



GUIDANCE NOTES ON

FIRE-FIGHTING SYSTEMS

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Foreword

Purpose

The ABS Rules incorporate many requirements intended to prevent the onset of a fire. However, even with all the preventative measures taken, shipboard fires still occur. Therefore, the proper design, installation and operation of the vessel's fire-fighting systems are critical to the safety of a vessel and the personnel onboard.

Since fire-fighting systems are so critical, the designs and arrangements of such systems should be carefully evaluated for compliance with the ABS requirements by the designer and ABS Engineering staffs. These Guidance Notes have been developed to assist in a better understanding of the ABS requirements for such systems. They are intended to provide a general overview of ABS requirements that should be considered during technical plan review activities. These Guidance Notes also examine the basic scientific fundamentals of fire, as appropriate for a proper understanding and application of the ABS requirements. Accordingly, this document should be considered as general guidance only and the technical reviews of fire-fighting systems should verify compliance with all ABS Rules applicable to the specific vessel involved.

Note: Rule references in these Guidance Notes (e.g. 4-7-2/1.1.1, etc.) are typically to the requirements found in the ABS *Rules for Building and Classing Steel Vessels*, unless noted otherwise.

Scope

The scope of this document is limited to the review of ABS requirements considered during the technical plan review of active fire-fighting systems onboard ABS-classed vessels. Passive fire protection arrangements, such as structural fire protection, as well as fire detection systems, are outside the scope of this document. Fire-fighting systems of offshore facilities and installations are also outside the scope of this document.

The review of fire-fighting systems for the International Maritime Organization's (IMO's) International Convention for the Safety of Life at Sea (SOLAS) requirements is also not within the scope of this document. However, in many cases, the ABS Rules for fire-fighting systems either incorporate or directly reference IMO SOLAS fire-fighting system requirements. Accordingly, within the discussions of the ABS requirements for various fire-fighting systems, related "interpretations" of the associated SOLAS requirements, as developed by the International Association of Classification Societies (IACS), are identified. These IACS interpretations are called Unified Interpretations (UI). As an IACS member, The Bureau (ABS) is obligated to apply these UIs as appropriate interpretations of the SOLAS requirements, unless directed otherwise by the Flag Administration. Interpretations provided in the UIs should be considered when conducting technical plan reviews.

Note: Development of appropriate Unified Interpretations and revision of existing UIs is an ongoing effort within the IACS Working Parties. Therefore, attention is directed to the latest edition of the IACS UI being available on the website <http://www.iacs.org.uk/index1.htm>.

In addition to the IACS UIs, IMO MSC Circular 847, "Interpretations of Vague Expressions and other Vague Wording in SOLAS Consolidated Edition 1997 Chapter II-2," also provides guidance regarding SOLAS fire-fighting system requirements. Many of the MSC Circular 847 interpretations are based upon the IACS UI interpretations, while others provide revised or additional interpretations of the SOLAS requirements. A number of the MSC Circular 847 interpretations have been included in the SOLAS 2000 consolidated edition. Consequently, these requirements were also incorporated into the ABS Rules. However, since the MSC Circular 847 interpretations identify useful information and guidance relative to certain Rule requirements, "selected" IMO MSC Circular 847 interpretations have also been identified.

Note: Regarding classification requirements, MSC Circular 847 interpretations which are not included within SOLAS have not necessarily been officially adopted by the Bureau and should only be applied as directed by the ABS Technical Consistency Department. Further, MSC Circular 847 interpretations may not be mandatory for any particular Flag Administration, except for those incorporated within SOLAS. Member Governments are only invited to use the annexed interpretations as guidance, and therefore, specific instructions from the ABS Regulatory Affairs Department should be obtained regarding the application of these interpretations on behalf of any particular Administration.

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SECTION 1 Basics of a Fire

Fire is a phenomenon with which everyone is familiar. We use it daily to heat our homes and cook our meals. When harnessed, the power and energy from fire serves us well; however, when it is uncontrolled, a fire can quickly consume and destroy whatever lies in its path.

While we are all familiar with fire, few of us are aware of its nature and complex processes. This Section examines the phenomena and various mechanisms at work within a fire and is intended to provide a better understanding of the requirements in fire-fighting scenarios.

1 Chemistry of Fire

1.1 Oxidation

Oxidation is a chemical reaction between the molecules of a substance and the oxygen molecules in the surrounding atmosphere. There are many common examples of oxidation, including the rusting of iron, the tarnishing of silver, or the rotting of wood.

What is known as *fire* is actually a chemical reaction involving the oxidation of the fuel molecules. However, the reaction occurs at a much faster rate and only under certain conditions (e.g., elevated temperatures, proper mixture, etc.). In addition, what is called *burning* or *combustion* is actually the continuous rapid oxidation of millions of fuel molecules. Recognizing that the fire or combustion process is actually a chemical reaction (involving the oxidation of the fuel molecules) is critical to understanding the basics of the fire phenomena.

The oxidation reaction is an exothermic process (i.e., one in which heat is given off). The molecules oxidize by breaking apart into individual atoms and recombine with the oxygen atoms to form new molecules. During this process, a certain amount of energy is released. In the examples of rusting iron or rotting wood, the amount of energy released is minimal since these oxidation processes occur at a very slow rate. However in a fire, the oxidation rate of the fuel molecules is much faster. Because of this rapid reaction, energy is released at a much greater rate. The released energy is actually felt and seen in the form of heat and light. The more rapid the oxidation rate, the greater intensity in which the energy is released. An explosion is, in fact, the oxidation of a combustible media at an extremely fast rate.

1.2 State of Products in “Fire” Oxidation Process

All substances exist in one of three states: as a solid, a liquid or a vapor (gas). For the oxidation process to occur, there must be an adequate intermixing of the oxygen and fuel molecules. For fuel molecules in either a solid or liquid state, the molecules are tightly bound and cannot be effectively surrounded by the oxygen molecules in the atmosphere. Therefore, molecules in either a liquid or solid state are not directly involved in the rapid chemical reaction of oxidation in a fire.

However, fuel molecules in a vapor state are free to mix with the atmosphere. These molecules become effectively surrounded by the oxygen molecules in the atmosphere and are available to become involved in the oxidation process. In fact, only fuel molecules in a vapor state are actually involved in the oxidation process.

While fuel molecules in the solid or liquid states are not directly involved in the oxidation process, when heated, these molecules will move about more rapidly. If enough heat (energy) is applied, some fuel molecules break away from the surface to form a vapor just above the surface. This new vapor can now mix with oxygen and can become involved in the oxidation process. Accordingly, the fuel molecules in a solid or liquid state do serve as the source of additional fuel vapors when exposed to heat.

Note: Usually, molecules in a liquid state can break free more easily than those in a solid state. In many cases, little or no additional heat is necessary for at least some of the fuel molecules in a liquid state to have sufficient energy to break free of the surface and enter the vapor state.

2 Fundamentals of a Fire

The combustion process, or *burning*, is in fact the rapid oxidation of millions of fuel molecules in the vapor form. Once there is sufficient oxygen and the fuel vapor molecules properly mix, an ignition source is typically needed for oxidation to be initiated. However, once oxidation is initiated, it is an exothermic process. If sufficient energy is released during the reaction to maintain the elevated temperature of surrounding oxygen and fuel molecules, and there are sufficient oxygen and vaporized fuel molecules available, then the oxidation process will continue.

The heat released by the oxidation of the fuel molecules is *radiant* heat, which is pure energy, the same sort of energy radiated by the sun and felt as heat. It radiates, or travels, in all directions. Thus, part of it moves back to the seat of the fire, to the “burning” solid or liquid (the fuel).

