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SRGE	TITLE: **ADDITIONAL REQUIREMENTS FOR BOT UNITS**		INTERNAL
			ESUP/PIES

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1 OBJECTIVE

1.1 This document complements General Technical Description (GTD) and its requirements are mandatory.

2 ADDITIONAL REQUIREMENTS

2.1 GENERAL

2.1.1 Two areas for gangway installation shall be provided on the Unit. The main area for gangway installation shall be away from the accommodation. The other shall be close to the accommodation for use in case of emergency, when it is not possible to disembark the team through the main area for gangway.

2.1.2 Laboratory design shall comply with following requirements.

2.1.2.1 The laboratory must be provided with two distinct environments: administrative room (office) and laboratory analysis room, separated by a partition, from floor to ceiling, with a hinged door, opening in the direction of escape. The upper part of the partition must be made of glass at a height that allows the technician to view the analysis room while carrying out activities in the office. The glass in this partition must be of the laminated type so as not to produce splinters when subjected to impact or explosion.

2.1.2.2 The laboratory must have two access doors, preferably opposite, one in the administrative room and the other in the analysis room. The doors must be opened in the direction of escape.

2.1.2.3 The minimum width for circulation in the laboratory must be 1200 mm.

2.1.2.4 The laboratory must have at least two fume hoods, one exclusively for oil and grease tests and the other for petroleum tests.

2.1.2.5 Sinks must be installed on separate benchtops. One sink dedicated to the inorganic benchtop (non-hazardous chemicals) and another sink dedicated to the organic benchtop (hazardous and toxic chemicals). An exhaust system must be installed over the organics bench.

2.1.2.6 The laboratory shall have a stainless-steel emergency shower, activated by a handle, located in an internal area, unobstructed, nearly of the entrance and exit door of the laboratory analysis room. The location of the emergency shower shall have a drainage system, on recessed floor, with the installation of a platform on the same level as the finished floor, avoiding depressions or protuberances. The emergency shower must not have eye washers. The installation of this equipment shall meet the requirements of ABNT NBR 16291.

2.1.2.7 The water that supplies the laboratory shall come from the potable water system, serving the fume hoods (organic and inorganic), sinks, emergency shower and eye-washers.

2.1.2.8 Electrical panels must not be installed inside the laboratory.

2.1.2.9 The laboratory shall have plastic ABS eye washers to be installed on benchtops, close to each sink.

2.1.2.10 The ceiling must be covered with halogen-free material (non-combustible and non-toxic) and the floor must be made of impact-resistant ceramic porcelain tiles [grade PEI 5] and hydrocarbons, with epoxy grout.

2.1.2.11 Utility lines must have general valves that allow fast locking in the case of leakage or accident in the Laboratory.

2.1.2.12 There shall be an external place for storing cases with cylinders for sampling of natural gas and pressurized oil. The area shall be dimensioned to store at least 32 cases (82 cm in length x 28 cm in width x 20 cm in height each), considering a maximum stacking of 5 units.

2.1.3 OIM Office and Coordinators Office shall be provided as close as possible to the Central Control Room (CCR).

2.1.4 An Operator's Room shall be provided close to the Process Plant. This room shall include at least 4 (four) office workstation, with printer available to allow PTW release and other operation technicians routines.

2.2 MAINTENANCE ESTRATEGY

2.2.1 All piping shall be arranged in such a manner as to allow fast and safe access to equipment, valves, sample connections and instruments, for maintenance as well as operation. Piping and supports shall be located in such a way as to allow all removable parts to be easily dismantled and removed.

2.3 PROCESS FACILITIES

2.3.1 Topside process pump with rated driver power above 500 KW shall have a dedicated minimum flow assurance system for each pump.

2.3.2 Instrument and Service Air System

2.3.2.1 Instrument and service air system shall be supplied by a set of air compressors having at least one spare equipment.

2.3.2.2 Sea water shall not be used as direct cooling medium for the inter- and after-coolers of the air compressor packages.

2.3.2.3 Air compression units installed indoor shall be designed to minimize the release of hot and/or humid air in the area.

2.3.3 All safety interlocks, fire & gas logics (including voting), sequencing, and on/off control present in the existing systems of the Production Unit must be displayed on the supervisory system screens in a matrix format (Cause x Effect Matrix), for operational use. These screens must be permanently kept consistent with the programming contained in the controllers of the Production Unit.

2.3.4 Transient conditions such as start-ups, scheduled and unscheduled process stops ("shutdown"), well blowouts, backflow (blow-by), etc. shall be considered in the design.

2.3.5 Pressure vessels shall be in accordance with ASME Section VIII Division 1 and Division 2.

2.4 AUTOMATION AND CONTROL

2.4.1 The automation and instrumentation design shall include provisions for at least 10% of additional instruments to be incorporated in the future. The infrastructure, ranging from the junction box in the field to the I/O card, shall be pre-wired to accommodate this expansion.

2.4.2 The automation and instrumentation design shall adopt the concept of fail safe for all hardwired and network signals, on-off valves, control valves and all related equipment.

2.4.3 Automation system panels, such as CPU and servers panels, shall be located in a room close to the CCR.

2.4.4 Grounding design and applications shall comply with IEC 61892 that describes grounding in offshore production units and IEC 60079 that has requirements for classified areas.

