Fixed Fire Extinguishing Equipment and Systems

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DESIGN AND INSTALLATION OF FTXED SYSTEMS

Fire extinguishing systems are designed and installed in a ship as a part of its original construction. The ship's master, officers, and crew members rarely have any influence on the type of fire fighting systems employed. Marine and fire protection engineers generally make these decisions to conform with Coast Guard Regulations. The crew's duties require them learn how the systems operate, perform proper maintenance and conduct required tests and inspections.

Many factors must be analyzed when a fixed extinguishing system (or combination of systems) is installed on a ship. A study is made of the overall ship design and the potential fire hazards. Among the things considered are:

Fire classes (A, B, C, and D) of potential hazards	Exposures
Extinguishing agent to be employed	Effects on the ship's stability
Locations of specific hazards	Methods of fire detection
Explosion potential	Protection of the crew

United States ships use seven major types of fixed fire-extinguishing systems:

Fire-main systems	Carbon dioxide systems
Automatic and manual sprinkler systems	Halon 1301
Spray systems	Dry chemical systems
Foam systems	

The first four systems are liquid extinguishing agents; the next two use gaseous agents, the last uses solid agents. Each of these systems is discussed in the sections that follow.

FIRE-MAIN SYSTEMS

The fire-main system is the ship's first line of defense against fire. It is required no matter what other fire extinguishing systems are installed. The fire-main system is composed of the fire pumps, piping (main and branch lines), control valves, hose and nozzles.

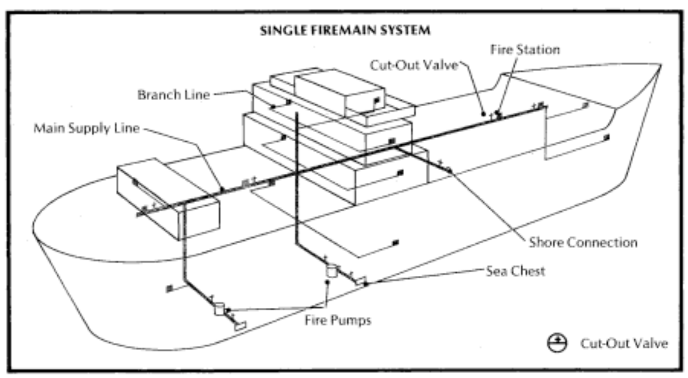

Figure 1: Typical Single Main System

Hydrants And Piping

The piping must be large enough in diameter to distribute the maximum required discharge from two fire pumps operating simultaneously. The water pressure in the system must be approximately 50 psi at the two hydrants that are highest or furthest, whichever results in the greatest pressure drop, for cargo and miscellaneous vessels, and 75 psi for tank vessels. This requirement insures that the piping is large enough in diameter so that the pressure produced at the pump is not lost through friction in the piping.

There are two basic main-pipe layouts, the single main (figure 1)and the horizontal loop (figure 2).

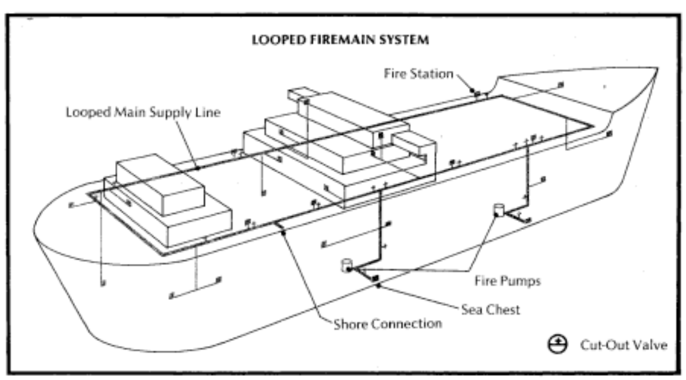

Figure 2: Typical Horizontal Loop Fire Main System

Single Main System

Single main systems make use of one main pipe running fore and aft, usually at the main deck level. Vertical and horizontal branch lines extend the piping system through the ship.

Horizontal Loop System
The horizontal-loop system consists of two parallel main pipes connected together at their furthest points fore and aft to form a complete loop.