The heat that radiates back to the fuel is called radiation feedback. This part of the heat serves to release more vapors and also serves to raise the vapor (fuel and oxygen molecule mixture) to the ignition temperature. At the same time, air is drawn into the area where the flames and vapor meet. The result is that the newly-formed vapor begins to burn and the flames increase, which starts a chain reaction. The burning vapor produces heat, which releases and ignites more vapor. The additional vapor burns, producing more heat, which releases and ignites still more vapor. As long as there is fuel and oxygen available, the fire will continue to grow.

For a fuel source with a limited amount of surface area available, the amount of vapor released from the fuel reaches a maximum rate and begins to level off, producing a steady rate of burning. This usually continues until most of the fuel has been consumed.

When there is less fuel vapor available to oxidize, less heat is produced and the process begins to die out. A solid fuel may leave an ash residue and continue to smolder for some time, while a liquid fuel usually burns up completely.

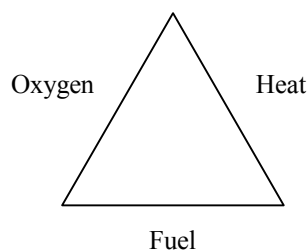
3 The Fire Triangle

There are three (3) components required for combustion to occur:

- Fuel – to vaporize and burn
- Oxygen – to combine with fuel vapor
- Heat – to raise the temperature of the fuel vapor to its ignition temperature

The following is the typical “fire triangle”, which illustrates the relationship between these three components:

FIGURE 1
The Fire Triangle



There are two important factors to remember in preventing and extinguishing a fire:

- i) If any of the three components are missing, then a fire cannot start.
- ii) If any of the three components are removed, then the fire will go out.

It is important to have a clear understanding of these three components and their inter-reactions in a fire. The following Paragraphs examine each of these items in further detail.

3.1 Fuel

Fuel is necessary to feed a fire, and without fuel, the combustion process will terminate. The fuel molecules involved in a fire must be in the vapor (gas) state. However, the initial fuel source may be in a solid, liquid or gaseous state. Many examples of each type of these fuels can be found onboard a vessel.

The following Subparagraphs provide a brief discussion on the various types of fuels and some of the technical issues that impact their involvement in a fire.

3.1.1 Solid Fuels

3.1.1(a) Sources. The most obvious solid fuels are wood, cloth and plastics. These types of fuels are found onboard a vessel in the form of cordage, dunnage, furniture, plywood, wiping rags, mattresses and numerous other items. The paint used on bulkheads is considered a solid fuel.

Vessels may also carry a variety of solid fuels as cargo, from baled materials to goods in cartons and loose materials, such as grain. Metals, such as magnesium, sodium and titanium are also solid fuels that may be carried as cargo.

3.1.1(b) Pyrolysis. Before a solid fuel will burn, it must be changed to the vapor state. In a fire situation, this change usually results from the initial application of heat. The process is known as pyrolysis, which is generally defined as “chemical decomposition by the action of heat.” In this case, the decomposition causes a change from the solid state to the vapor state. If the vapor mixes sufficiently with air and is heated to a high enough temperature (by a flame, spark, hot motor, etc.), then ignition results.

3.1.1(c) Burning Rate. The burning rate of a solid fuel depends upon the rate at which vapors are generated, which depends on a number of criteria, including the configuration of the fuel surface. Solid fuels in the form of dust or shavings will burn much faster than bulky materials (i.e., small wood chips will burn faster than a solid wooden beam).

Finely divided fuels have a much larger surface area exposed to the heat. Therefore, heat is absorbed much faster, vaporization is more rapid and more vapor is available for ignition, allowing the fire to burn with great intensity and the fuel to be quickly consumed. A bulky fuel will burn longer than a finely divided fuel.

Dust clouds are made up of very small particles. When a cloud of flammable dust (such as grain dust) is mixed well with air and ignited, the reaction is extremely quick, often with explosive force. Such explosions have occurred on vessels during the loading and discharging of grains and other finely divided materials.

3.1.1(d) Ignition Temperature. The ignition temperature of a substance (solid, liquid or gas) is the lowest temperature at which sustained combustion will occur. Ignition temperatures vary among substances. The ignition temperature varies with bulk, surface area and other factors. Generally accepted ignition temperatures of common combustible materials in various standardized configurations are provided in various handbooks.

3.1.2 Liquid Fuels

3.1.2(a) Sources. The flammable liquids most commonly found aboard a vessel are bunker fuel, lubricating oil, diesel oil, kerosene, oil-base paints and their solvents. Cargoes may include flammable liquids and liquefied flammable gases.

3.1.2(b) Vaporization. Flammable liquids release vapor in much the same way as solid fuels. The rate of vapor release is greater for liquids than solids, since liquids have less closely bonded molecules. In addition, liquids can release vapor over a wide temperature range. Gasoline starts to give off vapor at -43°C (-45°F). Since gasoline produces flammable vapor at normal atmospheric temperatures, it is a continuous fire risk, even without heating or back radiation. Heating increases the rate of vapor release and therefore the fire risk.

Heavier flammable liquids, such as bunker oil and lubricating oil, release lesser amounts of vapors at atmospheric temperatures. However, the rate of vaporization increases rapidly when heated. Some lubricating oils can ignite at 204°C (400°F). Because a fire reaches this temperature rapidly, oils that are directly exposed to a fire will soon become involved. Once a flammable liquid is burning, radiation feedback and the chain reaction of oxidation quickly increase flame production.

The vapor produced by most flammable liquids is heavier than air. Vapor that is heavier than air is very dangerous because it will seek low places, dissipate slowly and can quickly travel to a distant source of ignition. For example, vapor escaping from a container can travel along a deck and down deck openings until it contacts a source of ignition (such as a spark from an electric motor). If the vapor is properly mixed with air, then it will ignite and carry fire back to the leaky container, resulting in a fire.

3.1.2(c) Burning. Pound-for-pound, flammable liquids produce about 2.5 times more heat than wood when involved in a fire, and the heat is liberated 3 to 10 times faster from liquids than from wood. These ratios illustrate quite clearly why flammable liquid vapor burns with such intensity. When flammable liquids spill, they expose a very large surface area and release a great amount of vapor; therefore, they can produce great amounts of heat when ignited. This is one reason why large open tank fires and liquid-spill fires burn so violently.

3.1.2(d) Flash Point. The flash point of a liquid fuel is the lowest temperature at which the vapor pressure of the liquid is just sufficient to produce a flammable mixture at the lower limit of flammability. The flash points (temperatures) of liquids are determined in controlled tests and are usually reported as a “closed cup” or an “open cup” temperature. The flash point values of liquids are frequently established using the ASTM or Pensky-Martens testing apparatuses and procedures. However, other testing apparatuses are available.

It is important to note that the typical value identified as the flash point of a flammable liquid is based upon atmospheric pressure. However, the value of the flash point for a particular liquid will vary as the atmospheric pressure to which the liquid is exposed increases or decreases.

3.1.3 Gaseous Fuels

3.1.3(a) Sources. There are both natural and manufactured flammable gases. Those that may be found on board a vessel include acetylene, propane and butanes, as well as a number of liquefied gases carried as cargo on LNG and LPG vessels.

3.1.3(b) Burning. Gaseous fuels are already in the required vapor state. Only the proper intermixing with oxygen and sufficient heat are needed for ignition. Gases, like flammable liquids, do not smolder. Radiation feedback is not necessary to vaporize the gas, however, some radiation feedback is still essential to the burning process (i.e., provide continuous re-ignition of the gas).