2.4.5 Asset Management System shall be included in the automation design. Its objective is to monitor field instrumentation health status and all the available data from Hart devices, including transmitters and final control elements (control valves) related to preventive maintenance and improvement in performance.

2.4.6 Instruments shall be in accordance with API RP 551.

2.4.7 Junction boxes and passage boxes shall be made of AISI 316 Stainless Steel.

2.5 ELECTRICAL SYSTEM

2.5.1 Following requirements complement HIGH/MEDIUM and LOW VOLTAGE SYSTEMS of DISTRIBUTION SYSTEM section in GENERAL TECHNICAL DESCRIPTION.

2.5.1.1 HIGH/MEDIUM VOLTAGE SYSTEM

2.5.1.1.1 Medium Voltage switchgears and panels shall comply with IEC 62271

2.5.1.1.2 For Medium Voltage switchgears and panels:

• The panels shall be constructed so that thermal inspection by optical infrared thermographic devices could be safely performed with the circuits energized. This facility shall not compromise arc withstand capability to comply with IEC 62271-200

• Manufacturer shall provide an on-line Temperature Monitoring System for predictive temperature monitoring of all busbars connections, all circuit-breaker and contactors power connections and all outgoing bars for cables connection. This monitoring shall be performed in incoming, tie, busbar connection and outgoing functional units.

2.5.1.1.3 For MV Switchgears, all Panels shall have classification for internal arc IAC AFLR (all faces with category of restricted accessibility to authorized personal).

2.5.1.1.4 For MV Switchgears, all busbars compartments (horizontal and vertical), all outgoing cables compartments and all compartments with coupling parts of switching devices shall be provided with arc flash optical sensors connected to “Arc Monitoring Relay” for protection against short-circuit with electrical arcs.

2.5.1.2 LOW VOLTAGE SYSTEM

2.5.1.2.1 Low Voltage switchgears and panels shall comply with IEC 61439 and IEC TR-61641.

2.5.1.2.2 For Low Voltage

• Switchgears shall include online temperature monitoring devices to monitor temperature at power connections from horizontal busbars, vertical busbars, ACB (Air Circuit-Breaker) power connections and incoming/outgoing power cable connections in order to fully replace the need of optical infrared thermographic inspection.

• Panels shall include online temperature monitoring devices to monitor temperature at power connections from horizontal busbars, derivations to vertical busbars, current limiting reactors terminals, ACB (Air Circuit-Breaker) power connection contacts (in case panels includes ACB) and incoming power cable connections in order to fully replace the need of optical infrared thermographic in those points.

• These online temperature monitoring devices shall not include any kind of batteries to its power supply.

• Thermographic inspection shall be possible for outgoing power cables though front side of the panel by opening outgoing cable compartment door.

2.5.1.2.3 For LV Switchgears, all busbars compartments (horizontal and vertical), all outgoing cables compartments and all compartments with coupling parts of switching devices shall be provided with arc flash optical sensors connected to “Arc Monitoring Relay” for protection against short-circuit with electrical arcs.

2.5.1.2.4 In the case of low voltage panels, the incident energy resulting from a three-phase internal short circuit must be limited to 40 cal/cm2. This will be achieved by combining optimization of protection coordination (reduction of circuit breaker operating times) with the fast action of arc sensors. In spite of the requirement above, Contractor shall undertake every effort to achieve values of incident energy as low as 25 cal/m2.

2.5.2 Following requirements complement POWER TRANSFORMER section in GENERAL TECHNICAL DESCRIPTION.

2.5.2.1 Power transformers shall be preferably of the dry air-cooled type.

2.5.2.2 Liquid immersed type transformers may be used provided that the following criteria of IEC 61892-6 are complied with:

2.5.2.2.1 Transformers shall be installed in an area with provisions for containment and drainage of liquid leakage.

2.5.2.2.2 Consideration shall be given to the need for fire detection and extinguishing equipment and thermal and structural class A subdivision as a barrier between neighboring transformers, according to the guidelines of IEC 61936-1 - Power Installations exceeding 1kV AC and 1.5 kV DC, Part 1: AC, item 8.7 “Protection against fire”.

2.5.2.2.3 Suitable arrangements shall be provided for cooling and containing all the liquid which might escape from a damaged tank.

2.5.2.2.4 Transformers and their connections shall be protected against such mechanical damage, condensation and corrosion.

2.5.2.2.5 Consideration shall be given to the provision of a device capable of detecting leakage into the enclosure and provision of an alarm signal in either primary or secondary cooling circuit, as relevant. In addition, the forced flow of liquid coolant shall be monitored in order to operate an alarm in the event of a loss of flow.

2.5.2.2.6 A receiving tank shall be provided underneath the transformers and shall be connected to the open drain system.

2.5.2.2.7 The receiving tank may be common to several transformers.

2.5.2.2.8 The receiving tank capacity should not be less than 100 % of the volume of liquid of the transformer, or of the largest transformer in case of a common tank.

2.5.2.2.9 Consideration shall be given to the provision of a suitable temperature indicator and alarm facilities.

2.5.2.2.10 The oil type shall be K class and biodegradable synthetic or vegetal.

2.5.3 Following requirements complement UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM - AC AND DC section in GENERAL TECHNICAL DESCRIPTION.

