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INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	ORIGINAL
A	REVISED TO INCORPORATE THE RECOMMENDATION ISSUED FROM THE WORK GROUP ESTABLISHED TO EVALUATE THE INADEQUATE ACTUATION OF CO2 FLOODING SYSTEM AT P-75, AMONG OTHERS.

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	04/11/2022	04/17/2024							
DESIGN	ESUP	ESUP							
EXECUTION	CMH4	DXVM							
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APPROVAL	EK9U	EK9U							

SUMMARY

1 SCOPE

This document establishes the mandatory requirements for the design, installation, and testing of the inert gas clean agent IG-541 fixed firefighting total flooding system, that shall be installed in the Offshore Units.

The IG-541 fixed firefighting total flooding 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.
- CSS: Control and Safety System.
- DPC: Diretoria de Portos e Costas (Brazilian Maritime Administration)
- FGS: Fire and Gas System.
- HVAC: Heating, Ventilation and Air Conditioning.
- HMI: Human Machine Interface.
- I/O: Input/Output of CSS.
- LOAEL: Lowest Observed Adverse Effect Level
- NOAEL - No Observed Adverse Effect Level
- PLC: Programmable Logic Controller.
- P&ID: Piping and Instrumentation Diagram.
- SOS: Supervision and Operation System.

The following definitions are applicable:

- **Agent Concentration:** The portion of agent in an agent-air mixture expressed in volume percent.

- **Clean Agent:** Volatile or gaseous fire extinguishant that is electrically nonconducting and that does not leave a residue upon evaporation.

- **Design concentration:** Concentration of extinguishant, including a safety factor, required for system design purposes.

- **Extinguishing Concentration:** The concentration of agent in air that causes extinguishment of the test flame within the observation period.

- **Fill density:** Mass of extinguishant per unit volume of container.

- **Flooding quantity:** Mass or volume of extinguishant required to achieve the design concentration within the protected compartment.

- **Hold time:** Period of time during which a concentration of extinguishant higher than the fire extinguishing concentration surrounds the hazard.

- **Inert Gas Agent**: An agent that contains as primary components one or more of the gases Helium, Neon, Argon, or Nitrogen. Inert gas agents that are blends of gases can also contain inert gas as a secondary component.

- **Main IG-541 header:** Main distribution system that receives IG-541 from secondary IG-541 headers and conducts to directional valves.

- **Net volume:** Volume enclosed by the building elements around the protected compartments, minus the volume of any permanent impermeable building elements within the compartment.

- **Secondary IG-541 header:** Distribution systems that receives IG-541 from the cylinders through flexible hoses and conducts to the main distribution system (main IG-541 header).

- **Total Flooding:** The act and manner of discharging an agent for the purpose of achieving a specified minimum agent design concentration throughout a protected compartment volume.

- **Total Flooding System:** A system consisting of an agent supply and distribution network designed to achieve a total flooding condition in a protected compartment volume.

3 APPLICABLE REGULATION, CODES AND STANDARDS

This document establishes the mandatory requirements for the design of the IG-541 fixed firefighting total flooding system that shall be installed in the Offshore Units. Rules and guidelines that shall be followed during the design, installation and tests of IG-541 fixed firefighting total flooding system 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.

- IMO - FSS Code: International Code for Fire Safety Systems.

- IMO MSC/Circ. 848, Revised Guidelines for the Approval of Equivalent Fixed Gas Fire-Extinguishing Systems as Referred to in SOLAS 74, for Machinery Spaces and Cargo Pumprooms, 1998.

- IMO MSC.1/Circ.1267, Amendments to Revised Guidelines for the Approval of Equivalent Fixed Gas Fire-Extinguishing Systems, as Referred to in SOLAS 74, for Machinery Spaces and Cargo Pumprooms (MSC/Circ.848), 2008.

- NFPA 2001 - Standard on Clean Agents Fire Extinguishing Systems.

- ISO 14520-1 - Gaseous fire-extinguishing systems - Physical properties and system design - General requirements.
- ISO 14520-15 - Gaseous fire-extinguishing systems - Physical properties and system design - IG-541 extinguishant.
- ISO/TS 20885 - Gaseous media fire-extinguishing systems — Area coverage fire test procedure — Engineered and pre-engineered extinguishing units.
- ANSI/UL 2127, Standard for Inert Gas Clean Agent Extinguishing System Units, 2012 (revised 2015).
- I-ET-3010.00-5400-947-P4X-002 - SAFETY SIGNALLING.
- I-ET-3010.00-5400-947-P4X-004 - LIFE SAVING EQUIPMENT.
- Requirements of Flag and Classification Society of the Unit.

