services. Sufficient number of flanged cooling water connection points (supply and return) shall be made available on the aft main deck for any containerised equipment that may need cooling.

This cooling system shall have multiple fixed speed cooling fresh water pumps shall be installed, an expansion tank, two coolers (total capacity 150% of the expected cooling load) and by-pass over coolers. A crossover from Main LT systems to Auxiliary System shall be provided. The system shall be designed with appropriate redundancy.

Two variable speed auxiliary seawater pumps (one running, one standby), each with 100% capacity of the total need shall supply sea water to the auxiliary fresh water coolers. The frequency drive shall be arranged with an integrated PID-regulator designed for temperature control.

6.4.21 Fresh Water Generators

R6.166 Fresh water generators shall be installed with aggregate capacity of at least 60m³/day under seagoing conditions, which includes one Engine Room system shut down. This shall be achieved with a combination of two evaporators (only one of which may be in service) and reverse osmosis type freshwater generators, and associated equipment, including recommended pre-treatment filtration equipment. The type and combination of the fresh water generators shall be determined based on the available power and waste heat recovery across the operating profile.

The evaporators shall be equipped with a condenser, combined brine/air ejector pump with electric motor, fresh water pump with electric motor, control panel with motor starters, built in salinometer and instruments.

The pipe work shall be fitted with sufficient isolation valves so that each unit can run independently of the other, to allow maintenance on one unit while the other(s) maintains water production.

The output from the generators shall be led to the fresh water filling line for treatment before entering the storage tanks.

The heat source of the evaporators is to be the HT Fresh Water Cooling water... The system shall be supplemented with steam heating or thermal oil when engines are idle. Each fresh water generator shall be capable of producing its rated capacity at a sea temperature of 32°C. Under these conditions the distillate shall not contain more than 1.5 p.p.m sodium chloride.

The fresh water makers shall be arranged for automatic operation and equipped with salinity control and alarms. They shall be able to automatically discharge to a bilge well or bilge water tank when salinity content is high.

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Evaporator Materials

- Separator : Red brass
- Front cover : Stainless steel
- Bed frame : Steel (hot dip galvanised)
- Pipe for brine discharge : Red brass
- Evaporator/condenser plates : Titanium
- Demister : Stainless steel
- Pipe for seawater : Stainless steel
- Pipe for fresh water : CuNi 90/10
- Combined brine/air ejector housing : Red brass
- Combined brine/air ejector nozzle : Stainless steel
- Flange for evaporator : SG-iron (hot dip galvanised)
- Flange for condenser : Stainless steel

The fresh water generators shall draw sea water supply from a sea inlet which shall be placed at a safe distance forward of the overboard discharges especially sewage treatment plant discharges to avoid any pollution of the supplied water. The fresh water generators shall be able to be fed with sea water from, low sea chest or a dedicated sea chest as evaporator sea chests are not to have injection from electro chlorination unit.

The sea water pipework to Reverse Osmosis plant shall be fitted with high flow self-cleaning sand filters.

The fresh water generators shall be equipped with dosage equipment for feed water treatment to inhibit scale formation.

Ejector pumps shall be flexibly mounted to the ships structure and connecting pipe work in accordance with the URN requirements. Brine ejection shall be directly overboard on the port side.

The alarm system shall be connected into the alarm system in the engine control room.

6.4.22 Electro-Chlorination Unit

R6.167 An electro-chlorination unit, of suitable size, shall be fitted to protect the sea water system from marine growth, producing a dosage rate of 0.5 p.p.m chlorine and giving a residual reading of 0.01 – 0.05 p.p.m at the outlets. The unit shall inject into the sea chests, port and starboard, in each engine room. If any other seawater pumps are on separate sea chests they shall be included on the injection system with the EXCEPTION of fresh water generator sea suction.

Isolation valves shall be provided for the electro-chlorination unit dosing.

The electro-chlorination unit shall be skid mounted with transformer/rectifier power supply cell assembly, control panel, hydrogen removal tank and hypochlorite injection pumps.

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The dosage rate shall be adjustable to suit the differing operating conditions.

The pumped scientific clean seawater sampling system is NOT to be treated in any way.

6.4.23 Sea Water Cooling Pumps

R6.168 At least two variable speed sea water pumps, each of 100% capacity (main and standby) shall be supplied to serve each Engine Room to cool the main central plate coolers.

Two separate variable speed auxiliary sea water cooling pumps shall be installed for auxiliary cooling duty.

- Each frequency drive shall be arranged with an integrated PID-regulator designed for temperature control.

The pumps shall be vertical centrifugal type pumps, have cast bronze casings, phosphor bronze impellers, and 18% chromium 8% nickel stainless steel shafts and fitted with mechanical seal or gland packing. A stainless steel shaft sleeve shall be fitted in way of the gland packing. The casing shall be split on the centreline so that the impeller can be removed without disturbing pipe connections.

Consideration shall be given to using magnetic drive pumps without conventional drive shaft seals. Suction and delivery pressure gauges shall be fixed to each pump, with isolating cocks directly fitted to pump body.

Bottom bearings of vertical pumps shall be of internal water lubricated type.

All pumps shall be flexibly mounted to the ships structure and connecting pipe work in accordance with the URN requirements.

Valves connected directly to pumps shall be double flange type, in order to allow removal of pumps without draining of systems. Special attention shall be paid to providing access space around and lifting facilities above all these pumps for maintenance purposes and easy removal if required.

6.4.24 Bilge, Ballast, Fire and General Service Pumps

R6. 169 Centrifugal pumps shall be provided for bilge, ballast, fire and wash-deck duties with suction from the sea bay. The three pumps shall take their suction from the sea bay and they shall each be fitted with a single duplex sea suction strainer of sufficient size.

One self-priming, electric motor-driven, vertical centrifugal pump shall be installed as a dedicated bilge pump, capable of meeting Rule requirements for both bilge and fire duties. It must also be capable of the other general services, and the transferring of ballast.

Dedicated self-priming, electric motor-driven, centrifugal pumps shall be installed for each system for ballast, bilge and fire and washdeck duties. Capacities on bilge and fire duties are to meet the Rule requirements.

One self-priming, electric motor-driven, centrifugal pump shall be installed as a dedicated fire pump, capable of meeting Rule requirements for both fire and bilge duties. It must also be capable of the other general services, and the transferring of ballast.

Bilge, ballast, emergency fire pump and fire and wash-deck pumps shall be provided with remote starting facilities from the Bridge and Emergency Generator spaces with run indications in addition to local starting.

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Special attention shall be paid to providing access space around and lifting facilities above all pumps for maintenance purposes and easy removal if required.

The pumps shall be vertical self-priming centrifugal type pumps, have cast bronze casings, phosphor bronze impellers, and 18 % chromium, 8% nickel stainless steel shafts and fitted with gland packing. A stainless steel shaft sleeve shall be fitted in way of the gland packing. The casing shall be split on the vertical centreline so that the impeller can be removed without disturbing pipe connections.

Consideration shall be given to using magnetic drive pumps without conventional drive shaft seals.

Suction and delivery pressure gauges shall be fixed to each pump, with isolating cocks. Bottom bearings of vertical pumps shall be of internal water lubricated type.

All pumps shall be flexibly mounted to the ships structure and connecting pipe work in accordance with the URN requirements. Valves connected directly to pumps shall be double flange type, in order to allow removal of pumps without draining of systems.

6.4.25 Chilled Water Condenser Cooling

R6.170 Chiller unit condensers shall be cooled by sea water from the sea water cooling system. The plant shall be able to operate efficiently at water inlet temperature of maximum sea water temperature of 35°C.

6.4.26 Provision Room Machinery Cooling System

R6.171 Provision cooling compressor units shall be cooled by the auxiliary fresh water cooling circuit. The plant shall be able to operate efficiently at water inlet temperature of 38 °C.

6.4.27 Fuel Systems

R6.172 The fuel oil system including bunkering, overflow, transfer, purification and all necessary service systems for diesel engines, boilers/thermal oil heater, incinerator etc. shall be provided in accordance with the class requirements and in accordance with requirements from the relevant maker of equipment.

A fuel oil system shall be arranged as recommended by the engine builder to provide a totally independent supply to each engine complying with requirements of DP2 class. Fuel transfer and treatment serving each Engine Room shall be fully independent, with normally closed cross connection.

This system shall be under the control as well as monitoring of the VMS system. Main fuel bunker tanks and service tanks shall be provided of sufficient aggregate capacity to support the operations of the vessel.

The bunker tank system shall be fitted with an overflow system. A suitably sized overflow tank shall be incorporated complete with high level alarm. Emptying of the tank shall be by use of the fuel transfer pump.

The following service fuel tanks shall be arranged adjacent to or in the machinery space, capacities to be determined by the Contractor:

- Fuel oil settling tanks – port and starboard.
- Fuel oil daily service tanks – port and starboard.

These tanks are necessary to protect the vessel from poor quality fuels which might be the only fuel available in remote ports and shall be fitted with suitable sludging / water drain off arrangements. Water content monitoring with remote alarms shall be installed in the fuel system.

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Sounding pipes with manual self-closing sounding cocks shall be fitted to all fuel tanks.

Facilities shall be provided such that every fuel tank has a remote indicating contents gauge and high and low level alarm system displayed in line of sight to the fuel transfer pump and valve controls such that tank trimming and bunkering operations can be accomplished from one position (this requirement is also to be incorporated into the VMS).

Each fuel transfer pump is to have a coarse stainless steel filter with a drain cock fitted to the suction side of the pump in any event all tanks shall be fitted with sounding pipes in addition.

Considerations shall be given in meeting requirements of petroleum services from any fuel management partner selected by the vessel operator e.g. DNV Petroleum Services. Sampling points must be provided at key locations in fuel oil system to provide a picture of fuel quality variations throughout the fuel oil system. Example samples taken after the separators to ensure fuel treatment plants are operating at maximum efficiency.

Bulk fuel oil filling connections shall be arranged port and starboard on the main deck level and shall conform to MARPOL Requirements.

Fuel filters of the duplex type, together with coalescer filters for the removal of any water in the fuel, shall be included in the low pressure side of the system, and so arranged that they are remote from the engine exhaust systems. Differential pressure gauges shall be fitted.

Adequate drip trays shall be fitted below filters and fuel pumps with drain pipes to the fuel oil drain tank.

The primary fuel supply pumps shall be engine driven and shall take their suction from the daily service tanks. Standby electrical supply pumps are also to be provided.

6.4.28 Bunker Tanks

R6.173 Bunker tanks shall be fitted with an overflow system and a drain tank suitably alarmed. Air pipes from bunker tanks shall be fitted with anti-flash guards.

6.4.29 Diesel Oil (DO) Bunker and Transfer System

R6.174 A diesel bunkering and transfer system shall be installed.

Bulk fuel oil filling connections shall be arranged port and starboard on the main deck level and shall conform to MARPOL and USCG Requirements.

Bunkering capacity shall be 200m³/hr. The transfer system shall be arranged for transferring between all tanks including starboard, port, forward, aft, centre, to and from settling tanks, suction from overflow tank, and delivery to service tanks. In addition, the fuel transfer pumps shall be able to transfer the contents of the above tanks to the bunker station for discharge ashore. Transfer / suction lines shall have bell mouth at suction end, according to Builder's standard. The system shall have pneumatic or electric remote operated valves, and be controlled / monitored from the VMS.

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Two electric variable speed driven MGO/MDO transfer pumps shall be installed, one in each Engine Room, each with capacity of 100m³/h - 10.0 bar for pumping fuel ashore to stations through hose reel near port bunker station. Two electric driven MGO/MDO transfer pumps shall be installed, one in each Engine Room, each with capacity of 20m³/h - 3.0 bar for transfer of fuel within the ship, including filling of settling tanks. The transfer pumps shall be automatically stopped on high level in the Settling Tanks. The pumps shall be arranged as stand-by for each other. Controls shall be installed to prevent the pumps operating at the higher pressure and flow rate when transferring fuel between tanks (to avoid over pressurisation).

The Fuel Transfer Pumps shall be able to take suction from the Fuel Oil Overflow Tank and Fuel Oil Drain Tank.

The DO transfer system is also to supply fuel from service tank to the Emergency Generator fuel tank, workboat, incinerator tank and cargo tender. Two separate fuel oil transfer pumps shall be provided each 3m³/hr capacity for this purpose. In addition, the system shall be able to deliver fuel to working deck connections, complete with hoses, to enable portable diesel driven equipment to be re-fuelled. Boat and portable equipment refuelling facility on deck shall incorporate a hose, shut off nozzle, storage reel and provision for collecting any fuel drips.

The fuel oil transfer pumps are to have a cast iron casing, and shall be fitted with a full bore relief valve variable pressure to enable it to be set low for internal transfers and increased for bunkering bases, which bypasses back to the pump suction. The pumps are to have controls at the motor starters, and remote stops from push buttons outside the engine room, in accordance with Class and MCA Rules.

Over-bunkering protection system with high and low tanks alarms shall be provided for the bunker tanks. Overflow shall be routed to separate overflow tank. Each tank shall be connected, via goose-neck to common overflow and vent pipe, self-drained to nominated double bottom overflow tank (s). A sight glass and an overflow alarm shall be fitted in the last section before entering into the overflow tank. The nominated overflow tank shall be equipped with high-level alarm set at a low level in the tank. The overflow tank shall be part of VMS system with a tank content display and High and Low set points.

Each settling tank shall be arranged to over flow into the overflow tank and each service tank shall overflow into the settling tank for that engine room. It shall be possible to supply fuel to all main engines from both service tanks.

6.4.30 Bunker Stations Port and Starboard

R6.175 Bunker stations shall be arranged on the main deck, starboard and port, each for Diesel Fuel (MGO or MDO or LSDO), AVTUR aviation fuel, fresh water, lube oil, urea solution and mineral oil. The vessel shall be able to carry out simultaneous bunkering of fuel/fuels and fresh water.

The capacity of each system shall be designed for at least DO: 200 m³/hr, FW 20 m³/hr, AVTUR 100 m³/hr, Urea 60 m³/hr, and lube oil 5 m³/hr,

Each medium bunker connection point shall be clearly identified and labelled. There shall be sufficient clear deck area for the connection and arrangement of bunker hoses to the various bunker points with storage space for supplementary additive storage in 208 litre drums.(e.g. antigel, lubricity and biocide agents). Also provision shall be made for the injection of these chemicals into the bunkered fuel.

In addition shore discharge flange points shall be provided from sludge and sewage system at the bunker stations.

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Drip / spill trays shall be provided for the bunker stations (for fuel oil, lub. oil and other oil) in accordance with class requirements. The spill trays shall be connected with a drainage line fitted with a lockable valve to waste oil tank in engine room. An absorbent for the urea solution must be available near the bunkering station.

Flow meter shall be installed to measure both bunkered and transferred volume (for each type of fluid) with remote reading from Engine Control Room included. The stations shall be fitted with pressure gauge, stop valve and blank flange with sign.

A coarse strainer located away from the manifold (to remove risk of fuel spillage) with 0,5mm mesh, test/drain valve etc. shall also be fitted in the bunkering line.

For drawing out representative continuous MARPOL Annex VI sample of bunker at the time of bunker delivery, manual or automatic sampling methods defined in ISO 3170 or 3171 shall be provided at the bunker manifold.

Filling connections shall be of stainless steel

The bunker station shall be well-lit and easily accessible.

Separate Hose Reels shall be provided for MGO and AVTUR aviation fuel and be located on port side near the bunker station. Each hose reel shall have 300m of suitable hose for each product to transfer up to 100m³/hr.

6.4.31 Fuel Purifying and Filtering Systems

R6.176 Two independent centrifugal fuel separators of fully automatic self-cleaning/full discharge type shall be installed, one in each Separator / Fuel Pump Room, each with sufficient throughput to effectively treat the fuel oil.

A table with a bowl and drain for cleaning purifier disc stacks shall be provided.

Contractor shall install each purifier on a modular base unit. The fuel separators are to take suction from either the fuel settling tanks and discharge to service tanks.

Each fuel purifier shall be arranged to serve both Engine Rooms i.e. it shall be possible to fill both Port and Starboard Service tanks from one running separator.

Each fuel purifier shall have a duplex filter fitted before the separator feed pump. It shall have a fineness of 0.5 mm.

The single automatic sludge discharge shall discharge to sludge tank

6.4.32 Separator Rooms

R6.177 Separator rooms, one serving each Engine Room, shall be provided for the fuel oil and lube oil separators. The rooms shall be provided with a table with a bowl and drain for cleaning purifier disc stacks, along with the facilities for storage of tools and spare parts and workbenches for disassembly and assembly of the units.

6.4.33 Fuel Oil Service System

R6.178 Two separate fuel oil systems shall be arranged in accordance with DP2-class and redundant propulsion. One Settling Tank and one Service Tank each provided with internal heating coils and temperature monitoring as part of winterisation system and shall be provided for each engine room. The system shall be arranged so that each Service Tank normally supplies engines in one Engine Room and the other Service Tank normally supplies engines in the other Engine Room. In addition, cross-over supply lines shall be installed between the Service Tanks for redundancy. Fuel oil supply to auxiliary systems such as boilers thermal oil heaters shall be independent to fuel oil supply to engines.

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The daily settling tanks shall be fitted with high and low level float switches to stop the transfer pump automatically. The tanks shall be fitted with high and low level alarms at suitable distance above / below of stop switches

Approved quick closing valves, closable from outside the machinery spaces shall be fitted to the tanks. In addition each engine shall be fitted with quick closing valves on the fuel supply and return piping to isolate individual engines in manner that the isolation does not affect the working of the other engine.

All service and settling tanks shall be provided with spring loaded drain cocks for checking for the presence of water. Savealls shall be provided with drains to the fuel oil drain tank.

Service and settling tanks shall be connected to the common fuel oil, air and overflow system

Solid state flow meter with no moving parts shall be installed, both in suction and return flow lines, for measuring the consumption for each diesel engine and boilers, connected to the vessel automation system.

The fuel oil service tanks shall be located to provide sufficient static head to supply fuel at required pressure to enable the generators to start from black out without resorting to starting of emergency generator.

The capacity of the fuel service tanks to be minimum 24 hours fuel consumption for main generator sets at 100% MCR.

The emergency generator DO service tank shall have a capacity at least to maintain fuel supply for 36 hours at 90% MCR of the Emergency Generator.

6.4.34 Fuel Oil Overflow System

R6.179 A common fuel oil air and overflow system shall be installed, combining to a single overflow tank. The common overflow/ air pipe to be led to position close to the bulkhead deck so that in the event one of the tanks being flooded, other tanks in common loop cannot be flooded from the sea through the combined air pipes or the overflow main.

6.4.35 Lubricating & Hydraulic Oil Systems

R6.180 A lubricating oil system shall be arranged as recommended by the engine builder.

The following oil tanks shall be arranged adjacent to or in the machinery space, capacities to be determined by the Contractor:

- Lubricating oil storage tanks – port and starboard (free standing).
- Stern tube (if fitted) header tank.
- Inner shaft seal header tank (if necessary).
- Stern tube drain tank (if necessary).
- Main engine lubricating oil drain tank shall be capable of accepting the total of all engine sump contents.
- Renovated lubricating oil tank.
- Hydraulic oil tanks – bio-degradable, mineral and synthetic oils.

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Each storage tank shall be fitted with tank sounding arrangements with penetrations on top of tanks only

Flow meters for measuring filling of oil to main engines shall be included for monitoring lube oil consumption of each engine.

The engine lubricating oil replenishing lines shall be fitted with an electric pump to ensure that oil flow is not dependent on gravity.

Each engine shall have its own independent lubricating oil system, with a wet sump.

Lubricating oil pumps associated with the engine shall be engine driven.

The lubricating oil cooler shall be fitted to the engine.

An electrically driven pre-lubricating priming pump shall be fitted to each engine for circulation of lube oil through engine in standby mode.