2.5.3.1 BATTERIES

2.5.3.1.1 Batteries for A.C., D.C. and emergency lighting UPS shall be either alkaline type nickel-cadmium or lead acid batteries for these services.

2.5.3.1.2 High power, high reliability and long life (10 years for lead acid and 20 years for alkaline type) batteries are required.

2.5.4 Following requirements complement MAIN GENERATOR ELECTRICAL REQUIREMENTS section in GENERAL TECHNICAL DESCRIPTION.

2.5.4.1 Generators with rated voltage equal to or greater than 6kV and rated power equal to or greater than 5MVA shall have an 80pF coupling capacitor unit per phase suitable for interconnection to on-line monitoring of partial discharges.

2.5.4.2 The coupling capacitors shall be installed inside the power terminal box of the generator.

2.5.4.3 In addition, manufacturer shall also provide an auxiliary terminal box including all the necessary devices to allow the connection to portable monitoring equipment intended to partial discharges measurements.

Notes:

1) The coupling capacitors shall be positioned according to the IEC TS 60034-27-2 recommendations.

2) The coupling capacitors for partial discharge measurement shall comply with minimum performance according to IEC TS 60034-27-2.

2.5.5 ELECTRIC MOTORS

2.5.5.1 All motors with rated voltage 6 kV or greater and with rated power 5 MW or greater shall be supplied with a set of three units of 80 pF coupling capacitors to be used as sensor elements suitable for interconnection to on-line monitoring of partial discharges. Said couplers may be installed either in the Power Terminal Box or in a specific terminal box.

2.5.5.2 In addition, manufacturer shall also provide an auxiliary terminal box including all the necessary devices to allow the connection to portable monitoring equipment intended to partial discharges measurements (portable monitoring equipment shall be supplied by others).

2.5.6 CABLE TRAYS

2.5.6.1 Cable trays for internal areas shall be stainless steel AISI-316L or HDG (hot dipped galvanized) steel painted.

2.5.6.2 Cable trays for external areas shall be stainless steel AISI-316L or heavy-duty, non-metallic, manufactured in composite material reinforced with fiberglass.

2.5.7 Following requirements complement GENERAL of ELECTRICAL SYSTEM section in GENERAL TECHNICAL DESCRIPTION.

2.5.7.1 Electrical system shall be designed considering the momentary operation of all generators to allow the change between them without production loss.

2.5.7.2 If allowed power generation margins, the electrical system and PMS shall be designed considering the momentary operation of standby loads to allow the change between them without production loss.

2.5.7.3 All transformers rated 5 MVA or greater shall be additionally protected with differential protection.

2.5.7.4 All low voltage circuits intended to supply loads located in the external areas shall be protected by means of residual current devices (RCDs).

2.5.7.5 A dedicated remote operator workstation shall be provided to allow electrical system overall human machine interface (visualization and remote IED parametrization by using IEC 61850 interaction).

2.5.7.6 All external lighting fixtures and outlets shall be fully standardized for the whole FPSO (same brand and same type).

2.5.7.7 The electrical system shall be designed to operate at 60 Hz.

2.5.7.8 Regarding the low voltage system, the following standard voltages shall be adopted:

a) For AC circuits: 690 V, 440 V, 480 V and 220 V;
b) For DC circuits: 220 V, 125 V, 48 V and 24 V.

2.5.7.9 According to IEC 61892 the following items must be complied with:

- Only piping and integrated heat exchangers needed for operation of the electrical equipment shall be installed in the switchgear room.

- If it is unavoidable that pipes must be run adjacent to electrical equipment in switchgear rooms, there shall be no joints in the immediate vicinity of the electrical equipment. The piping shall be arranged so that the risk of leakage is minimized, tin order to reduce as far as possible any detrimental effect on other equipment installed in the room.

2.5.7.10 The emergency generator package shall be specified in compliance with the rules of the classification society.

2.5.7.11 In order to comply with the requirements of Labor and Welfare Ministry require (NR 10, item 10.2.3), by the time of unit commissioning Contractor shall provide and present to Petrobras a comprehensive data book encompassing the following documents:

- Single-line diagram;

- Set of procedures and technical and administrative instructions for safety and health implemented and description of existing control measures;

- Documentation of inspections and measurements of the lightning protection system and electrical grounding;

- Specification of the applicable collective and individual protection equipment and the tools;
- Documentation proving the adequate workers qualification, training, authorizations given for working in electrical installations and training courses carried out, according to NR 10 rules;
- Results of electrical insulation tests carried out on individual and collective protective equipment;
- Certifications of electrical equipment and materials in classified areas;
- Technical report of the updated inspections with recommendations, schedules of adjustments, contemplating the items above.

2.6 MARINE SYSTEMS

2.6.1 The operations of the hull systems shall be assisted.

2.6.2 Hull systems that interfere with the integrity of the ship's beam or the stability of the vessel shall not have automatic valve operation.

2.6.3 The use of steam in the design of hull systems is not acceptable.

2.6.4 The use of cargo heating coils inside cargo tanks and slops and any other tank operating under an inert gas/HC blanketing atmosphere is not acceptable.

