Marine fire protection regulations explained

By RICK FOSTER*

In most parts of the world, all commercial vessels must be constructed, registered and periodically surveyed according to the intended area of operation, intended use, size and type. The construction requirements and registration will be governed by one or more of several regulatory organisations as detailed in this article.

Various safety systems are required on all vessels and are designed to be part of an overall safety package to safeguard the lives of the crew and any passengers.

Many owners also elect – or are required – to have their vessel surveyed by a classification society.

The International Maritime Organisation (IMO) publishes the International Convention for the Safety of Life At Sea (SOLAS), in which the requirements for fire safety systems are detailed. As the "father" of the marine regulatory process, IMO provides much of the technical and organisational process by which Australia has developed its own regulations.

Most countries, have ratified this convention and also publish national regulations, which may adopt the SOLAS requirements, or expand on them.

Because of the international nature of the shipping industry, it had long been recognised that action to improve safety in maritime operations would be more effective if carried out at an international level rather than by individual countries acting unilaterally and without co-ordination with others.

The SOLAS Convention in its successive forms is generally regarded as the most important of all international treaties concerning the safety of merchant ships.

The main objective of the SOLAS Conventions is to specify minimum standards for the construction, equipment and operation of ships, compatible with their safety. Flag states are responsible for ensuring that ships under their flag comply with its requirements, and a number of certificates are prescribed in the Convention as proof that this has been done.

Control provisions also allow contracting governments to inspect ships of other contracting states if there are clear grounds for believing that the ship and its equipment do not substantially comply with the requirements of the Convention.

The Commonwealth of Australia Navigation Act - 1912 is administered by the Commonwealth Department of Transport and Regional Services which, through the Cross-Modal and Transport Division (XMT) implements Marine Orders pertaining to the construction and operation of vessels in Australia.

AMSA, the Australian Maritime Safety Authority, coordinates and implements Australia's international responsibilities and encompasses a number of divisions.

The Maritime Safety and Environmental Strategy covers flag state and port state policy functions encompassing operational standards of vessels in Australian waters to ensure their seaworthiness and safe operation and the enhancement of national and international maritime safety standards.

Maritime Operations covers ship inspection services for the survey and assessment of the seaworthiness of ships, the operational effectiveness of onboard safety equipment and procedures, safe and pollution-free transport, storage and handling of marine cargoes and ensuring crew members are appropriately qualified and can fulfil their duties.

The Port State Control Program is undertaken by AMSA under various international maritime safety and pollution prevention conventions, which allow inspection of ships of other flag states visiting Australian ports. The aim is to establish that a vessel's statutory certificates are valid and the hull, machinery, equipment and crewing meet convention requirements to ensure the safety of the crew.

If a ship is inspected and found not to comply satisfactorily with the requirements of the conventions, it may be detained until it is restored to a safe and seaworthy condition. In most cases, rectification of defects can be achieved during a ship's normal scheduled stay in port. However, if deficiencies of a major nature arise, a ship may be delayed in port beyond its scheduled departure time.

The Flag State Inspection Program is performed as part of AMSA's role in providing flag state administration for Australian-registered ships. It is based on the port state control inspection regime for overseas flag ships and the tanker surveillance program where Australian flag vessels undergo the same inspections as overseas vessels in Australian ports.

Ship operational standards administration, in relation to Australian vessels and vessels to which the Navigation Act 1912 applies, involves regulation of all aspects of vessel operations including engineering standards, navigational practices, cargo handling procedures, onboard oil pollution prevention requirements and other safety-related issues.

AMSA publishes the Marine Orders Part 15 (Ship Fire Protection, Fire Detection and Fire Extinction) which applies to all vessels under the Australian flag that are required to be registered for international trade where they may be subject to inspection by foreign governments, ie. SOLAS complying.

The Marine Orders are based, at a minimum, on the SOLAS regulations. Whilst most of the SOLAS provisions are contained within the Marine Orders, reference to the SOLAS publications is required to fully implement the Marine Orders.

The Australian Transport Council has adopted the Uniform Shipping Laws Code as a basis for uniform legislation within Australia's states and territories relating to the construction, survey, manning and operation of commercial vessels in Australian waters. The states and territories are responsible for implementation and administration of the Uniform Shipping Laws Code. A new safety standard is in the process of being implemented.