A back flushing automatic filter and centrifugal filter shall be fitted to each engine.

There shall be sufficient isolation valves in the system so that an engine or various parts of the system can be overhauled while still maintaining power.

A bulk lubricating oil filling / transfer system shall be arranged so that filling, transfer, purification and storage of oil can be carried out, without the need to manhandle large numbers of 205 litre drums of oil. Bulk oil filling connections shall be arranged port and starboard.

One electric motor driven rotary positive displacement pump with 2mm strainer shall be fitted for lubricating oil transfer duties tank to tank.

A lubricating and hydraulic oil schedule with bio-degradable oils maximised for all equipment shall be drawn up and every effort shall be made to keep the number of grades of oil required to be stored on board to a minimum.

6.4.36 Lubricating Oil Separators

R6.181 Each engine is to have its own onboard lubricating oil purifying system (i.e. one per engine EXEMPLAR: Dual Glacier Filters with changeover system.) arranged as recommended by the engine builder, It is usual for the lubricating oil to be purified continuously when the engine is in operation and the system shall be designed with this in mind.

Two LO purifiers system shall be arranged for batch purification of generator engine lub oil. For this method of purification, lub oil shall be pumped out to a Renovating Tank of sufficient capacity to accept two engine sump contents and the engine refilled with fresh lub oil or renovated lube oil. The LO centrifugal purifier shall then treat the oil taking suction from the Renovating Tank and discharging to a Clean Oil LO Tank.

The lubricating oil purifiers shall have a suction filter, separate pump and an electrical heater capable of raising the oil temperature to 90-95°C. The separator shall be of a type with controlled discharge of the bowl to minimise the lubricating oil losses.

The piping and valve system shall be arranged so as to preclude the possibility of cross contamination of one engine oil with another.

The purifiers shall have the necessary pipe work and valves for purifying from Renovating Tanks to a Cleaned Oil LO Tank.

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Each purifier shall be an automatic sludge discharge type rated for continuous running. Purifiers shall be built on modules with separate feed pump, heater, suction filter, control cabinet and integrated sludge tank.

A suitable hoist shall be mounted above the purifiers for easy removal of rotating assembly. A cleaning station shall be provided in the purifier room.

All piping associated with the lubricating oil systems shall be acid pickled, pacified, proven clear of obstruction and internally coated with lubricating oil, before installation in the vessel. Care shall be taken that oil passages in the cooler etc., are thoroughly clean before pipes are coupled.

Before commencement of the shop trials of any engines, the lubrication systems shall be cleaned, the lubricants being initially circulated through temporary fine filters. Connections to the bearings are not to be made until the systems are clean and the NERC representative has given approval.

If the engine has not been disturbed for either shipment or erection in the vessel following flushing, flushing in the vessel shall be limited to shipyard installed pipe work and fittings.

Temporary pipe work shall be fitted between lines to and from the main engines, to prevent flushing oil entering the engine and to ensure good circulation while flushing through temporary filters.

The system must be flushed through to the satisfaction of the NERC s representative before closing lines are made to the engines on board.

**6.4.37 Not Used
R6.182**

6.4.38 Domestic Fresh Water Systems

R6.183 Design and capacity of the system shall be based on the fresh water consumption of 200 litre/person/day including hot water consumption 50 litre / person / day.

Fresh water storage tanks shall also be filled from shore connections.

The output from the fresh water generators shall be treated before entering the storage tanks. For this purpose an automatic hypochlorination system shall be provided in the fresh water filling line to the storage tanks. This chlorination unit shall be able to treat both shore supplied water (200m³/h) and water produced onboard (60m³/h). The design of the potable fresh water system shall ensure that water is continually circulated around both hot and cold water systems to prevent degradation of the water without returning to main fresh water tanks. The system shall meet the requirements of the flag authority concerning sterilisation in full.

Filters shall be installed in the fresh water supply from the hydrophore tank. A by-pass shall be arranged to allow servicing without shutting off the supply. Each filter shall have a capacity for 3m³/h.

Two UV sterilisers shall be installed in the fresh water supply from the hydrophore tank, after a carbon filter. A by-pass shall be arranged to allow servicing of the UV unit without shutting off the supply. Two water softener filters shall be installed after the UV sterilisers, each with a capacity of 3 m³/h.

The construction of the evaporator shall be of non-ferrous materials.

6.4.39 Fresh Water Tanks

R6.184 Tanks shall be provided within the ship structures but shall not be peaks or double bottoms and ideally shall not incorporate a ship-side boundary.

If tank valves are not in main machinery spaces then pneumatic or electric remote operated tank valves are required.

Tanks shall be fitted with an automatic treatment system at point of entry from the filling line. A monitoring system is also to be provided within the final distribution system. Water from water makers shall be automatically treated before being distributed into the tank system.

A fresh water transfer pump of minimum capacity 20m³/hour at 4 bar shall be provided, connected on suction and discharge sides, to all fresh water tanks.

Fresh Water Tank suctions are to be placed above the tank bottom to avoid tank sediment from entering supply system.

The fresh water system shall be completely monitored by the VMS system. Remote reading of tanks contents is required as well as manual sounding pipes.

Tanks shall be filled through deck connections, one port and one starboard, at main deck level. .

On completion of the fresh water system and before putting it into service the entire fresh water and distribution system shall be sterilised completely using appropriate chemicals in accordance with MCA requirements including MGN 397.

Manholes shall be designed to make cleaning and inspection easy. The air vents of fresh water tanks shall protected against penetration of sea water and other contamination.

6.4.40 Fresh Water Distribution System

R6.185 A hydro-pneumatic pressure system shall be installed to supply fresh water to accommodation and scientific spaces, showers, baths, washbasins, water fountains, galley and washing of wheelhouse windows, through an ultra violet sterilize or silver ion and filter system as a final treatment.

Water supply for wheel house window washing shall be fed through inside of bridge and shall be well insulated to prevent icing up in Polar Regions.

The hydrophore tank shall be of capacity of 750 litres, maintained at 6 bar. Two electric driven centrifugal pumps, automatically controlled by the hydrophore tank level / pressure shall be installed, based on one running and one as stand-by pump and each with capacity of 3m³/h at 6 bar. The pump shall take its suction from the fresh water tanks and discharge through a stop check valve to the pressure tank and system. The choice and mounting of these pumps must be made carefully since typically their intermittent operation can generate noise which interferes with scientific equipment therefore shall be double raft mounted.

Two circulating pumps shall be provided for the hot water system, one running, and one standby.

Two circulating pumps shall be provided for cold water system, one running, and one standby. The hot and cold water circulation pumps shall have a capacity of about 2m³/h at 4bar.

Fresh water lines with insulation where necessary shall be provided for eyewashes and de-contamination showers as follows:

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- 4 - Eyewashes, one in the hangar area, two at suitable locations near the scientific laboratories, and one in the engine room workshop.
- 3 – De-contamination showers, one in the hangar area and two at suitable locations near the scientific laboratories.
- Battery locker locations
- External fresh water hose connections with internal pipework two on each deck port and starboard.

Fresh water supplies for eye wash to be pedal operation type. Fresh water supply for decontamination shower to be hanging grip operation type.

Where necessary (in engine room, provision room, laundry, cleaning locker etc.) faucet for hose connection shall be fitted. Outlets with quick connection for hose shall be arranged in galley and scullery.

All domestic accommodation taps on sinks and wash basins shall be spring loaded non-percussive type.

Isolating valves to be fitted for parts of the piping system (at least at each deck) for proper and easy maintenance.

The risk of Legionella shall be considered and appropriate means of prevention installed.

6.4.41 Technical Fresh Water System

R6.186 A technical water system shall be installed to supply equipment in machinery space and fresh water washing, including the heli-deck and aft working deck. The system shall be arranged with a storage tank, hydrophore pump with capacity of 6m³/h at 4 bar and hydrophore tank of 200 litre capacity.

Filling of the storage tank shall be from AC-units condensate water or direct FW filling line from bunker stations and from fresh water generators.

One fresh water line with insulation where appropriate and five hose connections for deck wash purpose to be provided on the upper decks and with further connections in the Hangar and Water Sampling Laboratory to take a hose for washing down scientific equipment. These latter outlets shall be lockable to prevent inadvertent waste. Fresh water taps shall be provided at two locations within the Science Hangar.

6.4.42 Domestic Hot Water System

R6.187 The hot water system for accommodation shall be designed for a maintained temperature of +55°C, throughout in accommodation, to avoid Legionella bacteria.

Hot water services shall be provided by a ring main served by one of two calorifiers, of non-ferrous construction, and one duty hot water circulating pump and one standby pump. Fresh water for the hot water calorifier shall be supplied from the fresh water system.

Two hot water calorifiers shall be installed capable of supplying 100% of the maximum anticipated hot water demand for the vessel. The heating medium shall be the steam (or thermal oil) system. Each calorifier shall also be provided with an electric element heater for use during shut-downs of the thermal oil or steam system.

Hot water taps shall be provided at two locations within the science hangar, helicopter hangar and in each engine room.

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6.4.43 Bilge System

R6.188 An efficient remotely controlled from the Bridge with run indications in addition to local starting bilge pumping system shall be installed, capable of draining any watertight compartment

A bilge system shall be connected to dedicated self-priming bilge pumps capable of operating at extreme heels and trims of the vessel. The vessel to be provided with three bilge pumps each with capacity of approx 100m³/hr or as determined by the class rules, whichever is higher.

The bilge system shall be completely monitored by the VMS system. Remote reading of tanks contents is required as well as manual sounding pipes.

Suctions with isolating valves shall be arranged from all relevant compartments with a priming connection from the technical water tank

All bilge suction lines shall be provided with mud boxes or strum boxes. In the larger compartments, at least two (2) bilge wells shall be fitted, in opposite corners. Minimum volume of bilge wells.0.15m³

Discharge shall be overboard on the port side through a lockable double shut-off valve.

The pump suction shall be cross connected to the ballast pump system and fire and wash deck pump system, but separated by a 'Blind' & 'Open' blank.

One bilge ejector, capacity approximately 10m³/h, shall be provided for drainage of the chain lockers. The bilge ejectors of bronze and driving water supplied from the fire main.

Emergency bilge suction from each Engine Room shall be provided from the other Engine Room.

The bilge pumping system shall incorporate suction from bilge wells in cargo hold, science hold and helicopter hangar.

Removal of bilge water from winch room(s) shall be specially considered and include provision for water introduced on wires and cables recovered from overboard as well as the water washing system.

6.4.44 Oily Bilge System

R6.189 In order to minimize of the amount of oily bilge water and processing of the oily bilge water and oil residue (sludge), the concept of the Integrated Bilge Water Treatment System (IBTS) as per MEPC.1/Circ.642 & 643 as amended by MEPC.1/Circ. 676 & 760 shall be adopted.

An Engine Room/Oily Bilge system shall be installed with suction in the Engine Rooms and Thruster Room bilge wells, discharging via an electrically driven oily bilge pump of 5.0m³/h at 4bar to an oily water bilge tank.

An oily bilge water separator, of minimum 5m³/hr capacity, shall be fitted complying with MARPOL Regulations. It shall be fitted with automatic oil discharge alarm and an approved 'White Box' water discharge logging system with a memory capacity of at least 18 months. The separator shall be a high speed centrifuge type providing a reduction in oil content of the water discharged to 5 ppm.

A non-emulsifying type oily bilge pump shall be fitted taking suction from the engine room bilge and oily bilge.

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There shall be no interconnections between the sludge tank discharge piping and bilge-water piping other than possible common piping leading to the standard shore discharge connection.

6.4.45 Sludge Pump

R6.190 A suitable self-priming pump with adequate suction lift and discharge pressure shall be provided with suction from all sludge tanks etc, of minimum capacity 8m³/h for discharge to the incinerator, or to reception facilities on deck or ashore via port and starboard discharge flange points. The shore discharge line to be trace heated. Sludge pump to have suction from sludge tanks and dirty oil tank. The sludge pump suction arrangement shall be generously sized and provision made for easily cleaning the suction strainer.

The pump shall include safety pressure relief valve re-circulating discharge side to suction side.

An emergency stop shall be provided local to each discharge flange point.

All sludge, waste oil etc shall be collected in a common waste oil tank and discharged to shore via trace heated pipework.

One electric driven sludge pump of screw type, capacity: approx. 8.0m³/hr at 6 bar shall be installed with suction from all sludge tanks etc and shall be able to discharge to incinerator sludge tank, common waste oil tank or to shore connection.

Emergency stop of sludge pump shall be arranged at the discharge manifold.

6.4.46 Sludge Tank

R6.191 A sludge tank shall be fitted in the double bottom to accept waste oil / sludge from purifiers, oily water separators and fuel oil and lubricating save-alls, capacity to be determined by the Contractor to meet current anticipated MARPOL rules. Remote and manual sounding facilities shall be fitted.

The sludge tank shall be fitted with tank heating coils. The discharge of the small pump shall be to a funnel (at a visible location) that drain to the bilge tank with a pump stop button locally fitted close to the funnel. The discharge line from the small pump shall be fitted with manually operated self-closing valves at its termination above the funnel

The oily bilge system shall be completely monitored by the VMS system. Remote reading of tanks contents is required as well as manual sounding pipes.

6.4.47 Ballast System

R6.192 The water ballast system shall be arranged to provide the following functions:

- Filling of any water ballast tank.
- Discharge of any water ballast tank overboard.
- Transfer between forward and aft water ballast tanks.
- Transfer between port and starboard water ballast tanks.
- Rapid transfer between designated port and starboard water ballast tanks without discharging ballast water and without using the BWTS. See Section 5.1.26

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The ballast transfer system shall be provided with remote control. Local control of pumps and valves shall be available in case of failure of the remote system. The ballast system shall be provided with appropriate means to prevent freezing, e.g. air bubbling and air vents shall be designed to allow escape of air and prevent pressurization of the tank.

Two electric driven ballast pumps of vertical in-line and self-priming centrifugal type shall be provided each with a suitable capacity taking into account rapid heeling requirements and ballast pump discharge head shall take account of the pressure loss across the treatment plant. The air vents shall be designed for the full head capacity of the ballast pumps when the treatment plant is by-passed). Generally the system shall be designed to operate with one pump only running. Rapid transfer between separate heeling system tanks shall be achieved using both Ballast Pumps running together.

This system shall be under the control of, as well as, monitoring by the VMS system.

Ballast pumps shall be provided with remote starting facilities from the Bridge with run indications in addition to local starting.

Remote reading of tanks contents is required as well as manual sounding pipes.

The ballast tanks shall be of sufficient size and disposition as to provide a means by which the draft of the vessel can be optimized for the operation of the bottom mounted hydrographic equipment.

A ballast treatment system shall be installed whereby ballasting can be carried out which preclude the need for ballast exchange procedures. Ballast Water Treatment plant shall be installed based on an approved system with a flow rate equivalent to the ballast pump capacity. The treatment plant shall be designed for operation in the specified low temperatures. No chemical release shall be permitted.

The ballast management system is to comply with IMO regulations and recommendations.

At least two tanks shall be arranged, one forward and one aft, e.g. fore peak, aft peak, for trimming purposes.

Pump filling/suction lines shall be taken from the each of the Water Ballast Tanks.

Ballast tank coating materials and application standards are to reflect the specified vessel service life.

6.4.48 Ballast Water Treatment Plant

R6.193 A ballast water treatment plant shall be fitted to comply with latest IMO standards. The treated water shall meet D-2 discharge standards of the Ballast Water Convention. The selection of Ballast Water Treatment system shall take into account the method of ballast water treatment and its impact on the environment. The selected system shall be fully compliant with USCG Regulations and approved by Lloyd's Register.

Ballast Water Treatment plant shall be installed based on an approved system with a flow rate equivalent to the ballast pump capacity. The treatment plant shall employ both physical separation and disinfection without using active substances, e.g. UV. Any system which makes use of, or generates, Active Substances, Relevant Chemicals or free radicals during the disinfection process to eliminate organisms shall not be selected.

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The unit shall be designed to minimise pressure drop across the unit. The unit shall include an automatic back-flushing facility comprising automatic back-flushing filter, and automatic back-flushing pump.

The treatment plant shall be designed for operation in the specified low temperatures.

No chemical or by-product release shall be permitted.

6.4.49 Ballast, Bilge and Gutter System

R6.194 All pipes such as bilge, gutter pipes, ballast, black, grey water, fresh water, fire fighting system etc exposed for risk of freezing shall be provided with steam or electrical tracing and suitably insulated.

6.4.50 Air Pipe Systems for Tanks

R6.195 Air pipes shall be fitted to all tanks, cofferdams, stores, sea chests etc., and shall be carried above the deck to open air. Automatic vent head (approved type) shall be installed.

From sewage tank, dirty oil tanks and incinerator/sludge tank the air pipes shall be carried to the top of the funnel.

Air pipes from fuel oil tanks shall be connected to a common ventilation and over-bunkering protection system.

Further attention must be paid with regard to the distance from shipside etc. in connection with stability requirements.

Overflow trays shall be arranged below vent heads from all type of oil tanks. Volume of overflow trays below vent head shall be marked as per oil major's requirement.

Electrical/steam trace heating, which shall maintain the surface of the pipe at 5⁰C shall be installed for weather exposed air pipes as part of winterisation.

6.4.51 Sounding Pipe Systems for Tanks

R6.196 Remote sounding arrangement shall be provided for all water ballast, freshwater, sludge, waste oil, lube oil/hydraulic oil storage, Fuel oil (MGO and LSDO) bilge tanks, grey and black water tanks and AVTUR fuel tanks and sludge tanks.

All sounding points shall be through the top of the tank.

The remote sounding system shall be part of the VMS System.

Fuel oil (MGO and LSDO) service and settling tanks and storage tanks for lube oil and hydraulic oil shall also have approved type of local level gauges in addition to remote reading from VMS.

Short sounding pipes in engine room are to have self-closing cocks and test cocks.

6.4.52 Fire & Wash Deck System

R6.197 A fire and wash deck system shall be connected to the self-priming fire and wash deck pump with sufficient hydrants to satisfy the Rules.

The capacity of the fire pumps shall be such that with one pump failed or unavailable location, there is sufficient capacity to meet the worst case demand. Calculations shall be submitted to demonstrate the adequacy of flow and pressure at hydrants located at extreme positions.

In addition to serving the branch lines to hydrants the following shall be supplied:

- Hi fog water mist system.

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- Heli-deck AFFF system.
- Paint Store Drencher system.
- Chemical Stores
- Boat Workshop / Garage
- Helicopter Hangar
- Main Deck Aft AFFF monitors
- Bilge ejector for chain lockers.
- Cleaning of sewage water tanks.
- Hawse pipes at the washing the anchor chain.
- Fire monitors service hazardous areas relating to the aviation fuel systems.
- AVTUR system deluge system (foam).

Three dedicated fire pumps shall be provided one of which will be designated as the emergency fire pump. The fire pumps shall be located in separate compartments such that in the event of fire in any one compartment, the fire pump in other compartment is not affected. The pump designated as emergency fire pump shall be connected to the emergency switchboard.

The fire pumps shall be provided with remote starting facilities from the Bridge with run indications in addition to local starting.

International shore connection shall be provided.

Fire pumps shall be electric driven self-priming centrifugal pumps. Pump capacity shall be confirmed on the basis of the greatest simultaneous demand being met.

As far as possible fire mains shall be run internally.

Exposed fire mains and hydrants on deck shall be fitted with trace heating and suitably insulated.

The fire pump suction with isolating valve shall be taken from the sea chests outboard of the sea bay.. Discharges with isolating valves shall be to the fire main and overboard.

Hydrants shall be located in strategic positions throughout the vessel in accordance with the Rules and shall not present interference with other equipment or present a risk of injury to personnel i.e. in alleyways they shall be recessed in bulkhead linings or place away from the main traffic routes.