2.6.5 On the main deck, the installation of the following equipment will be allowed: filters, slop treatment unit, drainage pumps, solenoid boxes, deck seal and p/v breakers, electric motors for cargo deep well pumps (if applicable), self priming units for pumps, slop vessels, slop vessel pumps, Non-classified Area – open drain filter, classified area – open drain filter, open drain tank – non-classified area, slop treatment centrifuge, automatic deluge valve (ADV) skids, water/foam monitors, hydrants and foam proportioner. Alternative design solutions shall be submitted for BUYER approval.

2.6.6 The effect of static electricity inside tanks operating under an Inert Gas/HC Blanketing atmosphere shall be minimized.

2.6.7 All remotely actuated valves shall have position indication on the Control Room panel, on the valves themselves and on the solenoid boxes or solenoid panel.

2.6.8 All manual seawater intake valves through sea chests, discharges through the side shell, communication between headers, system valves that guarantee pressure and vacuum levels in the controlled atmosphere tanks (Inert gas/HC blanketing) and any others that guarantee the balance of stresses of the ship's beam and the stability of the installation shall be indicated on the Control Room panel and also locally on the valves themselves.

2.6.9 All valves actuated via local hydraulic actuation boxes shall have a position indication on the box itself and on the control room panel.

2.6.10 The Loading System shall be able to operate continuously and allow more than one tank to be loaded at a time.

2.6.11 The installation design of the cargo pumps shall guarantee efficient drainage and minimize the amount of liquid remaining in the tanks after draining operations.

2.6.12 There shall be two independent ballast systems, one to serve the ballast tanks located in the Cargo Area and the other for the ballast tanks located aft of the Forward Bulkhead of the Engine Room. Both systems shall have alternatives for operational continuity during maintenance, guaranteeing the operation of any tank from any pump.

2.6.13 Ballast systems shall be designed to avoid gravity ballast operations.

2.6.14 Provision shall be made for filling the cargo tanks with seawater in contingency situations (heavy ballast). The cargo system shall be capable of directly discharging clean heavy ballast overboard or transferring it to the slop tanks in the event of oil contamination.

2.6.15 The inert gas shall be generated by dedicated inert gas generators which shall be actuated by the Control Room and a local panel. Boilers shall not be accepted for this purpose.

2.6.16 Portable cleaning machines shall not be used in the design. In case the design is unable to meet the mandatory MARPOL requirements regarding the shadow area, the use of bottom cleaning machines shall be submitted for BUYER's approval.

2.6.17 Remote pressure, temperature and ullage monitoring shall be provided for all tanks operating under a controlled atmosphere (Inert gas/HC blanketing). Interface monitoring shall be provided for tanks containing oil or water-oil mixtures in the Cargo Area. All indications shall be indicated in the Central Control Room.

Note: Tanks defined only with the off-spec oil function do not need to have an interface detector.

2.6.18 All high- and low-pressure alarm situations in tanks operating under controlled atmosphere (Inert gas/HC blanketing), visual and audible alarms shall be triggered and recorded in the Central Control Room

2.6.19 Atmospheric tanks (e.g. ballast, fresh water, diesel oil, bilge, sludge and others) shall have a level monitoring system which shall be available on the Control Room panel. Cofferdams and void spaces shall have a flood monitoring system.

2.6.20 Not applicable.

2.6.21 In case of using the P/V breaker as a protective device to prevent pressure or vacuum inside the cargo tanks, SELLER shall comply the following requirements:

- P/V Breaker discharge shall be routed to a safe location external to the hull side shell and lower than FPSO's depth as per dispersion study.
- Means to isolate P/V Breaker for inspection and maintenance shall be provided.
- P/V breaker shall have a magnetic type LG and a LIT with low and high level alarms.
- Means to remotely fill P/V Breaker shall be provided.

2.6.22 Two (02) slop tanks, one portside (Dirty Slop Tank) and other starboard side (Clean Slop Tank) shall be located at the aftermost cargo area. Each of slop tanks shall be back up of the other slop tank and therefore shall fully perform the functions of both slop tanks considering the eventual repair and Classification Society inspection activities on these tanks. Produced water shall not be directed to the dirty or clean slop tanks.

Note: alternative arrangements regarding the location of slop tanks (Dirty and Clean) for slop tanks are acceptable provided that SELLER shall consider all applicable aspects for this alternative in the FPSO design (Hull and Topside) due to the new operational trim and slop arrangement. The alternative arrangements for slop tanks shall be submitted to CS and BUYER for approval.

2.7 EQUIPMENT

2.7.1 Following requirements complement VAPOR RECOVERY UNIT (VRU) and CENTRIFUGAL GAS COMPRESSORS of GAS PROCESS PLANT section in GENERAL TECHNICAL DESCRIPTION.

2.7.1.1 VAPOR RECOVERY UNIT (VRU)

2.7.1.1.1 A removable T-type strainer without disassembly of the piping provided with differential pressure monitoring shall be installed in the suction line, close to each stage of compression.

2.7.1.2 CENTRIFUGAL GAS COMPRESSORS

2.7.1.2.1 A removable T-type strainer without disassembly of the piping provided with differential pressure monitoring shall be installed in the suction line, close to each stage of compression.

2.7.2 The fuel gas and liquid fuel (diesel) systems shall be designed to ensure complete fuel changeover for at least 'N' turbo generators running simultaneously.