Shore Connections
At- least one shore connection to the fire main system is required on each side of the vessel. A vessel on an international voyage must have at least one portable international shore connection available to either side of the vessel (figure 3).

Figure 3: Portable International Shore Connection for Ship's Fire Main.

FIRE PUMPS

Two independently powered fire pumps are required on a tank ship 76 meters (250 ft) or more in overall length or 1016 metric tons (1000 gross tons) and over on international voyages. A cargo or miscellaneous vessel of 1016 metric tons (1000 gross tons) and over also requires at least two independently powered fire pumps regardless of its length. All passenger vessels up to 4064 metric tons (4000 gross tons) on international voyages must have at least two fire pumps, and those over 4064 metric tons (4000 gross tons) must have three pumps, regardless of their lengths. On vessels that are required to carry two fire pumps, the pumps must be located in separate spaces. The fire pumps, sea suction and power supply must be arranged so that the fire in one space will not remove all the pumps from operation and leave the vessel unprotected.

Engineering personnel are usually charged with the responsibility for maintaining and testing the ship's fire pumps, to ensure their reliability during an emergency.

Water Flow
Each fire pump must be capable of delivering at least two powerful streams of water from the hydrant. outlets having the greatest pressure drop, at a pitot-tube pressure of 75 psi for tanker vessels and 50 psi for passenger and cargo vessels.

Safety
Every fire pump must be equipped with a relief valve on its discharge side. The relief valve should be set at 125 psi, or 25 psi above the pressure necessary to provide the required fire streams, whichever is greater. A pressure gauge must also be located on the discharge side of the pump.

FIRE STATIONS

Fire stations are located to ensure that the water streams from at least two hydrants will overlap. United States Coast Guard regulations specify hydrant locations as follows:

Fire hydrants shall be sufficient in number and so located that. any part of the vessel, other than main machinery spaces, is accessible to persons onboard while the vessel is being navigated and all cargo holds may be reached with at least two streams of water from separate outlets At least one of these streams shall be from a single length of hose.

In main machinery spaces, all portions of such spaces shall be capable of being reached by at least two streams of water, each of which shall be from a single length of hose from separate outlets.

Fire stations should be numbered sequentially as required by regulations on all vessels to be certified by the Coast Guard.

Hydrants
The fire station hydrant (figure 4) has three major components: (1) a control valve; (2) the hose connection, (either 1-1/2 or 2-1/2 in.) with appropriate threads; and (3) a hose rack.

Regulations require that:

- Each fire hydrant outlet must have a valve that allows the hose to be removed while there is pressure in the fire-main system.
- The fire hydrant outlet may be in any position, from horizontal to pointing vertically downward. It should be positioned to minimize the kinking of the fire hose.
- The threads on the fire hydrant outlet must be National Standard fire-hose coupling threads. These standard threads allow all approved hose to be attached to the hydrant.

A rack must be provided for the proper stowage of the fire hose. A hose must be stowed in the open or where it is readily visible.

All water enters the fire main system through the sea chest, which is frequently covered with marine growth. It would thus be good practice to fit all hydrant outlets with self cleaning strainers. These strainers remove matter that might clog the nozzle, particularly the fine holes in combination nozzles and low velocity applicators.

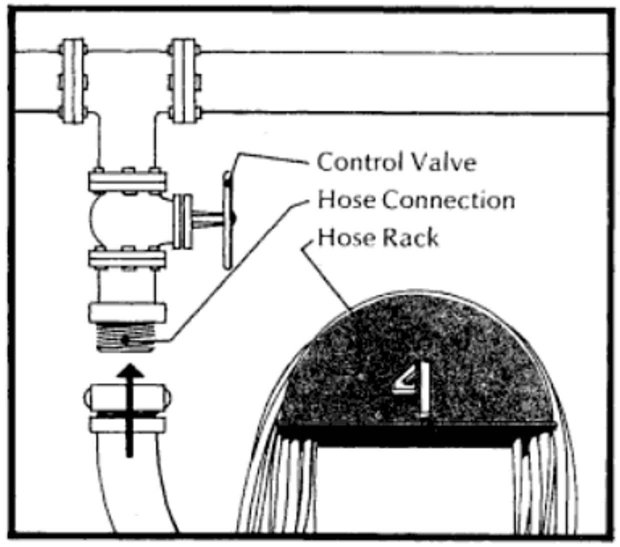

Figure 4: The required components of a fire station hydrant

Fire Hose, Nozzles and Appliances
A single station should have the following equipment:

Hoses - A single length of hose of the required size, type, and length: 63.5 mm (2-1/2 in.) diameter hose is used at weather deck locations; 38.1 mm (1-1/2 in.) diameter hose is used in enclosed areas. The hose must be 15 m (50 ft.) in length, except on the weather decks of tankers. The fire hose must be connected to the hydrant at all times, with the appropriate nozzle attached.