All hoses shall be stowed on reels.

Electrical/steam heat trace and thermal insulation to be provided for weather exposed parts of the fire main for winterisation purpose. All thermal insulation is to be appropriate for the stated operating environment and not soft shell lagging.

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The accommodation shall be provided with a constant pressure fire extinguishing system to tackle smaller fires consisting of fire hose reels permanently connected to technical water hydrophore system with emergency feed from domestic fresh water system shall be provided . The hose shall be operable when under pressure.

The system shall have a pressure of not less than 3 bar at the nozzle at the highest hydrant.

The hose reels shall be so located that any point in the accommodation can be reached with water spray from at least one hose reel.

1" or 1¼"hoses shall be used, water capacity shall be approx. 200 l/min and shall have a combined jet or spray nozzle. Hose length shall be maximum 20m per hose reel.

The hose reels shall be recessed and swing type to minimize obstruction of escape paths.

Conventional fire hose equipment supplied from the fire main shall also be provided to fight more extensive fires in the accommodation.

6.4.53 Sewage Systems (Black Water)

R6.198 A modern fresh water flushed sewage system shall be arranged, consisting of low volume fresh water flush vacuum toilets, vacuum pumps/ejectors, sewage treatment plants and sewage holding tank. The treatment plant shall treat both black water and grey water.

The black water system shall be designed with one separate main vacuum line serving each deck. Each separate main vacuum line shall be lead to the main vacuum tank(s). Each separate main vacuum line shall be fitted with a segregation valve at the vacuum tank(s) for sectional maintenance shut-down of the system. Water jetting / cleaning facilities shall be provided on all horizontal sewage pipe runs

The vacuum sewage system shall be fitted for the complement of 90 persons and the public toilets with the emphasis on quiet operation, so as not to compromise scientific operations with intermittent noise and the underwater noise requirements.

A backup connection from a seawater services line shall be fitted in the engine room.

The sewage plant is to meet as a minimum with Annex IV of the international IMO regulations (MARPOL 73/78), US Coastguard (USCG 33 C FR 159), all local regulations for the intended areas of operation and Lloyd's Register ECO notation requirements. Special consideration to be given for meeting zero discharge requirements if any for special areas including Arctic and Antarctic geographic zones.

Sewage treatment system of approved type. The system shall comprise two plants, each with capacity for 60 persons and shall be sized to include grey water such that the vessel qualifies for Lloyds Register ECO notation GW. This shall be on the same sizing basis as for black water so that the plant is sized for a total ships complement of 90 people, each unit being sized for 60% of this.

During periods when there are reduced numbers onboard it shall be possible to maintain one treatment plant in service and the other unit in a lay-up condition.

The sewage treatment plant shall be of a biological type, where supply of oxygen activates the biological action and dosage of hypochlorite for removal of remaining bacteria's in the treated water. The plant shall meet Type II USCG standards.

The system shall include 100% redundant vacuum pumps.

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The treated water from the sewage treatment plant shall be led to overboard connections on port side. The sewage treatment plants shall be equipped with emergency overflow connected to overboard connections above water line port and stbd.

The plant shall be provided with adequate securing mechanisms to prevent discharges of treated and untreated sewage while in No Discharge Zone. Example, padlocking, removable seacock handle.

The sewage treatment plant shall be ventilated to free air with a vent pipe terminating away from any air intake.

Mineral sludge which is building up in the sewage treatment plant shall at given intervals be pumped to a sludge tank or to a supply vessel. The discharge pumps shall be fitted with a shredder to macerate solids to an acceptable size for the pumps.

All grey water outlets from the Hospital shall be treating as black water and shall be connected to the sewage treatment plants.

Each sewage treatment plant is to be mounted on a skid and consist of following main components:

- One sewage treatment tank, with necessary division plates and external connections.
- Two air blowers,
- Two Discharge pumps,
- One dosing pump
- One control panel with necessary alarms and indication of operation

The discharge pumps of the treatment plant are to discharge overboard, or to the waste water tank for treated black and grey water or to the sewage holding tank.

Suitable hose connections shall be fitted on the sewage treatment unit to enable it to be flushed through with clean seawater without having to dismantle any pipes.

All overboard discharges from the sewage system shall be arranged below the waterline on the port side of the vessel aft of the main sea water inlet. Discharge from the sewage holding tanks shall also be arranged to a shore connection flange on the deck at port and starboard side with approved International flange connection.

Emergency stop of the discharge pumps shall be arranged at the discharge stations.

Grey water from laundries is to be lead to a separate waste water tank and then discharged automatically through the final chlorination chamber of the sewage treatment tanks. Laundry grey water filters shall be installed.

6.4.54 Waste Water Tanks

R6.199 A suitably sized waste water holding tanks shall be provided with a minimum of 45 days holding capacity for combined storage of both grey and treated black water.

These holding tanks shall be used for holding treated black water and grey water while operating in a designated as no discharge zone by EPA while the vessel is operating in America waters.

Tank monitoring / level indication and pump control shall be provided by pressure transducers suitable for use in sewage systems. Float switches are not to be used.

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The holding tank shall be connected to the main grey water gravity line via a by-pass valve. The holding tank shall have sufficient capacity while operating in no discharge zones and ports with restrictions.

For discharging of the waste water holding tank, a discharge pumps shall be supplied. The waste water discharge pumps shall discharge the contents of the tank through overboard connections below ballast line. Two waste water discharge pumps, centrifugal type, electric driven, and capacity each 20 m³/h at a head of 2 bar shall be provided for this purpose.

All vent lines from the sewage and grey water tanks shall be led to the funnel top.

Charcoal filters shall be provided on vent discharges.

6.4.55 Sanitary Systems, Discharges and Drain System

R6.200 The sanitary discharge / drain system shall be split into grey water and a black water system. The system capacities shall be designed based on total number of crew and actual discharges from galley and laundry equipment.

6.4.56 Waste Water System (Grey Water)

R6.201 Drains of wash basins, showers, galley, laundry, floor scuppers etc. shall be connected to the main grey water discharge lines. The grey water system shall be designed with main grey water drain lines on each deck connected to the main grey water gravity line(s). The main discharge lines on each deck shall have sufficient slope towards the main grey water gravity line to obtain drainage by gravity allowing for various states of trim and list.

Grey water to be discharged through last stage of sewage treatment plant such that the vessel qualifies for Lloyds Register ECO notation GW or overboard directly or into waste water holding tank.

Food waste shall not be mixed with either black water or grey water. Special designed holding tank for the ground food waste must be installed on the vessel to be used when the vessel is:

- (a) in port,
- (b) less than 3 nautical miles from the nearest land outside Special Areas or
- (c) less than 12 nautical miles from the nearest land inside Special Areas.

The food waste from galley shall be ground in a macerator system fitted to galley sinks. The slurry water from the macerators shall then transported by vacuum to the skid mounted holding tank. The contents of the holding tank to be pumped overboard where permitted. The vacuum system is proposed to lessen risk of blockages, reduce amount of water used and to make pipe smaller.

All galley grey water from the scuppers and sinks has to pass through a grease separator before it is discharged to the grey water system. The grease shall be drained to sludge tank through trace heated pipe. The grease separators shall be equipped with automatic grease level alarm that alerts when it is time to empty the separator of fat. Inside of grease separator there shall be a spray nozzle for cleaning with hot water.

All floor drains in toilet rooms, galley areas, laundries etc. to be provided with water seals and perforated stainless steel cover plates.

The holding tank shall be connected to the main grey water gravity line via a by-pass valve.

6.4.57 Starting Air Systems

R6.202 A starting air system shall be arranged as recommended by the engine builder and approved by the Classification Society.

At least two reciprocating air compressors one serving each Engine Room, shall be fitted, electric motor driven, air or water cooled 1200 rpm. and of similar size and capacity, each having an air delivery of sufficient capacity and pressure to suit the engine designer's recommendations.

Both compressors shall be able to fill either of the two air receivers.

They must have additional capacity, which may be required for control air duties, engine room and deck services in emergency.

Starting and stopping of compressors shall be automatic controlled by pressure in starting air receivers. Starting order shall be manually changeable.

One of compressors shall be designed as the first start unit and must be connected through the emergency generator circuit and be capable of being cooled adequately for this situation.

The air compressors shall be arranged on isolation mounts and fitted in acoustic booths.

Oil and water separators shall be fitted in pipe between compressors and receivers.

Two air receivers per engine room shall be fitted with a total capacity suitable to start the largest engine 6 times without replenishment by the compressors. The working pressure shall be to the requirements of the engine Manufacturer. Starting Air systems in each Engine Room shall be cross connected to allow either compressor to charge any of the air receivers.

6.4.58 General Service Air Systems

R6.203 General Service air shall be provided by two dedicated variable speed or soft start rotary vane compressors capable of 7 bar pressure and 11m³/min

A general service air receiver of minimum of 6 m³ capacity shall be provided, however they shall be as large as possible within the designated compartment to reduce compressor cycle time.

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The general service air shall supply soot blowing and urea atomization air required by the catalytic converters. In addition the air shall be distributed as a minimum throughout the following areas:

- Engine Room - 8 positions
- Auxiliary Machinery Rooms - 4 positions in each
- Scientific Winch Room (main)- 4 positions
- Scientific Winch Room (Port)- 2 positions
- Science Hangar - 2 positions
- Helicopter Hangar – 2 positions
- All Workshops - 4 positions each
- All Laboratories - 1 position each

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- Aft Working Deck - 3 positions each port and starboard
- Crane & “A” Frame Pedestals- 1 position each
- Side Working Deck - 1 position
- Fore deck - 1 position
- Hangar Top (if open deck) - 1 position
- Sea Chests - 1 position each

A link between the science use and general service air systems with a suitable pressure reducing valve shall be provided.

A bubbling air system for anti-freezing of ballast tanks shall be installed.

The air compressors shall be arranged on isolation mounts and fitted in acoustic booths.

6.4.59 Control Air Systems

R6.204 If the machinery system design requires it, a control and instrument air system shall be arranged with a dedicated control and instrument rotary vane air compressor, after cooler, oil eliminator, and duplex refrigerated air dryer.

A back-up supply shall be arranged, taken from the main air starting reservoirs, through a pressure reducing valve upstream of the oil eliminator and dryer. A further back-up supply shall be cross-connected from the general service air system.

6.4.60 Diesel Engine Exhaust Systems and Tier III for NOx and SOx

R6.205 The exhaust gas trunking from the main diesel engines shall be led to the funnel(s). Exhaust gas systems shall be arranged as recommended by the equipment *Manufacturers* and designed to reduce back pressure to a minimum and sufficient access space for lagging.

The use of any material containing asbestos is not allowed in lagging and gaskets. A suitable type lagging material shall be used to minimise health dangers due to dusts formed from brittle breakdown of the material due to prolonged heat exposure

The exhaust emissions from auxiliary engines shall comply with IMO Tier III NOx limits for operations in current designated North American ECA and the US Caribbean Sea ECA. The system shall be designed to operate in other ECAs which are expected to be designated in future for Tier III NOx control based on the operating profile of the vessel.

Each Main Engine exhaust shall be led to atmosphere via an SCR exhaust gas economiser, silencer / spark arrestor. The economiser may share the exhausts from two engines, but with separate gas paths.

Exhaust from the Harbour Generator shall be led to atmosphere via SCR, silencer / spark arrestor.

NOx emissions shall be reduced using a Selective Catalytic Reduction (SCR) technique. Emissions shall be reduced to the maximum level possible bearing in mind that the fuel used is the most conducive to the success of this process and 95% reduction would be a reasonable target.

Enhanced SCR reactors that include oxidation catalyst layers for the abatement of carbon monoxide (CO) and hydrocarbon (HC) emissions also shall be considered.

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The unit shall have reactor with catalyst elements, storage tanks, pump units for transfer and dosing of urea, nozzles for atomizing the urea solution using compressed air and mixing duct for mixing exhaust gas and atomized urea.

To ensure adequate amount of urea is always injected, urea dosing shall be based on the engine load and speed.

The unit shall have differential pressure sensors to monitoring the condition of the catalyst elements and a temperature transmitter for monitoring the exhaust gas outlet temperature.

The mixing duct shall have a manhole for inspection of the ducts.

The unit shall be equipped with a soot blowing system that operates at preset intervals for keeping the catalyst elements clean. Compressed air connections for soot blowing purpose shall be installed at each catalyst layer. The soot blowing connections shall be located on two opposite reactor walls, to ensure efficient cleaning of all catalyst elements.

The catalyst elements shall be able to be accessed for maintenance and replacing aged catalyst shall be possible through hatches in the reactor wall.

The size of the urea storage tank must be based on consumption matched to the engine type and the load profile for operating in ECA area at ice breaking power. The sizing of the urea tank shall also consider possible operation in future extended ECA regions. The shipyard to provide sizing calculations for NERC's review stating the number of days of operation in ECA, See Section 4.5, for their selected tank size.

The Urea Storage tank(s) shall be sized to contain enough urea to cater for a typical 50 day duration cruise taking into account the most onerous prediction of electrical power demand derived from the Typical Cruise Profiles. A means by which bulk delivery of the urea can be loaded directly into the tank through a bunker line on both sides of the vessel shall be provided.

The urea solution storage tank shall give a high level alarm when the high level is reached during bunkering.

The unit shall have control and automation system for automatic start and stop of urea injection based on starting and stopping of engines. The nozzles shall be purged of urea using compressed after stopping urea injection. An emergency stop button shall be provided on the control panel to initiate a quick shutdown of the system.

The operating conditions of the SCR's shall be specially considered in respect of diesel alternators running at low load for extended periods. This may require additional heaters. In the event that variable frequency diesel alternators are proposed the heaters may be omitted if the exhaust gas temperature from the engine running at part load can be demonstrated to be sufficient for the SCR operation.

The economic use of the SCR shall be considered. Removal of the catalyst shall be considered, or by-passing the catalyst (to prolong it life before replacement) shall be considered. In this case dummy replacement may be fitted.

The SCR's shall have an internal fire extinguishing system.

The system shall require the following elements to be accommodated in the vessel:

- Urea solution storage tank(s)
- Urea solution pumping and dosing unit (1 no. per exhaust)

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- Injection unit (1 no. per exhaust)
- Reactor housings (1 no. per exhaust)
- Catalyst elements (1 set per exhaust)
- Soot blowing unit (1 no. per exhaust)
- Control and automation system

Gas analyser system for each engine exhaust comparing results before and after the SCR and with an automatic memory facility for the readings covering at least 6 months operations.

The system shall be supplied by a Manufacturer who has a substantial and successful track record of installations over a number of years and in particular has utilised their units on engines of the size and type proposed for this vessel.

The reactor units shall be of the type that provides exhaust noise attenuation to a high level.

The main engine silencers shall be supplied and fitted in the upper casing and funnel in order to augment the noise attenuation to an aggregate value of at least 40dB. Note that exhaust noise on the aft working deck shall be limited to 75dB.

All elements of the exhaust system shall be efficiently stayed to prevent vibration and reduce noise in support of the requirements of the overall ship noise specification.

Adequate means of access and space for examination and cleaning of the silencers shall be provided. All exhausts shall be fitted with spark arresters.

Adequate means of access and space for removal and replacement of catalytic elements shall be provided.

Independently of the exhaust gas treatment plant each exhaust pipe shall be provided with a suitable sampling point at a common level and position across the engines for monitoring temperature, O₂, CO₂, NO_x and SO_x.

Sumps shall be arranged at the bottom of the vertical exhaust uptakes with drains leading to water drain pots. Exhaust extensions above the funnel top exposed to weather part shall be in Corten steel. These shall be angled outboard and to have angle cut ends to prevent rainwater ingress.

Suitable rain-catching arrangements shall be made at the top of the funnel, with drainpipes being led to deck scuppers.

The funnel may also be used to allow the escape of hot air from the engine room, jalousies and flaps shall be provided in the event of fire.

Particular attention shall be paid to protecting personnel from contact with hot surfaces.

Exhaust system lagging shall be arranged such that the surface temperature does not exceed 60 degrees C.

The emergency diesel generator exhaust shall be led directly to atmosphere at a convenient location away from main working areas. Personnel shall be protected from contact by cages and the exhaust shall be fitted with an automatic rain cap.

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6.4.61 Incinerator

R6.206 An incinerator in compliance with IMO resolution MEPC 244(66) shall be fitted in a separate space, external to the engine room, which is capable of burning waste oil from the engine room (transferred by the sludge pump). A USCG certificate is to be supplied for the Incinerator.

The incinerator shall be fully automatic with three-chambers and an induced draught air ejector for evacuation of the flue gases. The Incinerator shall be designed for simultaneous burning of solid waste and oil sludge with a water content of up to 50% without adding pilot fuel.

A compactor unit (compacting to approximate 300mm cube) shall be provided near the incinerator.

Its capacity shall be considered within the context of the overall waste management design of the vessel. The compressive strength of the compactor is to be sufficient enough to compact waste such that they can enter through the sluice door of the incinerator without having to unpack them.

The oil sludge mixing tank shall be provided for efficient agitation and comminution of the contents in the tank and be fully equipped with heating coils with temperature control valve, drain valve, level gauge, necessary fittings and necessary automation according to the incinerator maker's standard.

The Incinerator space shall be fitted with suitable ventilation, fire detection and fighting arrangements.

The independent incinerator exhaust shall be led to atmosphere at funnel top away from working areas and any scientific position which may be affected by its contaminating products.

The arrangements must include spark arrestors and means of controlling the solid particle content of the exhaust. It is to meet the requirements of applicable Regulations.

6.4.62 Lifting and Overhauling Gear

R6.207 Overhauling beams with travellers shall be provided over the main diesel engines, turbochargers and alternators, harbour generator (if installed) and emergency diesel generator.

Uninterrupted lifting facilities shall be provided for lifting any engine cylinder head connecting rod, cylinders and transporting it suspended from an overhead beam to a bench in the engine room workshop and or out of the vessel through hatchways. This same facility shall also be capable of servicing the engine turbochargers.

Adequate certified lifting lugs, eyebolts, shackles, bars etc. shall be provided above all other auxiliary machinery for overhauling purposes and as may be required for lifting items of spare parts. All lifting lugs, lifting beams, davits and portable lifting gear shall be proof tested, certified and clearly marked with their appropriate Safe Working Load (SWL.)

Lay down areas shall be provided next to groups of machinery whereby equipment can be landed and dismantled for survey, overhaul or repair. Adequate areas, headroom and movement routes shall be arranged. Also, clear lay down areas of sufficient size under engine room hatches to allow for slinging adjustments etc prior to installation/extraction from machinery spaces.

Hatchways should not be located completely in the corners of the machinery spaces, but allow sufficient boundary space to provide additional slinging/lifting points on all

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sides of the hatch for ease of handling of large or heavy items required to be manoeuvred underneath the open hatch.

A plan showing the lifting and overhauling arrangements for the main diesel engines, generators, shafting and propulsion unit(s) shall be submitted to NERC for approval.

Overhaul routes shall be shown particularly routes to the workshop and engine hatchway.

All hatchways in any position in the ship shall be provided with facilities for fitting temporary stanchions and wires to protect the opening when the hatch is in the open position. Suitable wires, stanchions, sockets and fixtures shall be provided and demonstrated.

Every item of heavy equipment and large in dimension, including general service bilge and ballast pump motors, is to have efficient lifting facilities over them for overhaul purposes.

6.4.63 Name Plates

R6.208 Each unit of machinery and equipment shall be marked or labelled by means of a nameplate with logical and consistent method of identification of equipment, valves etc and electrical installation.

All names plates, caution plates and instruction plates on all equipment and machinery shall be in English. Corrosion resistant metal nameplates in English shall be fitted to the hand wheels of all valves and to pumps, tanks, etc.

All ship system valves are to have dedicated code numbers engraved on the name plate that cross reference to the ship system drawings and VMS display.

