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Appendix A

**General Design and Material
Requirements**

for the

Vasco da Gama Class Frigates

Mid-Life Upgrade



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1 Document overview

This document describes the general design and material specifications for the Portuguese MEKO 200 frigates (FFGH VGAM) upgrade, hereafter referred as “the ships” focusing, particularly, in the interface requirements for electronic equipment and systems to be incorporated in the vessels, while fulfilling the operational requirements.

This document must be complementary to the Building Specifications for Portuguese Navy MEKO 200 Frigates. When no update to the requirement or standard is mentioned, the Building Specifications are applicable.

This document is organized by the following categories:

- Section 2 – Operational Employment;
- Section 3 – Survivability;
- Section 4 – Environmental Conditions;
- Section 5 – Signature;
- Section 6 – Construction;
- Section 7 – Power and Signaling;

2 Operational Employment related requirements

2.1 Dimensional limits

The ships are built with the following main dimensions:

- | | |
|---------------------------------------|--------------|
| - Length overall | 115.90 m |
| - Length on waterline | 109.00 m |
| - Breadth on waterline | 13.80 m |
| - Breadth 1 st deck | 14.80 m |
| - Depth 1 st deck at LWL/2 | 9.15 m |
| - Draught at design displacement | 4.10 m |
| - Design displacement | aprox.3180 t |

2.2 Availability

On conclusion of the upgrade the ships must be able to be fully sustained for the lifetime of 10 years.

The major indicators for the availability based on the operational deployment profile of the ships are outlined in the Table 1.



Table 1 – Availability indicators

Lifetime	10 years
Environment	Coastal areas, harbour entrances and heavy sea areas
Mission profile on yearly basis:	
▪ Duration of mission	Maximum of 30 consecutive days at sea up to a total of 120 days
▪ Equipment utilization rate	24 hours a day
Availability Systems (operational)	> 90%
Availability Critical items (operational)	> 90%
Maximum re-supply period	30 days
Maximum turnaround time	6 months

2.3 Speed

As a reference, the current performance of the propulsion installation of the ship is:

- Max. continuous with two Diesel Engines 18,2 kts
- Max. continuous with two Gas Turbines 33,2 kts

2.4 Autonomy

The ships must maintain as is a mission endurance of 20 days for a complement of 184 persons. The ships must have a fuel autonomy of up to 9.6 days traveling at a speed of 18 knots (4,143 nautical miles) maintaining a margin of fuel of 30%.

2.5 Seakeeping and Manoeuvrability

After the upgrade the ships must keep the original seakeeping and manoeuvrability performance characteristics as described in **Building Specifications chapters 0011.9 and 0011.10**.

3 Survivability related requirements

3.1 Subdivision

After the upgrade the ships must maintain the same subdivision as described in the **Building Specifications – Principal building Section 1**, in what concerns the basics and general outlines, construction of the hull, superstructures and deckhouses.

3.2 Stability



The ships must comply with the intact and damaged stability criteria as described in the in the **Building Specifications chapters 0011.8**.

3.3 Watertightness and Gas tightness

3.3.1 External watertightness

The ships must maintain the design watertight conditions. All passageways, accesses or penetrations (including cable glands and cables passageways) from the exterior to the interior must be watertight up to a pressure of 70 kPa. There will be no openings in the hull bellow main decks, except for piping (drainage pipes, sea inlet pipes, and sea chests).

3.3.2 Internal watertightness

There must be no openings in watertight bulkheads bellow main deck and between decks, except for the following watertight openings:

- a) Watertight hatches for normal passageway, cargo and equipment movement, and emergency escape routes;
- b) Watertight doors to the engine rooms;
- c) Watertight Piping and cabling penetrations.

3.3.3 Internal Gas tightness

The ships are equipped with a permanent overpressure citadel. The citadel is divided into 8 different sub citadels due to the ventilation system on compartment basis. Also, main engine rooms and power generator rooms are within the citadel.

After the upgrade the ships must maintain the same gas tightness condition.

Bulkheads and decks piping penetrations above main deck, as well as non-watertight, bulkheads cabling penetrations must also be gastight.

4 Environmental Conditions related requirements

The ship's equipment's must withstand the below-mentioned requirements without significant impairment of its operability.