4 TECHNICAL REQUIREMENTS

4.1 General

4.1.1 IG-541 fixed firefighting total flooding system shall be designed and tested in accordance with NFPA 2001, ISO 14520-1, ISO 14520-15, and all IMO-SOLAS applicable requirements. In case of conflict of requirements, Petrobras shall be consulted. The design concentration for each protect room shall be according NFPA 2001, considering the classes of fire in the room that require the highest concentration of agent.

4.1.2 Electric equipment rooms with installed capacity equal or higher than 1000 kVA, shall be protected by IG-541 fixed firefighting total flooding system. For Electric equipment rooms with installed capacity lower than 1000 kVA the necessity of protection shall be defined on the basic design phase and indicated at Safety Data Sheet.

4.1.3 Compartments that contain internal combustion machines with generation power greater than 375kW shall be protected by an IG-541 fixed firefighting total flooding system. For Compartments that contain internal combustion machines with generation power lower than 375kW the necessity of protection shall be defined on the basic design phase and indicated at Safety Data Sheet.

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

4.1.5 Calculation of IG-541 flooding quantity required for firefighting inside a compartment shall take into account gas tight requirements applicable to total flooding with IG-541.

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

environment.

4.1.7 All equipment used for firefighting shall be approved by a recognized institution, designed and tested according to recognized codes/standards. Certifying requirements for the IG-541 firefighting system materials shall be in accordance with the Classification Society requirements.

4.1.8 IG-541 fixed firefighting total flooding system shall not be applied for compartment located in columns and pontoons of Semi-Submersible Unit.

4.2 System Components

4.2.1 The IG-541 fixed firefighting total flooding system shall comprise the following components:

- IG-541 Central Cylinders Storage or local batteries of IG-541.
- IG-541 distribution system (Pipes, valves, fittings, nozzles, and hangers).
- Control and signaling devices.

4.3 IG-541 Central Cylinders Storage

4.3.1 The IG-541 Central Cylinders Storage shall comprise a high-pressure (150, 200 or 300 bar) cylinders battery for protection of more than one compartment, ready for use, sized to provide IG-541 total flooding to the largest compartment to be protected. In addition, high-pressure cylinders comprising, at least a 100% stand-by cylinders battery, shall also be provided.

4.3.2 The IG-541 cylinders shall be of seamless steel and constructed to withstand high pressure according to applicable standards.

4.3.3 The IG-541 batteries shall be installed in a closed compartment, in a safe and readily accessible location, with an access door, and not exposed to the environmental conditions. The cylinder rooms shall be effectively ventilated so that the agent cylinders are not exposed to ambient temperatures of more than 55°C. The spaces around the racks shall be provided with at least 1.0 m wide and 2.1 m high to facilitates the mechanical handling of cylinders.

4.3.4 The IG-541 cylinders shall be fitted with valves that, under normal conditions, are 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 IG-541. 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.

4.3.5 The IG-541 Central Cylinders Storage shall be 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 shall 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 protected compartment.

4.3.6 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 to permit electrical operation from the Unit Control and Safety System (FGS) by an electric solenoid and 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 SOS HMIs, either by command or by override, shall be forbidden. This control shall be according to NFPA 2001 for marine systems.

4.3.7 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.

4.3.8 It shall be guaranteed that the directional valve opens prior to the pilot valve.

4.3.9 Flexible connectors shall be used for linking up the cylinders with the secondary headers, which will interconnect the IG-541 Central Storage with the distribution system. A retention device shall be provided to avoid IG-541 back flow through flexible connectors.

4.3.10 A relief valve shall be installed at the main header to provide venting of small IG-541 leakage from the cylinders. This valve shall be automatically closed in case of effective IG-541 discharge. Furthermore, a pressure transmitter shall be provided to check pressure increase at the main header and detect a discharge failure.

4.4 IG-541 Distribution System

4.4.1 The IG-541 distribution system shall comprise a main header, pilot valves, lockout valves, directional valves, delayer, distribution piping, fittings, and nozzles. The system shall be designed in such a way to assure that the IG-541 will be discharged only into the required protected compartment.

4.4.2 Each compartment to be protected by IG-541 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, command, or override, at SOS HMIs. 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 IG-541, that means, pneumatic actuation of the directional valve using IG-541 gas itself will not be accepted.

4.4.4 Directional valves shall be supplied with limit switch that shall monitor the IG-541 discharge and show indication at SOS HMIs. 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 IG-541 supply and discharge nozzles. It shall be located upstream each directional valve, for all systems. These valves shall have their position indicated at SOS HMIs.

4.4.6 The IG-541 nozzles installed in the protected areas shall be sized and positioned to regulate the application of the IG-541 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 IG-541 fixed firefighting total flooding system monitoring shall be executed by FGS subsystem.

