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**DESIGN**: ESUP  
**EXECUTION**: RAUL  
**CHECK**: DANIELA  
**APPROVAL**: B. FERREIRA

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*FORM OWNED TO PETROBRAS N° 381 REV. L*
SUMMARY

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1 SCOPE

This document establishes the mandatory requirements for the design of the CO\textsubscript{2} fire fighting system that shall be installed in the Offshore Units.

The CO\textsubscript{2} Fire Fighting System supplier shall incorporate all these requirements to guarantee the supply and assembly of a reliable, safe and functional system.

Detailing Design shall be developed in accordance with the requirements herein established. Any modification shall be submitted to previous Petrobras approval.

2 ABBREVIATION AND DEFINITIONS

The following abbreviation are applicable:

- CCR: Central Control Room;
- PLC: Programmable Logic Controller;
- CSS: Control and Safety System;
- FGS: Fire and Gas System;
- HVAC: Heating, Ventilation and Air Conditioning;
- I/O: Input/Output of CSS;
- IHM: Human Machine Interface;
- P&ID: Piping and Instrumentation Diagram;
- SOS: Supervision and Operation System.

The following definitions are applicable:

- **Main CO\textsubscript{2} header**: Main distribution system that receives CO\textsubscript{2} from secondary headers and conducts to directional valves;
- **Secondary CO\textsubscript{2} header**: Distribution systems that receives CO\textsubscript{2} from flexible hoses connected to the cylinders and conducts to the main distribution system (main CO\textsubscript{2} header).

3 APPLICABLE REGULATION, CODES AND STANDARDS

This document establishes the mandatory requirements for the design of the CO\textsubscript{2} fire fighting system that shall be installed in the Offshore Units. Rules and guidelines that shall be followed during the design, installation and tests of CO\textsubscript{2} fire fighting...
systems are indicated below. In case of any conflict between them, Petrobras shall be consulted.

- IMO - SOLAS: Convention for the Safety of Life at Sea – 1974 and Amendments in Force;
- NFPA 12: Standard for Carbon Dioxide Extinguishing Systems;
- Brazilian Labor Ministry Regulation - NR-30;
- Brazilian Labor Ministry Regulation - NR-17;
- I-ET-3010.00-5400-947-P4X-002 - SAFETY SIGNALLING;
- I-ET-3010.00-5400-947-P4X-004 - LIFE SAVING EQUIPMENT;
- Requirements of Classification Society of the Unit.

4 TECHNICAL REQUIREMENTS

4.1 General

4.1.1 CO₂ flooding system shall be designed and tested in accordance with NFPA 12 and all IMO-SOLAS applicable requirements.

4.1.2 Electric equipment rooms with installed capacity equal or higher than 1000 kVA, shall be protected by CO₂ flooding system.

4.1.3 Compartments that contain internal combustion machines with generation power greater than 375kW shall be protected by a CO₂ flooding system.

4.1.4 Location of valves, fire fighting equipment and activation devices shall be according to ergonomic requirements (NR-17 Brazilian Standard) in order to ensure a safe and effective system operation.

4.1.5 Calculation of CO₂ amount required for fire fighting inside a compartment shall consider gas tight requirements applicable to total flooding with CO₂.

4.1.6 All components of the system shall be suitable for operating in a marine environment.

4.1.7 All equipment used for fire fighting shall be approved by a recognized institution, designed and tested according to recognized codes/standards. Certifying requirements for the CO₂ fire fighting system materials shall be in accordance with the Classification Society requirements.

4.1.8 CO₂ flooding shall not be applied for compartment located in columns and pontoons of Semi-Submersible Unit or to protect hard-to-access areas nor places with permanent presence of persons.
4.2 System Components

4.2.1 The CO₂ fire fighting system shall comprise the following components:

- CO₂ Central Storage;
- CO₂ distribution system;
- Control and signaling devices;
- Local CO₂ batteries.

4.3 CO₂ Central Storage

4.3.1 The CO₂ Central Storage shall comprise a high pressure cylinders battery, ready for use, sized to provide CO₂ total flooding to the largest compartment to be protected. In addition, high-pressure cylinders comprising a quantity of 25% of this battery, shall be also provided.