All nameplates shall be of the rectangular type, with engraved letters, and fitted with screws or solid rivets. Fixing of nameplates with glue or self-adhesive tape shall NOT be allowed.

Weather exposed nameplates to be made of brass and riveted or screwed with a plastic sheet.

Nameplates indicating hazards to be red coloured.

6.4.64 Sea Inlets

R6.209 Sea suction shall be located as low as possible to decrease the likelihood of ice being ingested. Sea chests shall be fitted clear of the ship's bottom. A means of clearing ice from all intake boxes shall be required.

Port and starboard sea chests, shall be fitted with hinged stainless steel (SUS 316L) suction grids on each side of the ship's structure in way of the sea bay.

The sea bay shall be connected to the port and starboard sea chest through back flushing strainer boxes with isolation valves to allow access to the strainer boxes for removing debris without the need of shutting down the vessel's systems. These large isolation valves shall be hydraulically actuated with provision for manual emergency operation.

Pipe work and valves shall be sized for the seawater-cooling requirements of all systems. For sufficient cooling water to enter the system, the area of the inlets and sea bay shall be based on total cross sectional area of seawater pumps plus fouling margin. Sea suction chests shall be sized to have a free area of at least 2.5 times the total area of the pipes it is serving. Calculations to be submitted to NERC for approval.

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Each sea chest shall have vent holes in the shell near the upper edge of the chest and drain hole(s) near the lower edge of the chest. Where vent holes are not practicable, sea boxes shall be fitted with adequately sized air vent lines with isolating valves, led to above main deck level.

The sea bay shall be isolated from the sea from time to time in severe mush ice conditions. During this scenario, the main seawater circulation system shall be re-circulated through the sea bay for temporarily using the keel plating as a cooler. A return line to the sea bay, with isolating valve shall be required as an alternative to the overboard discharge on all circulating systems for recirculation.

All overboard discharges shall be on the port side of the vessel.

The return line to the sea bay shall have its temperature controlled automatically by an air or electric powered control valve, which shall either return seawater to the bay, or divert it overboard. When seawater is diverted overboard, the sea bay shall not be isolated.

Compressed air connections shall be provided fitted with valves and tail pipes on all sea chests for ice and weed clearance.

Overboard discharge valves may be attached to flanged stand pipes welded to the hull, provided that the stand pipe thickness is equal to the hull plate thickness or not less than 13 mm whichever the greater, the pipe interior shall be protected in an agreed manner.

Bilge and sewage overboard connections shall be arranged well aft of the sea chests.

Stainless steel gratings shall be fitted to each sea chest. Gratings and securing nuts must not protrude beyond the outside of the shell plating. Securing nuts shall be of brass or stainless steel and locked in an approved manner to prevent them unscrewing. Gratings that weigh more than 40kg, shall be fitted with hinges to facilitate sea chest cleaning both underwater and in dry dock.

Suitable coatings and aluminium anodes shall be provided with at least 20 mA/m² for the wetted area of the sea bay and sea chests to protect the steel work in the sea chests and sea bay.

The sea bay shall be fitted with a least two access manholes, one port & one starboard.

A separate sea inlet for pumping scientific uncontaminated seawater for sampling shall be provided. This sea inlet shall be well forward of Sewage /Bilge/ Ballast and Sea water discharges. The sea water inlet shall not have any form of anti-foulant coating that could contaminate the Uncontaminated Sea Water system.

The uncontaminated sea water sampling intake shall comprise a retractable stainless steel probe. Valves shall be fitted that allow for cleaning. Piping is to be Teflon lined stainless steel.

6.4.65 Engine or Engine Rooms Engine Air Intakes

R6.210 Engine or Engine Room air intakes shall have a single stage air/water-dust separator (Premaberg two stage separator type P35 or equivalent), made of aluminium alloy. Water removal shall be at least 99.9% at 6 m/sec air inlet velocity for droplets of 4-6 microns.

All air/water-dust separators shall have trace heated drain pipes to open deck.

Engine air intakes must be with fire dampers for closing in case of fire.

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Maximum noise at air intakes shall be 75 dB(A) at 100% MCR on propulsion

Preheating is described under Winterisation.

6.4.66 Tank Heating Coils

R6.211 Tanks which are most vulnerable to freezing of the tank content shall be fitted with steam or thermal oil heating coils. Tank heating calculations shall be carried out to assess the heating coil length depending on the vulnerability of the tanks based on its location.

Technical water tank shall be provided with indirect tank heating from the steam or hot water system system. The indirect system shall include F.W. circulating pump and a heat exchanger that is supplied with steam or thermal oil so that both technical water and boiler feed water remain uncontaminated from each other.

6.4.67 Piping System – General Requirements

R6.212 Pipes and Joints, General Requirement

All pipes of 50mm bore and above are to have flanged connections with machined joint faces. Flange dimensions to be in accordance with the appropriate BSI Standard.

Particular attention shall be paid to the provision of ample flanges in all systems so pipelines can be removed easily for future maintenance without the necessity of major removals of other piping in way, to shut down plant or causing major system disruption.

Pipe thicknesses used throughout are to meet Lloyd's requirements; however a minimum of BS EN 10255 grade medium shall apply unless stated otherwise in the various clauses referring to the pipe systems.

Valves and fittings shall be certified or type approved by the Classification Society.

Control valves shall be sized from the flow and pressure drop requirements of the system and not from the size of the adjacent pipe work.

Pressure reducing valves shall be provided with inlet and outlet isolating valves and a manual by pass valve. One pressure gauge and one pressure relief valve shall also be provided on the downstream side of a pressure reducing valve.

Extended spindle valves shall be provided for any valves located 300mm or more below the floor plates or 2,000mm or more above. Spindle drives shall be robust and provided with an operating wheel and lever.

Main sea chest valves for the ships machinery cooling system shall be hydraulically actuated with provision for emergency manual operation.

All jointing materials employed shall be from recognised first class manufacturers. No material containing Asbestos shall be used.

All flanges shall be connected using nuts, bolts and washers protected from rust by zinc plating or by use of stainless steel.

R6.213 Fittings, General Requirements

Particular attention shall be paid to the provision of ample isolating master valves and by-pass lines in all systems so that auxiliaries can be overhauled without the necessity of shutting plant down.

All valves, except for small bore standard design, butterfly or gate valves, shall be of outside screw and yoke, rising stem type. In general, all valves for similar duties shall be of the same make and type. Screwed bonnet valves are not acceptable.

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Pressure gauge and instrument tapings shall be provided with isolating facilities at source. Where pressure gauges are located more than 5 metres from the sensing point, shut-off cocks shall be provided at the gauge in addition to the shut-off facilities at source. A test cock shall be fitted in each sensing line between the gauge/instrument and the shut-off facility to accept a suitable calibration unit.

R6.214 Materials for Piping

First class materials shall be used for all piping and shall generally be as indicated in this NERC Quality and Construction Standard. Steel pipes shall be not less than BS EN 10255 grade medium and shall be of solid drawn construction. See Details Below:

Main Engine Systems

System	Material	Max Velocity m/s	Jointing
Lubricating oil	Seamless Carbon Steel (BS EN 10216-1)	2	C.A.F
Fresh water cooling LT/HT circuits	Butt Welded Steel (BS EN 10255)	3.5	C.A.F
Starting Air	Seamless Carbon Steel (BS EN 10216-1)	6	C.A.F

Sea Water Systems

System	Material	Max Velocity m/s	Jointing
Main Engine and Auxiliary Cooling	CuNi	3 Rubber	Insertion

All fabricated pipe sections for galvanising shall be offered to the NERC's representative for inspection on a batch basis, before and after galvanising.

If 90-10 Copper-Nickel-Iron (Cupro-Nickel) is used then an extended guarantee of 5 years is required on the installation.

Uncontaminated Seawater System ABS plastic

NOTE: Special care shall be taken in fitting the jointing between flanges so that it is flush and does not protrude into the bore of the pipe, so collecting particles present in the sea water sample, to possible contaminate later samples.

System	Material	Max Velocity m/s	Jointing
Scientific Sea Water Cooling System	Corrosion resistant material to be proposed	2	Rubber Insertion
Fire and Washdeck	Galvanised Steel	4	Rubber
Bilge	Galvanised Steel	112m/min	Rubber

System	Material	Max Velocity m/s	Jointing
Low Pressure Fuel Oil (Transfer and Engine Supply)	Seamless Carbon Steel	2	C.A.F
Scientific Fresh Water Cooling System	Butt Welded Steel (BS EN 10255)	2	C.A.F.

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Domestic Fresh (up to 15mm dia)	Solid Drawn Copper	4	C.A.F
Domestic Fresh (over 15mm dia)	Galvanised steel or 'Yorkalbro'	4	C.A.F
Sanitary Water	Aluminium Brass	3	C.A.F
Sewage	Stainless Steel "Blucher" or similar Vacuum		Rubber
Grey' Water	Stainless Steel "Blucher" or similar Vacuum		Rubber
General Service Air (BS 3601 Gr 23/27)	Seamless Carbon Steel	6	C.A.F
Engine Exhausts	Fabricated Mild Steel		C.A.F.
Hydraulic Systems (over 100 bar pressure)	Stainless Steel or Corrosion Resistant austenitic stainless steel in exposed areas (BS EN 1652, 1653)		
(Up to 100 bar press. with no piping over 42mm bore).	90-10 Copper-Nickel-Iron (BS. 2875/CN 102)		

NOTE:

Butt welded steel pipes to BS EN 10255 are not suitable for cold bending.

Flanges and bolting for pipes shall be in accordance with B.S. MA51.

Flanges and bolting for engine exhausts shall comply with BS MA9.

Solid drawn copper lines may be used instead of steel for pressure gauge lines and lines below 15 mm provided the maximum working pressure does not exceed 10 bar.

For ship's compressed air systems over 7 bar flanged pipes shall be used. Below 7 bar "Ermeto" type couplings may be used.

Size of steel pipes

Steel pipes to be sized in accordance with BS EN 10255, grade medium.

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Materials for valves and fittings

Service	Component	Material/Remarks
Sea Water Main circulating lines and lines in constant use	Strainers	
	Body	Gunmetal (BS 1400 LG4) or fabricated 90/10 Copper Nickel-iron
	Screen	Monel alloy 400(BS 3072/5 NA13)
	Fixings	Monel alloy 400(BS 3076 NA13)
	Gate Valves	
	Body	Nickel-aluminium bronze (BS1400-AB2C)
	Wedge & Seat	Monel alloy 400 (BS 3076)
	Stem	Monel alloy 400 or K500(BS3076)
	Fixings	Monel alloy 400
	Butterfly Valves	Structurally to be BS MA65 Part 10, 1976. Only double flanged valves are acceptable, or U section valves with studs.
	*Body and disc seat	Nickel-aluminium bronze (BS1400-AB2C) Non-swelling high nitrite rubber or fluoropolymer.
	Stem and pins	Monel alloy 400 or K500
	Butterfly Valves Not in constant use	
	Body and disc	Rubber lined cast iron or steel. A separate seal is required to prevent seawater ingress to disc and body where the stem penetrates the lining.
Seat	As * above	
Stem and pins	Nickel-aluminium bronze BS 2874-CA 104)	

- NOTES:
1. The fresh water generators shall include stainless steel components, this is permitted.
 2. Where U section butterfly valves are employed it must be possible to remove the valves from the line without removing sections of line.
 3. Butterfly valves to be "Lug Type"

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Service	Component	Material/Remarks
Fresh Water Circulating Systems, Fuel and Lubricating Oil	Valves and Fittings of 50mm bore and greater	
	Body	Grey or ductile cast iron or cast steel.
	Trim	Bronze or gunmetal
	Valves and Fittings of 50mm bore	
	Body) Trim)	Bronze or gunmetal
Compressed Air	High Pressure Systems (above 10 bar)	
	Valves	Cast steel or forged steel
	Fittings	Cast steel
	Low Pressure Systems (below 10 bar)	
	Valves	Cast iron or gunmetal
	Fittings	Fabricated steel
Hydraulic Oil	Valves	Cast steel or forged steel
	Fittings	Cast steel
	Flexible Hoses	Material and construction to BS EN 853:2015, BS EN 856:2015 Double steel wire braided.
Domestic Fresh Water	Valves and Fittings	Bronze or gunmetal

R6.215 Piping System, General Requirements

Particular attention shall be paid to the provision of ample isolating master valves and by-pass lines in all systems so that, auxiliaries can be overhauled without the necessity to shut down the plant. The following overall requirements shall be embodied in the piping installation:-

- a) Pipes and fitting supplied integrally with auxiliary units may be to the manufacturer's normal standard for the equipment but wherever possible shall be in accordance with this NERC Quality and Outfitting Standard.
- b) Piping systems shall be designed to minimise superimposed stresses on valves and fittings due to dead-weight and expansion/contraction loads. Adequate pipe supports and anchors shall be provided, and shall not be more than 2 metres apart.

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- c) Sufficient flanges shall be fitted into the pipe work to facilitate removals, and shall be no more than 3 metres apart. Sleeved joints are not acceptable
- d) Piping arrangements shall provide for direct access to valves from the main working levels wherever possible. Where this is not practicable, extension spindles or additional access platforms shall be provided.
- e) Headroom of at least 2.1 metres shall be provided where pipes pass over frequently used levels or platforms and this clearance shall be maintained after the insulation and pipe supports are in place. Clearways for access and maintenance purposes shall be adequate, particularly for piping beneath the bottom platform where ample space shall be left for access to the main engine holding down bolts. Piping shall be arranged as far as possible so that any length may be removed without disturbing neighbouring pipelines.
- f) A short straight length of pipe or a standard bend shall be provided between pumps and cooler doors etc. and their isolating valves to facilitate the removal of equipment when necessary.
- g) Air operated control valves if fitted, shall be provided with hand jacks and the valves shall be arranged with actuators positioned vertically.
- h) Sufficient clearance shall be provided in way of all valves to allow their internals to be removed without removing any valve body from the pipeline.
- i) Pipes subject to condensation of outside surface shall not be run above electrical equipment unless adequate insulation is provided and all joints shall be kept well clear of such equipment. Classification rules regarding separation of oil pipes from heated surfaces and keeping such pipe above floor plates shall be strictly followed.
- j) Bosses for pressure switches shall be provided on piping before the non-return discharge valve of pumps arranged for automatic starting.
- k) Where flexible rubber bellows pieces are provided in pipeline attachments to pumps, compressors, etc. the piping shall be accurately aligned before fitting the bellows. Bellows piece flanges shall be reinforced in way of bolt holes.
- l) Pipes, which pass through ballast tanks, shall be one gauge heavier than the standard size required conforming to Rule requirements for the duties involved.
- m) Clear lifting space shall be left over all heavy auxiliaries where practicable, and pipelines shall not obstruct lifting gear.
- n) All piping runs shall be as direct as possible.
- o) The number of branches bends and valves to be kept to a minimum.
- p) Branch connections shall be "swept" tees, if possible. If a right angle tee must be used the branch radii must be as generous as possible.
- q) The radius of any bend shall not be less than 2 pipe diameters.

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- r) Flanged connections shall be carefully made to provide accurate mating of the bores. Gaskets shall be good fits and must not project into the bores.
- s) Brazed joints to have the minimum amount of brazing metal exposed to seawater.
- t) Downstream of all bends, branches, valves and other turbulence raisers a straight length of pipe, at least 6 diameters, shall be fitted. Control valves shall also have at least 6 diameters length straight pipe fitted immediately upstream of valve. Any divergence from this requirement to be discussed with assistance of 3D modelling.
- u) Air release connections shall be fitted to all high positions in the system.
- v) All bends shall be smooth, "Lobster back" fabricated type bends are not to be used. Bending filler material shall not be detrimental to the pipe material during service. Pitch is not to be used as a filler material.
- w) Surface contaminants, such as carbon film after local heating, shall be removed from pipe internals.
- x) Galvanising of pipes shall be carried out after all welding and bending has been completed, with a heavy duty coating of zinc of not less than 530-gm/sq. m.
- y) Pipes passing through non-watertight decks and bulkheads must be flanged on at least one side of the division to permit easy removal, the penetration being compensated and sufficiently large to permit the flange to pass through it.
- z) Pipes passing through watertight divisions must employ an approved penetration piece and the line shall be flanged on both sides of the penetration. Studded bulkhead pieces are not acceptable.
- aa) All Class I and II pipes and their associated fittings shall be tested by hydraulic pressure. Further all feed compressed air and fuel oil pipes, together with their fittings, shall be similarly tested where the design pressure is greater than 3.5bar. The test shall be carried out after completion of manufacture and before installation on board and, where applicable, before insulating and coating. The test pressure shall be 1.5 times the design pressure.
- bb) Fuel oil piping shall be tested by hydraulic pressure, after installation on board, to 1.5 times the design pressure, but in no case less than 3.5 bar.
- cc) All pipe work after assembly on board shall be tested with low-pressure air and soapy water for leaks.
- dd) All piping shall be colour coded in accordance with ISO 14726:2008. This may be solid colour or colour banding. If the latter colour banding shall be applied to each separate pipe next to a flange.
- ee) Pipe flange connections are not to be positioned over any electrical equipment.
- ff) Pipe flange connections near electrical equipment shall be fitted with flange guards.
- ff)gg)

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| ~~gg)~~hh) In the interests of longevity all sounding pipes and deck scupper pipes shall be fabricated from at least BS 10255 grade heavy pipe.

| ~~hh)~~ii) All control valves used in the engine cooling system shall be positioned in an accessible position for overhaul or replacement and due consideration given to ensure that no pipe diameter reductions, bends or other features occur within the close proximity of the control valve disrupting flow patterns or generating noise.

| ~~ii)~~jj) Butt welds are to have full penetration and to be finished relatively flush internally being free from weld spatter and excessive weld deposits. For galvanised pipe this shall be a particular inspection and approval item prior to the galvanising process. All piping shall be free from welding slag and foreign matter before installation.

6.5 ELECTRICAL SYSTEMS

6.5.1 General

R6.216 The vessel shall be powered by a diesel electric power plant employing multiple diesel generator units and large capacity batteries to form a hybrid system, the aggregate output of which shall be controlled by a Power Management System (PMS) utilising 'power station' principles.

The arrangement must be capable of supporting 24 hour UMS operation.

The essence of the design will be the balancing of the various demand modes in the most efficient manner while incorporating sufficient spinning margins to meet transients.

While auto-start/auto-stop of units will be incorporated, where a major load demand is expected, the engineers may pre-empt its connection by putting another unit on the board.

Power balances shall be calculated on the basis of 90% of the generator output as a maximum, with one engine not in use.

The design, implementation and installation of all electronic and electrical equipment shall be in accordance with Lloyd's Register and the Institute of Electrical Engineers (I.E.E.E.) with the exception that harmonic distortions within the main power systems should be limited to 3% as the target and 5% as a maximum under all conditions of switchboard loading and generator combinations. The system should be balanced to ensure this is achieved when running any number of generators at wide variations of loading.

All electrical systems switchgear and control equipment shall be equipped with suitable cooling systems, and be installed in spaces which have sufficient environmental controls, to ensure that the equipment does not suffer from harmful contaminations, such as salt rime, oil and water, and will continue to operate at acceptable temperature levels with all machinery at its maximum rating in the extremes of outside temperatures defined in this document. Switchboards and frequency converter panels should be located in air conditioned spaces to minimise the corrosive effect on the solid state components and provided with redundant means of air conditioning (package air conditioning units and supply from air handling units (AHU)).

Cable tray runs shall be carefully designed to avoid runs over areas of significant fire risk, e.g. generator engines.

The electrical system shall be operable in the environmental conditions in Section 6.5.55 R6.270 Electromagnetic Environmental Effects.

Non-watertight boxes, cabinets and enclosing cases shall be of drip-proof construction and shall not have knockouts. All cables shall be glanded into their respective enclosures.