Fire hose may not be used for any purpose other than testing and fire drills.

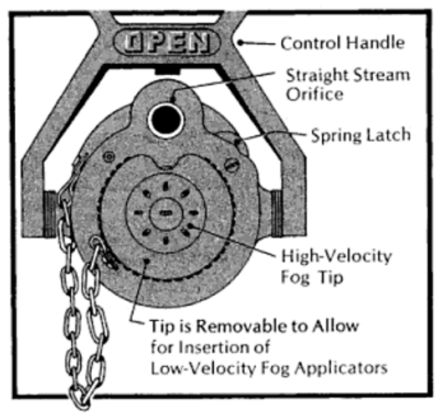

Figure 5 - All Purpose Nozzle

Nozzles - A nozzle, preferably of the combination or all purpose type (figure 5) so that water flow may be controlled, must be connected to the hose at all times.

Fog Applicator - A low-velocity fog applicator for use with the required combination nozzle, must be provided at each station. On exterior decks, applicators should be 3.0-3.6 m (10-12 ft.) in length. In machinery spaces, applicators are limited to 1.8 m (6 ft.) in length.

Other Useful Tools - A spanner wrench whose size matches the hose coupling, or an adjustable spanner wrench. Depending on the location of the fire station, a pick head ax may also be required. A fully equipped fire station is shown in Figure 6.

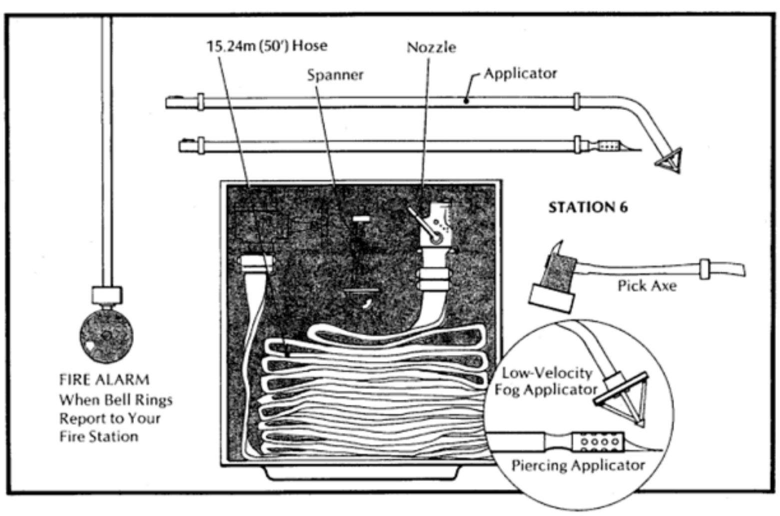

Figure 6 - Shipboard Fire Station Equipment

WATER SPRINKLER SYSTEMS

United States ships are constructed in accordance with Method I of the Safety of Life at Sea (SOLAS) convention. Method I calls for fire protection through the use of non combustible construction materials, rather than reliance on automatic sprinkler systems. For this reason, sprinkler systems are not widely used on U.S. merchant vessels. They are generally used only to protect living quarters, adjacent passageways, public spaces, and vehicular decks on roll-on/roll-off (ro-ro) vessels and ferryboats.

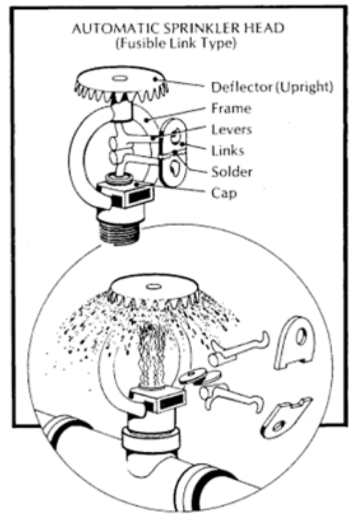

Figure 7
Sprinkler Head Operation

Components of Sprinkler Systems

All sprinkler systems consist of piping, valves, sprinkler heads, a pump, and a water supply.

