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1. OBJECTIVE

This document establishes mandatory requirements for water and foam firefighting system specification, which shall be installed in the Offshore Units.

2. ABBREVIATIONS AND DEFINITIONS

2.1 ABBREVIATIONS

- ADV: Automatic Deluge Valve;
- AFFF: Aqueous Film-Forming Foam;
- AR-AFFF: Alcohol-Resistant Aqueous Film-Forming Foam;
- DPC: Diretoria de Portos e Costas;
- ESD: Emergency Shutdown;
- FWP: Fire Water Pump;
- PFP: Passive Fire Protection.

2.2 DEFINITIONS

Coamings: Partitioning the main deck floor to contain possible liquid spills from equipment, pipes, fittings etc;

Fire Water Main: Firefighting water main distribution pipe until ADV, usually in ring-shaped;

FWP Set: Sets of pumps and their sources of power, electrical and control cables, fuel tank, piping and control valves.

3. APPLICABLE REGULATIONS, CODES AND STANDARDS

Regulations to be followed in the design, installation and testing of the water and foam firefighting are stated below:

- IMO - SOLAS: Convention for the Safety of Life at Sea – 1974 and Amendments in Force
- IMO-MODU CODE: Code for the Construction and Equipment of Mobile Offshore Drilling Units
- FSS CODE: International Code for Fire Safety Systems

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- ISO 13.702: Petroleum and Natural Gas Industries – Control and Mitigation of Fires and Explosions on Offshore Production Installations
- API RP 14G: Recommended Practice for Fire and Prevention and Control on Open Type Offshore Production Platforms
- NFPA 11: Standard for Low-, Medium-, and High-Expansion Foam
- NFPA 15: Standard for Water Spray Fixed Systems for Fire Protection
- NFPA 16: Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems
- NFPA 20: Standard for the Installation of Stationary Pumps for Fire Protection
- NFPA 25: Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems
- CAP 437 - Offshore Helicopter Landing Areas – Guidance on Standards
- Applicable Rules of the Brazilian Maritime Administration (DPC) - NORMAM; NORMAM-27 – Normas da Autoridade Marítima para Homologação de Helipontos Instalados em Embarcações e em Plataformas Marítimas;
- Brazilian Ministry of Labour and Social Security – Brazilian Regulatory Standards
- Rules of the Classification Society of the Unit
- DR-ENGP-M-I-1.3: Safety Engineering Guideline
- Piping Standard and Material for Oil Production and Process Facilities applicable to the current project

4. TECHNICAL REQUIREMENTS FOR FIRE WATER SUPPLY SYSTEM

In addition to the provisions of DR-ENGP-M-I-1.3, the design of the firefighting system of the Unit shall consider the requirements contained in this specification and the Classification Society of the Unit.

The components of water firefighting systems shall be located in such a way that they are not affected by a fire in the area they protect, or that can obstruct its access and functionality. Therefore, it shall be considered the results of the FIRE PROPAGATION AND SMOKE DISPERSION ANALYSIS.

Rates of application of fire water to be considered for sizing the deluge system shall attend the requirements of Safety Engineering Guidelines (Table 3), ISO 13.702, Classification Society, and NFPA 15.

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The water firefighting system shall be composed by:

- Fixed system (water deluge system).
- Manual systems (hydrants and fixed and portable monitors for water).

4.1 FIRE WATER PUMPS

The fire water supply by FWP shall be sized to the higher demand as defined in DR-ENGP-M-I-1.3.

At least two main FWPs, plus another FWP reserve capable of replacing any of the main BCIs, shall be provided.

The FWP set shall be autonomous and dedicated exclusively for firefighting function.

The components of firefighting system shall be installed considering that in any foreseen accidental scenario there is no impairment of 100% of the maximum design flow.

The system shall be pressurized by jockey pumps (2 x 100%) connected directly to the firewater main ring.