Watertight plugs shall be of the pin protected type with a metal shell completely covering the pins.

Switches installed in motor circuits shall have the power rating not less than the motor locked rotor rating.

All electrical equipment shall be protected or shielded to prevent the equipment from being damaged by exposure to oil, water or excessive heat.

Where ever possible equipment shall be flush mounted when installed in linings and ceilings, and the electric cables shall be concealed.

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Equipment designed on the basis of the standard 40°C or 50°C ambient temperatures shall require no special design considerations for short duration shut-down of ventilation systems.

Electric wiring and equipment shall be installed in areas where maintenance can be accomplished without removing a portion of the deck or steel bulkhead.

Power consuming equipment shall operate as specified with a steady state voltage tolerance of plus or minus 5 percent, and with a frequency tolerance of plus or minus 3 percent.

Temporary voltage dips or frequency excursions during motor starting or ship manoeuvring shall not cause damage or interruption of service to equipment.

Power panels serving 230V single-phase loads shall have the loads distributed to balance the phases to within 15% deviation from the average value of the three phases.

Consideration should be given to circuit designations to separate as far as possible essential and non-essential circuits to enable fault finding to be carried out with the least disruption to the normal operation of the vessel.

Waterproof metal enclosed equipment and impervious sheathed cables shall be used in all locations subject to condensation of vapours and in locations either temporarily or permanently exposed to the weather or subjected to routine washing down by hose. This shall particularly apply to equipment on open deck locations.

Rotating machinery shall be drip-proof protected at a minimum. Equivalent ingress protection (IP) rated enclosures may be used as allowed by the regulations. Space heating shall be provided within all exposed motors and control equipment

Connection boxes, outlet boxes, junction boxes and similar wiring fittings and fixtures installed in locations exposed to weather, condensation or excessive dampness shall, unless otherwise specified or shown, be watertight and made of brass, bronze or other approved non-corrosive material.

All electrical equipment and wiring, including spare parts, shall be treated and otherwise suitably protected against corrosion, moisture, salt, mould or other destructive agents to which they may be exposed under adverse climatic conditions during normal operation in either high latitude or equatorial areas.

The frames or cases of all permanently installed generators, motors, controllers, transformers and instruments for which the arrangement and method of installation does not assure positive grounding e.g. resilient mountings, shall be permanently grounded through grounding straps.

All electrical equipment requiring external wiring shall be provided with suitable terminal boards or blocks equipped with solderless terminals to which the Contractor shall make all necessary connections.

Electric machinery and equipment shall be selected for the highest operating efficiency that is commensurate with reliability, maintainability, duty cycle and requirements of minimum size and weight.

Controllers required to have stop stations and remote manual control shall have 110V AC control circuits via integral control transformers.

6.5.2 Electric Load Balance

R6.217 An electrical load balance shall be prepared giving a schedule of electric loads for various modes of ship operation. The modes to be included in the load balance calculation are:

- Transit at 13 knots
- Hydrographic survey at 11 knots
- Hydrographic survey at 6 – 8 knots
- Ice breaking
- Dynamic positioning
- Manoeuvring
- Harbour
- Cargo transfer

The result of the electrical load balance shall determine final rating of the main diesel engines, alternators and the circuit breakers in the main switchboard. In general, the total load should not exceed 90% of the operating generators' maximum continuous rating with one generator not in use (including DP). During Ice breaking mode it may be acceptable for all generators to be on line (the total load shall not exceed 90% MCR on any generator set), however a level of redundancy is required and in the case of a failure of one generator the vessel is to retain capability for navigation in ice. Any reduction in performance is to be identified and stated (some reduction in speed could be accepted). The generating system shall meet the requirements for DP2 operation.

The DP capability (case 1 & 2) shall be met with one diesel alternator not running, but available. Generator sets running shall not be required to run at above 90% MCR. It is not expected that this would be the determining requirement for the installed power generation.

6.5.3 Short Circuit Evaluation

R6.218 A short circuit study shall be performed to determine the maximum symmetrical and asymmetrical fault levels developed in the electrical AC system.

Protective device evaluation analysis shall also be performed which shall compare the making and breaking ratings of the protective devices (fuses, breakers, etc.) to the available fault duties determined shall be available at their location by the short circuit study.

This evaluation shall determine if the system protective devices can withstand the available short circuit duties that the system can deliver. If problem areas are revealed, recommendations shall be made and corrections of the system deficiencies shall be implemented.

The study shall be based upon the one line diagrams provided for the electrical system. Bus, distribution board and branch number identifications shall be assigned to the system for easy reference between the one-line diagram and the computer printouts.

Faults shall be simulated starting from the generator bus including the distribution buses and distribution boards for each voltage system.

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A circuit analysis software program shall be used to calculate the per unit impedance of each element in the system (cables, transformers, motors, etc.). Motor contributions to faults shall be modelled in conformance with the IEC 60363 standard.

The circuit analysis software program printouts shall summarize all modelled elements with their appropriate parameters (i.e., cable sizes, lengths, etc.)

The input data shall be confirmed in a printed report as a complete listing, as well as a summary of input data illustrated on a single line for easy review.

The study shall be performed on a digital computer utilizing IEC 61636 standard. The output will be a tabulation of symmetrical and asymmetrical RMS short circuit values for both interrupting and momentary duties.

A summary of short circuits shall be listed on a single line for easy review by the vessel owner.

6.5.4 Protective Device Co-ordination Study

R6.219 Using the data derived from the short circuit study, time current coordination curves shall be drawn and plotted to show overcurrent protective device time current characteristics and the coordination between these devices as shown on the one-line diagram.

The time-current coordination curves will show the optimum attainable coordination between the protective devices. The coordination curves will include, as a minimum, the following information:

- Transformer damage curves
- Cable damage lines
- A partial one-line diagram identifying the devices plotted
- Short circuit current levels used for coordination

The system coordination study will include all feeder switch-gear breakers (including AC distribution boards), to the generator bus. Both phase and ground fault overcurrent devices shall be included.

The coordination study shall also include a complete list of settings with regard to other protective functions in addition to the overcurrent devices.

The recommended settings of system protective devices referred to above will be plotted and the coordination between the devices will be studied. Where devices are inadequate to protect or coordinate, the study will point out the deficiencies and make recommendations for improvement.

The system coordination study shall also include 24V DC systems.

6.5.5 Total Harmonic Distortion(THD)

R6.220 The harmonic distortion level shall be maintained 3% THD and shall be verified by an analysis of the electrical system. This analysis shall utilize a proven computer power system analysis program, (any recognized program using the principles found in IEEE Std. 399 is acceptable), to determine the harmonic contributions, and their effects, from the propulsion system, large motors (>45kW), UPSs, major cyclic loads, motors with Variable Frequency Drives (VFDs, etc. The system should be modelled in the steady state condition using the data in the most consuming mode of operation in the load analysis.

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An analysis of the Total Harmonic Voltage Distortion (THD) on the networks shall be performed when several harmonic sources are present, due to the use of 12 pulse configurations for thrusters and propulsion drives. Where necessary harmonic filters shall be provided.

The simulation result shall be presented in time-domain waveform and in frequency-domain spectrum and shall be presented in graphic and text formats.

Maximum acceptable levels on the generation network shall be documented harmless for the connected equipment and the maximum acceptable levels on the distribution network shall be limited to 3% as the target and 5% as a maximum under all conditions of switchboard loading and generator combinations. A report detailing the results of the harmonic analysis shall be delivered to NERC .

On site measurement shall also be taken onboard the Vessel, with all machinery and equipment running, during sea trials, for comparison with the THD calculation.

6.5.6 Voltage Drop Analysis

R6.221 A Voltage drop analysis during start of large AC motors shall be performed, to ensure that voltage dip during the starting period of such motors will not cause disturbance to other loads on the AC system and that the voltage dip is within the Class requirement.

6.5.7 Battery Sizing Calculation

R6.222 A battery sizing study shall be performed to determine the required minimum capacity for the battery systems. The study shall also include recommended charging rate.

6.5.8 Illumination Intensity Study

R6.223 An Illumination Intensity calculation shall be performed, to verify the required quantity of Light fittings and Floodlights. One Illumination Intensity calculation shall be performed for accommodation/technical rooms/scientific spaces and one calculation shall be performed for open decks.

6.5.9 Power Supplies

R6.224 Power generation (AC) and propulsion machinery equipment (AC or DC as appropriate) characteristics shall be specially chosen but should not require undue specialist knowledge or experience from qualified marine engineering staff.

The main power supplies to be utilised for machinery and equipment shall be as follows. Capacity to be determined by detailed electrical load analysis.

Main power generation, main propulsion prime movers (if not DC):

- 3 phase, 60Hz, 3 wire system

The primary power supply for all other machinery and ship equipment is to be:

- 440V, 3 phase, 60Hz, 3 wire system.

Domestic supplies are to be:

- 230V, 50 Hz,
- 440V, 3 phase, 60Hz for, for example, some Galley equipment

Electric hand tool supplies on deck and in all working spaces are to be:

- 110V, single phase centre tapped to earth, 50Hz.

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Laboratory Supplies:

- 230V 50Hz 1ph (2 x 60KW Motor Generator sets fed from the LAB SWBD (ultimately fed off the 415V SWBD). This provides 230V 50Hz 1ph supply to all scientific spaces.
- 110V 60Hz 1ph (2 x 15KW Motor Generator sets fed from a Scientific Switchboard These provide all 110V supplies at 60Hz wherever they may be found in scientific spaces.
- 230V 50H 3ph Clean Supply (2 x 100KW 230V 50Hz 3-phase Motor-Generator sets fed from the main switchboard. This feeds all Clean Supply sockets, wherever they may be found, UIC, laboratories, workshops etc.

Solid state systems may be proposed as an alternative to motor generator sets.

Stabilised power supplies shall be provided as follows:

- 230V, single phase, 50 Hz
- 415V, 50 Hz
- 110V, single phase, 60 Hz

Capacity to be determined by detailed electrical load analysis.

'Stabilised' in this case means:

- Voltage and frequency to be maintained at better than $\pm 0.5\%$
- The sine wave form shall be as close as possible to the theoretical value with minimal ripples.
- Transient harmonics imposed from external sources will be zero.
- Solid state means (as opposed to motor generation) of achieving the stability would be preferred.

The stabilised power shall be distributed throughout the laboratory and working spaces utilising local independent distribution boards. Cabling shall be screened where necessary to protect the supply from transients.

Laboratory containers supplies complete with local distribution boards (DB) as necessary will be:

- 415V, 3 phase, 50Hz, 3 wire 32 amp.
- 230V, single phase, 50Hz. 63 amp.
- 230V, single phase, 50Hz. 32 amp Stabilised
- 110V, single phase, 60Hz. 32 amp Stabilised(for US standard laboratories)

Machinery & Control containers supplies will be:

- 415V, 3 phase, 50Hz, 3 wire 500amp with DB (soft start)

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- 440V, 3 phase, 60Hz, 3 wire 150 amp with DB (soft start) for ROV Supply
- 230V, single phase, 50Hz 63 amp.
- 110V, single phase, 60Hz 63 amp.

Deck Services

Aft Deck

- 415V, 3 phase, 50Hz 200 amp.
- 230V, single phase, 50Hz 63 amp.
- 110V, single phase, 50Hz 63 amp.

Science Hangar

- 415V, 3 phase, 50Hz 200 amp.
- 230V, single phase, 50Hz 63 amp.

See Schedule of Electric Sockets R6.288 for approximate quantities in all spaces

Power sockets shall be colour coded to aid identification and to be double pole switched.

24V DC system supply complete with necessary UPS systems will include:

- GMDSS reserve source (normally the GMDSS radio station shall be fed from 230V main supply and 230V emergency supply).
- 24V bridge equipment.
- 24V engine room/ ECR equipment.
- Starting battery for emergency generator
- Safety Systems

The system shall be operable in the environmental conditions in section 6.5.55 R6.270 Electromagnetic Environmental Effects.

6.5.10 Hybrid Electrical System

R6.225 A hybrid electrical system consisting of large capacity battery and main engines shall be installed to allow the vessel to operate on single main engine where otherwise need running of two engines. This mode of operation precludes the need to run one engine or more than one engine at part load just to provide enough spinning reserve for transient spike loads.

A large capacity battery back-up system which operates in parallel to the main power source and controlled by the Power Management System (PMS) shall be installed to provide continuity of supply if the failure of single operating main engine during certain vessel operations can be detrimental to the safety of operation. This system shall be able to supply essential electrical loads during the interim period while a standby diesel alternator is starting and also during any spike in demands such as starting of high load consumers. For converting DC to AC sufficient inverters shall be provided.

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The back-up battery will have to meet the instant load at the time of failure of the power supply. The demand will then be rapidly reduced by reduction in pitch or power to the propulsion motor (to a level providing adequate navigation control), non-essential load shedding. Essential loads should be taken to mean navigation systems, ship control systems (including pitch control), and residual loads after load shedding, Engine Room services necessary for starting stand-by generator sets.

In addition, the system shall be able to charge the batteries by absorbing power at times of surplus generation. For this purpose of converting AC to DC sufficient converters shall be provided. The converters/battery chargers shall be able to maintain the charging voltage to match the characteristics of the storage battery.

The battery shall be able to operate at all angles of inclination, vibrations and operating temperatures of the vessel.

The battery shall not ignite due to excessive charging current due to breakdown of converters/chargers.

The battery design shall be such that the positive and negative electrodes are precluded from short circuiting.

The battery shall not ignite even at high temperature of 130°C.

The location of the battery storage compartment shall be outside of the accommodation area. If installed on shelves, there should be sufficient gap at the front and the back to encourage ventilation of the shelves. The battery shall be secured to prevent fall from its stowed positions.

A-60 rated fire walls, doors shall be provided to protect the battery compartment from fire. Rooms adjacent to the battery space shall be provided with fire detection and fire extinguishing system to prevent a fire spreading from adjacent rooms to the battery space.

The battery storage compartment shall be fitted with gas monitoring system for detecting flammable, toxic or appropriate gases generated gases with alarm via VMS. The alarm shall be generated at 20% of the Lower explosive limit of the flammable gas. This gas detector system shall cut out any non-explosion proof electrical equipment if located within the same battery compartment.

A fire detection system shall be installed and automatic and appropriate firefighting system suitable for electrical appliance depending on the battery type selected shall be installed.

A fixed fire extinguishing system that will suit the battery type shall be installed in the battery compartment. The quantity of the firefighting media should take into account the ability of some battery electrode material to produce oxygen e.g. lithium. Due consideration should be paid to the IP rating of the battery system and type of fire extinguishing media used.

The battery compartment shall have an independent forced ventilation system consisting of two 100% capacity fan units. An alarm shall be initiated on failure of ventilation system. The ventilation system shall be an exhaust type. The ventilation system shall take into account operating temperature of the battery and the ambient temperature. The ventilation system shall be automatically stopped in the event of activation of the fire extinguishing system.

Battery type shall not release flammable gases under normal operating conditions.

All electrical equipment in the battery compartment shall be explosion proof electric equipment.

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A battery management system which can monitor temperature, voltage, and current shall be installed for control the charging and discharging of the battery. For this purpose the battery system shall have flame resistant signal wires to measure its voltage, current and temperature. The battery management system shall be able to give an a larm if any battery is being overcharged or when abnormal rise in temperature is detected. The battery management system shall be able to monitor the maximum cell temperatures over lifetime to give indication on whether the battery can be used further or needs replacement after a critical fault involving high temperatures.

Each cell shall have separate current sensor in order to detect increased impedance that can lead to overheating. The alarm shall be interlocked with the charging device such that the charging/discharging system is automatically isolated from the battery on initiation of an alarm or by Ships Staff via a remote Emergency Shut Down

In order to maximize battery life expectancy and be able to utilize the full capacity of the battery system, a battery management system should be included in the battery management system. An active or passive system to remove energy from the batteries with the highest state of charge to batteries with low state of charge shall be employed for this purpose.

The following calculation shall be submitted for owners review;

- Short circuit current calculation
- Voltage drop calculation
- Protective device coordination study
- Risk assessment

6.5.11 Alternators

R6.226 The preferred solution is for the alternators to be incorporated with their prime movers, hard coupled and mounted on a double rafting system to ensure compliance with the URN requirement.

The alternators shall be brushless, tropicalised, two bearing units, sealed from the engine room atmosphere and fresh water cooled (twin walled tubing with water leak detection arrangements.).

The windings of the alternators shall be arranged to minimise the propagation of noise.

They shall be fitted with temperature monitoring (Thermistor type).

The system shall be operable in the environmental conditions in section 6.5.55 R6.270 Electromagnetic Environmental Effects.

6.5.12 Switchboards

R6.227 The main switchboards, distribution switchboards, group starter boards, emergency switchboards, distribution panels and individual starters are, where possible, to be constructed by one manufacturers to ensure standardization of components, methods and quality of construction.

The main switchboard and group starter boards shall be located in an air conditioned compartment.

The switchboard configuration shall be such that generated power can be distributed and balanced according to the various demands.

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The main switch board shall consist of panels for alternators, thrusters, shore connection and distribution section. Separate switchboards shall be arranged for 440V consumers with feeder panel for 415V consumers. Other switchboards to include;

- 415V clean power switchboards
- 230V switchboards
- 230V clean power switchboards
- 440V Emergency switchboard.

The switchboards shall be equipped with Arc protection for fast isolation in case of fault. An advanced segment protection system shall be employed which will detect and isolate the faulty segment of the switchboard in a short circuit situation.

Switch boards shall be dead front type with hinged doors and fitted with suitable forced ventilation.

They shall be fitted with active mimic diagrams, internal lighting, earth monitoring on all systems, anti-condensation heaters and fire/smoke detection heads linked to the main and/or an auxiliary fire detection system

All ACBs and MCBs shall be withdrawable and function tested without the need for a dead board.

Remotely located switchboard sections may be considered for high value consumers.

A remote emergency switchboard shall be provided allied to the emergency generator. The system shall be operable in the environmental conditions in section 6.5.55 R6.270 Electromagnetic Environmental Effects.

The switchboard shall be designed and built to provide ready front access for inspection, maintenance and repair, and shall include hinged panels with door stops and holding devices to secure them in the open position, a lock off and tag out facility of all circuit breakers is required for Health & Safety procedures.

All metal cased components shall be earthed. An approved non-slip fire retardant and insulating floor material shall be provided at the front and rear of all switchboards.

Smooth insulated hand rails shall be mounted on the front of the switchboards. The rails shall be attached in such a manner that panels can be removed or opened without rail removal, and they shall not extend more than 4 inches from the surface of the switchboard.

The switchboards shall be provided with drip shields extending at least 100mm from the top edge.

Switchboard lighting shall be provided that adequately illuminates the switchboard without excessive glare. The lighting shall consist of a row of LED lamps with lenses that are mounted integral to the drip shields and extend the full length of the switchboard. The fixtures shall be connected to emergency, battery-powered ballasts.

All indicator/pilot lights in the switchboards shall be provided with momentary push-to-test capability.

Cable entry should be from the bottom of the cubicles as far as practicable.

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If any cable enters the switchboard near the top of the switchboard, they shall enter the rear panel beneath the drip shield. A drip loop shall be provided in each cable in way of the penetration to the switchboard.

The switchboards must have at least 600mm free space at the back.

All bus work shall be hard drawn, commercially pure copper with the bars and connections provided with silver surfaced contacts. The bars and fastenings shall be braced to withstand the maximum available short circuit current as determined by the fault current analysis.

The switchboard distribution sections shall be designed and sized for at least 20% future expansion in capacity. Positions within the switchboard designated for future breakers shall include fully insulated and braced connections and all other parts/features necessary to accept the breakers. The Contractor shall assume an even distribution of the five most frequently used breaker types/sizes when allocating space for the future expansion capacity.