4.3.2 The CO₂ cylinders shall be of seamless steel and constructed to withstand high pressure. The CO₂ cylinders shall be provided with internal dip tubes to ensure that discharge takes place in the liquid phase.

4.3.3 The CO₂ cylinders shall be fitted with valves that, under normal conditions, will be held closed by the gas pressure itself. On the top of the valves shall be fitted the discharge heads, whose purpose will be to open the valves to discharge the CO₂. The cylinders shall be supplied only with valves to specific functions, i.e. master cylinders with pilot valves and slave cylinders with slave valves, to avoid a general cylinder to be used on two different functions.

4.3.4 The CO₂ Central Storage is divided up into smaller groups of cylinders and shall not be connected directly to the main header. It shall be connected to a dedicated secondary header which is interconnected to a main header through check valve. For each cylinder there must be a check valve installed on the secondary header. These groups shall be arranged in such a way to assure that no more than the required amount of gas will be released into the compartment.

4.3.5 Pilot cylinders shall be used for discharging the specific groups of cylinders required by the area to be protected. The corresponding pilot valves shall be designed so as to permit electrical operation from the Unit Control and Safety System (FGS) by an electric solenoid and also to allow the actuation by a hand operated mechanical control, independent of electric power. The electrical actuation of these valves shall be made from manual push buttons integrated in FGS. The actuation by CSS HMIs shall be forbidden. This control shall be according to NFPA 12 - chapter 9: Marine Systems.

4.3.6 The electric solenoid shall be energized to open the pilot valve. The reset of these valves shall be only locally by means of hand mechanical control and only after switching off power to the solenoid valve.
4.3.7 It shall be guaranteed that the directional valve opens prior to the pilot valve.

4.3.8 Flexible connectors shall be used for linking up the cylinders with the secondary headers, which will interconnect the CO₂ Central Storage with the distribution system. A retention device shall be provided to avoid CO₂ back flow through flexible connectors.

4.3.9 A relief valve shall be installed at the main header to provide venting of small CO₂ leakage from the cylinders. This valve shall be automatically closed in case of effective CO₂ discharge. Furthermore, a pressure transmitter shall be provided to check pressure increase at the main header and also detect a discharge failure.

4.3.10 The CO₂ batteries shall be installed in a sheltered place, with an access door, and not exposed to the environmental conditions.

4.4 CO₂ Distribution System

4.4.1 The CO₂ distribution system shall comprise a main header, pilot valves, lockout valves, directional valves, delay valve, distribution piping, fittings and nozzles. The system shall be designed in such a way to assure that the CO₂ will be discharged only into the required protected compartment.

4.4.2 Each compartment to be protected by CO₂ shall be provided with a corresponding directional valve installed at the discharge piping of the compartment. This valve shall be designed to permit the operation through either a solenoid valve or manual activation (without electrical energy). It shall not be permitted activation of these valves through virtual pushbutton at SOS HMI. The solenoid valve shall be energized to open the directional valve.

4.4.3 It shall not be permitted activation of directional valves by means of CO₂, that means, pneumatic actuation of the directional valve using CO₂ gas itself will not be accepted.

4.4.4 Directional valves shall be supplied with limit switch that shall monitor the CO₂ discharge and show indication at SOS HMI. The reset of these valves shall be only locally by means of hand mechanical control and only after switching off power to the solenoid valve.

4.4.5 A hand operated valve that can be locked on closed position (lockout valve), shall be provided between the CO₂ supply and discharge nozzles. It shall be located upstream each directional valve, for all systems. These valves shall have it position monitored as CSS HMI.

4.4.6 The CO₂ nozzles installed in the protected areas shall be sized and positioned so as to regulate the application of the CO₂ and ensure adequate distribution.
4.5 Control and Signaling Devices

4.5.1 The remote manual actuation (by pushbutton switches), the operation signaling and the CO₂ flooding system monitoring shall be executed by FGS system.