**This is the first in a series of articles on marine fire protection, by Rick Foster, an ex-marine engineer who is now the (Australian) National Marine Coordinator for Tyco. For further information contact: Tyco Technical Services Group.*
PH: +61 7 5455 5455, FX: +61 7 5455 5202, web: www.tycotech.com.au/marine

Marine fire detection principles

By RICK FOSTER*

When a fire starts, it produces a variety of environmental changes that can be used to detect its presence. A number of mechanical, electrical and electronic devices have been developed to detect these changes.

The most common elements of fire that can be detected are heat, smoke (aerosol particulate), carbon monoxide and light radiation. Complicating the matter is the fact that not all fires produce all of the elements and non-fire conditions can also produce similar ambient conditions.

With the exception of flammable liquid and gas fires, there are four stages in the development of a fire: the incipient stage, the smouldering stage, the flame stage and the heat stage.

Fire detectors are available which respond to each of these four stages.

Thermal (heat) detectors

Thermal detectors are the least expensive and have the lowest false alarm rate of all automatic fire detectors, but are also the slowest in detecting fires.

They are best suited for fire detection in either a small confined space where rapidly building high heat output fires are expected, in compartments where ambient conditions would not allow the use of other fire detection devices, or where speed of detection is not the prime consideration.

Thermal detectors respond either when the detecting element reaches a predetermined fixed temperature or to a specified rate of temperature change. Thermal detectors may be fixed temperature, "rate of rise", a combination of both or "rate compensated" types.

Smoke detectors

Smoke detectors are identified by their operating principle. Two of the operating principles are ionisation and photoelectric. Smoke detectors operating on the photoelectric principle respond faster to the smoke generated by low energy smouldering fires. Detectors using the ionisation principle provide somewhat faster response to high-energy open flaming fires.

Carbon monoxide detectors

For many years it has been known that carbon monoxide's presence can be used as a means of providing early warning of fire. It is an odourless, colourless and tasteless gas. Exposure to low levels for just one or two minutes can lead to permanent brain damage or death. Slow developing and smouldering fires produce large quantities of the gas before traditional detectable smoke aerosols and particulates escape from the fire. In these situations, using carbon monoxide fire detectors, detection occurs hours before ion-chamber or photoelectric smoke detectors operate.

The carbon monoxide fire detector displays other advantages over ion-chamber and photoelectric smoke detectors in its immunity to false alarm sources such as steam or smoke from burnt toast.

Carbon monoxide detection is suitable for a wide range of applications and environments, and is especially appropriate to occupied areas where early warning for escape or action is essential.

Flame detectors

Flames from most fire sources emit electromagnetic radiation including ultra-violet and visible light, and infra-red radiation in various intensities and characteristics of each particular source. Other sources, particularly sunlight and lighting, generate radiation in the same parts of the spectrum and therefore flame detectors must be selected to discriminate flame from other radiation sources.

Flame detectors may be of the ultra-violet type or infra-red type and respond when the radiant energy in their respective sensing band exceeds a preset threshold. They should be chosen for applications where there is the likelihood of rapid flame development so that an alarm is required before products of combustion or heat would have reached smoke or thermal detectors.

The choice of infra-red detectors or ultra-violet detectors or some combination will depend on the typical radiation from the expected fire hazard and the presence of false alarm sources.

Combination UV/IR detectors and dual or triple spectrum IR detectors have largely overcome the inherent false alarm problems of single spectrum detectors.

Gas detectors

Although not a fire detector, detection of flammable and combustible gases or liquid vapours is desirable to alert the possibility of fire or explosion should a source of ignition become present.

Control and indicating equipment

The great technological change in the electronics industry over the past 25 years has seen the microprocessor replace the relay as the heart of the fire alarm panel. Similarly, the "intelligent" microchip has replaced a simple contact switch as the source of alarm in modern fire detectors.

From the 1940s to the later 1970s fire detection systems were relatively simple. A group of detectors, associated with a zone, was linked on a circuit to an alarm group module in a fire alarm panel. If a detector alarm occurred, a red lamp lit up on the panel to indicate the general alarm location and the fire alarm circuit was activated.

The introduction of solid state, transistorised detectors and solid state fire alarm panels enabled the first form of "addressability" to be introduced by incorporating low cost LED alarm indicators in each detector.

Later developments with the availability of inexpensive microprocessor chips allow much of the decision making to be done in the panel, now called control and indicating equipment (CIE). Alarm decisions can now be made under the control of software, and the central processing unit of systems is itself microprocessor based.