Note: **Building Specifications, Principal Building Sections 1 - 7 and 9** are applicable when no requirement is mentioned in this document.

4.1 Ship motion angles



- a. Roll: 30° to both side, period of 10 sec.
- b. Pitch: 10° bow to stern, period 10 sec.
- c. Permanent trim: $\pm 3^\circ$
- d. Permanent list: $\pm 15^\circ$

The simultaneous appearance of maximum roll and pitch will not be considered.

4.2 Environmental conditions (outside ship)

- a. Exterior air temperature: -15°C up to 45°C
- b. Exterior relative humidity: 100% (permanently)
- c. Seawater temperature: -2°C up to 32°C
- d. Percentage of salt:
 - i. Air: 1 mg/m³
 - ii. Seawater: 3,5%
- e. Ice accretion: up to 2,5 cm

4.3 Open deck installed equipment – wind conditions

All open deck installed equipment must be capable of withstanding forces generated from winds up to 100 knots attached to their foundations, with the following limits:

- a. 40 kts constant and 75 kts in gusts, without degradation of the performance.
- b. 40 kts to 90 kts constant and 120 kts in gusts, some degradation is accepted, according to the performance conditions and levels of degradation set out in the requirements for each individual system/ equipment.

4.4 Open deck installed equipment – green water loads

Open deck installed equipment must be protected from sea effects and must be capable of withstanding at least loads of 36 kPa originated from green seas attached to their foundations, under the performance conditions and levels of degradation set out in the requirements for each individual system/ equipment. All shock mounts installed in the open deck must be provided with the relevant cover shield to protect the on-mount equipment against environmental conditions.

4.5 Air Open deck installed equipment – rain and lighting

The equipment must be designed to withstand driving rain of 30mm/h with wind speeds up to 35 kts.



A reduced performance is accepted for driving rain up to 60 mm/h with wind speeds up to 35 kts.

Note: Pre-wetting systems are not applicable.

The outside placed equipment of the system (for example antennas) must survive an indirect lightning strike with an intensity of 200 kA.

4.6 Inside installed equipment – heating, ventilation and air conditioning (HVAC)

The ship's equipment and systems installed inside the ship must be able to operate fully under the specified environmental conditions for each compartment ensured by the HVAC system. Unless otherwise stated the upper and lower temperature limits for the most important ship rooms are to be maintained according to the [Table 2](#) and independent of the equipment cooling requirements.

Table 2 - Compartments environmental standard operating temperatures

Compartment	Maximum temperature limit (°C)	Relative Humidity (%)	Minimum temperature limit (°C)
Habitational	25	35 to 65	20
Combat Information Center (CIC), Bridge, Radio Room, Machinery Control Room (MCR), Crypto Room	25	35 to 65	20
Sickbay	25	35 to 65	22
Machinery and Engine rooms	45	-	0
Toilets	-	-	15
Showers	-	-	22
Electronic Equipment rooms	35	-	15
Workshops	35	-	15
Storage rooms	30	-	0
Magazines and explosives store	30/40*	< 80	0
Galley	30	-	15
Laundry	40	-	15

*According to the type of ammunition

4.6.1 Equipment cooling

Equipment must be provided with air or water cooling.

Equipment which needs a higher cooling capacity must be provided with a water-cooled heat exchanger cooling system. The water and cooling requirements for each cabinet must be specified in the Equipment Data Sheets.



Failing of equipment cooling, resulting in excess temperature, must be indicated on the equipment itself. In case overheating leads to extensive damage of equipment parts, an “automatic/manual switch-off facility” must be incorporated.

For those equipment parts which are not normally manned, a remote indication of the temperature to a manned instrument must be available.

Water cooled equipment must be provided with manually removable chokes and measures must be taken to protect the built-in equipment against damage caused by splashing water.

4.7 Electric and Electronic Index of Protection

The ships equipment and systems installed, unless otherwise approved by the NSPA, will have the minimum Index of Protection (IP) defined in the table, by the Classification Society rules, and within the standards **IEC 60529** and **IEC 60034-5**. The ~~Table 3~~ **Table 3** identifies the correspondent IP depending on the type of equipment and its location.