3.1.3(c) Flammable Range. A flammable gas or the flammable vapor of a liquid must mix with air in the proper proportion to make an ignitable mixture. The smallest percentage of a gas (or vapor) that will make an ignitable air-vapor mixture is called the Lower Flammable Limit (LFL) of the gas/vapor. If there is less gas in the mixture, it will be too lean to burn. The greatest percentage of a gas/vapor in an ignitable air-vapor mixture is called its Upper Flammable Limit (UFL). If a mixture contains more gas than the UFL, it is too rich to burn. The range of percentages between the lower and upper flammable limits is called the flammable range of the gas or vapor. It is therefore important to realize that certain ranges of vapor-air mixtures can be ignited and to use caution when working with these fuels.

The flammability ranges of specific types of fuels are published in various handbooks. Refer to such documentation for the particular product of concern.

3.2 Oxygen

Because the combustion process involves the oxidation of the fuel molecules, the availability of oxygen is vital for the process to exist. Accordingly, the second side of the fire triangle refers to the oxygen content in the surrounding air. Air normally contains about 21% oxygen, 78% nitrogen and 1% other gases, principally argon, and therefore, sufficient oxygen is typically available unless some type of controlled atmosphere (i.e., inerted, etc.) is involved.

3.3 Heat

For fuel molecules to undergo the oxidation process and result in a self-supporting fire, the molecules must be at elevated temperatures (i.e., ignition temperature). Without this elevated temperature, there will be no rapid oxidation or combustion of the fuel molecules. Further, the generation of additional fuel vapors is largely dependent upon feedback radiant heating of the fuel, except for gaseous fuels. Therefore, heat is the third side of the fire triangle. The production of energy from the initial reaction tends to raise the temperature of other molecules to the necessary elevated temperatures and tends to create the self-supporting nature of fire.

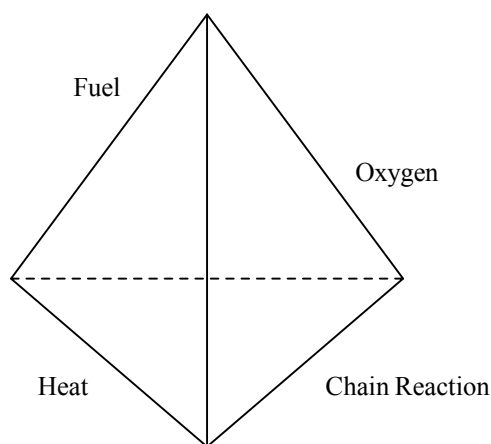
4 The Fire Tetrahedron

The fire triangle (Section 1, Figure 1) is a simple means of illustrating the three components required for the existence of fire. However, it lacks one important element when trying to understand the nature of fire and the effectiveness of extinguishing mechanisms available. In particular, it does not consider the chemical reaction of the oxidation process and the chain reaction needed for a fire to continue to exist.

The fire tetrahedron (Section 1, Figure 2) provides a better representation of the *combustion process*. A tetrahedron is a solid figure with four triangular faces and is useful for illustrating the combustion process because it shows the chain reaction and each face touches the other three faces.

The basic difference between the fire triangle and the fire tetrahedron is that the tetrahedron illustrates how flaming combustion is supported and sustained through the chain reaction of the oxidation process. In a sense, the chain reaction face keeps the other three faces from falling apart. This is an important point, because the extinguishing agents used in many modern portable fire extinguishers, automatic extinguishing systems and explosion suppression systems directly attack and break the chain reaction sequence in order to extinguish a fire.

FIGURE 2
The Fire Tetrahedron



5 Extinguishment Considering the Fire Tetrahedron

A fire can be extinguished if any one side of the fire tetrahedron can be destroyed. If the fuel, oxygen, or heat is removed, the fire will die out. Likewise, if the chain reaction is broken, the resulting reduction in vapor generation and heat production will also result in the extinguishment of the fire. (However, additional cooling with water may be necessary where smoldering or reflash is a possibility.)

5.1 Removing the Fuel

One way to remove fuel from a fire is to physically move it. In most instances, this is an impractical fire-fighting technique. However, it is often possible to move nearby fuels away from the immediate vicinity of a fire, so that the fire does not extend to these fuels.

Sometimes the supply of liquid or gaseous fuel can be cut off from a fire. When a fire is being fed by a leaky heavy fuel oil or diesel line, it can be extinguished by closing the proper valve. If a pump is supplying liquid fuel to a fire in the engine room, the pump can be shut down to remove the fuel source and thereby extinguish the fire; these arrangements are required by the Rules.

5.2 Removing the Oxygen

A fire can be extinguished by removing its oxygen or by reducing the oxygen level in the atmosphere. Many extinguishing agents (e.g., carbon dioxide and foam) extinguish a fire with smothering action by depriving the fire of oxygen.

This extinguishment method is difficult (but not impossible) to use in an open area. Gaseous smothering agents like carbon dioxide are blown away from an open deck area, especially if the vessel is underway. However, a fire in a galley trash container can be snuffed out by placing a cover tightly over the container, blocking the flow of air to the fire. As the fire consumes the oxygen in the container, it becomes starved for oxygen and is extinguished.

Tank vessels that carry petroleum products are protected by foam systems with monitor nozzles on deck. The discharged foam provides a barrier over the fuel, and when used quickly and efficiently, a foam system is capable of extinguishing a sizeable deck fire.

To extinguish a fire in an enclosed space such as a compartment, engine room or cargo hold, the space can be flooded with carbon dioxide. When the carbon dioxide enters the space and mixes with the atmosphere, the percentage of oxygen in the atmosphere is reduced and extinguishment results. This medium is used to combat fires in cargo holds. However, it is important to seal the enclosed space as reasonably gas-tight as possible to maintain the concentration of CO₂ and the reduction in oxygen.

It is also important to note that there are some cargoes known as *oxidizing substances* that release oxygen when they are heated or, in some instances, when they come in contact with water. Substances of this nature include the hypochlorites, chlorates, perchlorates, nitrates, chromates, oxides and peroxides. All contain oxygen atoms that are loosely bonded into their molecular structure, that is, they carry their own supply of oxygen, enough to support combustion. This oxygen is released when the substances break down, as in a fire. For this reason, burning oxidizers cannot be extinguished by removing their oxygen. Instead, for most oxidizers, large amounts of water, limited by vessel stability safety needs, are used to accomplish extinguishment. Oxidizers are hazardous materials, and as such, are regulated by the Flag Administration in association with the SOLAS Regulations.

5.3 Eliminating the Heat

The most commonly used method of extinguishing fire is to remove the heat. The base of the fire is attacked with water to cool the fuel surface, which reduces the amount of fuel vapor being generated. Water is a very effective heat absorber. When properly applied, it absorbs heat from the fuel and absorbs much of the radiation feedback. As a result, the chain reaction is indirectly attacked both on the fuel surface and at the flames. The production of vapor and radiant heat is reduced. Continued application will control and extinguish the fire.

Heat, which is a critical element in the fire tetrahedron, can be transferred from a fire by one or more of three methods: conduction, radiation and convection. Each of these methods of heat transfer must be considered when engaging a fire.

5.3.1 Conduction

Conduction is the transfer of heat through a solid body. For example, on a hot stove, heat is conducted through the pot to its contents. Wood is ordinarily a poor conductor of heat, but most metals are good conductors. Since most vessels are constructed of metal, heat transfer by conduction is a very real potential hazard. Fire can and will move from one hold to another, one deck to another and one compartment to another via heat conduction through the steel structure, unless structural fire protection arrangements are provided to prevent such propagation.