The most important change that has occurred, however, is that detectors cannot be considered separately from the panel. Rather, the detectors and CIE are truly part of a unified communication system.

In analogue addressable systems each detector contains smart electronics that can transmit a signal that is an analogue of the level of heat, smoke, etc. sensed by the detector. The measured parameter is converted in the detector from an analogue value to multiple levels which is then transmitted as digital pulses with other data such as detector type, location, and so on. The analogue signals from each detector are monitored by the CIE, which compares each signal level with a predetermined threshold level set by software in the CIE, ie. the decision making as to whether there is an alarm condition is made at the CIE, not at the detector.

*This is the second in a series of articles on marine fire protection by Rick Foster, the National (Australian) Marine Coordinator for Tyco Technical Services. PH: +61 7 5455 5455, FX: +61 7 5455 5202, web: www.tycotech.com.au/marine

Firefighting with FM200 has advantages

FM200 is a mature, tested and approved firefighting Hydroflourocarbon agent and currently one of several favoured replacement agents for Halons in the marine industry.

Under normal conditions FM200 is an odourless and colourless gas with a density about six times greater than air. It contains no particulates or oily residues and is produced under an ISO 9002 manufacturing regime.

Present understanding is that FM200 extinguishes fire by a combination of heat absorption and chemical interference with the chain reaction of flame propagation by action of the fluorine radical.

With a design concentration for marine applications set at 8.7 per cent (the current IMO design concentration), and where FM200 has a No Observable Adverse Effects Level (NOAEL) of nine per cent and a Lowest Observable Adverse Effects Level (LOAEL) of 10.5 per cent; FM200 would be permitted under various standards to be used in normally occupied areas subject to inbuilt system safety features.

When discharged into machinery spaces that contain no hot or working internal combustion machinery, such as the bow thruster or propulsion rooms, or machinery or generator rooms where the diesel engines are not operating; FM200 poses no safety risks to personnel occupying such spaces.

Personnel in such spaces should, however, be aware that the discharge will cause a reduction in visibility, air turbulence, noise and the risk of direct contact frostbite burns to exposed skin and should evacuate the area without delay.

When discharged into machinery spaces where hot equipment exists, it should be noted that FM200 decomposes at temperatures above 700°C to form halogen acids.

Marine systems are arranged for manual discharge usually after manual fire fighting intervention has become ineffective. Accordingly personnel should be aware that discharge of FM200 in such "hot" spaces where exhaust manifolds and the like exist, can produce toxic decomposition products and they should evacuate the space without delay.

Where discharge of FM200 occurs into spaces where internal combustion engines are running, and, where the combustion air is drawn from within the spaces, it should be noted that the resultant FM200/air mixture will be ingested and the exhaust will contain toxic products of decomposition. Accordingly steps should be taken to shut down such operating equipment if safe to do so and ensure that the exhaust products are prevented from being blown on to the deck area or taken into the general air intakes for the ship.

When discharged into machinery spaces under fire conditions, it should be noted that FM200 decomposes at temperatures above 700°C to form halogen acids. Whilst these decomposition products are toxic, it should be remembered that the products of decomposition from the fire are also toxic. Accordingly, FM200 discharge should only be effected after ensuring that all personnel are evacuated from the compartment.

FM200 is stored in fabricated steel containers constructed to International Standards at a pressure of 2.48MPa at 20°C. As the FM200 has a vapour pressure of 0.3MPa at 21°C the container is pressurised to 2.48MPa with nitrogen to provide the required energy source for discharge.

Each container is fitted with a discharge valve, which holds the agent within the container. On actuation of this valve, the agent is discharged into the protected compartment.

Typical installation consists of six 180 litre containers arranged in two rows.

Where containers are installed outside the protected compartment, a control unit encompassing an isolating valve and manual pull station together with operation instruction plates is required.

Audible and visual alarms are provided in each protected compartment to alert occupants of impending discharge. These alarms are actuated by a microswitch at the appropriate control unit. Each alarm unit comprises a sounder and a flashing beacon. Warning signs on the entry doors and/or hatches to the compartment are also required.

After release of the agent from the container(s), it is discharged into the protected compartment by means of fixed pipework and distribution nozzles.

The system shall be designed such that 95 per cent of the agent is discharged in 10 seconds to provide an 8.7 per cent concentration of FM200 within the protected compartment.

Container selection can be from a standard range of containers with capacities from 3.25kg to 180kg.