2.7.3 For all compressor services, variable speed shall be adopted whenever the molar weight ratio (max./min.) between the design cases and/or for the same case throughout the life cycle is greater than or equal to 20% as the minimum criterion to define whether to use fixed (with suction throttling) or variable speed drive for compressors.

Note: For fixed-speed compressors, the maximum absorbed power shall account for the pressure drop caused by the throttle valve, even when fully open, which will result in a reduction in the suction pressure with a consequent increase in the required head.

2.8 STRUCTURAL DESIGN

2.8.1 Seller shall consider, for laydown areas, a minimum load of:

- Local Design: distributed load = 40 kN/m² and point load = 40 kN;
- Primary and Global Design: distributed load = 30 kN/m².

2.8.2 SLAMMING LOADS

2.8.2.1 Slamming is a different phenomenon than Wave Slap. Inspired on “On the slamming of ships - Development of an approximate slamming prediction method, Delft University of Technology, 2018”, Slamming Load is the pressure load due to the Hull's entrance into the seawater or with the combined effect between Hull movement and water wave movement in a low inclined structure (<= 45°), while Wave Slap is the pressure load due to the wave impact into the Hull in a high inclined surface (> 45°).

2.8.2.2 Fairlead support structures, mooring balconies, riser balconies, aft hull structures and other attached structures subject to wave slamming loads and/or wave slap loads shall be designed and positioned in a way to avoid or minimize the effects of wave slamming and/or wave slap. Sufficiently inclined flat plates at the bottom of each of these structures and/or more transparent concepts shall be employed.

2.8.2.3 Structures that are potentially subjected to wave slamming loads shall be analyzed considering the slamming and/or wave slap pressure combined with other environmental loads for a period of return of 100 years for yield and buckling analysis. Significance of effects on onboard comfort, as well as on stresses in hull and vibrations (whipping) in the hull girder are also to be addressed.

2.8.2.4 Slamming and/or wave slap loads loads can be calculated considering CFD software, model tests or by approximations as described in DNVGL-RP-C205 – “Environmental Conditions and Environmental Loads” or ABS Guide for Slamming Loads and Strength Assessment for Vessels.

2.8.2.5 As from the Slamming phenomenon or Wave Slap, it shall be calculated the long-term probability of occurrence for each part of the Hull considering the wave scatter presented on Metocean Data, based on the relative velocity between the Hull and wave particle higher than the threshold velocity. If this long-term probability of occurrence of slamming and wave slap, for any part of the Hull individually, is higher than 0.01%, the fatigue for structure detail of topsides and other structures attached to hull shall be considered with the whipping effect

whenever the Hull Girder Natural Frequency and that of the Structure under design are closer than 20% for full range of drafts.

2.8.2.6 The threshold velocity is expressed as:

$$V_{THRESHOLD}(m/s) = 0.1\sqrt{g(m/s^2) * L_{PP}(m)}$$

2.8.2.7 For each sea state presented on Metocean shall be calculated the probability of slamming occurrence based on reference velocity higher than threshold velocity:

$$Prob(V_R \geq V_{THRESHOLD}) = e^{-(\frac{V_{THRESHOLD}{}^2}{2m_0})}$$

Where m_0 is the square root of reference velocity RMS from hydrodynamics model.

2.8.2.8 The number of occurrences of slamming per 3-hours sea state is:

$$N_S = Prob_{SLAMMING} * 10800 * \frac{1}{2\pi}\sqrt{\frac{m_2}{m_0}}$$

Where m_2 is the second moment of area of the reference velocity response spectrum from hydrodynamics model.

2.8.2.9 The long-term probability of occurrence of slamming and wave slap shall be calculated considering the operational lifetime as defined in GTD.

2.8.2.10 Flowchart presented below details the logical sequence of the slamming consideration for the yield, buckling and fatigue analysis for the structure design.