5.3.2 Radiation

Heat radiation is the transfer of heat from a source across an intervening space. No material substance is involved. The heat travels outward from the fire in the same manner as light, that is, in straight lines. When it contacts a body, it is absorbed, reflected or re-transmitted. Absorbed heat increases the temperature of the absorbing body. For example, radiant heat that is absorbed by an overhead will increase the temperature of that overhead, perhaps enough to ignite its paint. Radiant heat travels in all directions, unless it is blocked, and can extend a fire by heating combustible substances in its path, causing them to produce vapor and then igniting the vapor.

5.3.3 Convection

Convection is the transfer of heat through the motion of heated matter (e.g., through the motion of smoke, hot air, heated gases produced by the fire and flying embers). When it is confined as within a vessel, convective heat moves in predictable patterns. The fire produces lighter-than-air gases that rise toward high parts of the vessel. Heated air, which is lighter than cool air, also rises, as does the smoke produced by combustion. As these heated combustion products rise, cool air takes their place. The cool air is heated in turn and then rises to the highest point it can reach. As the hot air and gases rise from the fire, they begin to cool, and as they do, they drop down to be reheated and rise again. This is the convection cycle. It is important to recognize that heat originating from a fire on a lower deck will travel horizontally along passageways and then upward via ladder and hatch openings, and it can ignite flammable materials in its path.

5.4 Breaking the Chain Reaction

Another mechanism for destroying the fire tetrahedron, and therefore, extinguishing the fire, is by the interruption of the chain reaction. Once the chain reaction sequence is broken, the heat generation is reduced. This reduces the fuel vapor generation, as well as the heating of the vapor oxygen mixture, and as a result, the fire is extinguished. The extinguishing agents commonly used to attack the chain reaction and inhibit combustion are dry chemicals and Halon alternatives. These agents directly attack the molecular structure of compounds formed during the chain reaction sequence by scavenging the “O” and “OH” radicals. The breakdown of these compounds adversely affects the flame-producing capability of the fire.

It should be borne in mind that these agents do not cool a deep-seated fire or a liquid whose container has been heated above the liquid’s ignition temperature. In these cases, the extinguishing agent must be maintained on the fire until the fuel has cooled down naturally.

6 Hazardous/Combustible Materials

There are a number of hazards produced by a fire, including flames, heat, gases and smoke. Each of these combustion products can cause serious injuries or death and should be considered in the overall scope of fire-fighting arrangements onboard a vessel.

6.1 Flames

The flaming region of a fire is that portion of the combustion zone where the fuel and oxygen molecules are of an appropriate mixture and temperature to support the oxidation process. The direct contact with flames can result in totally or partially disabling skin burns and serious damage to the respiratory tract. To prevent skin burns during a fire attack, crewmen must maintain a safe distance from the fire unless they are properly protected and equipped for the attack. This is the reason that protective clothing, such as fireman’s outfits, is required by the Rules. Respiratory tract damage can be prevented by wearing breathing apparatus.

6.2 Heat

As a result of a fire, the temperature in an enclosed space can reach temperatures in excess of 93°C (200°F) very rapidly, and the temperature can build up to over 427°C (800°F) quickly. Temperatures above 50°C (122°F) are hazardous to humans, even if they are wearing protective clothing and breathing apparatus. The dangerous effects of heat range from minor injury to death. Direct exposure to heated air may cause dehydration, heat exhaustion, burns and blockage of the respiratory tract by fluids. Heat also causes an increased heart rate. A firefighter exposed to excessive heat over an extended period of time could develop hyperthermia, a dangerously high fever that can damage the nerve center.

6.3 Gases

The particular gases produced by a fire depend mainly on the fuel. The most common hazardous gases are carbon dioxide (CO₂), the product of complete combustion, and carbon monoxide (CO), the product of incomplete combustion.

Carbon monoxide is the more dangerous of the two. When air mixed with carbon monoxide is inhaled, the blood absorbs the CO before it will absorb oxygen. The result is an oxygen deficiency in the brain and body. Exposure to a 1.3% concentration of CO will cause unconsciousness in two or three breaths and death in a few minutes.

Carbon dioxide works on the respiratory system. Above normal CO₂ concentrations in the air reduce the amount of oxygen that is absorbed in the lungs. The body responds with rapid and deep breathing, which is a signal that the respiratory system is not receiving sufficient oxygen.

When the oxygen content of air drops from its normal level of 21% to about 15%, human muscular control is reduced. At 10% to 14% oxygen in air, judgment is impaired and fatigue sets in. Unconsciousness usually results from oxygen concentrations below 10%. During periods of exertion, such as fire-fighting operations, the body requires more oxygen, and these symptoms may then appear at higher oxygen percentages.

Depending upon the fuel source, there may be several other gases generated by a fire that are of equal concern to firefighters. Therefore, anyone entering a fire must wear an appropriate breathing apparatus.

6.4 Smoke

Smoke is a visible product of fire that adds to the problem of breathing. It is made up of carbon and other unburned substances in the form of suspended particles. It also carries the vapors of water, acids and other chemicals, which can be poisonous or irritating when inhaled.

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SECTION 2 Classification of Fires

The characteristics of fires and the effectiveness of extinguishing agents differ with the fuels involved. While particular extinguishing agents are very effective on fires involving certain fuels, they may be much less effective or even hazardous for use on other types of fires. Take for example, the use of a portable water extinguisher. Water is a good extinguishing medium and is very effective on deep-seated fires, such as burning wood or rubbish. However, a firefighter would not want to use a portable water extinguisher on a fire involving a “live” electrical panel or switchboard due to the conductivity of the water and the possible shock that could result.

Considering the different types of fuels that may be involved in a fire, the different types of extinguishing agents available and the different mechanisms which the various agents use to extinguish a fire, it is important to be able to identify the type of fire on which a particular medium will be effective. The job of selecting the proper extinguishing agent has been made easier by the classification of fires into four types, or classes, lettered “A” through “D”, based upon the fuels involved. Within each class are fires involving those materials with similar burning properties and requiring similar extinguishing agents. Thus, knowledge of these classes is essential to efficient fire-fighting operations, as well as familiarity with the burning characteristics of materials that may be found aboard a vessel.

1 Overview

The International Maritime Organization (IMO) mentions two standards in IMO Resolution A.602(15) which define the various classes of fires. The first is the International Standards Organization (ISO) Standard 3941, and the second is the National Fire Protection Agency (NFPA) 10 Standard.

Section 2, Table 1 identifies these classes of fire as they are listed in IMO Resolution A.602(15). IMO Resolution A.602(15) is included in Annex of the International Code for Fire Safety System (IMO FSS Code).

While the types of combustibles covered by ISO and NFPA are very similar for Classes “A,” “B” and “D,” the combustibles covered by Class “C” designation differs substantially. Considering that the classification of the various types of combustibles used in the ABS Rules (e.g., Notes in 4-7-3/Table 4 of the *Rules for Building and Classing Steel Vessels*, 4-5-1/Table 1 of the *Rules for Building and Classing Steel Vessels Under 90 meters (295 feet) in Length*, etc.) more closely follows the NFPA designations, the Guidance Notes will use the NFPA classifications.

In the remainder of this Section, the fuels, their burning characteristics, by-products, etc., within each fire class are discussed in more detail.

TABLE 1
Fire Classifications

<i>ISO Standard 3941</i>	<i>NFPA 10</i>
Class A: Fires involving solid materials, usually of an organic nature, in which combustion normally takes place with the formation of glowing embers	Class A: Fires in ordinary combustible materials, such as wood, cloth, paper, rubber and many plastics.
Class B: Fires involving liquids or liquefiable solids.	Class B: Fires in flammable liquids, oils, greases, tars, oil-based paints, lacquers and flammable gases.
Class C: Fires involving gases.	Class C: Fires which involve energized electrical equipment where the electrical non-conductivity of the extinguishing medium is of importance.
Class D: Fires involving metals.	Class D: Fires in combustible metals, such as magnesium, titanium, zirconium, sodium, lithium and potassium.