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Table 3 – Minimum IP Requirements

Compartment	Component	IP
Machinery rooms	Lighting	55
	Transformers	44
	Control Switchboards /Equipment	44
	Communications and alarms systems/ equipment	55
	Junction boxes	67
	Sockets 440V	67
	Sockets 230V/ 115V	56
Open deck (exterior)	Lighting	66/67
	Communications and alarms systems/ equipment	66/67
	Junction boxes	66/67
	Sockets 440V	67
	Sockets 230V/ 115V	56
Bridge; CIC; Communication room; Mast (interior)	Lighting	22
	Control Switchboards/ Equipment	22
	Communications and alarms systems/ equipment	67
	Junction boxes	67
	Sockets 230V/ 115V	22
Habitational, workspaces	Lighting	22

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Compartment	Component	IP
and other compartments above the main deck (inclusive)	Control Switchboards /Equipment	22/ 44
	Communications and alarms systems/ equipment	67
	Junction boxes	67
	Sockets 440V	67
	Sockets 230V/ 115V	20
Habitational, workspaces, storage compartments and other compartments below the main deck	Lighting	55
	Control Switchboards /Equipment	44
	Communications and alarms systems/ equipment	67
	Junction boxes	67
	Sockets 440V	67
	Sockets 230V/ 115V	56
Compartments EX (including magazines and explosives stores)	All components IP 67, in complement to other specific requirements for the compartment	



Equipment with a built-in ventilation system using air for cooling must be provided with quickly replaceable dust filters on the air inlets. To obtain a reasonable operating time (about 2000 hrs) between replacement of the dust filters, the selection of the dust filters should be based on air which has gone through the filter and wherein the amount of dust parts greater than 1.5 mm is not more than 0.4 mg/m³ air.

4.7.1 Protected equipment

Cabinets with built-in equipment, must withstand a water level of 25 cm, measured from the lower side of the shock mount, without damages or degraded performance. Protected equipment, not built into cabinets will be mounted at least 30 cm from the ships deck.

4.8 Storage

The equipment and spares must be able to withstand, without harmful consequences, storage in a temperature under the specified environmental conditions of the compartments ensured by the HAVC system, unless otherwise stated.

5 Signature related requirements

5.1 Radar cross sections (RCS)

By principle, in case of major structural modifications, the ships RCS must be reduced as much as possible by means of changing the geometrical profile of the open-deck equipment, without the use of any Radar Absorbing Material (RAM), taking into account the following guidelines:

- a. Elimination of any unnecessary holes, cavities or portholes;
- b. Elimination of unnecessary small components, including them in the main body of the equipment;
- c. Elimination of unnecessary components on the open deck, locating them in the interior;
- d. Maximize the transverse inclination towards the centre line aiming to achieve an inclination of 12.5° with the vertical inwards;

Maximize the longitudinal inclination towards amidships aiming to achieve an inclination of 15° with the vertical inwards.

5.2 Infrared (IR)

By principle, the IR signature must be reduced as much as possible by using standard insulation materials approved by the NSPA, and correspondent certificate according [IMO MSC.307\(88\) Fire test Procedure \(FTP\) code certification](#) must be provided in accordance with Annex C.



5.3 Underwater noise

Underwater noise must be reduced as much as possible, and no equipment must be a source to significantly increase the underwater noise, taking into account the following guidelines:

- a. Airborne noise reduction;
- b. Structural vibrations reduction by means of using adequate mounts;
- c. Installation of noise reduction insulation;
- d. Installation of viscoelastic materials to decks and flooring (if required);
- e. Adequate fixation of pipes and cables;
- f. Reduction of fluid velocity within pipes (if required).

5.4 Airborne noise

The ships air borne pressure noise in dB(A) must be in the limits stated in **STANAG 4293**, and the specified limits in the compartments mentioned in the [Table 4Table 4](#).

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Table 4 - Compartments airborne noise

Vital Spaces at 20 kts and 30 kts	Maximum sound pressure dB(A)
CIC	60
Machinery Control Room	70
Bridge	65
Communication rooms	60
Manned spaces at 20 kts	
Accommodations	65
Hospital	60
Galley	75
Electrical and Electronics workshop	65
Mechanical workshop	80
Unmanned spaces at 20 kts	
Engine rooms	100
Ventilation rooms	85



Note: The noise level of each room depends on the number of equipment/systems installed inside. As a guideline, the individual noise level for individual components should not exceed more than 7 dB(A) below the noise requirement for the room.