4.2 FIRE WATER DISTRIBUTION

The fire ring main shall be routed away from areas subject to mechanical damage and shall be positioned so that the structure of the Unit protects it from those damages, and still be located as close as possible to the edges of the deck, mainly in the FPSO Units. The fire water main shall be exclusive to the firefighting system consumers.

The firewater main ring and its branches shall be provided with block valves for insulation in case of maintenance or damage. It shall be ensured that no area of the Unit is totally deprived of water supply in case of maintenance or damage to a part of water ring and/or branches. In the case of supply of hydrants, it shall be ensured that 50% of hydrants serving the same fire zone are fed by a separate and isolatable section of the ring that feeds the other 50% of hydrants. In addition, the branches of the hydrants shall be distinct from the branches of the deluge system of the same protected fire zone.

All block valves of the fire water main shall be easily accessed and preferably operable from the same level of the Unit. Additionally, it shall be properly identified to permit easy visibility.

The branch pipes of firefighting water, when located at high points, shall be provided with means to avoid water hammer.

Valves and piping accessories shall comply with Petrobras' piping specification.

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4.2.1 Requirements for Piping and Valves of the System

All piping, valves and fittings shall agree with the Petrobras' piping specification.

All firefighting equipment shall be suitable for operation in marine environment. Equipment, piping and accessories used for firefighting shall be suitable to stay with seawater. Connections between them shall be of mutually compatible materials from the galvanic corrosion point of view or shall be properly isolated from each other.

All system components shall be suitable to the maximum operating pressure in the hydrants in any area. The maximum operating pressure for hydrants shall 1373 kPa (14.0 kgf/cm²).

The location of the valves, firefighting equipment and operating devices shall follow ergonomic factors, in order to ensure an efficient and safe operation as required by the Brazilian Standard NR-17.

4.2.2 Requirements for Fire Water Main

The fire water main shall be optimized to reduce the piping diameters.

Hydraulic balancing of water main shall be performed.

Due to the not periodic use of fire water main and aiming to reduce diameters, may be admitted maxim flow velocity of 6.72 m/s, in agreement with that recommended by API RP 14G Appendix D, for Cu-Ni pipes.

The firewater mains shall be kept full and pressurized at a minimum pressure of 1 kgf/cm² at the lowest point in the mains, the lowest pressure point.

The system shall be pressurized by jockey pumps connected directly to the fire water main.

4.3 REQUIREMENTS FOR AUTOMATIC WATER SPRAY DELUGE SYSTEMS

The water spray deluge systems (valves, ADVs, piping, nozzles, etc), and shall be in accordance with NFPA 15.

The Unit shall be divided into several fire zones. Each consumer of fire water shall be determined according to the areas that protects. The selection of areas that shall compose each consumer system shall be defined considering the following criteria of the deluge system:

- Affected area by fire.
- Adjacent areas to the affected area, according to DR-ENGP-M-I-1.3.

Note: Zones may be limited by means of "A" or "H" class type fire bulkheads and decks.

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- Deluge system activation shall be automatic upon fire confirmation at the respective areas by fire detectors (fusible-plug and/or flame detectors).

The follow equipment and piping shall be protected with water deluge:

- Tanks and pressurized vessels containing flammable and/or combustible fluids.
- Pumps and compressors (except those enclosed) handling flammable and/or combustible fluids.
- Manifolds and their SDVs.
- Receivers and pig launchers.
- Riser connection and SDVs in production, gas injection and oil / gas exportation.
- Oil metering stations.

The need for the application of water spray in piping containing flammable and/or combustible fluids shall be determined from the results of Escalation Analysis Due to Collapse of Equipment and Piping under Fire Study in order to verify and guarantee the mechanical integrity of the isolated pipe section, considering the longer duration of the fire, or 60 minutes, whichever is less. This analysis shall be approved by the Classification Society.