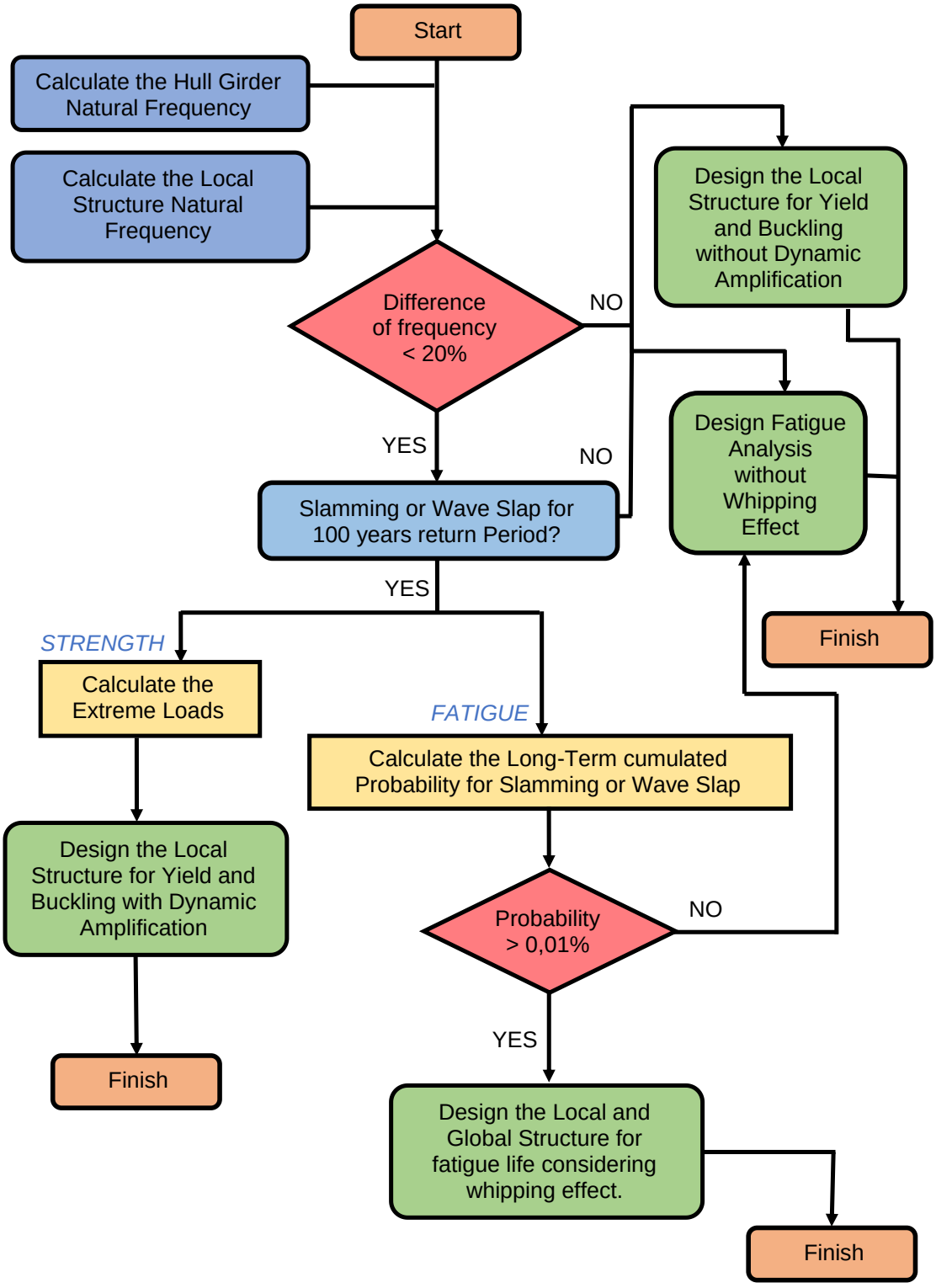

Figure 2.8.2.10 - Logical sequence of the slamming consideration for the yield, buckling and fatigue analysis for the structure design

2.8.3 Design Fatigue Factors (DFF) presented on Tables 2.8.3.A to 2.8.3.C are BUYER minimum requirements. Structure shall be designed considered DFF presented.

Table 2.8.3.A: - Minimum Design Fatigue Factors (DFF): General

Position	Classification of structural components based on the consequence of failure (4)	Accessibility for inspection and repair		
		Accessible		Not accessible (3)
		Above the minimum operating draft	Below the minimum operating draft	
Hull	High	3	5	10
	Low	2	3(2)	5
Topside	High	2	-	10
	Low	1	-	5

(1) Not applicable;

(2) DFF = 2 Internal structure, accessible and not welded directly to the submerged part (applicable only to ballast tanks and void spaces);

(3) Includes areas that can be inspected under dry or submerged conditions, but requires dry docking for repair and areas at the splash zone. For external areas of hull below minimum draft (drive for in-service diving to be minimized) to be DFF = 10.0.

(4) “Critical” implies that failure of these structures would result in the rapid loss of structural integrity and/or produce an event of unacceptable consequence.

NOTE: High indicates that the failure of these structural components would lead to a rapid loss of structural integrity, potentially resulting in an event with unacceptable consequences (e.g., primary and special structures). Low refers to all other structural elements.

Table 2.8.3.B: – Minimum Design Fatigue Factors (DFF): Hull structures

Structural components (except for joints not accessible)	DFF
Hull	
Main deck and side shell region above minimum draft, plate and longitudinal	2.0

Side shell region below minimum draft, double bottom plating and longitudinal	3.0
Bulkheads, plating and longitudinal and transverse stiffeners	2.0
Web frames, beams and girders	2.0
Foundations in hull for stools, Equipments Foundations, Riser Balcony Foundations and Mooring Support Foundations (Internal Hull Structure)	3.0
Topside Support Structure Foundations, including pipping supports	2.0
All elements inside vessel tanks, except for locations where higher safety factors are required	2.0
Hull appendix	
Mooring balconies, above and below minimum draft, respectively	5.0/10.0
Fairlead structures	10.0
Bilge Keel	10.0
Lower Riser Balcony and support, external balcony	10.0
Upper Riser Balcony and support, external balcony	5.0
Stools and Topside Support Structure	2.0
Crane pedestal and their foundation in hull	2.0
Flare tower and its connections to hull	2.0
Flare tower connections to hull if it is not accessible (or if a side is not accessible)	10.0
Pipe rack and piping support in general	2.0
Pull-in equipment support structure	2.0
Offloading hose support (above minimum draft)	2.0