5.5 Shock and vibrations

The shock requirements for equipment depend on:

- a. The location in the ship: shock zone.
- b. The direction: vertical, athwart ship, longitudinal.
- c. The stiffness of the apparatus: stiff or flexible.
- d. The mass of the apparatus.
- e. The rigidly or spring mounted.

New systems must comply with the limits mentioned in **Building Specifications Section "04 Shock, Vibrations and Noise"** without any exceptions.

5.5.1 Proof of shock and vibration

The proof of shock and vibration resistance must be provided by Report using appropriate engineering methods and tools such as Finite Element Analysis modelling. The proof of vibration for equipment must be specified according to **MIL-S-901D standards**.

6 Construction related requirements

6.1 Calibrations and certifications

The Contractor must provide all equipment that requires calibration calibrated together with their **calibration certificates**/labels, with a validity of at least 2 years starting from the delivery of equipment, in accordance with **ISO/IEC 17025**.

6.2 Design engineering rules

The design and engineering rules must comply with the recommendations of the International Maritime Organization (IMO), International Association of Classification Societies (IACS) recommendations, European Union (EU) Directives and other Standards mentioned in this document. In the eventuality contradictions are found between the different rules, it is up to the NSPA to decide which requirements to follow.



6.3 Structural works

Structural works of any kind must be done using certified materials, by certified workers, and using welding certified procedures by a classification society belonging to IACS (certificates to be presented upon request), taking into account the following rules/ standards/ recommendations and ships technical documentation:

- a. **IACS 47 Shipbuilding and Repair Quality Standards** - standard level or superior;
- b. **IACS URW – Requirements concerning Materials and Welding;**
- c. Standards and good production practices must be used to avoid the direct contact between materials prone to develop galvanic corrosion, e.g. steel, aluminium..

6.4 Piping works

Piping works of any kind must be done using certified materials, by certified workers, and using welding certified procedures by a classification society belonging to IACS (certificates to be presented upon request), taking into account the following rules/ standards/ recommendations and ships technical documentation

- a. **IACS Unified Requirements P1:** Rules for pipes, and P2: Rules for piping design, construction and testing;
- b. **IACS URW** – Requirements concerning Materials and Welding;
- c. Standards and good production practices must be used to avoid the direct contact between materials prone to develop galvanic corrosion, e.g. steel, aluminium.;

6.5 Auxiliary systems – seawater

The ships have a firefighting seawater circuit permanently pressurized to 9 bar that must not be used for normal refrigeration purposes.

Any equipment seawater refrigeration circuit must be guaranteed by a dedicated system.

6.6 Auxiliary systems – fresh water

The ships have a fresh drinking water circuit that must not be used for refrigeration purposes.

Note: The ships will have chilled water closed circuit that can be used for cooling purposes.

6.7 Auxiliary systems – compressed air

All equipment compressed air requirements must be identified and should be compatible with the pressures available onboard or, alternatively, provide the necessary reducing valves. Available compressed air pressures onboard:

- a. Main circuit of 250 bar;
- b. Main circuit for engine start of 40 bar;



- c. Circuit branch for general use of 6 bar.

6.8 Fixed fire extinguishing systems

The electric and electronic equipment own fire-extinguishing system (if required) must be supplied by the contractor and comply with **IMO SOLAS** requirements and **IACS** regulations, in accordance with their application.

6.9 Habitability and ergonomic

All structural, piping, electrical and outfitting works must be done maintaining the following habitability and ergonomic standards, safety directives and building specifications:

- a. **ANEP – 24: Guidelines for Ship Board Habitability**;
- b. **ANEP – 26: Ergonomic data for Shipboard Space Design in NATO Surface Ships**
- c. All equipment must comply with the safety rules identified in **EU directive 2006/42/EC– Machinery Directive**, as long as their performance is not affected;

6.10 Outfitting works

Outfitting works must be done using certified materials, taking into account the following rules/ standards/ recommendations and ships building specifications:

All non-metallic materials must be certified according **IMO MSC.307(88) FTP** code certification and must be applied according to the ship's fire class location.