This is the latest in a series of articles on marine fire protection by Rick Foster, the Australian Marine Coordinator for Tyco.

For further information contact:
Tyco Technical Services,
PH: +61 7 5455 5455, FX: +61 7 5455 5202,
web: www.tycotech.com.au/marine

Litton Marine wins contract to supply navigation electronics for fast attack craft

Litton Marine Systems has won an order from Thomson-CSF Signaal to provide navigation radar systems for three new fast attack craft to be built for the Hellenic Navy.

Signaal is the supplier to UK shipbuilder Vosper Thornycroft of the combat system for the three 62 metre "Super Vita" fast attack craft, which will be built at Elefsis Shipbuilding and Industrial Enterprises in Greece under a cooperation agreement with the designer Vosper Thornycroft.

Each of the vessels is to be fitted with a Decca BridgeMaster E radar with special naval transceiver and two 250mm color ARPA display consoles. The BridgeMaster E radar will be integrated with Signaal's Scout MK II low probability of interception (LPI) tactical radar, and will also interface with the Signaal TACTICOS combat management system. Signaal will supply the integrated combination to Vosper Thornycroft.

Under a separate contract with Vosper Thornycroft, Litton Marine Systems will also supply a Sperry MK39 MOD3A ring laser gyro inertial navigation system for each ship. The system will be used to provide outputs of position, heading, attitude and velocity data for fire control stabilization and weapons initialization.

Vosper Thornycroft is responsible for the design and integration of the three fast attack craft, which will be built at the Elefsis shipyard near Athens. The vessels will have a steel hull and aluminum superstructure, with speeds of around 35 knots. They will be equipped with surface-to-air and surface-to-surface missiles.

For further information contact:
Litton Marine, 1070 Seminole Trail, Charlottesville, VA 22901, USA.
PH: +1 804 974 2000, FX: +1 804 974 2259.
web: www.litton-marine.com

CO_2 firefighting systems need careful installation

Due to its use over many years, CO_2 has, by default, received international approval and is specifically nominated within SOLAS and other marine regulations as applicable for machinery space and cargo hold protection.

In low concentrations CO_2 is not a toxic gas, however, exposure to the high concentrations required for firefighting, will quickly kill a person. It is most important, therefore, that those involved with design and operation of CO_2 systems should be acquainted with all safety requirements.

A CO_2 firefighting system consists of a fixed supply of carbon dioxide connected to fixed piping with nozzles to direct the agent into the protected compartment. Marine CO_2 systems are always of the total flooding type and are used to protect three principal compartment types, each of which have different design considerations:

- Cargo holds.
- Cargo spaces and Ro-Ro decks on vessels carrying vehicles with fuel in their tanks.
- Machinery spaces and other flammable liquid risks including cargo pump rooms, paint lockers and the like.

Machinery compartment systems are always manually operated using several control stages. Such a structured release process is necessary because of the agent's inherent danger.

Cargo hold protection is also always manually operated and often includes a "smoke sampling" system where the CO_2 distribution pipework is also used to draw a sample of the compartment atmosphere for analysis.

In high pressure installations, the CO_2 is stored in forged steel or extruded aluminium containers, usually of 45kg or 32kg capacity. Containers are manifolded together to provide for the discharge of all necessary containers required for the particular compartment.

Each container is fitted with a discharge valve. On actuation of this valve, the agent is discharged into the manifold and thence to the protected compartment.

In a low-pressure storage tank the CO_2 is refrigerated in order to maintain the pressure at around 2.1MPa at -18°C. Storage tank sizes range from four to 60 tonnes.

CO_2 storage is only required to be provided for the largest compartment. Under SOLAS, containers must be installed outside the protected compartment.

A Control Unit encompassing an isolating valve and manual operating station together with Operation Instruction Plates is required. Machinery compartment control and actuation may be effected by various manually-operated means including systems employing cables, pneumatics or electrics.

In all control and actuation options an isolating valve is provided in the supply pipe to the compartment. This valve may be arranged for manual opening or may be pneumatically or electrically operated. The opening of the valve requires a distinct and separate function to that of discharging the containers.

Cargo hold control and actuation may be effected by the same means although the isolating or directional valves are almost always manually operated.

Audible and visual alarms are required to be provided in each protected compartment to alert occupants of impending discharge and warning signs are required at the entry points.

After release, the agent is discharged into the protected compartment by means of fixed pipework and distribution nozzles. Machinery compartment distribution of the agent should ensure that all areas are protected.