4.5.2 For all protected compartments, the IG-541 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 IG-541 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 2001 - 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 pushbuttons 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.

4.5.4 It shall be foreseen a local reset function at the IG-541 Central Storage (Local Panel) to permit the restart of the logic for a new discharge after the end of an IG-541 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 IG-541 if this operation has been effectively started (two pushbuttons of a pair of pushbuttons have been pressed). The purpose of the reset function is to restart the logic for a new discharge after the end of an IG-541 release or after an eventual undesired operation of only one of the commands pushbuttons.

4.5.5 IG-541 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 IG-541 release. However, the discharge time delay for compartments with difficult access such as engine room shall be analyzed taking in consideration the worst evacuation condition, as indicated at NFPA 2001.

4.5.6 Full-body communication booths (where applicable) located in compartments protected by a fixed IG-541 fire-fighting system shall have a visual and audible alarms to inform of IG-541 release within the protected compartment. IG-541

discharge shall be preceded by a visual and audible alarm inside the communication booths.

4.5.7 The audible alarm shall be activated pneumatically by means of discharged IG-541.

4.5.8 It shall be foreseen signaling at SOS indicating the effective IG-541 discharge. This indication shall be originated from a pressure switch installed downstream of the directional valve.

4.5.9 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.

4.5.10 The time delay shall be done by a pneumatic delayer device activated by the discharged IG-541. In case of failure in the delayer device, it shall be foreseen a mean for manual actuation able to allow full flow of IG-541 gas.

4.5.11 Each compartment protected by the IG-541 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: “GÁS INERTE - RISCOS A SUA SEGURANÇA. QUANDO ACIONADO O ALARME NÃO ENTRE NO AMBIENTE” (meaning: Inert gas – safety hazardous. When alarm is activated, do not enter into the compartment). The red lamp shall start blinking 30 seconds before the IG-541 release to indicate that the system is activated.

4.5.12 The warning sign shall be located at all entrances of the protected compartments and at the IG-541 Central Storage. The warning sign should be installed no more than 1.0 m above the entrance doors in a visible place.

4.5.13 It shall be provided limit switches (reed relay type) for all compartments protected by IG-541 fixed firefighting total flooding system, in the access doors of the protected compartments. If any door of a compartment remains opened for more than 20 seconds an alarm will sound in the SOS HMI, indicating “open door”. If any door of a compartment remains opened for more than 10 seconds after the IG-541 fixed firefighting total flooding system actuation, a failure signaling shall be activated at SOS HMIs (CCR), indicating “IG-541 activated with open door”. In this case the effectiveness of the system will be impaired.

4.5.14 A high-pressure indicator transmitter fitted to the piping downstream of each pneumatic time delay shall be supplied to monitor the release of the IG-541, with signaling at SOS HMIs (CCR), in confirmation of IG-541 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”.

4.5.15 The manual operation (remote or mechanical) of the IG-541 fixed firefighting total flooding system shall generate, prior to the release of the IG-541, 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 IG-541 fixed firefighting total flooding system actuation, a failure signaling shall be activated at SOS HMIs (CCR), indicating “IG-541 activated with open damper”. Regardless of this failure, the firefighting continues, and, in this case, the effectiveness of the system will be impaired.

4.5.16 All IG-541 system components (signaling, pushbuttons 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).

4.5.17 To avoid unpredicted release of IG-541 due to common cause and reduce the risk of a non-intentional release of IG-541 the following shall be followed:

4.5.17.1 The electrical cables and related multicables of each push-button shall be independent and each one directed to different junction boxes. This avoids accidental actuation due to a cable failure such as a rupture or junction box maintenance.

4.5.17.2 The solenoids of the pilot and directional valves shall be connected to exclusive junction boxes, i.e, junction boxes containing only directional valves and other junction boxes containing pilot valves. This prevents accidental actuations of both directional and pilot valves during a maintenance of a junction box.

4.5.17.3 As an extension of item 4.5.17.2, multicables shall also not mix signals for directional valves with signals for pilot solenoid valves, even for different compartments/rooms.

4.5.17.4 Cables for directional solenoid valve and the cable of its respective limit switch for open position indication shall be directed to different junction boxes. Since there is an interlocking between directional valve actuation with its position, both cannot be accidentally actuated during a maintenance of a junction box.

4.5.17.5 The solenoids of the pilot and directional valves and its respective pushbuttons shall be connected to different I/O cards (discrete inputs) to avoid unpredicted release of IG-541 due to common cause failure.

4.6 Local IG-541 Batteries cylinders

4.6.1 The false floor or ceiling of CCR with electrical cables shall be protected by a local and exclusive set of IG-541 cylinders. A specific directional valve for each compartment (floor and ceiling) shall be provided and shall be dimensioned to comply with the largest compartment.