All insulation material, deck coverings, panels, ceiling, fabrics and other outfit material, must be non-combustible, fire retardant and non-toxic in the presence of flame and must be certified in accordance with **IMO MSC.307(88) (2010 FTP CODE)**;

- a. All piping insulation materials must be adequate for the required temperature insulation.
- b. Materials used in the end item configuration must be non-combustible or fire retardant in the most hazardous conditions of atmosphere, pressure, and temperature and must be in accordance with the **MIL-HDBK-454** guideline 3 and 4 as applicable.

The **certificates** for the materials used for the outfitting works must be provided in accordance with Annex C.

6.11 Protective surface treatments - Galvanization

Galvanized surfaces must have a minimum galvanized surface of 50 microns and must comply with the following standards and guidelines:

- a. **ISO 14713-2** - Zinc coatings — Guidelines and recommendations for the protection against corrosion of iron and steel in structures — Part 2: Hot dip galvanizing;



- b. **ISO 1461** - Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods;
- c. Pipes must only be galvanized after molding.

6.12 Protective Surface treatments – Painting

Painting systems applied to the ships or to any of its equipment must be approved by the NSPA. The paintings must have a life expectancy of 15 years with maintenance intervals not less than 5 years, and comply with the following standards and requirements:

- a. Corrosion protection level CX, must be according to **ISO 12944** (unless otherwise approved by the End User);
- b. Steel preparation must be according to **ISO 8501-3**
- c. Steel grade preparation must be St 3 or Sa 2.5, according to **ISO 8501-1**;
- d. **AEP- 59** – Application Process for Optimum Paint and Coatings Systems' Performance;
- e. **AEP- 60** – Performance Requirements for Exterior Topsides Coatings;
- f. **AEP- 61** – Performance Requirements for Underwater Hull Paint Systems;
- g. Application and quality verification must be according to ISO 19840.

6.13 Color for painted surfaces

Unless otherwise required by NSPA, the colors to be applied on the ships, according to the location, must be as below:

- a. Open deck structures – bulkheads and vertical structures grey color BS631
- b. Open deck equipment – grey color BS631 or Black (RAL to be defined);
- c. Interior located equipment – according to the manual **1200/DE – 631/19891770**.

6.14 Signalling, nameplates and product markings

Labels and warning signs must be applied following international standards recommendations and the contractors experience, good practices and the following requirements:

- a. Signals and labels must be provided in English language;
- b. Open-deck installed equipment must not have any visible references to manufacturer or suppliers;
- c. Signals must comply, as much as possible with **ISO 3864**, and **IMO/ MSC.A.1116(30) - 2017** Escape Route Signs and Equipment Location Markings;



- d. All electrical and electronic equipment with voltage above 50V must be properly marked with voltage value and danger of electrocution;
- e. All batteries storage compartments must be properly signalized;
- f. All electric equipment and systems must have all its power sources identified;
- g. All electric and electronic equipment with high capacity capacitors must be properly identified;
- h. Equipment and equipment components must have identification plates (identifying its serial number, model, manufacturer and main characteristic), made in stainless steel AISI 316 L (in the exterior) or gravoply (in the interior), with round corners and securely fasten.

6.15 Accessibility

Equipment and systems must have access for operation and maintenance, observing the following requirements:

- a. Space necessary for operation of equipment and systems must be assured, taking into consideration the habitability and ergonomic requirements stated in 6.9;
- b. Space around equipment necessary to maintain them (maintenance envelope), to fasten them to foundations, for ventilation and to operate peripheral circuits must be assured;
- c. Equipment and systems components subjected to periodical maintenance or catastrophic failure will be able to be removed from inside the ship without any cut on its structure, namely racks and electronic.

6.15.1 Access – dimensions for operation

Access dimensions for operation of equipment, systems and peripheral circuits' components must comply with **ANEP 24** and **ANEP 26**, as well as IACS rules.

6.15.2 Access – dimensions for maintenance

Dimensions of equipment and systems components subjected to maintenance must be, as much as possible, limited to be moved through the doors, hatches and passageways.

Components with larger dimensions must be subjected to NSPA approval.

6.15.3 Transport

Equipment exceeding 10 kg in mass must be fitted with handgrips or other provisions for transportation.