The ADV shall be supplied with markings to indicate "open" and "closed" positions, in individual skids, including by-pass valves. The skids shall be easily identified and installed in safe and easily accessible areas, so that a fire in the area covered by them shall not prevent their operation. The ADV location shall be verified according to the results of FIRE PROPAGATION AND SMOKE DISPERSION ANALYSIS.

The minimum pressure at the most remote nozzle in each deluge water main shall be 140 kPa (1.43Kgf/cm²).

The fixed firefighting systems, including ADV and firewater distribution pipe shall be designed so that firewater protection is effective within 20 seconds after demended. This requirement does not comprise the time needed for the start of diesel FWP.

4.4 FIRE WATER MANUAL SYSTEMS

It shall be possible to reach any point of the unit by at least two water jets – derived from different hydrants. One of them shall derive from a 15 m hose line and the other, from two extensions of 15 m hose lines (total of 30 meters). Hydrant nozzles shall provide the combination of fog and straight stream.

The internal areas of the accommodation module shall be protected primarily by hydrants provided with a 1½ "diameter nozzle outlet and 15 m long hoses, installed along the corridors.

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The external areas shall be protected by hydrants provided with two 2½ "diameter outlets, along the periphery of all decks. Their location shall be such that a fire in the area protected by them does not prevent its operation, unless there are other accessible fire hydrants covering the same area.

Of the total number of firefighting lockers installed in the process area, 10% shall have portable monitors.

The pressure at hose nozzles shall be 5,0 Kgf/cm², as a minimum.

For firefighting equipment specification, see I-ET-3010.00-5400-947-P4X-003 - FIREFIGHTING EQUIPMENT.

5. TECHNICAL REQUIREMENTS FOR FOAM FIREFIGHTING SYSTEM

The main consumers of the foam firefighting system are:

- Monitors and coamings' fixed spray system, in the main deck of FPSO Units.
- Hydrants and fixed spray system, at the process plant.
- Hydrants and monitors at offloading areas.
- Monitors for helideck protection.
- Hydrants for helicopter refueling system (when applicable).

For areas with the possibility of fires in flammable or combustible fluids, the foam concentrate to be used in the foam formation shall be of the type for hydrocarbons - AFFF 3% (Aqueous Film-Forming Foam 3% - AFFF 3%).

For areas with the possibility of fires in flammable or combustible polar fluids, the LGE to be used in the foam formation shall be of the type for polar solvents – AR-AFFF 3% (Alcohol Resistant Aqueous Film-Forming Foam 3% - AR-AFFF 3 %).

FSO and FPSO type units shall be provided with a foam system to protect the area on top of cargo tanks on the main deck and protect the cargo tanks that store oil, in case of rupture, in order to extinguish the fire inside the tank, in accordance with the requirements of SOLAS Chapter II-2, FSS Code and the Classification Society. The foam application shall be by means of fixed spray system and foam monitors. The definition of mixture supply (water and AFFF) for a single eductor or specific for coamings shall be determined considering a cost analysis and be approved by Petrobras. For foam system in main deck area, the application time shall be 30 minutes due to HC Blanketing Cover Tank System in accordance with item 4 from Regulation 61, Chapter II-2, SOLAS.

The foam protection system for process plants shall be by means of portable systems, as specified in NFPA 11, with autonomy for at least 30 minutes. Therefore, shall be considered the use of hydrants and AFFF containers (50 L). In addition, a fixed foam spray system for

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the process plant modules shall be provided and designed in accordance with NFPA-16, considering the application time of 20 minutes and the application rate of 6.5 L/min/m².

Foam ADV shall be supplied in individual skids, including by-pass valves. The skids shall be easily identified and installed in safe and easily accessible areas, so that a fire in the area covered by them shall not prevent their operation. The ADV location shall be verified according to the results of FIRE PROPAGATION AND SMOKE DISPERSION ANALYSIS.

The helideck protection system design shall attend the provisions of NORMAN-27 and CAP 437.