4.5.2 For all protected compartments, the CO₂ discharge shall be initiated either by remote manual actuation, by means of pushbutton switches located outside the protected compartment (in the vicinity of the doorways) or at the CO₂ Central Storage through a Local Panel. It may also be initiated by mechanical manual actuation, by means of clearly identified directional valve and pilot valve levers. All these controls shall be according to NFPA 12 - chapter 9: Marine Systems.

4.5.3 Two pushbuttons shall be provided for each point of actuation to allow manual remote activation. The pushbuttons shall be specified as normally open, press to close, non-retentive type with return by spring. The two push-buttons shall be installed inside individual enclosures, clearly identified. The enclosure shall be of “lift and push the button” type, colored safety yellow with safety red color stripe, painted diagonally. The electrical cables and related multicable of each push-button shall be independent in order to avoid unpredicted release of CO₂ due to common cause failure.

4.5.4 It shall be foreseen a local reset function at the CO₂ Central Storage (Local Panel) to permit the restart of the logic for a new discharge after the end of a CO₂ release. It shall be permitted the reset action if only one pushbutton for a protected compartment is activated. The reset function shall never abort or interrupt the release of CO₂ if this operation has been effectively started (directional and pilot valves opened). The purpose of the reset function is to restart the logic for a new discharge after the end of a CO₂ release or after an eventual undesired operation of only one of the command push-buttons.

4.5.5 CO₂ discharge shall be preceded by a visual and audible alarm inside the protected compartment and an external intermittent visual alarm activated at least 30 seconds before the CO₂ release. However, the discharge time delay for compartments with hard access such as engine room shall be analyzed taking in consideration the worst evacuation condition, as indicated at NFPA 12.

4.5.6 The audible alarm shall be activated pneumatically by means of discharged CO₂.

4.5.7 It shall be foreseen signaling at CCR indicating the effective CO₂ discharge. This indication shall be originated from a pressure switch installed downstream of the directional valve.

4.5.8 The horn audible alarm system shall be intermittent. The acoustic pattern of the alarm shall be clearly differentiated from other acoustic alarm systems adopted at the Unit. Additionally, all high noise level compartments (above 90 dB) shall be supplied with strobe red lights located to assure that it can be seen from any place of the compartment.
4.5.9 The time delay provided by the delayer, a pneumatic device activated by means of discharged CO₂. In case of failure in the delayer device, it shall be foreseen a mean for manual actuation able to allow full flow of CO₂ gas.

4.5.10 Each compartment protected by the CO₂ system shall be provided with a local alarm consisting of a red lamp located above the warning sign, outside the room next to the access doors, with the following legend: “GAS CARBÔNICO (CO₂) PODE CAUSAR FERIMENTO OU MORTE. QUANDO O ALARME OPERAR NÃO ENTRTE ATÉ QUE O AMBIENTE ESTEJA VENTILADO”. (meaning: Carbon Dioxide gas can cause injury or death. When alarm operates, do not enter until ventilated). The red lamp shall start blinking 30 seconds before the CO₂ release to indicate that the system is activated.

4.5.11 The warning signal shall be located at all entrances of the protected compartments and at the CO₂ Central Storage.

4.5.12 It shall be provided limit switches (reed relay type) for all compartments protected by CO₂ flooding, in the access doors of the protected rooms. If any door of a compartment remains opened for more than 20 seconds an alarm will sound in the CCR, indicating “open door”. If any door of a compartment remains opened for more than 10 seconds after the CO₂ flooding system actuation, a fail signaling shall be activated at SOS HMIs (CCR), indicating “CO₂ activated with open door”. In this case the effectiveness of the system will be impaired.

4.5.13 A high pressure indicator transmitter fitted to the piping downstream of each pneumatic time delay shall be supplied to monitor the release of the CO₂, with signaling at SOS HMIs (CCR), in confirmation of CO₂ system actuation. If confirmation of system actuation does not occur up to 20 seconds in addition to the discharge time delay specified to the compartment, an alarm at SOS HMIs (CCR) shall be activated, indicating “discharge failure”.