Equipment exceeding 45 kg mass must be fitted with hoisting facilities.

During transportation, buttons and protruding parts must be sufficiently protected against damage.



Handling instructions must be provided.

The mass of equipment must be specified on the Equipment Data Sheets and the installation documentation.

6.15.4 Doors, panels and racks

Hinged panels, doors and covers which are liable to be moved by ship's motion must have a facility to be retained in the open position for servicing even during ship's motion. Hinged doors and panels must be easily removable and replaceable.

Racks which are withdrawable on slides must have automatic locks to hold the rack in open position during servicing.

6.15.5 Fittings of front and cover plates

Front and cover plates which requires frequent removal/dismount must be fitted with quick fasteners. If this is not possible, captive cylinder head screws must be provided.

6.16 Materials

Materials safety sheet must be delivered in accordance with Annex C to the End User for all applicable material and equipment.

6.16.1 Structure, piping and outfitting materials

All materials must be certified and adequate to use in naval construction, and compatible to use with the construction materials mentioned in the **Building Specifications** without causing or being affected by galvanic corrosion.

MIL-STD-889B must be adhered to with regard to galvanic corrosion (inter-metallic contact points).

Where it is necessary that any combination of dissimilar metals be assembled, a method must be used to decrease electrolytic corrosion.

6.16.2 Dangerous materials

The following materials must not be applied in the construction, or be part of any equipment or system:

- a. Asbestos and asbestos containing materials;
- b. Ozone Depleting like CFK11, CFK12 and Halon;
- c. Mercury and mercury-containing materials;
- d. Cadmium and cadmium-containing materials;
- e. Polycyclic aromatic hydrogen carbons, polychlorobiphenyls (PCB's) and polychlorotrifenylys (PCT's);



- f. Any substances known to be Carcinogenic, Reprotoxic, or Radioactive substances;
- g. Any refrigeration fluid that is not approved by ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers), or that have the potential to be explosive in the presence of flame;
- h. Other hazardous substances used in electrical and electronic equipment specified in the **Directive 2011/ 65/ EU** of the European Parliament.

7 Power and signalling requirements

7.1 Electrical installation

The ships electrical installation must comply with the following requirements:

- a. Design rules establish by the International Electrotechnical Commission (IEC);
- b. **IEEE 45** - Recommended Practice for Electric Installations on Shipboard;
- c. **STANAG 1008** - Characteristics of shipboard 440V/230V/115V 60Hz, 440V/115V 400Hz and 24/28Vdc Electrical Power Systems in warships of the NATO navies;
- d. **ANEP 100** - Characteristics of shipboard 440V/230V/115V 60Hz; 440V/115V 400Hz and 24/28Vdc Electrical Power Systems in warships of the NATO navies.

7.1.1 Available Power Supplies

The ships have the following segregated power supply networks available:

- a. 440V, 60 Hz, three phase; unearthed;
- b. 440V, 400 Hz, three phase; unearthed;
- c. 115V, 60 Hz, three phase; unearthed;
- d. 115V, 60 Hz, two phase; unearthed;
- e. 115V, 400Hz, three phase; unearthed;
- f. 220V, 60 Hz, two phase; unearthed;
- g. 24V DC (UPS);

Note: Other power supplies may be considered, subjected to NSPA approval.

7.1.2 Electrical power limits

All electrical circuit distribution and protection information will be provided by the NSPA, including circuit breakers for each circuit, fusing, delta-star transformers, emergency power switch gear and local distribution. Required equipment control voltages are Contractor's responsibility and must be provided by means of separated transformers which core must be earthed.

7.1.3 Electric installation material requirements

Electric installation components must comply with the following requirements:



- a. Components made of aluminium or any aluminium alloy will not be accepted as part of the electric installation, but it may be considered as part of the equipment;
- b. Non-metallic components must comply with **UL94 V0** - Standard for Safety of Flammability of Plastic Materials for Parts in Devices and Appliances testing;

7.2 Earthing

7.2.1 Safety earthing

The ships electric and electronic equipment and components (including switchboards, switches and sockets) must have earth connection according with the following guidelines:

- a. Earth connection must be done to the steel structure and not to any panel/ ceiling, or other outfitting material;
- b. The earth must be made through an electrical cable with ring terminals, contact washer and locking system, fastened to the electrical component on one side and to the steel structure on the other, properly protected against corrosion.