Where space is provided for the future installation of a circuit breaker, it shall be complete in all respects with the exception of the circuit breaker and lugs. All necessary circuit breaker studs and mounting hardware shall be provided. The front panel shall be cut out and fitted with a suitable cover plate. The switchboards shall be to IP23.

6.5.13 Distribution Circuits

R6.228 Supplies shall be distributed throughout the vessel via liberally applied and strategically placed local distribution boards sized and equipped to suit the local demand but with at least 20% additional spare ways in all distribution boards. Distribution boards shall be provided to serve all spaces between water tight bulkheads to reduce the need for multiple watertight glanding at bulkheads.

The distribution boards shall be fitted with MCBs. The use of fuses shall be avoided.

Each UPS main distribution board section shall be fitted with fault detection and common alarm.

The earth fault detection system shall as a minimum be of a type that enables manual fault finding of each outgoing circuit. Space shall be provided for fault finding of the outgoing circuits using portable apparatus.

Selection and coordination of protection devices shall ensure selectivity in all modes of operations.

For operational and safety purposes all power and lighting circuits in individual laboratories, scientific service spaces, galley / laundry / air conditioning spaces, fan rooms and AVTUR aviation fuel pump room shall be provided with pushbutton emergency shutdowns located outside the entry door or doors to each space. The spaces to be provided with this facility are:

- Science Workshop
- Rough Workshop
- Wet Laboratory
- Deck Laboratory
- Clean Laboratory
- Controlled Environment laboratory

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- Main Laboratory
- Salinometer Room
- Electronics Workshop
- Data Suite
- Server Room
- Dark Room
- Meteorological Laboratory
- Aerosol Laboratory
- Uncontaminated Sea Water laboratory

Pushbuttons shall be large, clearly marked and protected from inadvertent operation. All power sockets shall be double pole switched.

Low power sockets (230V domestic, 230V clean, 110V) in laboratories and scientific service spaces shall be mounted on trunking located on the bulkheads above the rear of workbenches or at the deckheads over finger benches. The trunking and socket system shall be to UK Standards and chosen so that new socket units could be added or old units moved to new locations in the future.

The system shall be operable in the environmental conditions in section 6.5.55 R6.270 Electromagnetic Environmental Effects

6.5.14 Controllers and Motor Control Centres

R6.229 Individual controllers and motor control centres (MCCs) shall have the same characteristics and shall be designed to accommodate plug-in, combination starters with internal circuit breakers. They shall be rated for at least the maximum short circuit current available.

Controllers for single-speed, non-reversing motors of less than 0.5kW may be of the manual across-the-line type. Controllers for all other motors shall be of the magnetic across-the-line type unless momentary voltage drop conditions require a current limiting type starter.

Combination type motor controllers shall be provided unless specifically approved otherwise. They shall include a non-fusible disconnect switch of the flange operated visible blade type, or other arrangement allowed by the regulatory bodies. The disconnect handle shall be lockable in the "OFF" position. There shall be a provision to open the controller door with the handle in the "ON" position by means of a defeater screw.

Variable-speed motor controllers shall be designed to meet the speed control requirements of their respective motors. All variable speed controllers shall be supplied with filtering circuits to minimize the effects of induced harmonics to the power system.

Controllers installed in interior locations shall have drip-proof enclosures.

Controllers in weather or damp or corrosive environments shall have IP65 minimum enclosures.

Controllers located in hazardous zones shall be explosion-proof.

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All magnetic controllers shall be sized to the horsepower rating of the motor.

All controllers shall be capable of operating when inclined at an angle of 30 degrees from the vertical in any direction.

All controllers shall be built by one manufacturer if possible.

All motor controllers shall utilize suitably rated contactors.

Starters shall have external manual overload reset, and have overload relays or ambient compensated bimetallic thermal overload relays.

Motor controllers shall have all pushbuttons, switches and indicator lights required for operation mounted on the face of the controller.

Remote operating stations shall be provided where control from more than one location is required or when the motor starter cannot be located near the motor and also as required by other sections of the specifications or regulatory bodies. Voltage to remote stations shall be 110V or less.

Motor controllers shall have provisions to allow connection to and operation from the VMS.

Starter panels or motor controllers should have means of recording running hours of the particular machine it relates to.

Low voltage protection shall be provided in all motor controllers except those specifically required to be of the low voltage release type by the regulatory bodies.

Magnetic controllers that operate from a remote (automatic) 2-wire pilot device (pressure switch, etc.) shall be provided with the additional relay necessary to provide for low voltage protection. They shall be provided also with a local manual three position selector switch for "Hand," "Off" and "Automatic" operation. Generally, the local selector switch shall be arranged to spring return to "Off" from the "Hand" position.

When motor and control units cannot be mounted within sight of each other, the motor disconnect device must be capable of being locked in the open position. Where no visual indication of equipment operation exists, such as for fans, controllers they shall be provided with the necessary fused circuits for energizing "power on" indicating lights.

Individual control circuit transformers shall be provided operating at 110V AC.

Control transformers shall be fused on both primary and secondary windings.

Pushbutton and switch operators shall be watertight/oil tight, momentary for LVP functions and maintained (selector switch) for LVR functions.

Indicator lights shall be transformer type with low voltage bulbs. They shall have a push-to-test feature and use glass or plastic lenses with integral colour.

Controllers with an AUTO mode shall have blue indicator lights to indicate when the controller is in the AUTO setting. Green indicator lights shall be used to indicate when the motor is running.

All operators and indicators shall be labelled with nameplates that mount on the circumference of the device. Label plates shall be either engraved phenolic or metal and shall indicate the purpose, function, position or condition, as required.

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The controller shall have an external label that shall indicate the controller name, circuit number, motor horsepower, circuit breaker rating and overload rating.

A fire resistant control wiring diagram shall be installed inside the access door of each controller.

AC line and line-to-ground filters shall be provided as required to protect against line voltage spikes, switching surges and electrical noise.

6.5.15 Transformers

R6.230 Transformers shall be so located that they will be protected from excess moisture or exposure to liquids and so that the ventilation is not impeded by other equipment, structure or protective shielding.

All power and lighting transformers shall be of the 3-phase marine type having insulation class F, temperature class F, Vector group Dyn11, IP 23 enclosure and designed for ambient temperature 45°C. They shall be installed in dry, clean and well-ventilated rooms.

The transformers shall be equipped with two temperature sensors in each of the secondary phases. Cable connection points shall be of copper or tinned aluminium. Earthed copper or aluminium electrostatic earthed screen between high and low voltage windings shall be provided.

The transformers' windings shall be vacuum pressure impregnated (VPI), shall resist moisture, sea air and oil vapours, and shall be braced to withstand the thermal and electromagnetic effects of short circuits.

Each transformer for distribution shall have capacity of 120% of the total load of the actual switchboard indicated in the electrical load analysis. The transformers shall be arranged with stand-still heating and automatic change over to standby transformer, should the supplying transformer fail.

All transformers shall have anti-condensation systems.

Transformers of low noise type shall be used as required to meet the noise limits.

6.5.16 Transformer for Main Power Distribution System

R6.231 At least two transformers shall be installed, with sufficient capacity for supplying 440V / 415V loads. The capacity of each shall be decided based on load analysis. The transformers shall have high reactance in order to reduce the short circuit capacity on the distribution system.

6.5.17 Transformer for 440V ROV system, 690V/440V

R6.232 Two transformers 690V/440V shall be installed, with sufficient capacity for supplying 440V deck load. The capacity of each shall be decided based on load analysis. The transformers shall have high reactance in order to reduce the short circuit capacity on the 440V distribution system.

6.5.18 Transformer for 230V Main System

R6.233 At least two transformers shall be installed, with sufficient capacity for supplying 230V ship load. The capacity of each shall be decided based on load analysis. The transformers shall have high reactance in order to reduce the short circuit capacity on the 230V distribution system.

6.5.19 Emergency Lighting Transformers,

R6.234 Two transformers with sufficient capacity to supplying all 230V emergency power and lighting shall be installed in emergency generator room. The capacity of each shall be decided based on load analysis. The transformer shall have high reactance in order to reduce the short circuit capacity on the 230V distribution system. Stand-still heating shall be provided.

6.5.20 Galley Transformer

R6.235 One air cooled isolation transformer, shall be supplied with sufficient capacity for supplying galley equipment. Capacity shall be by load analysis. The transformer shall have high reactance in order to reduce the short circuit capacity on the 440V distribution system. Alternatively a Fixed Earth Fault detection system to be considered (then the galley transformer can be removed).

6.5.21 UPS Transformers

R6.236 Necessary transformers for voltage adaptation, air cooled, shall be supplied for mounting in engine room/Computer rooms, electronic equipment room, instrument room, with sufficient capacity for UPS units.

6.5.22 Welding Transformer

R6.237 A welding transformer/rectifier shall be installed, 63 amp IP56 socket outlets, in the following areas:

- Aft scientific store.
- Main switchboard room.
- Main Engine rooms
- Winch room.
- Auxiliary machinery room.
- Forward thruster room.
- HVAC room.
- Electronics space navigation bridge deck.
- Emergency generator room.
- Engineers' workshop.
- Propulsion rooms
- Aft deck
- Science Hangar
- Heli Hangar

6.5.23 Propulsion Converters (Vfd Drivers) for Electrical Propulsion Motors.

R6.238 Each of the electrical propulsion motor shall be supplied from at least two frequency controlled drive of ample size. The frequency converter shall be based on insulated-gate bipolar transistor (IGBT) pulse width modulation (PWM) type. The speed drive control system shall provide rapid power reduction to avoid blackouts in case of failure of the power supply system. The frequency converters shall be water-cooled with water leak detection system and shall preferably have separate supply (low power) to charge capacitors before start and also to excite the power transformer.

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Converter shall have temporary supervision/ alarm. Output voltage shall be according to propulsion motor voltage. Frequency converter shall be equipped with interface to the DP Joystick system, power management system, load control and black out prevention system.

Each propulsion converter unit shall be supplied as a totally enclosed, free standing unit. Instruments and control switches shall be mounted on front hinged doors.

Removable panels shall be secured by knurled machine screws made captive in the panel. All doors and panels shall have gaskets to provide EMI shielding.

All bus work shall be copper. The bus bar connections shall be silver plated. All bus work shall be insulated, covered or physically separated to eliminate arc over and arc propagation. All bus work shall be braced for not less than 1.5 times the maximum fault current.

AFE (Active Front End drive systems can be proposed in compliance with this SoR.

6.5.24 Power Converter Transformer for Propulsion

R6.239 One 3-windings phase shifted transformer shall be installed in each propulsion room if required.

The transformers shall be fresh water-cooled and of ample size for the propulsion motors and frequency converters and designed to reduce the voltage distortion to a minimum.

The two secondary windings shall have different phase angle (e.g. +/- 30° phase shifted), and shall have sensors for temperature supervision/alarm.

6.5.25 General Lighting

R6.240 All internal lighting shall be based upon the use of LED lights where practicable and any external lighting to be provided with winterisation features.

Deck, Science Hangar and Heli Hangar lighting shall be based upon the use of LED lights but may be augmented by floodlights strategically placed to prevent glare in relation to crane, winch and equipment operators and particularly bridge personnel. All floodlights shall be 'white source' (LED sealed for life type) type.

General Lux levels (at working/walking levels) and the controls required are as follows:

Control Stations

- | | |
|--|---------|
| • (W/House/Winch/Engine Control etc.)
(individually switchable, dimmable) | 500 Lux |
| • Alleyways | 300 Lux |
| • Stairways | 500 Lux |
| • Cabins | 300 Lux |
| • Lobbies | 500 Lux |
| • Hospital | 500 Lux |
| • Mess Rooms & Amenity spaces
(individually switchable, dimmable) | 500 Lux |
| • Galley | 500 Lux |

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- | | |
|---|---------------|
| • Laboratories and Workshops
(individually switchable, dimmable) | 500 Lux |
| • Stores Spaces | 300 Lux |
| • Machinery & Plant rooms | 300 Lux |
| • Hangar | 500 Lux |
| • Deck lighting | 150 – 300 Lux |

Lighting a power circuits are always to be separated.

Low energy type light fittings shall be installed, using LEDs as far as practical.

However for reference purpose please see the following:

Please see the HSE 'lighting at work' HSG38 document.

The document refers to the CIBSE SLL code for lighting, which is the European standard adopted by the UK, which is available on the link below;

<http://www.cibse.org/knowledge/cibse-ig/sll-code-for-lighting>

The British Standards document (which is the suggested standard suggest is available on the link below;

<http://shop.bsigroup.com/en/ProductDetail/?pid=000000000030206727>

LED type navigation lights shall be installed of a type with integral defrosting.

EXEMPLAR: Aqua Signal

Explosion proof light fittings shall be used in the following spaces:

- Science Hold / Chemical Stores (including ventilation systems)
- Cargo Holds (including ventilation systems)
- Helicopter Hangar (including ventilation systems)
- Gas Bottle Stores
- Battery Rooms
- Paint Stores.
- Within areas identified as Hazard Zones

6.5.26 Lighting - Wheelhouse.

R6.241 Generally, red lighting shall be provided in the approaches to the wheelhouse, to accustom the eye for night vision. Three-position toggle switches, indicating ON-OFF-RED, shall be provided and installed to control the red lighting.

All LED lighting (including the transitional fixtures and "exit" lights) shall be supplied with appropriate electronic ballasts to assist in reducing harmonics.

6.5.27 Lighting Laboratories

R6.242 In general, LED fixtures shall be high efficiency type with energy saving ballasts. Each of the Laboratory and related spaces shall be fitted with local switches in each space, so as to permit the lights to be extinguished in the spaces not in use. Switches at each entranceway to each space shall be capable of controlling all of the lighting in that space. Additionally, in Laboratory and related spaces which exceed 40 sq.m., lighting must be sectioned into equal areas not exceeding 40 sq.m. each, with each section having its own separate switch, in order to permit reduced lighting levels in the space.

Laboratory and related space lighting shall be designed to achieve the following lighting levels:

- Laboratories - 1000 lux (+/- 20%)
- Other Science Work Rooms – 500 lux (+/- 20%)

Lighting fittings in the Wet Laboratory and other wet spaces are to be at least IP 55 standard.

6.5.28 Lighting Scientific Spaces

R6.243 Lighting shall be provided throughout the space by recessed flush light fittings in the deckhead linings. These shall be of LED type and must be arranged and sized to provide a lux level on the bench tops of 500 lux with the port light blinds and doors closed. Undue shadowing shall be avoided.

The lighting shall be on multiple circuits so that individual light units can be switched off as desired.

6.5.29 Lighting Cabins

R6.244 Lighting shall be provided throughout the spaces by recessed flush light fittings in the deckhead linings. These shall be generally of LED type and must be arranged and sized to provide adequate lux levels with the port light blinds and doors closed. Undue shadowing shall be avoided.

Cabin lighting is to provide a general lux level of 300 augmented by table lighting as appropriate.

6.5.30 Lighting Public and Amenity Rooms

R6.245 Lighting shall be provided throughout the spaces by recessed flush light fittings in the deckhead linings. These shall be generally of LED type and must be arranged and sized to provide adequate lux levels with the port light blinds and doors closed. Undue shadowing shall be avoided.

Public rooms shall be provided with lighting sufficient to give 500 lux at 1 metre above the deck. The lighting shall be on multiple circuits so that individual light units can be switched off as desired.

6.5.31 Emergency Lighting

R6.246 Emergency lighting shall be provided in accordance with Regulations. The lighting shall be incorporated within the general lighting system by the use of maintained fittings. About 30% of light fittings shall be connected to the Emergency lighting supply.

6.5.32 Floodlighting

R6.247 Floodlighting shall be provided to cover all working deck areas (including the Science Hangar and Heli Hangar in addition to local fittings) and over-side along the starboard side, across the stern, along the port side to 10m from the stern and any other overboard deployment positions such as lifeboats and liferafts/pilot embarkation points.

Floodlighting shall be provided on all lifting equipment arranged to illuminate the load and its handling area at all times.

Floodlighting shall be white source (LED sealed for life type).

General Lux levels shall be sufficient for safe operations. Close working lighting shall be provided by local portable units.

Floodlights shall be strategically placed to prevent glare in relation to crane, winch and equipment operators and particularly bridge personnel.

At least two large searchlights, located port and starboard shall be provided on the wheelhouse top, controllable from inside the wheelhouse. These shall be located to cover the sea surface along and out from each side of the vessel for both security, safety (man overboard) and science purposes (equipment location and retrieval at night).

EXEMPLAR: Colorlight

A wheelhouse controlled searchlight (which may be portable) shall be provided at the bow of the vessel to illuminate the forward sea surface in high latitudes.

Drawings shall be prepared for floodlights and searchlights showing their areas of prime illumination both onboard and overboard so that advice can be provided by NERC as to the suitability of the arrangement before installation commences.

6.5.33 Helideck Lighting

R6.248 Helideck lighting shall be provided to meet Regulations.

6.5.34 Lighting Control Panel

R6.249 This shall be positioned in or close to the wheelhouse consoles. It is to have two power supplies, one from the main switchboard and one from the emergency board. The emergency board is to provide at least 30% of the overall lighting power requirement.

The panel is to have a reserve switch and cable capacity to enable future alterations and additions to the system.

Spare cables shall be installed from the control panel to the following locations and terminated in suitably sized IP56 junction boxes and labelled. All junction boxes shall be mounted below the deckhead in accessible positions.

6.5.35 Shore Power Connection

R6.250 Shore power connection boxes shall be provided on both port and starboard sides.

They shall be sized, as a minimum, based upon the ship's hotel loading with the air conditioning demand at its maximum, galley loading, domestic services including refrigeration plant plus the use of the storing crane, the engine room hatch crane, the Hangar gantry and the largest of the aft cranes.

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Two dead front, interlocked, 440V, 3ph, receptacles shall be provided for shore power as determined by the maximum load from the in-port load condition in the load analysis plus a 20 percent growth margin. Receptacles shall be watertight, and shall be located one on each side of the vessel. A control switch and a white pilot light to indicate circuit energized and labelled POWER ON must be included.

Shore power circuit breakers shall be of the current limiting moulded case type.

The shore connection shall contain a suitably sized circuit breaker, shore power available light and automatic phase sequence relay and meter. Shore power voltmeter, ammeter and synchronizing equipment shall be provided on the 440V distribution switchboard.

6.5.36 Cabling

R6.251 General cabling shall be laid in open trays or ladder racks and properly restrained in accordance with regulations.

Cables shall be one single uninterrupted length without use of junction boxes between source and supply.

Signal cabling is not to be laid with or close to power cabling.

Separation of cable runs or adequate cable shielding measures shall be adopted which may include the use of stainless steel trunking or piping for additional screening.

All cabling shall be properly identified at each end by the use of crimped or heat shrunk ferrule type tags and detailed supporting listings shall be prepared and presented on completion with the ship's data package.

The cable markings shall be clearly visible after cleating and strapping.

Outdoors in exposed and wash down areas the cable marker shall be of stainless steel. Each cable shall have a marker located:

- On both sides of multi-cable transits
- At both ends

Outside cabinets with gland / CT entries

6.5.37 Machinery Control, Alarm and Monitoring Systems

R6.252 The main machinery shall be controlled and monitored by a computer based VMS system that provides both monitoring and control functions.

The VMS system shall be integrated with the Power Management System (PMS) and the DP system (as appropriate).

It is expected that about 3500 I/O points will be required to satisfy the requirements.