4.5.14 The manual operation (remote or mechanical) of the CO₂ flooding system shall generate, prior to the release of the CO₂, the isolation of the compartment ventilation, by closing the dampers in the HVAC system of the affected area and, if appropriate, shutdown of the ventilation fans as well. If any damper of a compartment remains opened for more than 10 seconds after the CO₂ flooding system actuation, a fail signaling shall be activated at SOS HMIs (CCR), indicating “CO₂ activated with open damper”. In this case the effectiveness of the system will be impaired.

4.5.15 All CO₂ system components (signaling, push-buttons etc.) and the control circuits shall be monitored to check integrity, continuity and short-circuit through PLC I/O cards. Fail signaling shall be activated at CCR (SOS HMIs).

4.5.16 The solenoids of the pilot and directional valves and its respective push-buttons shall be connected to different I/O cards (discrete inputs) to avoid unpredicted release of CO₂ due to common cause failure.
4.6 Local CO₂ Batteries

4.6.1 Local CO₂ batteries shall be installed at sheltered places with access doors and shall not be exposed to climate conditions. Any fire at the areas protected by these batteries shall not expose them to risk. The location of local CO₂ batteries shall permit quick and easy access for operation, inspection and maintenance of the system including the cylinders replacement.

4.6.2 The false floor or ceiling of CCR with high voltage cables shall be protected by a local and exclusive set of CO₂ cylinders. A specific directional valve for each compartment (floor and ceiling) shall be provided and shall be dimensioned to comply with the largest compartment.

4.6.3 Local CO₂ batteries shall be provided with backup batteries. It shall be possible the battery selection (main and backup) through manual key installed near the local CO₂ batteries.

4.6.4 Fire fighting water pumps rooms shall be provided with a CO₂ fire fighting system designed to total flooding.

4.6.5 Galley exhaust shall be provided with a CO₂ fire fighting system designed to local application. This system shall comprise a Local CO₂ battery and piping to inject CO₂ gas through galley exhaust and ducts. CO₂ discharge shall be started by manual remote activation (pushbutton located near the galley exhaust) or by manual mechanical activation through the pilot valve.

4.6.6 A local CO₂ battery for the atmospheric vent (vent stack snuffing system) and vent psot shall be supplied and installed by the respective MODULE SUPPLIER. A reserve battery, ready to use, shall also be provided in this case.

5 ADDITIONAL REQUIREMENTS

5.1.1 The racks of CO₂ cylinders shall be arranged in such a manner as to allow fast and easy access for operation, inspection and maintenance of the system, including changing of cylinders.

5.1.2 The corridors around the racks shall be provided with at least 1.0 m wide and 2.1 m high.

5.1.3 Means for weighting the cylinders shall be provided in the vicinity of the CO₂ cylinders.

5.1.4 It shall be installed outside of all rooms protected by CO₂ an autonomous breathing apparatus, duly conditioned, in each access of the rooms.

5.1.5 In case of any line spec break, it shall be located downstream the delayer.

5.1.6 Piping through which CO₂ flows shall not be welded to its support.

5.1.7 It shall be provided an Emergency Escape Breathing Device, duly conditioned and supplied complying with I-ET-3010.00-5400-947-P4X-004 LIFE SAVING EQUIPMENT, in every access of the protected compartment.
5.1.8 As a minimum required documentation, certificates approved by Brazilian Maritime Administration (DPC) shall be provided.

6 CO₂ BATTERIES SIZING

6.1.1 The size of the CO₂ Batteries shall be calculated according to IMO-SOLAS, IMO_FSS CODE and NFPA 12 - Chapter 9: Marine Systems.

7 ANNEXES

Annexes I to IV show typical details shall be adopted for all the compartments provided with CO₂ total flooding systems by central battery. The CO₂ system P&ID shall be issued by Detailing Design based on these typical details.
7.1 Annex I – Typical arrangement for CO₂ batteries
7.2 Annex II – Typical arrangement for CO$_2$ total flooding system

7.3 Annex III – Typical arrangement for CO$_2$ local flooding system
7.4 Annex IV – Logic for CO₂ flooding

Annex IV.pdf