2 Class “A” Fires

Class “A” fires involve three groups of materials commonly found onboard a vessel, including:

- Wood and wood-based materials
- Textiles and fibers
- Plastics and rubber

The following Paragraphs discuss Class “A” fires involving each of these materials:

2.1 Wood and Wood-based Materials

Wood products are often involved in fire, mainly because of their many uses. Marine uses include furniture, furnishings, dunnage and staging, as well as numerous other uses. Wood-based materials are those that contain processed wood or wood fibers and include some types of plywood and paneling, paper, cardboard and pressboard.

The burning characteristics of wood and wood-based materials depend on the particular type of wood involved. For example, seasoned, air-dried maple (a hard-wood) produces greater heat upon burning than does pine (a softwood) that has been seasoned and dried similarly. However, all these materials are combustible, and they will char, smolder, ignite and burn under certain conditions.

Wood is composed mainly of carbon, hydrogen and oxygen, with smaller amounts of nitrogen and other elements. In the dry state, most of its weight is in the cellulose. Some other ingredients found in dry wood are sugars, resins, gums, esters of alcohol and mineral matter.

2.1.1 Burning Characteristics (Wood)

The ignition temperature of wood depends on many factors, such as size, shape, moisture content and type. Generally, the ignition temperature of wood is taken to be about 204°C (400°F). However, it is believed that if wood is subjected to temperatures above 100°C (212°F) over a long period, under certain conditions ignition can take place. Similarly, the rate of combustion and heat release rate of wood and wood-based materials depends heavily on the physical form of the material, the amount of air available, the moisture content and other such factors.

For wood to become involved in a fire, the solid components of the surface of the wood must first be heated to the point where pyrolysis, the process whereby the solid components on the surface are converted to combustible vapors, is sufficient to support combustion.

The heat necessary to produce pyrolysis can come from a number of sources, including direct contact with a flame, contact with some other heated element or as a result of radiant heat from a separate fire. The combustible vapors resulting from the pyrolysis are released from the surface of the wood and mix with the surrounding air. When the mixture of combustible vapor and air is within the flammable range, any source of ignition may ignite the combustible vapor mass almost instantly. Even without an ignition source, if the surface temperatures rise sufficiently, auto-ignition can occur.

Flames move across the surface of combustible solids in a process called flame spread. Flame spread is the result of adjacent surfaces being heated by the existing flames to a point where the adjacent surface produces sufficient flammable vapors to support and fuel combustion. It is important to note that the orientation of the adjacent surface to the fire does play a role in the rate of flame spread. Flames will typically spread faster in an upward direction, since such locations are heated by radiant heat from the flame, as well as convective heat from the fire plume. The process of flame spread will continue until all fuel is consumed or there is not sufficient heat available to promote adequate pyrolysis of adjacent surfaces.

Bulky solids with a small surface area (for example, a heavy wood beam) burn more slowly than solids with a larger surface area (for example, a sheet of plywood), and solids in chip, shaving or dust form (wood, metal shavings, sawdust, grains and pulverized coal) burn even more rapidly, since they represent a much larger total area per mass of fuel. The larger surface area allows combustible vapor to be generated and released at a greater rate. (This is also true of flammable liquids. A shallow liquid spill with a large area will burn off more rapidly than the same volume of liquid in a deep tank with a small surface area.)

2.1.2 By-products of Combustion (Wood)

Burning wood and wood-based materials produce water vapor, heat, carbon dioxide and carbon monoxide. The reduced oxygen levels and the carbon monoxide present the primary hazard to crewmembers and firefighters. In addition, wood and wood-based materials produce a wide range of aldehydes, acids and other gases when they burn. By themselves or in combination with the water vapor, these substances can cause irritation at least, and in high enough concentrations, most produced gases are toxic.

2.2 Textiles and Fibers

Textiles, in the form of clothing, furniture, carpets, canvas, burlap, ropes and bedding are used extensively in the marine environment, and others are carried as cargo. In addition, almost all textile fibers are combustible. These two facts explain the frequency of textile-related fires and the many deaths and injuries that result.

2.2.1 Natural Textiles

2.2.1(a) Plant Fibers. Vegetable fibers consist largely of cellulose. They include cotton, jute, hemp, flax and sisal. Cotton and the other plant fibers are combustible [the ignition temperature of cotton fiber is around 400°C (752°F)]. Burning vegetable fibers produce heat and smoke, carbon dioxide, carbon monoxide and water. The ease of ignition, rate of flame spread and amount of heat produced depend on the construction and finish of the textile and on the design of the finished product.

2.2.1(b) Organic Fibers. Organic fibers, such as wool and silk, are solid and are chemically different from vegetable fibers. They do not burn as freely and they tend to smolder. For example, wool is a protein. It is more difficult to ignite wool than cotton [the ignition temperature of wool fiber is around 600°C (1112°F)], it burns more slowly and is easier to extinguish.

2.2.2 Synthetic Textiles

Synthetic textiles are fabrics woven wholly or mainly of synthetic fibers. Such fibers include rayon, acetate, nylon, polyester, acrylic and plastic wrap. The fire hazards involved with synthetic textiles are sometimes difficult to evaluate, owing to the tendency of some of them to shrink, melt or drip when heated. Rayon and acetate resemble plant fibers chemically, whereas most other synthetic fibers do not. Almost all are combustible in varying degrees, but differ in ignition temperature, burning rate and other combustion features.

2.2.3 Burning Characteristics (Textiles/Fibers)

Many variables affect the way in which a textile burns. The most important are the chemical composition of the textile fiber, the finish on the fabric, the fabric weight, the tightness of weave and any flame retardant treatment.

Vegetable fibers ignite easily and burn readily, giving off large amounts of heavy smoke. Partially burned vegetable fibers may present a fire risk, even after they have been extinguished. Half-burned fibers should always be removed from the fire area to a location where re-ignition of the material would not create an additional problem. Most baled vegetable fibers absorb water readily. The bales will swell and increase in weight when large quantities of water are used to extinguish fires in which they are involved.

Wool is difficult to ignite, and it tends to smolder and char rather than to burn freely, unless it is subjected to considerable external heat. However, it will contribute toward a fierce fire. Wool can absorb a large amount of water – a fact that must be considered during prolonged fire-fighting operations.

Silk is a less dangerous fiber. It is difficult to ignite and it burns sluggishly. Combustion usually must be supported by an external source of heat. Once set on fire, silk retains heat longer than any other fiber. In addition, it can absorb a great amount of water. Spontaneous ignition is possible with wet silk. There may be no external evidence that a bale of silk had ignited, until the fire burns through to the outside.

The burning characteristics of synthetic fibers vary according to the materials used, but the characteristics of some of the more common synthetics are given in the following table.

TABLE 2
Burning Characteristics of Synthetic Fibers

<i>Synthetic</i>	<i>Burning Characteristics</i>
Acetate	Burns and melts ahead of the flame. Ignition point is similar to cotton.
Acrylic	Burns and melts. Ignition temperature approx. 560°C (1040°F). Softens at 235-330°C (455-626°F).
Nylon	Supports combustion with difficulty. Melts and drips; melting point, 160-260°C (320-500°F). Ignition temperature approx. 425°C (797°F) and above.
Polyester	Burns readily. Ignition temperature 450-485°C (842-905°F). Softens at 256-292°C (493-558°F) and drips.
Plastic wrap	Melts.
Viscose	Burns about the same as cotton.