Sprinkler Heads

The heads are actually valves of a special design. They release water from the system and form the water into a cone shaped spray. A sprinkler head is made up of a threaded frame (for installation into a branch pipe), a waterway, and a deflector for forming the water spray pattern. Sprinkler heads for automatic systems may be equipped with a fusible link. The link keeps the head closed normally. Heads for manual systems are open normally and do not require a fusible link (figure 7).

USCG regulations require that each protected space have sufficient heads located so that no part of an overhead or vertical projection of a deck is no more than 2.1 m (7 ft) from a sprinkler head.

Fusible Links

A fusible link is a pair of levers, held within the sprinkler head frame by two links. The links are connected by eutectic alloy or a similar low melting-point metal (Figure 7). In operation, heat from the fire melts the solder holding the fusible links together. As the links separate, the levers holding the valve closed come apart. Water pressure is then able to push the cap off the sprinkler outlet allowing water to flow up against the deflector. The water then forms a fine spray which falls on the fire. The spray then absorbs the heat of the fire by changing state from water to steam. This event cools the fire by removing the latent heat of vaporization required by the steam and also smothers the fire because the steam quickly displaces the oxygen needed by the fire.

Table 1 - Common Color Code and Operating Temperatures of Sprinkler Heads

Color Code	***Operating Temperature, F***
Uncolored	135, 150, 160, 165
White	175, 212
Blue	250, 280, 286
Green	325, 340, 350, 360
Orange	450, 500

The sprinkler heads used on some ships may be color coded to indicate the temperature at which the fusible metal (solder) will melt and activate the head. Table 1 provides the standard operating temperatures of sprinkler heads and the corresponding color codes. The color is painted on the frame arm of the sprinkler head. No other part of the sprinkler head should be painted, especially the fusible element. The paint would insulate the fusible metal from the heat of the fire and keep it from melting at its operating temperature.

The sprinkler heads normally used on ships are those that operate between 135F and 165F or 212 F and are unpainted or white. Heads with lower operating temperatures are used in spaces where normal temperatures can be expected, such as living spaces. Higher temperature heads are used where temperatures above normal are expected, such as galley areas.

Automatic sprinkler systems (figure 8)are not used extensively on U.S. merchant ships. The automatic sprinkler makes use of closed sprinkler heads (figure 9.9) so the piping can be charged with water. The fusible links serve as the fire detectors and the activating devices. The pressure tank serves as the initial water source and is two thirds filled with fresh water. The remainder of the tank is pressurized with air and propels the water through the system.

The manual sprinkler differs from automatic systems in two respects: 1) the sprinkler heads are normally open and (2) the piping does not normally contain water. Water is supplied to the manual system by the ship's fire pumps. No pressure tank is required in this system.