4.6.2 Local IG-541 batteries shall be provided with backup batteries. It shall be possible the battery selection (main and backup) through manual key installed near the local IG-541 batteries.

4.6.3 Firefighting water pumps rooms / compartments / containers shall be provided with

an IG-541 firefighting system designed to total flooding.

5 ADDITIONAL REQUIREMENTS

5.1 In case of fire at firewater pumps compartments or emergency generator compartments, automatic shut-off of the fuel oil supply valve is not required (see ANNEX II, note 3).

5.2 Means for control and monitoring pressure (pressure gauges) of each cylinder shall be provided direct connected to the cylinder valve.

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

5.4 Piping through which IG-541 flows shall not be welded to its support.

5.5 The protected compartments shall have sufficient structural strength and integrity, including resistance of doors, tight dampers and sealing of cables and ducts passages, to contain the extinguishant discharge and prevent failures due to over pressurization of the compartment. Pressure relief venting devices or time delay on dampers may be provided to avoid over pressurization.

5.6 All door drains shall have traps, and the traps shall be designed to have water or other compatible liquid in them at all times.

5.7 To prevent loss of extinguishant through openings to adjacent hazards or work areas, openings shall be permanently sealed or equipped with automatic closures.

5.8 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.

5.9 As a minimum required documentation, certificates approved by Brazilian Maritime Administration (DPC) shall be provided.

5.10 The maximum exposure time assumed by the safety precautions is 5 minutes. Exposure times longer than 5 minutes may involve physiological or toxicological effects.

5.11 After the agent design concentration is achieved, it shall be maintained for a sufficient period to allow effective emergency action by trained operator's personnel. In no case shall the hold time be less than 15 minutes.

6 IG-541 BATTERIES SIZING

6.1 The size of the IG-541 Batteries shall be calculated according to NFPA 2001 and IMO-SOLAS, IMO_FSS CODE.

6.2 The design shall be according to NFPA 2001. Where the provisions of Chapter 9 (Marine Systems) of this standard conflict with the provisions of Chapter 1 through Chapter 8, the provisions of Chapter 9 shall take precedence.

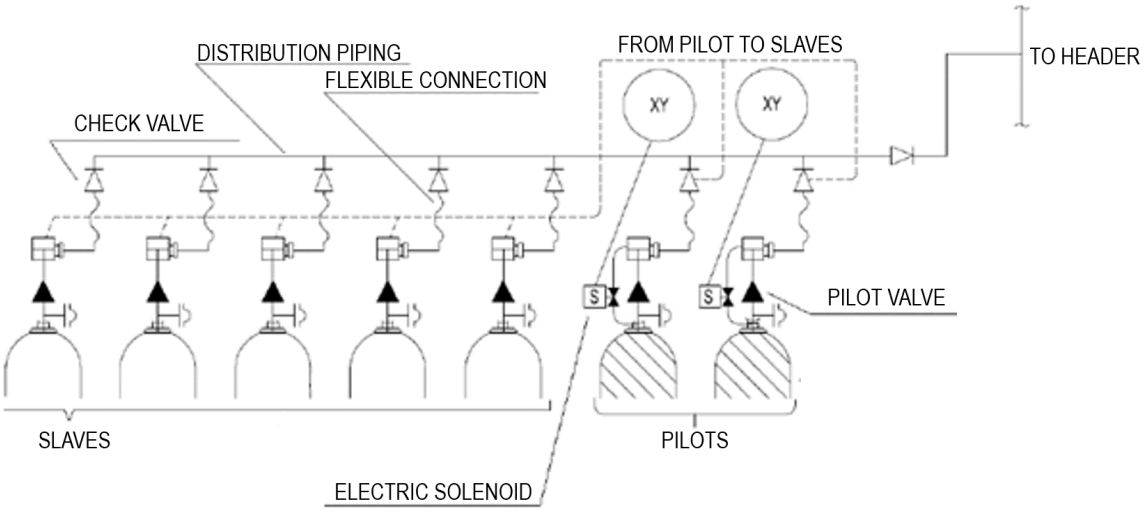
6.3 A design concentration for combinations of different fuel types on same compartment shall be derived from the flame extinguishment value for the fuel requiring the greatest concentration.

6.4 The design quantity of agent shall be based on the net volume of the protected compartment.

7 ANNEXES

Annexes I and II show typical details shall be adopted for all the compartments provided with IG-541 fixed firefighting total flooding system by central battery. The IG-541 system P&ID shall be issued by Detailing Design based on these typical details.

7.1 Annex I – Typical arrangement for IG-541 batteries



7.2 Annex II – Logic for IG-541 fixed firefighting total flooding system

Logic for IG-541
total flooding syste