Support for casings and caissons (e.g. for seawater in-take), including defense structures, above splash zone/at splash zone/below minimum draft	2.0/5.0/10.0
Elements in secondary design areas, except those classified above	2.0
Non-critical external elements: at the splash zone/below minimum draft (to be considered as non-inspectable)	5.0/10.0

Table 2.8.3.C: - Minimum Design Fatigue Factors (DFF): Topside structures

Structural components (except for joints not accessible)	**DFF**
Nodes of secondary structure	1.0
Nodes of main structure	2.0
Topside connection / module vs hull	2.0
Topside connection / module vs hull (not-inspectable parts)	10.0

2.8.4 Structural design shall be carried out using either the Working Stress Design (WSD) or the Load and Resistance Factor Design (LRFD) methodologies. Preferably, the LRFD methodology should be used, as it is a semi-probabilistic method with less conservative results.

2.8.5 All steel serrated bar grating and stair treads shall have a mesh 30x100 mm: height 30 mm; minimum bearing bars thickness 4.76 mm; cross bars diameter 8 mm, except as stated on paragraph below; grating panels with edge bars welded to bearing bars around perimeter and penetrations.

On routes where deck trolleys will transit, heavy duty steel grating shall be provided with mesh 24 x 50 mm, height 100 mm, minimum bearing bars thickness 10 mm and cross bars diameter 10 mm. Grating panels with edge bars welded to bearing bars around perimeter and penetrations.

In case of using grating in regions subjected to vibration, the following requirements shall be complied in order to mitigate the loss of the fasteners tightening / preload:

- regions near to 250 kW dynamic equipment: minimum of 4 regular fasteners per panel or per square meter.
- regions within 2 m from 250 kW to 1 MW dynamic equipment: minimum of 8 regular fasteners or 4 anti-vibration fasteners per panel or per square meter.

- regions within 4 m from ≥ 1 MW dynamic equipment: minimum of 8 regular fasteners or 4 anti-vibration fasteners per panel or per square meter.

Steel grating shall be designed for a minimum 5 kN/m2 distribuited load and for a concentrated load 5 kN applied in 200x200 mm area not applied simultaneously. Steel gratings applied in areas with load higher than 5 kN/m2 shall be verified for this specific load condition. Stair thread shall be designed for a concentrated load of 1.33 kN for each 600 mm or fraction of the stair width. Grating shall follow Figure 2.8.5.A criteria.

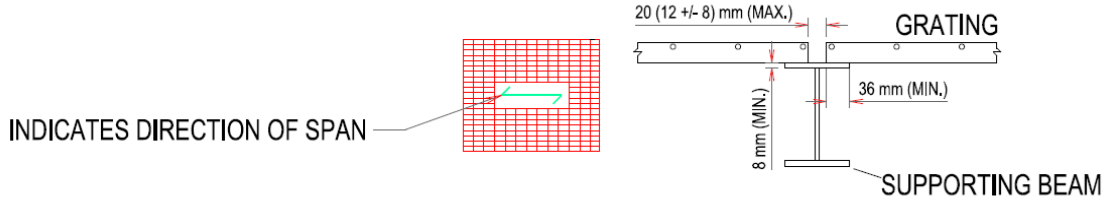

Figure 2.8.5.A – Direction of Span and Supporting Beams details

Minimum grating supporting length is 36 mm. Maximum clearance between gratings is 20 (12 +/- 8) mm.

Flange of steel grating supporting beam shall have thickness equal or greater than 8 mm and minimum width greater than 72 mm.

Metallic removable floor grating shall be equalized (grounded) to structure potential.

Detailed design shall issue a report with measurement of resistance between removable grating and reference grounding.

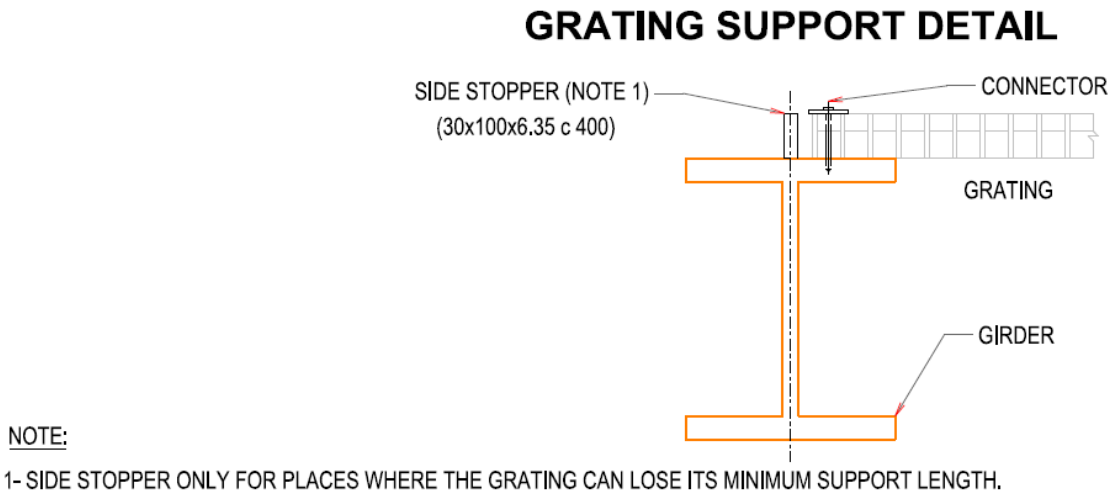

Figure 2.8.5.B – Grating Support Details

2.9 HVAC SYSTEMS

2.9.1 In case of adopting water as condenser cooling fluid, fresh water in closed circuit shall be used.

2.9.2 The HVAC system for batteries room shall consider

- The air discharge shall be, at least, 3 meters far from any electric motor, instruments, actuators or any other electrical item.
- The exhaust air duct shall be built air-tight over its positive pressure part (downstream from the fan).
- The pressure in the room shall be monitored at 50 Pa negative comparing to adjacent areas.