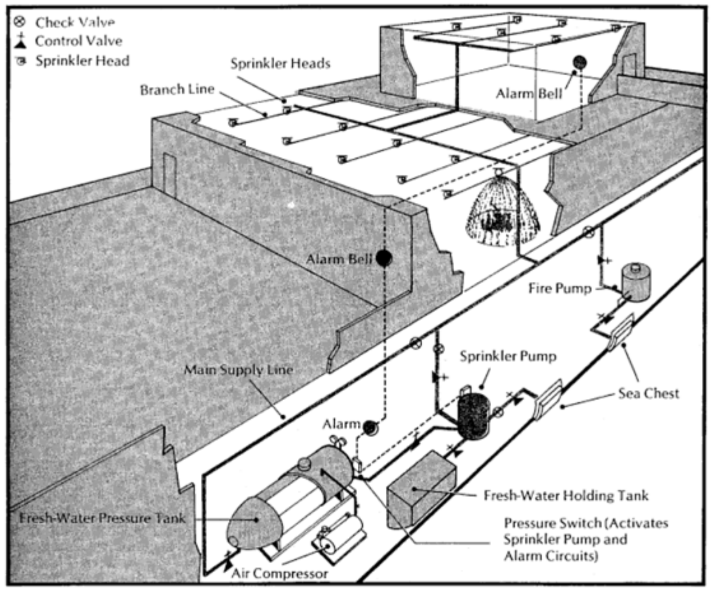

Figure 8 - Automatic Sprinkler System

FOAM SYSTEMS

Foam is used mainly in fighting class B fires, although low expansion foam with a high water content can be used to extinguish class A fires. Foam extinguishes mainly by smothering with some cooling action. Chemical foam is produced by chemical reactions taking place in water. The foam bubbles are filled with CO_2. Mechanical- foam is produced by first- mixing foam concentrate with water to produce a foam solution then mixing air with the foam solution. The bubbles are then filled with air.

Chemical foam generators have been replaced by mechanical foam generators on almost all vessels. Chemical foam systems are no longer approved for installation by the U.S. Coast Guard. However, older ships may still use chemical foam systems provided they are in good condition and operate properly.

Mechanical foam concentrate is available in 3% and 6% concentrations. It may be mixed with either fresh or salt water to produce a foam solution. To mix 100 gallons of mechanical foam, 3 gallons of 3% concentrate is mixes with 97 gallons of water. Likewise, 6 gallons of 6% solution is mixed with 94 gallons of water.

When the foam solution is then mixed with air, it expands. The expansion ratio of the foam indicates the proportions of air and water it contains. A foam expansion ratio is defined as the quantity of moisture contained in a given quantity of foam. A 4:1 expansion ratio means that there are 3 gallons of air per gallon of foam solution. High expansion foam has a ratio of approximately 1000:1.

CARBON DIOXIDE SYSTEMS

Carbon dioxide (CO_2) systems are used to protect cargo spaces, pump rooms, generator rooms, storage spaces such as paint and lamp lockers, galley ranges and duct systems. They are also used in engine rooms and to protect individual generators.

As an extinguishing agent, C02 is especially adaptable to shipboard use. It will not damage expensive cargo or machinery and it leaves no undesirable residue to be cleaned off equipment and decks. Additionally, it does not conduct electricity, and so can be used on live electrical equipment. Typically it is released as a liquid under pressure and expands to a dense gas at atmospheric pressure. It will remain at the lower levels of a space until it diffuses with time and a temperature rise.

There are some disadvantages to C02. The amount that can be carried on a ship is limited because it. must be stored in cylinders under pressure. CO_2 has little cooling effect on materials that have been heated by the fire. Instead, C02 extinguishes fire by smothering, i.e. by displacing the oxygen content in the surrounding air to 15% or lower.

CO2 is hazardous to humans. The minimum concentration sufficient to extinguish fire does not reduce the oxygen content of the air to a hazardous level. However, when inhaled, the C02 raises the acidic level of the blood. The prevents the hemoglobin from absorbing oxygen in the lungs which can lead to a respiratory arrest. Thus it is extremely dangerous to enter any compartment in which CO2 has been discharged.

