Fixed CO_2 fire-extinguishing systems - consequences of delayed release

Introduction

One of the most commonly used fire-extinguishing agents in ships' engine rooms is carbon dioxide (CO_2). CO_2 gas has excellent fire-extinguishing capabilities and is relatively inexpensive, but may pose a serious risk to personnel as it primarily extinguishes fires by reducing the available oxygen in the atmosphere. In addition to concerns about the safety hazard to personnel, Gard also has concerns as to how the final outcome of a fire can be influenced by the type of extinguishing system used. With CO_2 systems, the period between detecting a fire and releasing the gas often seems quite long. Unclear evacuation and mustering procedures combined with the crew's worries about the lethal effects of CO_2 can cause unnecessary delays in release – or as experienced in one of Gard's recent cases, no release at all. Minor fires have been allowed to escalate and cause severe and costly damage to ships and their equipment, in some cases also injury and loss of life due to extensive smoke development.

Unless the crew fully understands the functionality of and limitations associated with CO_2 systems, they may not be sufficiently confident and prepared to provide timely and effective emergency response during a fire. The purpose of this circular is to create awareness of the inherent risks of fixed CO_2 fire-extinguishing systems; highlight limitations in their method of application when used in ships' engine rooms; and stress the importance of proper procedures and training for their use on board.

Safeguarding against risks to human life[1]

The concentration of CO_2 above certain levels in fire-fighting applications is a major concern amongst fire safety regulators. Some safety regulators even prohibit the use of CO_2 as a fire-extinguishing agent in spaces where personnel has access during normal operation; one such example can be found in the safety regulations applicable to the offshore oil and gas industries in Norway.[2] The IMO Safety of Life at Sea (SOLAS) Convention does not prohibit the use of CO_2 in systems protecting a ship's engine room, or other spaces where crew has access during normal operation. But the risks to personnel are clearly recognized and SOLAS calls for various safeguards, such as two separate and interlocked controls, pre-discharge alarms and time-delays, to protect personnel in the engine room. SOLAS does not, however, allow portable CO_2 extinguishers to be placed in the accommodation spaces on board ships, due to the associated risk to personnel.[3]

Ensuring timely and effective emergency response during a fire

Emergency response to engine room fires can be better organised and carried out more efficiently if the crew is properly trained in the safe use of the ship's fire-extinguishing systems. The time it takes to make a decision to release the fixed fire-extinguishing system is considered to be one of the most critical factors during emergency response and main concerns related to use of CO_2 as the extinguishing agent in ships' engine rooms can be summarised as follows:

Delayed release: For the typical engine room fire involving flammable liquids, it is important to introduce the required quantities of CO_2 quickly to limit the escalation of the fire. Investigations reveal that evacuation, muster and head counts during engine room fires often take longer than expected because "*the crew was running around and was difficult to count*".[4]

Engine room not properly sealed prior to release: The extinguishing capabilities of gas can be compromised if the integrity and tightness of the boundaries of the protected space are not sound. On more than one occasion, the effectiveness of a CO_2 system has been limited by excessive leakage of gas through open or improperly closed doors, vents or ventilation ducts.

Limited availability of fire-extinguishing agent: The quantity of CO_2 gas available on board ships is normally limited to that required for a single discharge into a protected space.

[1] Gard has previously addressed the risks to human life associated with the use of CO_2 as a fire-extinguishing agent on board ships, see article "Lack of air" in Gard News 179.

[2] See Sec.20.4 in NORSOK S-001 concerning technical safety on board offshore installations, a standard referenced by the Norwegian Petroleum Safety Authorities.

[3] See SOLAS Reg.II-2/10 "Fire Fighting" and the IMO Fire Safety Systems (FSS) Code Ch.5 "Fixed gas fire-extinguishing".

[4] See also article "Fire safety in the engine room" in Gard News 170.

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Premature re-entry into and ventilation of the engine room after release: The re-entry into the engine room following a fire where gas has been used involves perhaps one of the most dangerous aspects of fire fighting. CO_2 has limited cooling effect and the temperature of equipment and structures in the engine room may be very high, in particular if the time it took to release the fixed fire-extinguishing system was long. Fire fighters or crew entering the space too soon, thus allowing entry of oxygen-rich air, can cause the fire to reignite.

Risk assessment

SOLAS allows the use of fixed fire-extinguishing systems applying either gas, foam or water to protect ships' engine rooms. Some agents perform better than others in a particular application and all have some limitations that have to be dealt with when extinguishing fires. Gard's advice to shipowners with newbuilding programmes is therefore to carefully evaluate the pros and cons of all commercially available fire-extinguishing systems prior to specifying the desired system. The safety of the crew should always be prioritised and the inherent risks of a CO_2 system, and the limitations in its method of application, should be taken into account. As far as performance is concerned, systems using "equivalent gases", like halocarbon or inert gases, or water mist, are all comparable to CO_2, but factors to be considered in the risk assessment and selection process are:

- Other available gas systems are less harmful to people than CO_2 but some, e.g. halocarbon gases, may create life-threatening by-products during the fire.
- All gas systems, not only CO_2, are vulnerable to the integrity/tightness of the boundaries of the protected space; they are usually limited to a single discharge and they have limited cooling effects.
- Water mist systems can be brought into action faster than gas systems since it is not necessary to close openings, shut down ventilation or evacuate the space before release.
- The time needed to extinguish fires with water mist can be longer than for gas, but water mist also cools the space and controls smoke in the process. An unlimited water supply is also usually available.
- True gas systems provide "three-dimensional protection", while the effectiveness of water mist systems can be affected by the size of the fire, degree of obstruction of the fire, ventilation and the layout of the protected space.

Recommendations

For shipowners specifying and operating CO_2 systems, Gard strongly recommends fostering awareness of the hazards related to their use - through detailed and unambiguous procedures, proper training and prescribed maintenance. Some ships have extensive quality and safety management systems but lack sufficient details to assist the crew in dealing with an emergency situation such as a fire. The following is recommended:

- Regular fire drills should be as realistic as possible.
- Emergency response procedures should contain sufficient details to assist the crew in dealing with all stages of the emergency and should cover:
  - actions to be initiated prior to release of CO_2,
  - instructions for holding/cool down times before re-entering and ventilating the space,
  - lines of communication, both on board and with relevant shore organizations.
- Evacuation and mustering procedures should include a simple but reliable system for head-counts in order to avoid any misunderstanding concerning the whereabouts of crew.
- Manuals, piping schematics, instruction placards and labelling of the CO_2 system must be in accordance with the actual installation.
- The person tasked to release the system must be a person designated in the muster list.
- Maintenance procedures for the CO_2 system should include manufacturers' recommendations and should be based on the IMO guidelines (MSC.1/Circ.1318).
- Periodic servicing of the CO_2 system should be carried out by authorised service suppliers.
- Regular inspections should ensure that evacuation routes and exits in the engine room are clearly marked and kept free from obstructions at all times.
- The dangers of CO_2 must be continuously stressed and training and experience transfer between crew should create a common understanding of the functionality, limitations and hazards associated with the ship's specific CO_2 installation.

Common for all ship fire fighting systems are the requirements imposed by SOLAS Reg.II-2/10 statement of purpose: "*to suppress and swiftly extinguish a fire in the space of origin*." Yet, experience shows that the inherent risks of a fixed CO_2 fire-extinguishing system, and the need for evacuation of a ship's engine room prior to discharge, often cause substantial delays in its release.

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