In cargo holds, distribution should be at deckhead level, especially if a smoke sampling system is incorporated.

For machinery compartments the system shall discharge 85 per cent of the agent in two minutes. For cargo spaces and Ro-Ro decks, 67 per cent shall be discharged in 10 minutes. Note that unless a vehicle space can be completely sealed, CO_2 would not be allowed to be used.

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For further information contact:
Tyco Technical Services.
PH: +61 7 5455 5455, FX: +61 7 5455 5202,
web: www.tycotech.com.au/marine.

Machinery space fire suppression systems – an overview

The requirements for the protection of Category "A" machinery spaces in vessels are detailed within SOLAS (and in Marine Orders Part 15 in Australia). These regulations require that a machinery space be fitted with either a fixed gas fire extinguishing system, a high expansion foam system or a pressure water spraying system.

Gaseous systems

With the demise of Halons and the emergence of the plethora of alternative gaseous agents, the various National administrations are unlikely to accept steam or inert gas systems as meeting modern fire protection performance requirements.

The first stage of this change in attitude was the publication of IMO MSC Circular 848 (June 1998) which detailed a real fire test regime which candidate gaseous agents were required to undergo and pass before being accepted as "alternative" agents.

A variety of gaseous agents have been tested and may be considered to be candidates for marine systems.

CO_2

A mature, tested and approved agent and currently the only agent listed in SOLAS. It is in use in many marine systems. The design concentration (30 to 40 per cent) is above the Lowest Observed Adverse Effects Level (LOAEL) and the No Observed Adverse Effects Level (NOAEL).

NAF S-III

A mature, tested and approved agent currently in use in many commercial vessels and some naval vessels. As with all Halocarbons, high levels of HF production occur on decomposition. The design concentration (12 per cent) has recently been assessed as being above the NOAEL and LOAEL of 10 per cent.

NAF S-III is classified as a transient replacement agent and may only be utilised for the replacement of existing halon systems in unmanned machinery spaces. It has passed the IMO test regime and has USCG and UK MCA approvals.

FM200

Currently a favoured replacement agent for halons in the US Navy, FM200 is in use in commercial vessels and some other naval vessels. As with NAF S-III high levels of HF production occur on decomposition. The design concentration (8.7 per cent) is below the LOAEL (10.5 per cent) and the NOAEL (9.0 per cent). It has passed the IMO test regime and has USCG and MCA approvals.

Inergen

A mature, tested and approved agent in use in some commercial vessels. Unlike halocarbons, no HF production occurs on decomposition. The design concentration (40 per cent) is below the LOAEL (52 per cent) and the NOAEL (43 per cent).

It has passed the IMO test regime and has AMSA, USCG and MCA approvals.

Foam systems

National administrations are unlikely to accept high expansion foam systems as meeting modern fire protection performance requirements.

Water spray systems

National administrations are unlikely to accept the "specified" pressure water spraying systems.

IMO MSC Circular 914 (June 1999) details a real fire test regime which candidate water systems are required to undergo and pass before being accepted as "alternative" agents.

Various companies have developed and tested "water mist" systems to meet the new performance criteria. Important points to consider regarding water mist are:

- Water mist cannot be likened to a gaseous system where the quantity of water is based on the compartment volume.
- Most fire protection companies are involved in some degree of equipment and fire testing for water mist.
- In the IMO tests, candidate fire extinguishing agents, which include halocarbon gases and water mist systems, are tested in an enclosure of a minimum $100m^2$ and five metres in height. An engine mock-up is installed within this enclosure. Various pan and pressure fires using diesel, heptane and a wood crib are ignited and the candidate agent/system is required to extinguish the fires within a specified time.
- Gaseous systems, once successful at this $500m^3$ test protocol, are deemed acceptable up to any volume at their tested nozzle spacing. Water mist systems, however, are limited to the volume tested as water mist does not act like a gaseous agent. The concept of deckhead only nozzles and separate lower level protection however is part of the test.
- IMO will soon be promulgating requirements for local water mist systems to be installed on new vessels, especially tankers and quite possibly offshore production ships. Such systems are designed to provide automatic water mist fire suppression on and around specific high hazard areas in machinery spaces. The adoption of such systems is thought to be one answer to the difficulty in protecting very large spaces with a single water mist system.

In summary, the choice for machinery space protection to meet SOLAS and national requirements now rests between CO_2, FM200, Inergen and water mist.

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web: www.tycotech.com.au/marine.