These characteristics are based on small-scale tests and may be misleading. Some synthetic fabrics appear to be flame-retardant when tested with a small flame source, such as a match. However, when the same fabrics are subjected to a larger flame or a full-scale test, they may burst into flames and burn completely while generating quantities of black smoke.

2.2.4 By-products of Combustion (Textiles/Fibers)

All burning materials produce hot gases (called fire gases), flame, heat and smoke, resulting in decreased oxygen levels. The predominant fire gases are carbon monoxide, carbon dioxide and water vapor. Burning vegetable fibers such as cotton, jute, flax, hemp and sisal give off large amounts of dense smoke. Jute smoke is particularly acrid.

Burning wool gives off dense, grayish-brown smoke. Another product of the combustion of wool is hydrogen cyanide, a highly toxic gas. Charring wool forms a sticky, black, tar-like substance.

Burning silk produces a large amount of spongy charcoal mixed with ash, which will continue to glow or burn only in a strong draft. It emits quantities of thin gray smoke, somewhat acrid in character. Silk may produce hydrogen cyanide gas under certain burning conditions.

2.3 Plastics and Rubber

A variety of organic substances are used in manufacturing plastics. These include phenol, cresol, benzene, methyl alcohol, ammonia, formaldehyde, urea and acetylene. The cellulose-based plastics are largely composed of cotton products. However, wood flour, wood pulp, paper and cloth also play a large part in the manufacturing of many types of plastic.

Natural rubber is obtained from rubber latex, which is the juice of the rubber tree. It is combined with such substances as carbon black, oils and sulfur to make commercial rubber. Synthetic rubbers are similar to natural rubber in certain characteristics. Acrylic, butadiene and neoprene rubbers are some of the synthetic types.

2.3.1 Burning Characteristics (Plastics/Rubber)

The burning characteristics of plastics vary widely and depend upon the specific material involved, as well as the form of the product (solid sections, films and sheets, foams, molded shapes, synthetic fibers, pellets or powders). Most major plastic materials are combustible at least to some extent, and in a major fire, all contribute fuel to the fire.

Plastics may be divided roughly into three groups with regard to burning rates:

- i) *Materials that either will not burn at all or will cease to burn if the source of ignition is removed.* This group includes asbestos-filled phenolics, some polyvinyl chlorides, nylon and the fluorocarbons.
- ii) *Materials that are combustible, burn relatively slowly, but may or may not cease to burn when the source of ignition is removed.* These plastics include the wood-filled formaldehydes (urea or phenol) and some vinyl derivatives.
- iii) *Materials that burn without difficulty and can continue to burn after the source of ignition is removed.* Included in this group are polystyrene, the acrylics, some cellulose acetates and polyethylene.

In a class of its own is the oldest well-known form of plastic, celluloid, or cellulose nitrate plastic. It is typically considered the most dangerous of the plastics. Celluloid decomposes at temperatures of 121°C (250°F) and above with great rapidity, and without the addition of oxygen from the air. Flammable vapor is produced by the decomposition. If this vapor is allowed to accumulate and is then ignited, it can explode violently. It will burn vigorously and is difficult to extinguish.

The caloric value of rubber is roughly twice that of other common combustible materials. For example, rubber has a heating value of 17.9×10^6 kilo-joules (17,000 BTU/lb), whereas pine wood has a value of 8.6×10^6 kilo-joules (8200 BTU/lb). Most types of natural rubber soften when burning and may thus contribute to rapid fire spread. Natural rubber decomposes slowly when first heated. At about 232°C (450°F), it begins to decompose rapidly, giving off gaseous products that may result in an explosion. The ignition temperature of these gases is approximately 260°C (500°F).

Synthetic rubbers behave similarly, though the temperature at which decomposition becomes rapid may be somewhat higher. This temperature ranges upward from 349°C (660°F) for most synthetics, depending on the ingredients. Latex is a water-based emulsion and so does not present fire hazard.

2.3.2 By-products of Combustion (Plastics/Rubber)

Burning plastic and rubber produce the fire gases, heat, flame and smoke. These materials may also contain chemicals that yield additional combustion products of a toxic or lethal nature. The type and amount of smoke generated by a burning plastic material depends on the nature of the plastic, the additives present, whether the fire is flaming or smoldering and what ventilation is available. Most plastics decompose when heated, yielding dense to very dense smoke. Ventilation tends to clear the smoke, but usually not enough for good visibility. Those plastics that burn cleanly yield less dense smoke under conditions of heat and flame. When exposed to flaming or non-flaming heat, urethane foams generally yield dense smoke, and in almost all cases, visibility is lost quickly.

Hydrogen chloride is a product of combustion of chlorine-containing plastics, such as polyvinyl chloride, a plastic used for insulating certain electrical wiring. Hydrogen chloride is a deadly gas that has a pungent and irritating odor.

Burning rubber produces dense, black, oily smoke that has some toxic qualities. Two of the noxious gases produced in the combustion of rubber are hydrogen sulfide and sulfur dioxide. Both are dangerous and can be lethal under certain conditions.

2.4 Locations of Class “A” Materials Onboard

Although vessels are constructed of metal and may appear incombustible, there are many flammable products aboard. Practically every type of material (Class “A” and otherwise) may be carried as cargo. It may be located in the cargo holds or on deck, stowed in containers or in bulk stowage. In addition, Class “A” materials are used for many purposes throughout the vessel.

In accordance with SOLAS (2000 Amendments) Reg. II-2/5.3.2, a certain amount of combustible materials may be used in the construction of facings, moldings, decorations and veneers in accommodation and service spaces. In addition, the furnishings found in passenger, crew and officer accommodations are usually made of Class “A” materials. Lounges and recreation rooms may contain couches, chairs, tables, bars, television sets, books and other items that may be constructed of Class “A” materials.

Other areas in which Class “A” materials may be located include the following:

- Bridge contains wooden desks, charts, almanacs and other such combustibles.
- Wood in many forms may be found in the carpenter shop.
- Various types of cordage are stowed in the boatswain’s locker.
- Emergency locker on the bridge wing contains rockets and/or explosives for the line-throwing gun.
- Undersides of metal cargo containers are usually constructed of wood or wood-based materials.
- Lumber for dunnage, staging and other uses may be stored below decks.
- Large numbers of filled laundry bags are sometimes left in passageways, awaiting movement to and from the laundry room.

2.5 Extinguishment of Class “A” Fires

It is a fortunate coincidence that the materials most often involved in fire, Class “A” materials, may best be extinguished by the most available extinguishing agent, water, provided by the required fire main system. In addition, other types of extinguishing mediums, such as foam and certain types of dry chemicals are also effective on Class “A” combustibles.

3 Class “B” Fires

Class “B” fires involve two groups of materials commonly found onboard a vessel:

- Flammable liquids
- Flammable gases

3.1 Flammable Liquids

SVR 4-6-1/3.23 indicates that for the purposes of SVR Sections 4-6-1 through 4-6-7, a flammable fluid or liquid is any fluid, regardless of its flash point, liable to support flame, and that “aviation fuel, diesel fuel, heavy fuel oil, lubricating oil and hydraulic oil are all to be considered flammable fluids.” Accordingly, all types of liquids that will burn are typically considered to be flammable fluids, including oil-based paints and solvents.

3.1.1 Burning Characteristics (Flammable Liquids)

As previously noted, it is the vapor of a flammable liquid, rather than the liquid itself, which burns or explodes when mixed with air and ignited. These liquids will vaporize when exposed to air and at an increased rate when heated.

Flammable vapor explosions most frequently occur within a confined space, such as a tank, room or structure. The violence of a flammable vapor explosion depends upon:

- i) Concentration and nature of the vapor,
- ii) Quantity of vapor-air mixture present, and
- iii) Type of enclosure in which the mixture is confined.