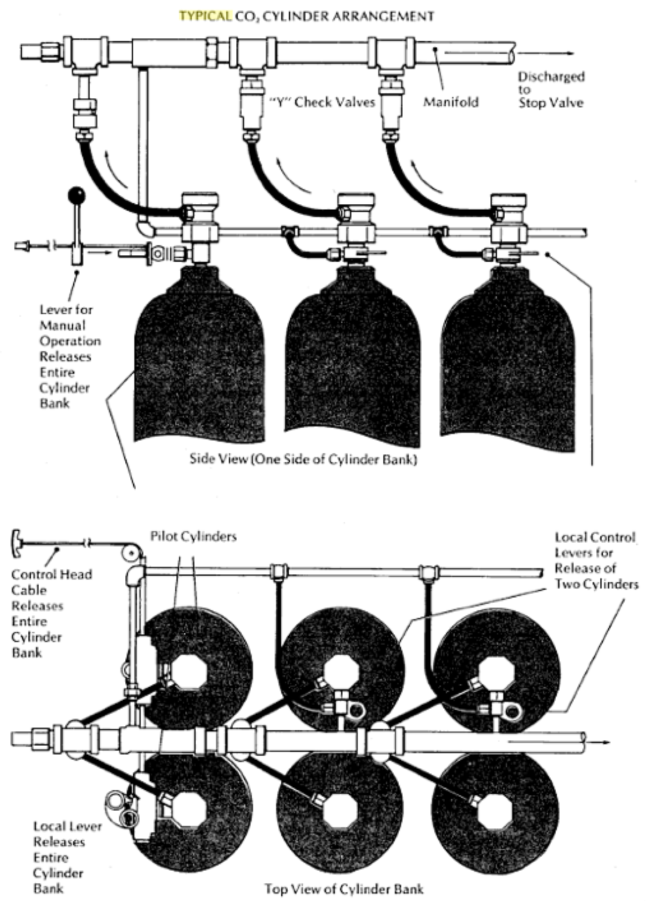

Figure 9 - Typical CO2 Cylinder Arrangement

Types of CO2 Marine Systems

Two fixed CO2 systems (figure 9) are used for the vessel's protection. The total flooding system is used for machinery spaces and the cargo system for holds and compartments. A total flooding system for the machinery space is activated only as a last resort after all other extinguishing methods have been tried and have failed t.o control the fire. This system for machinery spaces expels 85% of its total CO2 capacity within 2 minutes to achieve rapid saturation of the air with CO2 and quick extinguishment.

The cargo system is not activated immediately upon discovery of the fire. The involved space (usually a cargo hold) is first sealed, then the agent is introduced into the space at- a preset rate to reduce and maintain the oxygen content at a level that will not support combustion. Cargo systems are used in a break-bulk, ro-ro and stacked-container cargo holds.

Actuating a Typical Total Flooded System

The total-flooding system is actuated manually by pulling two cables (figure 10). Coast Guard regulations require that the pull boxes be located outside the area being protected, for example, outside an engine room doorway that would be a normal route to escape. The cable pull-s are protected by glass to prevent tampering.

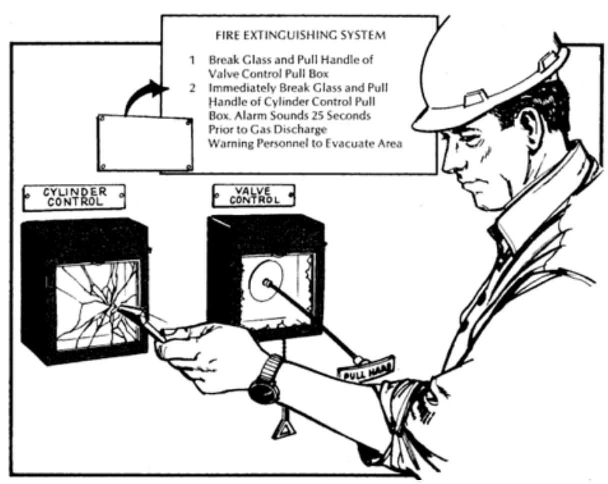

Figure 10 - Actuating a Total Flooding CO2 System

The cables must be pulled in the required sequence. Instructions explaining how to actuate the system should be posted over the pull boxes (Figure 9.20) . One cable is connected to the control heads on the pilot cylinders; the other is connected to a control head mounted on the pilot port valve. When both cables are pulled, CO2 discharges from the two pilot cylinders and opens the pilot port valve. The CO2 is delayed from discharging into the fire area by a stop valve. About 20 seconds is required for the C02 to pass through the discharge delay device. During this time, ventilation systems are shut down and alarm devices are actuated. After the approximately 20 second delay, the C02 acts on a pressure control head mounted on the stop valve. The valve opens permitting C02 to discharge into the protected space.

Carbon Dioxide Warning Alarm

An approved audible alarm must be installed in every space protected by a C02 extinguishing system (other than paint and lamp lockers and similar small spaces) and normally accessible to persons onboard while the vessel is being navigated. The alarm must be arranged to sound automatically for at least 20 seconds prior to the discharge of CO2 and must not depend on any source of power other than the C02 The alarm must be conspicuously and centrally located and marked “WHEN ALARM SOUNDS VACATE AT ONCE. CARBON DIOXIDE IS BEING RELEASED”.