The following machinery systems shall be included in the system:

- | | |
|-----------------------------------|--------------------------------|
| • Power generation & distribution | Control and Monitoring and PMS |
| • Main propulsion | Monitoring |
| • Thrusters | Monitoring |
| • Manoeuvring systems | Monitoring |

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- Fuel System Control and Monitoring
- Ballast System Control and Monitoring
- Fresh Water systems Monitoring
- Fire and wash deck systems Monitoring
- Sewage system Monitoring
- Scientific Cooling Water Monitoring
- Fresh Water generators Monitoring
- Bilge and Oily water separation Monitoring
- Provision Rooms and Garbage Monitoring
- Exhaust gas treatment & quality Monitoring
- Heeling system Control and Monitoring
- Chilled Water System Control and Monitoring

The primary machinery systems shall be comprehensively equipped with monitoring transducers and the system is to provide VDU Display unit(s) based mimic diagrams of systems showing key data with control functions at the main control console with three operator stations in the Machinery Control Room (MCR)

All tank gauges and level alarms shall be incorporated in the system mimic diagrams providing real time read-outs of content and level alarms.

The system is to accept alarm set points, bandwidths, etc. and provide historical trend analyses of key data for proper control and monitoring of equipment.

A patrol alarm shall be incorporated.

6.5.38 Remote Diagnosis System

R6.253 As part of the VMS system equipment enabling remote diagnosis through an existing communication link to shore shall be included for assisting the crew in fault finding and corrections.

6.5.39 ECOmeter

R6.254 As an integrated part of the VMS system there shall be functionality for estimating the vessel's fuel consumption, as a powerful support tool for optimal operation of the vessel. The system shall show instantaneous and historical values for fuel consumption and how the engines are loaded, compared to speed and distance.

Features to include are:

- Provides information for the optimal operation of the vessel
- Visualisation of estimated fuel consumption and power utilisation
- Exploits the flexibility of a multi-engine solution
- Advisory tool for speed/power adjustments according to estimated time of arrival (based on available navigation data)

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- Facility to record and store digitally all running hours for motors / fans / pumps.
- Reports

6.5.40 Power Management System (PMS)

R6.255 The power management system shall have the following functions included:

- Manual operation of breakers and main engines
- Load dependent start and connection of main engines
- Load dependent disconnection and stop of main engines
- Automatic changeover of main engine load reduction request on a connected main engine
- Splitting of busbars with asymmetric load, active or reactive
- Monitoring of critical parameters
- Load Control of “dynamic” consumers to prevent overload on generators. Power available to thrusters and main propulsion converters
- Blackout prevention
- Blackout restart and connection of main engines after failure.
- Interface with speed controllers
- Harbour Generator with short-time parallel operation.

There shall be two PMS cabinets

6.5.41 Mounting On Control Console

R6.256 All relevant instruments should be incorporated in the console. All indicating instruments, where fitted, are to have their normal operating range marked with a green quadrant, the upper limit being indicated by a red graduation on the scale.

Telephones and communications

Engine room/bridge telephones shall be located in the control console and additionally a Sound Powered emergency telephone,

6.5.42 Audio Visual Alarms

R6.257 Audio Visual Alarms indicating machinery alarm conditions shall be situated to give complete coverage throughout the machinery spaces and winch room and all Audio Visual Alarms are to operate with each alarm condition and shall be silenced by a common muting button on the control console. Audio Visual Alarms must be continuously rated and have a tone distinct from other audible warnings.

6.5.43 Alarm Annunciator (VMS Output)

R6.258 An annunciator panel shall be installed in at each operator station to give visual indication of fault conditions arising in the main and auxiliary plant. The annunciator shall be a VDU. A printer is to provide a continuous read-out of alarms.

6.5.44 Pressure Sensors and Indicators

R6.259 Sufficient pressure sensors and indicators shall be fitted locally to all items of equipment in order to monitor the performance of that equipment, with essential services having a readout as part of the alarm and control system.

Where local pressure gauges are fitted at equipment the pressure sensing elements of pressure gauges shall be either bourdon tubes or diaphragms; for switch sensors a diaphragm or bellows mechanism is acceptable.

Pressure gauges are to comply with BS Standard, be of a 100mm nominal size, and have a black case and bezel ring. The gearing between the sensing element and pointer shall be of the "Helical" type. The connection between the pressure sensing element and the anchorage and end piece shall be by brazing or welding, depending on the element material. The use of tin-lead solders is unacceptable.

Safety blow out devices shall be provided in sensor cases to relieve pressure in the event of sensing element rupture and sintered porous plate pulsation eliminators shall be used where shocks and surges are likely to occur in the measured fluids.

Sensor connections shall have an isolating cock at source and another cock at the sensor if it is more than 5 metres from the source.

All locally mounted gauges shall be clearly visible by a patrolling watch keeper.

All instruments shall be mounted in pockets making removal for repair or replacement possible without disturbing the system.

Other gauges recommended by the engine builder or auxiliary machinery supplier are also to be included as follows:

- At each pump, suction and discharge pressure.
- At each air reservoir, starting air pressure.
- At each auxiliary plant item in accordance with the manufacturer's standard.
- After each reducing valve, downstream of the valve.

Test connections shall be incorporated in all sensing lines to permit routine testing without any dismantling. Push fit/quick release connections are not acceptable.

Engraved nameplates shall be fitted to identify all process and pressure gauges.

6.5.45 Engine Performance Monitoring

R6.260 An integrated engine performance and condition monitoring system shall be provided for fault finding and health checking of the main generator engines (**EXAMPLAR:** Digitec Dieseltune or Icon Diesel Doctor)

Video Display Units (VDUs) are also to be provided at the bridge console and the engineer's office.

6.5.46 Vibration Monitoring System

R6.261 A vibration monitoring system shall be provided for each primary machinery element including all rotating machinery either critical in nature or rated above 1kW.

This shall be bench-marked during trials and standard spectra provided for each item.

The monitoring system is to provide comparisons with benchmarking during operations and alarms are to initiate where deviations and trends become apparent. This is to be achieved by a central processing device capable of the following:

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- Storing baseline vibration spectra for each item of plant/equipment and measurement point.
- Accepting data from each vibration measurement device.
- Comparing measured vibration frequency spectrum to the baseline spectrum for the plant/equipment measurement point.
- Communication (via serial data link) to the Vessel Monitoring System to allow transfer of monitoring information and alarms to VMS users.

This system shall be compatible with the Conditioning Monitoring requirements of the Classification Society as a minimum.

Vibration measurement and evaluation techniques shall be compliant with ISO10816 series of standards (Mechanical Vibration – Evaluation of Machine Vibration by Measurements on Non-rotating Parts).

Attention should also be paid to ISO6954:2000 (Mechanical Vibration – Guidelines for the Measurement, Reporting and Evaluation of Vibration with regard to Habitability on Passenger and Merchant Ships.) and ISO17359:2011 (Condition Monitoring and Diagnostics of Machines – General Guidelines).

6.5.47 Earth Fault Detection System

R6.262 A suitable system, such as High Resistance Grounding, shall be installed to ensure that appropriate earth fault detection and protection is provided.

EXEMPLAR: Bender Ground Fault Detection system.

6.5.48 Batteries

R6.263 All Emergency back-up batteries (not the Hybrid battery system) will be Standard sized Marine Lead Acid and shall be so located that the batteries' temperature at all times remain within the manufacturer's specification. A location at open deck exposed to sun and frost will not be accepted.

Battery banks shall be provided and installed for the following consumers:

- Two for starting of emergency generating set.

The voltages shall be 24VDC unless otherwise specified by the makers of the receptacle equipment.

Capacity, discharge rate as well as number of sets for each of the above batteries shall be in accordance with regulations and maker's recommendation.

All battery banks for bridge equipment shall be installed in the compartment below wheelhouse, and shall be mounted in heavy-duty fibre glass boxes with rubber waffle matting underneath them.

All batteries for engine room equipment and starting batteries for emergency generator shall be mounted in heavy-duty fibre glass boxes with rubber waffle matting underneath them.

All battery banks shall be labelled on the outside on the box cover with Duty, DC System Voltage and Ampere-hours, and shall be labelled inside on the cover with recommended battery charging current.

All batteries shall be secured within the boxes by means of wooden blocks and shall be ventilated according to Class and Authority's rules and regulations. A drain hole shall be drilled 2" above the bottom of the battery boxes.

6.5.49 UPS Units

R6.264 UPS units shall be installed in racks/enclosures, according to Maker's standard. The UPS battery banks shall be installed close to the rectifier and converter, and shall preferably be mounted in heavy-duty fibre glass boxes with rubber waffle matting underneath them.

The following consumers shall be supplied from one of two alarm, control, and communication batteries or UPS:

- Public Address System
- Automatic telephone plant
- Other essential consumers for alarm and control etc.
- Autopilot etc.

The following consumers shall have independent UPS

- One GMDSS radio equipment
- One Fire detection plant (internal)
- Two Alarms, control, monitoring equipment for engine room (redundant systems)

Alternatively, supplier standard of class-approved UPS may be used. Batteries of "sealed for life" type may be mounted together with inverter.

6.5.50 Battery Chargers

R6.265 Each battery bank shall have separate charging device with volt and current control for high rate and trickle charging with uninterrupted power supply to the specified consumers.

Battery banks for navigation and automation battery sets shall each have two battery chargers. Each of the chargers shall have sufficient capacity for 100% of the load in order to get 100% redundancy of power for important equipment. One of the chargers for each of these battery banks shall be fed from the emergency switchboard.

Each battery charger shall be fitted in the vicinity of the respective battery in a dry area.

Each battery charger shall be designed for 100% charging capacity.

All battery chargers shall withstand a total harmonic distortion (THD) of at least 8%.

The charging rate shall be sufficient to replace 100% battery capacity within 12 hours at which point the charger shall automatically revert to trickle charging rate.

One portable spare battery charger, 24VDC, 25A, connected with a 6m cord (2x1,5mm² + earth) and plug for 230V supply, a 6m cord (2 x 4 mm²) with alligator battery clips for 24VDC charging, shall be stored in electrical workshop, for use as reserve for both bridge and engine room battery systems.

One additional automatic/manual battery charger for 2VDC, 5VDC, 6VDC and 12VDC, portable batteries shall be installed in the electrical workshop. Capacity 15A.

6.5.51 UPS Systems

R6.266 UPS units shall be of the microprocessor based PWM - IGBT converter of 12 pulse type. To avoid voltage and frequency transients during switching on and off of

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heavy consumers, which can cause UPS to cycle back and forth to batteries, the UPS units shall be provided with a so called "Chopper" unit. In addition, the UPS shall also be fitted out with input and output noise filters.

All UPS units shall be provided with advanced battery monitoring with failure alarms, connected to the Vessel Automation System.

All batteries for UPS units shall be mounted in battery rooms. Battery room temperature sensors shall be connected to the UPS unit's charging control.

If the UPS control panels do not have easy access, a remote control panel should be provided, preferably in the UPS distribution board.

All UPS units shall be provided with automatic by-pass, in the event of UPS/battery failure.

UPS shall be capable of supplying power for at least 30 minutes following normal power failure, unless otherwise stated.

6.5.52 Uninterruptible Power Supply (UPS) for DP, Computers, Vessel Management, PMS, Thruster Control and Navigation

R6.267 Sufficient number of three phase three wire Online UPS units matching with the control voltage of DP, computers and navigation system shall be provided. It shall come with battery back-up for minimum 30 minutes and shall be installed in the switchboard room (one unit to be installed on bridge/instrument room). Capacity shall be determined by load analysis.

The UPS units shall supply clean and stabilized power to computer system and nautical consumers.

These UPS units are in addition to UPS units supplied with the Dynamic Positioning equipment.

Distribution boards for UPS shall be installed in ECR and on the bridge

6.5.53 Electrical Power and Lighting Systems for Laboratories

R6.268 Laboratories and related spaces shall be furnished with 230V AC electrical power supplied from electrical distribution panels connected to the Vessel's electrical switchboards. These spaces shall also be supplied with 110V AC electrical power from distribution panels connected to the Uninterruptible Power Supply (UPS).

Receptacles in all "wet" areas shall be of the Ground Fault Interrupting (GFI) type, or shall be connected to GFI type circuit breakers in the electrical distribution panels from which they are supplied. Fume Hood installations shall not be connected to electrical supplies via receptacles, but shall be wired directly to circuit breakers within electrical distribution panels.

6.5.54 Scientific Laboratory Power Sockets

R6.269 Double pole switched power sockets shall be provided for 3 types of supply:

230V, single phase, ship's domestic supply - 1 or 2 of f per space as necessary primarily utilised for cleaning machines.

230V,, single phase, stabilized supply - 6 off in groups over work station benches and spaced at 1.5m intervals otherwise around the space.

110V, single phase, stabilized supply - 1 of over work station benches and spaced at 1.5m intervals otherwise around the space.

Sockets shall be arranged in banks of 4 for each supply group.

Sockets shall be set at least 100mm above the bench tops. Where bench tops are not adjacent to bulkheads the power sockets shall be mounted on brackets suspended below the deckhead lining above the centres of the bench tops, such that the height from the finished floor covering to each socket is no more than 1.7m.

The height shall be adjusted such that they can be reached by a person of average height standing on the deck.

Bus rail conduits shall be used incorporating suitable circuit protections and allowing positional changes to be made as necessary later on.

Continuous dado rail trunking shall be used for the sockets incorporating suitable circuit protections and allowing positional changes to be made as necessary later on.

230V, 50Hz, sockets shall be type G (UK standard 3 pin, BS1363), colour coded for type of supply.

110V, 60Hz sockets shall be type B (USA 2 flat and one earth pin)

All sockets shall be double pole switchable locally.

All power sockets in 'wet' laboratories shall be waterproof.

6.5.55 Electromagnetic Environmental Effects (E3)

R6.270 Radiators and receptors of electromagnetic energy and related electronics on the ship must be designed and installed to ensure electromagnetic compatibility (EMC) and to avoid hazards from electromagnetic radiation to personnel. Personnel at or en route to normal operating stations, including the forward observation lab, must not be exposed to electromagnetic energy in excess of the limits established in IEEE Std C95.1, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

All HF transmit antennas shall be installed with non-metallic personnel guards located so as to provide a minimum distance of 1200 mm horizontal and 2400 mm vertical separation from any working areas, manned stations and personnel access areas. All areas within this region must be designated as hazard areas, by painting the deck, and provided with warning signs in accordance with IEEE Std C95.2, IEEE Standard for Radio-Frequency Energy and Current-Flow Symbols. Areas outside this region that violate the safe levels as defined in IEEE Std. C95.1 must be identified as personnel "no loiter areas." Warning signs must be provided to designate no loiter areas.

Automated control systems, communication systems and scientific electronic systems must not respond spuriously to electromagnetic interference (EMI) from radiating sources or transients on power lines.

Minimum immunity of scientific equipment to EMC/EMI phenomena on board the vessel shall be as per BS EN 61000-6-1: 2007. The below should be used for the interpretation and implementation of measures to combat EMC/EMI. The latest amendments should be used.

- BS EN 55016-1-4:2010+A1:2012 Specification for radio disturbance and immunity measuring apparatus and methods. Radio disturbance and immunity measuring apparatus. Antennas and test sites for radiated disturbance measurements.

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- BS EN 55016-2-2:2011 Specification for radio disturbance and immunity measuring apparatus and methods. Methods of measurement of disturbances and immunity. Measurement of disturbance power.
- BS EN 55016-2-4:2004 Specification for radio disturbance and immunity measuring apparatus and methods. Methods of measurement of disturbances and immunity. Immunity measurements.
- BS 6299: 1982 Methods of measurement of the suppression characteristics of passive radio interference filters and suppression components BS EN 55017:2011 Methods of measurement of the suppression characteristics of passive EMC filtering devices.
- BS EN 55032:2012 Electromagnetic compatibility of multimedia equipment. Emission requirements.
- BS EN 50561-1:2013 Power line communication apparatus used in low-voltage installations. Radio disturbance characteristics. Limits and methods of measurement. Apparatus for in-home use.
- BS 6299: 1982 Methods of measurement of the suppression characteristics of passive radio interference filters and suppression components
- BS EN 55022: 1998 Specification for limits and measurements of spurious signals generated by data processing and electronic equipment
- BS EN 61000-6-1: 2001 EMC; Generic standards. Immunity for commercial and light industrial environments
- Institution of Electrical Engineers (IEE): Regulations for the Electrical and Electronic Equipment of Ships. 6th Ed. with 1st Amendment.
- International Electro technical Commission (IEC)
- IEC 60945–08: 2002. Maritime Navigation and Radio communications equipment and systems. Methods of testing and required test results
- IEC 60533–11: 1999. Electrical and electronic installations in ships - Electromagnetic Compatibility
- Lloyds Register of Shipping: Electromagnetic interference tests for electronic equipment (susceptibility tests)
- UK Department of Transport: MPT 1270: Code of Practice for ships wire antenna systems for radio telegraphy transmissions

Builder shall take care that EMI does not affect or change the performance of control systems for below equipment. An electrically “clean” supply is necessary for the susceptible items

- Navigational aids, including echo sounders
- Engine room and propulsion control systems
- Scientific echo sounders
- Oceanographic instruments
- Communication receivers

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- Computers
- Internal communication systems
- Switched-mode power supplies (used in many instruments and equipment)

Measures to control Radio frequency interference (RFI) often involve the use of advanced filtering and screening techniques for areas where critical equipment or sensitive instruments are operated. Examples of the areas where such measures are likely to be necessary are designated 'S' in following Table 1.

Table 1

Area Description		
Wheelhouse		Table 2
Electronics & Communications	S	Table 2
Bridge Wings		Table 3
Aircon Room		Table 3
Ship & Scientific Offices		Table 3
All Cabins		Table 3
Meteorology Laboratory		Table 2
Conference Room & Library		Table 3
Scientific Engr. Office		Table 3
Bottom Sensor Spaces	S	Table 2
Main Laboratory	S	Table 2
Wet Laboratory		Table 3
Deck Workshop		Table 3
Rough Workshop		Table 3
Electronics Workshop		Table 3
Clean Laboratory		Table 2
Controlled Environment Laboratory		Table 2
Hospital		Table 3
Data Suite	S	Table 2
Container Laboratories	S	Table 2
Galley		Table 3
Video Room		Table 2
Recreation & Coffee Area		Table 3
Offices		Table 3
Switchboard & Control Room	Lloyd's Rules	
Gyro And Gravimeter Room		Table 2
Engr. Workshop & Stores		Table 3
Engine Room	See Section Below	
Winch Room		Table 3

These are the areas designated 'S' in Table above and the precautions listed below are expected to be necessary to meet the EMC/EMI requirements.

- Power supply to be suitably filtered to prevent conducted interference
- Construction of laboratory areas to form a screened enclosure
- EMI gaskets to be fitted where joints are bolted or riveted
- Doors to be covered with screening material and EMI gaskets fitted
- Portholes and windows to incorporate mesh screen to attenuate RFI
- Ventilation ducts to have honeycomb construction to attenuate RFI

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- Cable entries bonded to room screening at point of entry
- Cables shall be CAT 7

Levels measured in the areas shown as 'S' will need to comply with BS 1597 in the extended form shown in Figure 1, (down to 1 kHz).

In Table above the references to TABLE 2 and TABLE 3 refer to the allowable radiated and conducted levels of emissions as shown in Tables 2 and 3 below (IEC 60533).

IEC 60533 (Table 2)			
Radiated Levels		Conducted Levels	
Frequency	Limits	Frequency	Limits
150 – 300 kHz *	80 – 52 dB Mv/m	10 – 150 kHz	96 – 50 dB μ V
300 kHz – 30 MHz *	52 – 34 dB μ V/m	150 kHz – 350 kHz	60 – 50 dB μ V
30 MHz – 2 GHz	54 dB μ V/m	350 kHz – 30 MHz	50 dB μ V
156 – 165 MHz		24 dB μ V/m	
* measured 3 m from source			

The levels given in Table 3 apply to those areas where less critical equipment/systems will be used.