The flashpoint is commonly accepted as the most important factor in determining the relative hazard of a flammable liquid. However, it is not the only factor. The ignition temperature, flammable range, rate of evaporation, reactivity when contaminated or exposed to heat, density and rate of diffusion of the vapor also determine how dangerous the liquid is. However, once a flammable liquid has been burning for a short time, these factors have little effect on its burning characteristics.

The burning rates of flammable liquids vary somewhat, as do their rates of flame travel. The burning rate of gasoline is 15.2 to 30.5 cm (6 to 12 in.) of depth per hour, and for kerosene, the rate is 12.7 to 20.3 cm (5 to 8 in.) of depth per hour. For example, a pool of gasoline 1.27 cm (1/2 in.) deep could be expected to burn itself out in 2.5 to 5 minutes.

3.1.2 By-products of Combustion (Flammable Liquids)

In addition to the usual combustion products, there are some products that are peculiar to flammable liquids. Liquid hydrocarbons normally burn with an orange flame and give off dense clouds of black smoke. Alcohols normally burn with a clean blue flame and very little smoke. Certain terpenes and ethers burn with considerable boiling of the liquid surface and are difficult to extinguish. Acrolein (acrylic aldehyde) is a highly irritating and toxic gas produced during the combustion of petroleum products, fats, oils and many other common materials.

Liquid paint can also burn fiercely and gives off much heavy black smoke. Explosions are another hazard of liquid paint fires. Since paint is normally stored in tightly sealed cans or drums up to 150-190 liters (40-50 gallons) capacity, fire in any paint storage area may easily heat up the drums and cause them to burst due to excessive pressure. The contents are likely to ignite very quickly, possibly with explosive force with the exposure to air.

3.1.3 Locations of Flammable Liquids Onboard

Large quantities of flammable liquids, in the form of heavy fuel oil, diesel oil, lubricating oil and hydraulic oil are also stowed aboard a vessel, for use in propelling and generating electricity. In addition, heavy fuel oil and diesel oil are frequently heated during the purification process or in preparation for injection into a boiler or an engine, which introduces additional hazards due to the additional volume of vapors capable of being created and the existence of those vapors at elevated temperatures. Fires involving these particular Class “B” combustibles are usually associated with machinery spaces.

In addition, flammable liquids of all types are carried as cargo by tank vessels, and flammable liquids in smaller packages may be found in holds of vessels carrying dangerous goods, as well as in the tanks of vehicles being transported in ferries or ro-ro vessels.

Most paints, varnishes, lacquers and enamels, except those with a water base, present a high fire risk in storage or in use. Accordingly, ABS-classed vessels are required to carry such products in designated paint or flammable liquid lockers.

Other locations where combustible liquids may be found include the galley (hot cooking oils) and the various mechanics shops and spaces where lubricating oils are used. Fuel and diesel oil may also be found as residues and films on and under oil burners and equipment in the engine room.

3.1.4 Extinguishment of Flammable Liquids

In general, the Rules require a fixed fire-fighting system to be installed in spaces specifically subject to Class “B” fires. Various types of fixed systems are discussed in detail in following Sections and are in addition to the required fire main system, as well as the various required portable and semi-portable appliances.

A few examples are provided below:

- *Machinery Spaces.* Category “A” machinery spaces are required to be fitted with a fixed gas extinguishing system, fixed water spray system or high expansion foam system, in accordance with SVR 4-7-2/1.1.1.
- *Cargo Tanks.* In addition to an inert gas system intended to maintain the cargo tanks in an inerted condition, oil and chemical carriers with cargo tanks carrying flammable liquid cargoes are required to be fitted with a foam system for coverage on the deck, in accordance with SVR 5-1-7/27 and 5-9-11/3. The cargo pump rooms for such spaces are also required to be fitted with fixed fire extinguishing systems.
- *Ro-Ro Spaces.* Ro-ro spaces are required to be fitted either a fixed gas extinguishing system or a water spray system, in accordance with SVR 5-10-4/3.3.
- *Paint Lockers.* Paint lockers must be fitted with a CO₂ system, a fixed water spray system or a dry powder system, in accordance with SVR 4-7-2/5.1.

3.2 Flammable Gases

While most solids and liquids can be vaporized when their temperature is increased sufficiently, the term “gas” is taken to mean a substance that is in the gaseous state at atmospheric temperatures and pressures. In the gaseous state, the molecules of a substance are not held together, but are free to move about and take the shape of its container.

Any gas that will burn in the normal concentrations of oxygen in air is considered a flammable gas. As with other gases or vapors, a flammable gas will burn only when its concentration in air is within its combustible range and the mixture is heated to its ignition temperature.

Flammable gases are usually stored and transported aboard vessels in one of three ways:

- *Compressed.* A compressed gas is one that, at normal temperatures, is entirely in the gaseous state under pressure in its container.
- *Liquefied.* A liquefied flammable gas is one that, at 37.8°C (100°F) has a Reid vapor pressure of at least 2.8 bar (40 psi). At normal temperatures, it is partly in the liquid state and partly in the gaseous state under pressure in its container.
- *Cryogenic.* A cryogenic gas is one that is liquefied in its container at a temperature far below normal temperatures and at low to moderate pressures.

3.2.1 Basic Hazards

The hazards presented by a gas that is confined in a container differ from those presented when a gas that has escaped from its container. They will be discussed separately, although these hazards may be present simultaneously in a single incident.

3.2.1(a) Hazards of Confinement. When the exterior of a tank or cylinder containing gas is exposed to a fire, the internal pressure of the container increases due to the heating of the gas. If the pressure increases sufficiently, a gas leak or a container failure could result. In addition to the increasing pressure, heating of the container surface (e.g., contact of flames with the container, radiant heat, etc.) can reduce the strength of the container material.

To prevent the failure of tanks or cylinders containing compressed flammable gases, pressure relief valves and fusible plugs are typically installed. When the pressure exceeds a set limit, the relief valve opens allowing gas to flow out of the container, normally through a relief piping system to some safe location, thereby reducing the internal pressure. Typically a spring loaded device closes the valve when the pressure is reduced to a safe level.

A fusible plug is another protective device. The fusible plug is constructed of a metal that will melt at a specific temperature. The plug seals an opening in the body of the container, usually near the top. Heat from a fire, threatening the tank or cylinder, causes the metal plug to melt allowing the gas to escape through the opening. Excessive pressure within the tank is prevented. However, the opening cannot be closed and the gas will continue to escape until the container is empty.

Failure of the containment can occur when these safety devices are not installed or fail to operate properly. Another cause of failure is the very rapid build-up of pressure in a container at a rate that the pressure cannot be relieved through the safety valve opening fast enough to prevent the excessive build-up of pressure.

3.2.1(b) Container Protection. Compressed or liquefied gas represents a great deal of energy being held within the container. If the container fails, this energy is released-often very rapidly and violently. The gas escapes and the container or container pieces are scattered.

Failure of a liquefied flammable gas container due to exposure to a fire is of great concern due to the concern with boiling liquid-expanding vapor explosion, or BLEVE (pronounced “blevey”). Because of these concerns, the Rules require relief valves to be of a capacity that is capable of handling the flow rate of vapors during a maximum fire exposure.

3.2.1(c) Hazards of Gases Released from Confinement. The hazards of a flammable gas that has been released from its container depend on the properties of the gas, as well as the location and conditions where it is released. Any released flammable gas can present a danger of a fire or explosion or both.

A volume of released gas will not burn or explode if either:

- i) The concentration of gas is not sufficient to result in a flammable air-gas mixture, or
- ii) Any resulting flammable air-gas mixture does not come into contact with an ignition source.