Independent Carbon Dioxide Systems

The paint locker, lamp locker, engineer’s paint locker and generator rooms can be protected by independent fixed CO2 systems,i.e., each system has its own CO2 supply , independent of other CO2 systems.

Inspection and Maintenance of Carbon Dioxide Systems

Carbon dioxide systems are reliable when they are maintained properly. At least once a month each fixed C02 system should be checked to ensure that nothing has been stowed so as to interfere with the operation of the equipment or with access to its controls. All nozzles and piping should be checked for obstruction by paint, oil or other substances. The semi-portable hose reel horn valve should be operated several times. any damaged equipment must be replaced immediately.

It is recommended that a qualified fire protection technician or engineer make an annuaL inspection. A cylinder is considered satisfactory if its weight is within 10% of the stamped full weight of the charge.

MARINE HALON 1301 SYSTEM

A halogenated extinguishing agent, Halon 1301, has been accepted by the Coast Guard for limited use in fixed fire fighting systems aboard U.S. ships. Halon 1301 is a very efficient extinguishing agent for fires involving flammable liquids and gases and live electrical equipment. It is a clean agent; its residue does not contaminate electrical contacts or circuits. It is a nonconductor of electricity. Halon 1301 is a colorless, odorless gas. It may be toxic when exposed to flames. When the flames are extinguished quickly, a minimal amount of toxic material is produced. Slow extinguishment allows increased production of toxic materials at levels that could be dangerous to personnel. When applied in the proper concentration and at the proper delivery rate (usually less than 10 seconds), it extinguishes flames very rapidly. The spaces for which Halon 1301 systems have been approved are those normally protected by C02 systems. Thus, Halon 1301 systems must meet all the design requirements for CO2 total flooding systems (figure 11).

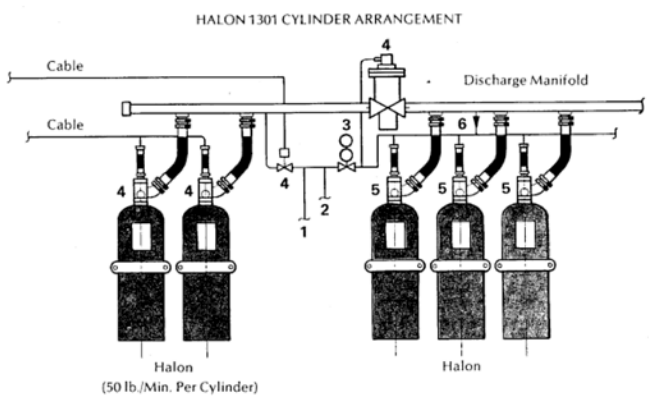

Figure 11 - Halon 1301 System

GALLEY PROTECTION

Three areas within the galley are especially subject to fire. These are the cooking area, including the frying griddles, broilers, deep-fat fryers and ovens; the area immediately behind the filter screens. called the plenum; and the duct system that vents heated gases.

Fire Prevention

Ventilation plays a critical part in protecting the range area against fire. The function of the exhaust blower is not simply to remove odors, its main function is to move sufficient air to keep the entire facility at a safe operating temperature. The blowers and the airflow under the hood and the ducts are designed to keep the temperature from exceeding 200 F.

Dry Chemical Galley Range System

The dry chemical galley system is composed of a pressurized dry chemical cylinder, piping, nozzles and detectors. Several types of fire detectors can be used. Most systems use several- fixed temperature fusible links connected by stainless steel cable. The links and cable are connected to a stretched spring. If any fusible link melts, the cable releases the spring, which closes an electric circuit. The resulting current opens the valve of the dry chemical cylinder, releasing its entire contents into the system.

STEAM SMOTHERING SYSTEMS

Steam smothering systems for fire fighting are not installed on U.S. ships contracted on or after January 1, 1962. Steam for smothering systems may be generated by the main or auxiliary boilers and the steam pressure should be at least 100 psi. The boilers should be capable of supplying at least 1 lb. of steam per hour per square foot of the largest cargo compartment

Valves and Controls

The steam supply line to each manifold must be fitted with a master valve at the manifold. The branch line to each compartment must be fitted with a shutoff valve. The valve must be clearly marked to indicate the protected space.