Helideck shall be foam supplied by three independent systems, composed each one of a foam concentrate tank and an in-line proportioner (Venturi type). The biggest helicopter expected to operate is Sikorsky S-61 N, with 22.2 m length (as per CAP 437), category H2 (as per NORMAN 27). Thus, a minimum of 3 foam monitors shall be provided, and the tank capacity shall not be less than 0.5 m³ of foam concentrate.

Each foam monitors shall be capable of providing 6 l/min/m² of 3% AFFF solution during 10 minutes, at a pressure of at least 687 kPa (7kgf/cm²) at the foam eductor inlet.

5.1 FOAM CONCENTRATE PUMPS AND MAIN

The foam concentrate pumps shall be driven by electric motors, which shall be double fed from two separate essential busbars with automatic switching panel between the feeders. The pumps shall be located in a safe place, sheltered and outside hazardous areas. In the event of start failure of the main pump, the reserve pump shall start automatically. The pumping system shall have overpressure protection at the discharge, pressure control with valves and return line to the foam concentrate tank.

The foam ring main of 3% AFFF, plus the branch pipes to consumers foreseen to supply the foam to fixed foam system shall also supply foam to foam monitors at main deck.

The minimum pressure at the nozzle further away from the foam deluge main shall be 140 kPa (1.43 kgf/cm²), to be confirmed in the Detail Design.

5.2 FIXED FOAM SYSTEMS

It shall be foreseen two independent fixed foam firefighting systems, one for oil processing modules of process plant and other to attend the area over cargo tanks, at main deck.

Each system shall be provided with independent:

- Two foam concentrate (2 x 100%) pumps, one main and one stand-by.
- Foam concentrate reservoir can be dedicated to each foam system or can be specified as two-part to attend both main deck and topside foam systems. In this case, the tank shall be dimensioned to hold the foam concentrate volume of topside

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in one compartment, and in another, the volume of foam concentrate to serve the main deck system.

- Foam concentrate ring-shaped main.
- Set of proportioners dedicated to each foam system.
- Water/Foam Deluge Valves (ADV) dedicated to each foam system.

5.3 MANUAL FOAM SYSTEM

In the foam firefighting manual system design, shall be considered the following topics:

- Protection for fixed foam monitors to stern and bow offloading areas, as well as facilities for the use of hydrants and containers (50 L) as additional protection;
- The capacity of any fixed monitor protecting the main deck area shall be at least 3 l/min of foam solution per m² of deck area protected by that monitor. Such area shall be entirely forward of the monitor. The capacity shall be not less than 1250 l/min, according to FSS Code;
- Fixed foam monitors for protection of cargo tanks as defined in IMO SOLAS, and additionally, facilities for the use of hydrants installed in areas with coupling to the AFFF containers (50 L).
- In the foam system design the number of fixed monitors needed shall be defined through a study also considering the following items:
 - Coverage area of fixed foam monitors (shadow analysis, including supplying the maps of the analysis);
 - The foam monitors shall be preferable installed outside the plant projection line, in a manner that the fire from the areas protected by them does not compromise their use;
- Portable monitor shall be foreseen on main deck, which each flow shall not be less than 400 l/min and the reach, in any climatic conditions, shall not be less than 15 m, as required in the FSS Code.
- Process areas where there is equipment operating with flammable and/or combustible liquids shall also be protected by fire-extinguishing manual applicators, according to NFPA 11 requirements. The eductors shall be capable of delivering at least 200 l/min and 343.21 kPa (3.5 kgf/cm²) at the tip of the nozzle, using 30 m of 1½" hose, a foam solution formed by 97% of water and 3% of the foam concentrate type AFFF.

For firefighting equipment specification, see I-ET-3010.00-5400-947-P4X-003 - FIREFIGHTING EQUIPMENT.

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6. MINIMUM DOCUMENTS REQUIRED

Classification Society Certificates of Approval issued by Ministério da Marinha – DPC.