2.9.3 Additionally, all applicable sections of the following codes and standards shall be used in the development of the Unit:

- ISO 7547, 8861, 8862, 9099 and 16890;
- AMCA 99, 201, 202 and 203;
- ASHRAE Fundamental Handbook; Systems and Equipment Handbook;
- ASHRAE 52.2;
- ASHRAE Standard 62.1;
- ASHRAE Laboratory Design Guide;
- SMACNA HVAC System - Duct Design; HVAC Duct Construction Standards - Metal and Flexible;
- Industrial Ventilation Manual of Recommended Practice for Design
- NEEB Procedural Standards for Testing Adjusting and Balancing of Environmental Systems
- NFPA 96

2.10 COATING AND INSULATION

2.10.1 The coating systems shall have a very high durability (as per ISO 12944-1 definition) with minimum maintenance repair, during the UNIT lifetime and shall comply with contractual coating warranty requirements.

2.10.2 SELLER must consider the marine atmosphere (CX for atmospheric zone and IM-2/Im1 for splash and immersion zone according to ISO 12944-Part 2) for the design of external coating of piping and equipment.

2.10.3 Flare tower structure and piping shall be Thermal Spray Aluminum coated.

2.10.4 Selection of external insulation systems and sealing systems shall be performed by SELLER based in recognized standards and with provision to avoid corrosion under insulation.

2.10.5 Carbon steel piping provided with thermal insulation must be painted in order to avoid corrosion.

2.10.6 Not applicable.

2.11 PIPING

2.11.1 The use of flange isolating kit, that include isolating gasket, shall be defined by SELLER considering the fluid and the material dissimilarity electrode potential.

2.11.2 SELLER shall propose during Basic and Detail design the methodology for assessment of avoidance of piping vibration failure.

2.11.3 The use of dresser type expansion joints for services which contains flammable or combustible fluids or steam shall not be acceptable.

2.11.4 For valve designs which allows retained pressure in body cavity (when valve is fully closed or fully open), plugs capable to mitigate risk of an accident under an eventual remotion shall be used. In this case, those ports shall be closed with plugs having a constructive configuration that allows pressure relieving to atmosphere (relief hole) during the beginning of plug remotion.

2.12 HULL MARKS AND COLOR PAINTING

2.12.1 GENERAL

2.12.1.1 SELLER shall paint hull marks such as:

- FPSO name;
- Port of registry;
- IMO number;
- No Smoking sign;
- PETROBRAS logo.

2.12.1.2 FPSO hull shall be preferably painted as bellow:

- External Hull Above water: PETROBRAS Green (MUNSELL notation 2.5 G 5/10).
- External Hull Splash Zone: Light Grey (MUNSELL notation N 6.5).
- External Hull Riser Balcony area: Light Grey (MUNSELL notation N 6.5).
- Bulwark External Surfaces: Black (MUNSELL notation N 1).
- Bulwark Internal Surfaces: Ice Grey (MUNSELL notation N 8).
- Turret, if is the case, (internal and external): Ice Grey (MUNSELL notation N 8).

2.12.2 FPSO NAME, IMO NUMBER AND PORT OF REGISTRY

2.12.2.1 The FPSO marks shall be made on:

- Transom;
- Accommodation front bulkhead;
- Midship starboard;
- Bow port side and starboard;
- Bow transom, if applicable.

2.12.3 The transom, accommodation front bulkhead and bow portside/starboard letters shall be cut from a 6mm thickness steel plate of the same quality as the plate where it will be welded. The letters shall be welded with continuous fillet welds.

2.12.4 Midship starboard and bow transom marks shall be made by intermittent welding beads and painted inside.

2.12.5 Welding and paintings shall be performed after BUYER confirms the position.

2.12.6 The letter type and PETROBRAS logo details will be informed during Detail Design Phase.

2.13 CORROSION MONITORING

2.13.1 As a minimum, corrosion monitoring equipment shall be provided at points and with techniques defined by SELLER in the project for the following systems:

(a) Free Water Separator (if applicable)
(b) HP Separator (if applicable)
(c) LP Separator (if applicable)
(d) Test Separator
(e) K.O. Drum
(f) Fuel gas
(g) Treated gas line after H2S /CO2 removal unit
(h) Gas Dehydration Unit
(i) MEG – Recycle line in de-salting circuit (if applicable)
(j) Poor amine/ Meg system (if applicable)
(k) Compression Unit
(l) Hot water
(m) Fresh water cooling (closed loop)