7.2.2 Electrostatic Discharge (ESD) earthing point

Each cabinet with ESD sensitive devices must have two ESD earthing points (resistance to earth 1 M Ω) and must be clearly marked as such in accordance with **IEC 61340-5**.

7.3 Power failure and interruptions

Electrical/electronic equipment must not be damaged due to accidental cut-off of the main power supply. After an accidental cut-off, the equipment may require a period of time before being operational without human interaction.

The operation of the equipment must not be influenced by power interruptions up to 200ms.

7.4 Anti-condensing heating

Electrical/electronic equipment must be provided with anti-condensation heating through separate connections.

The 115V supply for this heating must be switched on automatically when the main power supply is switched off. Visual indication must be provided to indicate that the heaters are powered.

7.4.1 Elapsed time indicators

For high power equipment and other equipment of which maintenance is dependent on operating time (e.g. moving parts that require lubrication or oil change) or which contains expensive parts such as travelling wave tubes, magnetrons, must be equipped with elapsed operating time indicators.



7.4.2 Dimmable button illumination and indication

Where applicable (ex: bridge) the equipment must be provided with dimmable illumination and indications on control panels of the equipment. The colour scheme must be in accordance with **ISO 2412**.

7.5 Electromagnetic Compatibility (EMC)/ Electromagnetic Interference (EMI)

The ships systems installed must comply with the following electromagnetic compatibility and electromagnetic interference standards:

- a. **IEC 61000**: Electromagnetic Compatibility (EMC);
- b. **IEC 60533**: Electrical and electronic installations in ships - Electromagnetic compatibility (EMC) - Ships with a metallic hull;
- c. **IEC 60945**: Maritime navigation and radio communication equipment and systems - General requirements - Methods of testing and required test results.

For specific equipment, the following standards must applicable:

- a. Command and control equipment and systems, computer networks - **MIL-STD-461**: Electromagnetic Interference Characteristics Requirements for Equipment; alternatively the equipment and systems must be properly shielded;
- b. Command and Control of electric motors – **IEC 61800-3**;
- c. Uninterruptible power supply units – **IEC 62040-2**;
- d. Lighting components - **European Standard (EN) 55015**;
- e. Lighting components near navigation equipment - **IEC 60945**.

7.6 Electromagnetic Radiation (EMR) and Radiation Hazards (RADHAZ)

The selection and allocation of the electric and electronic equipment must be in accordance with **MIL-STD-464**: Electromagnetic Environmental Effects, Requirements for Systems, and **AACP-2**: Naval Radio and Radar Radiation Hazards Manual.

All of the following areas, and area limits, must be identified and characterized as follows:

- a. Hazards of Electromagnetic Radiation to Personnel (HERP);
- b. Hazards of Electromagnetic Radiation to flammable liquids and fuels (HERF);
- c. Hazards of Electromagnetic Radiation to ordinances and ammunitions (HERO);
- d. Hazards of Electromagnetic Radiation to equipment (HERE).



7.7 Cabling

7.7.1 General requirements

All cables must be defined by the electric and electronic equipment manufacturer, and must comply with **IEC 60092**, **IEC 60228**, **IEC 60331**, **IEC 60332** and **IEC 60533**.

7.7.2 Cable cores

Spare wires must be available in each multi-core cable to allow repairs, except for power and Ethernet cables..

7.7.3 Connectors

Connectors must be equipped with EMC earthing cones. For making the connections between equipment, the equipment must be provided with receptacles. The appropriate mating connectors must be delivered by the Contractor. Receptacles (with exception of those inside the equipment) which are not used must be provided with EMC and mechanically protective caps.

7.7.4 Cable glands

Cable glands must be equipped with EMC earthing cones. Glands which are not used must be provided with watertight covers. Glands must be in accordance with **DIN 89280**.

7.7.5 Fibre optic cables and interfaces

Fibre optic cables must enter cabinets, junction panels and applicable equipment through cable glands and be terminated in a patch panel.

The fibre optic cores must be separately connected to the opto-electrical interface via miniature optical connectors. The optical mating patch cables must be delivered by the supplier.