IEC 60533 (Table 3)			
Radiated Levels		Conducted Levels	
Frequency	Limits	Frequency	Limits
150 kHz – 30 MHz *	80 – 50 dB μ V/m	10 – 150 kHz	120 – 69 dB μ V
30 MHz – 100 MHz *	60 – 54 dB μ V/m	150 kHz – 500 kHz	79 dB μ V
100 MHz – 2 GHz	54 dB μ V/m	500 kHz – 30 MHz	73 dB μ V
156 – 165 MHz		24 dB μ V/m	
* measured 3 m from source			

6.5.56 Switchboard and Control Room

R6.271 This area must conform to the Rules of Lloyds Register of Shipping. Switchboard meters and associated systems should be chosen so that a high immunity exists to EMI from the main radio transmitters. Suppressors shall be fitted to meters where necessary. If meters incorporate transistorised circuits they must meet the susceptibility test requirements of Lloyds Register of Shipping, see Section 6.4.

Engine metering systems must also be immune to transmissions from handheld transceivers. Regulating and measuring signals should be current, not voltage based, with a preferred range of 4 – 20 mA.

6.5.57 Engine Rooms

R6.272 No specific requirements are given for this area in the various regulations but IEC 60533 (Table 3) shall apply, similarly for thruster rooms.

6.5.58 Methods of EMI Reduction

R6.276 Consideration should be given to isolating certain sections of the vessel from one another by means of filters where this will be beneficial to the overall EMC/EMI situation.

Layout of cable runs, screening and earthing should follow the recommendations in the IEE Regulations (Section 6.2). Coupling paths between cables of an inductive or capacitive nature must be taken into account to prevent a deleterious effect on the operation of equipment.

Cable ducting between laboratories must be dedicated to that purpose and provide adequate screening from adjacent ducting or cables carrying ships services. Equipment manufacturers should be consulted about the allowable proximity between their cables and others in the same ducting. A similar requirement exists for cables from slipping winches and those cables running between laboratories and equipment on the bridge.

All cables, trunking and conduits should be installed in accordance with the IEE Regulations. Echo sounder transducer cables require special protection and may need to be run in heavy gauge screwed water pipe. High quality, heavy duty, flexible screening must be provided for cables from the moonpool cursor assemblies to the transducer connection room.

Cables carrying digital signals should not be run closely alongside analogue cables.

In general, power cables should be grouped together and spaced by at least 250 mm from cables carrying control or other low level signals unless a greater distance is specified. Shielding should be by earthed trunking where appropriate. Measures should be taken to ensure that cables run over weather decks are sufficiently well shielded to prevent the radiated fields from radio, public address system and radar sources being picked up and re-radiated inside the vessel. The shielding should be such as to prevent interference picked up inside the vessel from being radiated and causing interference with radio reception.

Manufacturers of motors and generators should be required to supply details of the radiated and terminal levels of noise for each item. Transformers should be shielded to reduce the effects of inductive coupling to cables or equipment. Those transformers supplying designated areas are to incorporate an earthed screen between primary and secondary windings.

Wideband, impulsive interference from recurrent switching of power supplies by rectifiers, thyristors, high power transistors, or similar devices should be taken into account and appropriate filtering and screening provided. Lighting by LED may be unacceptable in specialised areas 'S'.

6.5.59 Laboratories

R6.274 Those laboratories listed as examples in Table 1 with the designation 'S' will contain sensitive scientific instruments and computers. These areas should be constructed, where possible, to represent an enclosure screened from RFI. At the junction of the steel decks, bulkheads and deck heads, joints should be made by a continuous weld. If sections of the joints shall be bolted, or riveted, EMI gaskets should be fitted. Doors should be covered with screening material and EMI gaskets should be fitted to ensure that good electrical contact is made with the framework. Ventilation ducts or other openings to have a form of RFI screening such as a honeycomb construction.

Cables should enter an area designated 'S' at the same point as far as possible. Screening of these cables should be bonded to the room screening at the point of entry.

Data transmission cables carrying low level signals should be treated as exceptionally sensitive circuits and screened by heavy gauge screwed water pipe if necessary; this applies particularly to all scientific echo sounder transducer cables. Electrical trunking is not acceptable. The depth-finding echo sounder/s, Doppler log and ADCP transducer cables may need to be run in heavy gauge screwed water pipe. No breaks should occur over the length of the run and termination of the pipe at the transducer

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end should be by screwed joint into the transducer junction box. Electrical trunking is not acceptable for these cables.

Limits of spurious signals generated by data processing equipment must conform to BS EN 55032: 2012 & BS EN 50561-1: 2013.

6.5.60 Container Laboratories

R6.275 The use of these laboratories will be subject to the scientific requirements for a specific cruise but it will be necessary to take precautions to meet the EMC/EMI conditions for the operation of scientific instruments. These may include electromagnetic screening and the filtering of power cables. The containers must be carefully grounded to ensure that an electrical shock hazard does not exist due to the use of EMI filters in the power supply.

Control or signal cables need to have an overall screen throughout their length from the source to the container and the screen peripherally bonded at the point of penetration. Screened connectors are also required. Internal cabling must be routed flush to the container surface using clips or cable trays.

Filters shall be installed in a metal box bonded to the container. LED light fittings must meet the EMC standard EN 55015 (f): 2013

Scientific laboratory containers must be either bolted to the deck or grounded using bond straps.

6.5.61 Bridge Equipment

R6.276 The instruments and equipment used on the bridge are susceptible but are themselves capable of causing EMI/RFI. Where remote monitors or indicators shall be connected to any of these items, suitable screened cables and connectors are required. Co-axial cables for composite signals. Screened, balanced feeder can be used if specified by the unit manufacturer. Tri-axial cable and connectors may be necessary for some navigational systems. Where tri-axial cables are used, only the outer braid may be terminated at each penetration through decks, bulkheads, or deckheads.

The depth-finding echo sounder/s, Doppler log and ADCP transducer cables may need to be run in heavy gauge screwed water pipe. No breaks should occur over the length of the run and termination of the pipe at the transducer end should be by screwed joint into the transducer junction box. Electrical trunking is not acceptable for these cables.

6.5.62 Radio Communication Equipment

R6.277 The Electronics and Communications room is at the rear of the bridge deck. Radio receivers and associated equipment are therefore sited as high as possible in the ship, away from major sources of machinery generated EMI but close to antenna transmitting radio frequencies. Careful attention must be given to the installation of this equipment particularly with regard to the safe distances for transmitter feeders. If radio frequency (RF) filters are used in the mains supply feed to transmitters, care must be taken to ensure that detuning does not result from the inserted impedance.

Special precautions are needed to ensure that computer data are not contaminated by EMI on any Local Area Network (LAN) connected to the laboratories or other regions of the vessel, nor that any form of EMI has an effect on the installed computers and ancillary equipment.

Cables interconnecting power equipment items that utilize solid-state high frequency switching devices and cables that carry high amplitude pulses must be physically separated from more sensitive cables whose signal data would be distorted by induced interference.

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Cableway crossings must be as nearly perpendicular as practical with maximum practical separation. Cables must be routed within the ship structure and protected from electromagnetic radiation from on-ship transmitting antennas to the maximum extent practicable.

All transducer cabling must be shielded.

Cables routed in topside areas exposed to the weather must be shielded. Shielding must be accomplished through the selection and use of shielded cable or by routing cable through shielding conduit. Shielding conduit must be rigid pipe, flexible metal hose, or enclosed cableways or trunks. Armoured cable does not meet these shielding requirements. The outermost overall cable shield of shielded cables must be grounded at weather deck or weather bulkhead penetration points. Fibre optic cabling is to be utilised where noise/interface would affect critical system and where normal screening methods are insufficient to prevent radio frequency interfaces.

Pipes, metal tubing and waveguides routed in topside areas must be grounded at deck or bulkhead penetration points. Tubing and pipes must be grounded by welding or by a welded flange or must utilize the method specified for cable shield grounding.

Waveguides must be grounded by replacing the weather flange gasket with an electrically conductive gasket.

Close attention must be given to the electromagnetic compatibility and immunity of all below items;

- Main electrical power supplies containing strong harmonics
- Magnetic fields from power cables
- Propulsion systems: use of multi-phase thyristor/transistor controls
- Electrical propulsion motors
- Multi-frequency radio transmitters
- Portable transceivers
- Switched-mode power supplies
- Fan motors
- Thruster motors
- Radar transmitters
- Navigational aids

6.5.63 Equipment Earthing and Bonding (See IEC 61892-6, Clause 4)

R6.278 Earthing shall comply with IEC 61892-6, with the exception of field equipment which shall be earthed through supply cable.

Only corrosion resistant components shall be used as earthing parts.

Connections shall be secured against becoming loose due to vibration.

Unless otherwise accepted, only one core shall be connected on each terminal point.

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Earth bars shall be located in front of equipment and junction boxes to allow easy access for usage, inspection and maintenance.

All earthing bars and terminals shall be visible and possible to be checked also after termination of cables.

If aluminium is used for any part of the main structure, attention shall be given to ensure that continuity in the structural earth is maintained at aluminium/steel interface points.

The main earth reference points shall consist of earth bosses welded to the structure as close as possible to the cabinet/equipment. Alternatively, earth bars mounted on earth bosses welded to structure may be used.

6.5.64 Earthing of Exposed Conductive Parts (See IEC 61892-6, 4.2)

R6.279 Field equipment shall be connected to the protective earth (PE) system through the cable. The braid armour should be the earth conductor and it shall be electrically continuous from the field to the central equipment PE bar.

For power cables where the braid armour does not have sufficient cross section, (refer to IEC 61892-6, Table 1,) the equipment shall be earthed through a separate earthing conductor in the cable.

Equipment supplied by single core cables shall be connected to PE by a separate earth cable. The separate earth cable shall run alongside the power cables to form a "cable system" and be terminated to the field equipment earth terminal as well as feeding end earth bar/terminal.

The copper braid of the single core cables shall be earthed at one end, isolated in the other end. Where hazardous areas are involved, the copper braid shall be earthed in the hazardous area.

The PE earth cables or braids armour of cables, connected to a switchgear, cabinet, equipment etc., shall be connected to a PE earth bar as close as possible to the cable entry of the switchgear, cabinet, equipment, etc.

6.5.65 Science Power Cable and Ancillary Installations

R6.280 A separate, dedicated cableway shall be installed to serve scientific requirements.

The cableway shall interconnect the laboratories and wheelhouse.

The cableway shall be separated as far as practicable from main power cableways. These cableways shall be steel or fibreglass, and of open construction. Provisions for the easy installation and removal of temporary cabling shall be made. Watertight multi-cable transits (MCTs), Rox System, or equal, shall be installed in fire-rated and/or watertight bulkheads and decks serving the cableways. Sizes shall be determined by the Contractor.

150mm diameter steel pipe cable pass-through ports shall be installed in deckhouse exterior bulkheads and decks, with threaded caps on the exterior side. The location of these ports shall enable access to the scientific cableways and be approved by NERC

Threaded caps to be corrosion proof.

Watertight 415V, 3Ø, 50Hz, 3-wire, 250 amp and 230V 50Hz and 230V 50Hz Clean receptacles shall be provided on the weather decks to serve the portable container locations, for temporary installation on the ship when required for science operations.

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Penetration locations should be such that, when the containers are installed, there is no cabling run along the deck.

6.5.66 Cabin Power Sockets

R6.281 Cabin power sockets, at least four, shall be liberally provided for 230V, single phase, 50Hz, ship's domestic supply, 230V, 50Hz sockets shall be UK standard 3 pin square type.

All sockets shall be double pole switchable locally.

6.5.67 Equipment Name Plates and Markings

R6.282 All electrical equipment shall be fitted with identifying label plates in English.

Any special instructions or precautions shall be included on the label plate or on a separate plate on or adjacent to the equipment. Blank name plates shall be provided for spare feeder switches and circuit breakers.

Switchboard and distribution panel buses shall be stamped in a readily visible location with their polarity or phase identification.

Circuit-identifying nameplates shall be fitted to all connection and terminal boxes.

Markings of conductors shall be accomplished by any of the following methods, whichever best serves the particular application:

- Synthetic resin tubing, fibre or approved plastic wire markers.
- Stamping directly on the terminals.

Where separate markers are used, they shall be attached as near as practicable to the terminals marked so as to preclude faulty identification.

Name plates for the switchboard, distribution panels and controls shall have engraved or photo etched lettering in a contrasting colour and shall be sized for legibility at normal viewing distances.

All cables shall be tagged with their identification at each point of connection, and on both sides of bulkheads and decks, with tags of aluminium (or other non-corrosive metal) with embossed figures.

6.5.68 Measurement of Electromagnetic Interference

R6.283 Two sets of measurements with all ships services operating when vessel running at 11 knots and vessel at MCR shall be carried out

6.5.69 Measuring Equipment and Test Results

R6.284 Approved equipment (EMC Consultancy Standard) to be used for measurement purposes, see BS EN 55016-1-4:2010+A1:2012, BS EN 55016-2-2:2011 and BS EN 55016-2-4:2004.

Measurements must demonstrate that the EMC specification has been met within all areas listed in Table 1 under the above conditions and that EMI generated aboard the vessel has been minimised in accordance with the appropriate documents. Definitions relating to terms used can be found in IEC 60050-161: 1990.

6.5.70 Measurement Procedure

R6.287 All scientific instruments and equipment must be in full working condition during the course of measurements, including echo sounders.

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Measurements of conducted and radiated noise should be made under realistic, but controlled conditions, starting with the electrical supply systems running lightly loaded. Electronic equipment and instruments will be started and run in groups as each designated area is examined. Navigation aids will be run in transmit modes where appropriate. Communication systems will be run at full power on each of the typical operating frequencies.

6.5.75 Schedule of Electric Sockets

R6.288 The Contractor shall arrange to install the following approximately 1680 Electric Power Outlets throughout the vessel with locations to be identified at final design:

Size	Type	Quantity
440V, 60Hz, 63 amp	IP65 enclosure c/w MCB	10
415V, 50Hz, 500 amp	IP65 enclosure c/w MCB	10
415V, 50Hz, 250 amp	IP65 min sockets	10
415V, 50Hz, 125 amp	IP65 sockets	15
415V, 50Hz, 63 amp	IP65 sockets Welding machine	20
415V, 50Hz, 32 amp	IP65 sockets	15
230V, 50Hz, 100 amp	IP56 enclosure c/w MCB	10
230V, 50Hz, 63 amp	IP56 sockets	30
230V, 50Hz, 32 amp Stabilised	IP56 sockets	25
230V, 50Hz, 13 amp Stabilised	standard 13amp UK	420
230V, 50Hz, 13 amp Stabilised	IP 56 sockets	360
230V, 50Hz, 13 amp domestic	standard 3 amp UK.(Lab spaces Red)	400
230V, 50Hz, 13 amp domestic	IP 56 sockets (Lab Spaces Red)	80
110V, 60Hz, 32 amp Stabilised	IP65 socket coded	15
110V, 60Hz, 16 amp Stabilised	2-pin US standard labs only	75
110V, 60Hz, 16 amp Stabilised	2-pin US standard labs only P 56 sockets	65
110V, 50Hz, 16 amp	Portable tool outlets IP56 on all units	120

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6.6 AIR CONDITIONING & VENTILATION

6.6.1 Ambient Conditions & Requirements

R6.289 The air conditioning system shall be capable of operating effectively on an unrestricted worldwide basis from high latitude ice margins (Arctic/Antarctic) to equatorial regions including the highest air/water temperature regions (e.g. The Red Sea) as follows:

Climatic conditions:

SUMMER:	Primary Outside ambient	+40°C, 85% RH
	Inside requirements	+25°C, 55% RH
	Secondary Outside ambient	+45°C, 80% RH
	Inside requirements	+30°C, 50% RH
WINTER:	Outside ambient	- 40°C 100% RH
	Inside requirements	+22°C, 50% RH
SEAWATER	Temperature range	- 2°C to +35°C

Exception:

a) Maximum inside temperature for warm condition:

- Lab (CT*, chemical, deck): t = from 0°C to -30°C (+/- 1 K)
- Switchboard rooms t = 30°C
- Deck store, paint store: t = 40°C
- Engine Room: t = 52,5°C (according DIN 8861; dt=12,5 K)
- Cargo Hold t = 30°C
- Science Hold t = 30°C
- Science Hangar t = 30°C
- Deck Workshop t = 30°C
- Rough Workshop t = 30°C
- Helicopter Hangar t = 36.5°C

b) Minimum inside temperature for cold condition:

- Laundry: t = 15°C
- Stores and Workshops: t = 10°C
- Cargo Hold t = 10°C
- Science Hold t = 10°C
- Helicopter Hangar t = 10°C
- Not occupied technical rooms: t = 10°C
- Switchboard rooms t = 10°C

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- Deck store, paint store: t = 10°C
 - Engine Room: t = 10°C
- c) Galley, Laundry:
- Constant supply temperature: t = 20°C

*CT- Controlled Temperature

6.6.2 Noise

R6.290 The system chosen shall be compatible with the requirements for Underwater Radiated Noise and Internal Noise limits such that the vessel will achieve a DNV Silent (R) notation.

To minimise the noise impact of intermittently operated equipment, all such items must be selected not only on the basis of cost/ mechanical efficiency/ size etc but also on the basis that their design is such that strong tonal characteristics are not exhibited.

The HVAC system shall be designed generally with a low to medium speed regime to limit noise.

Main ventilation fans shall be sound attenuated and where possible two speed so that a reduced duty may be achieved for quiet running.

Maximum noise creating from HVAC system in one meter distance to the air inlet / outlet:

SPACE	NR	dB(A)
Wheelhouse	55	60
Offices	50	55
Stores	60	65
Main Engine Room (harbour mode):	-	80
Engine Control Room	60	65
Engine Room Workshops	70	75
Galley	60	65
Scientists Common Quarters	45	50
Crew Common Quarters	45	50
Scientist and Crew Cabins	40	45
Electronics & Communication Room	55	60
Hospital	55	60
Technical rooms:	-	60
Decks area:	-	65
AC Room:	-	70

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Careful consideration must be given to preventing noise transmission via the ductwork system, particularly from one room to the next, through phonic insulation and construction methods.

6.6.3 Thermal Insulation

R6.291 The heat transmission shall be calculated according following data:

Walls:

Outside walls and decks	$u = 0.6 \text{ W/m}^2 \text{ K}$
Inside walls and decks	$u = 0.8 \text{ W/m}^2 \text{ K}$
Walls and decks to main engine room	$u = 0.8 \text{ W/m}^2 \text{ K}$

Windows:

Cabins:	$u = 6.5 \text{ W/m}^2 \text{ K}$	$G_s = 240 \text{ W/m}^2$
Public space, wheelhouse:	$u = 3.5 \text{ W/m}^2 \text{ K}$	$G_s = 240 \text{ W/m}^2$
Laboratories:	$u = \text{max. } 2.5 \text{ W/m}^2 \text{ K}$	$G_s = 140 \text{ W/m}^2$

Wild heat loading from equipments, lighting and human occupancy shall be accounted by proper assessment and calculation for all the spaces.

To determine the amount of required air changes in each space, a thermal calculation shall be carried out taking into account a realistic number of people, electric load, heat release from equipment etc. and heat transmission factors.

Heat loss calculations to be carried out as follows;

- According to ISO 7547 for accommodation.
- According to ISO 8862 for Engine control rooms
- According to ISO 8863/8864 for Wheelhouses.

Exceptions shall be defined.

The air volumes for the galley shall be calculated according ISO 9943. The air volumes for the main engine room shall be calculated according ISO 8861. Exceptions shall be defined.

Duct pressure loss calculations shall be performed in order to obtain fan system pressure requirements.

6.6.4 Air Changes

R6.292 Air changes and flows shall be designed on the basis of the heat load in the various rooms. The fresh air change per person shall be at least $30 \text{ m}^3/\text{hr}$ in each room or 6 changes per hour, whichever is the most onerous.

The minimum air changes per hour shall be based upon:

- 12 - Public amenity spaces
- 8 - Officer's, Crew and Scientists cabins
- 10 - Offices
- 12 - Laboratories