A volume of released gas will burn without exploding if:

- i) There is an insufficient concentration of gas anywhere but in the immediate vicinity of the point of release due to the dissipation of the gas into the atmosphere, or
- ii) Because the initial release of gas was ignited so quickly that sufficient volumes of the un-ignited air-gas mixture did not have time to accumulate. These types of fires are normally referred to as jet fires.

Where a sufficient volume of flammable gas is released in a manner that creates an un-ignited gas-air mixture within the flammable concentration range, an explosion can, and typically will, occur, if ignited. Such concentrations can be readily achieved if a flammable gas is released in an enclosed area. However, even on an open deck, if a massive release occurs, a gas cloud of sufficient concentration and volume can be created (unless ignition at the point of release occurs immediately). Explosions of such open area gas clouds are known as open-air explosions or space explosions. Liquefied gases, hydrogen and ethylene are subject to open-air explosions.

3.2.2 Properties of Some Common Gases

Properties of a number of flammable gases are presented in the following pages. These properties lead to varying degrees and combinations of hazards when the gases are confined or released.

3.2.2(a) Acetylene. Acetylene is composed of carbon and hydrogen. It is used primarily in chemical processing and as a fuel for oxy-acetylene cutting and welding equipment. It is non-toxic and has been used as an anesthetic. Pure acetylene is odorless, but the acetylene in general use has an odor due to minor impurities mixed in with the gas.

Acetylene is subject to explosion and fire when released from its container. It is easier to ignite than most flammable gases and it burns more rapidly. This increases the severity of explosions and the difficulty of venting to prevent explosion. Acetylene is only slightly lighter than air, which means it will mix well with air upon leaving its container.

3.2.2(b) Anhydrous Ammonia. Anhydrous ammonia is composed of nitrogen and hydrogen. It is used primarily as fertilizer, as a refrigerant and as a source of hydrogen for the special atmospheres needed to heat-treat metals. It is a relatively toxic gas, but its sharp odor and irritating properties serve as warnings. However, large clouds of anhydrous ammonia, produced by large liquid leaks, have trapped and killed people before they could evacuate the area.

Anhydrous ammonia is subject to explosion and fire (and presents a toxicity hazard) when released from its container. However, its high LEL and low heat of combustion tend to minimize these hazards. In unusually tight locations, such as refrigerated process of storage areas, the release of the liquid or a large quantity of gas can result in an explosion.

3.2.2(c) Ethylene. Ethylene is composed of carbon and hydrogen and is used in chemical processing, such as the manufacture of polyethylene plastic. Smaller amounts are used to ripen fruit. It has a wide flammable range and burns quickly.

While nontoxic, ethylene is an anesthetic and asphyxiant, and is subject to explosion and fire when released from its container. Ethylene has a wide flammable range and high burning rate. In a number of cases involving rather large outdoor releases, open-air explosions have occurred.

3.2.2(d) Liquefied Natural Gas (LNG). LNG is a mixture of materials, all composed of carbon and hydrogen. The principal component is methane, with smaller amounts of ethane, propane and butane. LNG is nontoxic but is an asphyxiant. It is used as a fuel.

Liquefied natural gas is shipped as a cryogenic gas in insulated tanks. LNG is subject to explosion and fire when released from its container.

3.2.2(e) Liquefied Petroleum Gas (LPG). LPG is a mixture of materials, all composed of carbon and hydrogen. Commercial LPG is mostly either propane or normal butane, or a mixture of these with small amounts of other gases. It is nontoxic but is an asphyxiant. It is used principally as a fuel and, in domestic and recreational applications, sometimes known as “bottled gas”.

LPG is subject to explosion and fire when released from its container. As most LPG is used indoors, explosions are more frequent than fires. The explosion hazard is accentuated by the fact that 3.8 liters (1 gallon) of liquid propane or butane produces 75 to 84 m³ (245 to 275 ft³) of gas. Large releases of liquid-phase LPG outdoors have led to open-air explosions.

3.2.3 Usual Locations Onboard

Many of the liquefied flammable gases, such as LPG and LNG, are transported in bulk on gas carriers, and fire protection requirements for such vessels are found in SVR Section 5-8-11. Additionally, acetylene is typically found stored in cylinders for use on board.

3.2.4 Extinguishment of Flammable Gases

Flammable gas fires can be extinguished with dry chemicals that interrupt the chain reaction of the combustion (oxidation) process. The installation of a fixed dry chemical system is required on gas carriers in accordance with SVR 5-8-11/4. In addition, water spray systems are required to provide heat shields for certain portions of the structure from the radiant heat of gas fires in accordance with SVR 5-8-11/3.

The procedure for fighting a flammable gas fire tends to be allowing the gas to burn until the flow can be shut off at the source. Extinguishment is normally not attempted unless such extinguishment leads to shutting off the fuel flow, since the release of un-ignited gas can result in a more dangerous explosion. Until the flow of gas supplying the fire has been stopped, fire-fighting efforts are normally directed toward protecting areas that may contain materials that may be ignited by flames or radiated heat from the fire. Water, in the form of straight streams and fog patterns, is usually used to protect such exposures. When the gas is no longer escaping from its container, the gas flames should go out. However, if the fire is extinguished before shutting off the gas flow, firefighters must be careful to prevent the ignition of gas that is being released.

4 Class “C” Fires

Electrical equipment involved in fire, or in the vicinity of a fire, may cause electric shock or burns to firefighters. This Subsection discusses some electrical installations found aboard a vessel, their hazards and the extinguishment of fires involving electrical equipment.

4.1 Types of Equipment

- *Generators.* Generators are machines that produce electrical power. These machines are usually driven by internal combustion engines, or in older vessels, steam produced in an oil-fired boiler. The electrical wiring in the generator may be insulated with a combustible material. Any fire involving the generator or its prime mover will involve a high risk of electrical shock to personnel.
- *Panel boards.* A panel board has fuses and automatic devices for the control and protection of lighting and power circuits. The switches, fuses, circuit breakers and terminals within a panel board all have electrical contacts. These contacts may develop considerable heat, causing dangerously high temperatures and unnecessary operation of overcurrent devices, unless they are maintained in good condition. Overcurrent devices are provided for the protection of conductors and electrical equipment and open the circuit if the current in that circuit produces an excessively high temperature.
- *Switches.* Switches are required for the control of lights and appliances and for disconnecting motors and their controllers. They are also used to isolate high voltage circuit breakers for maintenance operations. Switches may be of either the air-break or the oil-break type. In the oil-break type, the device that interrupts the circuit is immersed in oil.

The chief hazard is the arcing produced when the switch is opened. In this regard, oil-break switches are the more hazardous of the two types. The hazard increases when a switch is operated much beyond its rated capacity, when its oil is in poor condition or when the oil level is low. Then the arc may vaporize the remaining oil, rupture the case and cause a fire. However, if properly used and maintained, these switches present no hazard.

- *Electric Motors.* Many fires are caused by electric motors. Sparks or arc, from short circuiting motor windings or improperly operating brushes, may ignite the motor insulation or nearby combustible material. Other causes of fires in motors include overheating of bearings due to poor lubrication and grimy insulation on conductors preventing the normal dissipation of heat.

4.2 Electrical Faults that Cause Fires

- *Short Circuits.* If the insulation separating two electrical conductors breaks down, a short circuit occurs. Instead of following its normal path, the current flows from one conductor to the other. Because the electrical resistance is low, a heavy current flows and causes intense local heating. The conductors become overloaded electrically, and they may become dangerously overheated unless the circuit is broken. If the fuse or circuit breaker fails to operate, or is unduly delayed, fire can result and spread to nearby combustible material.
- *Overloading of Conductors.* When too large an electrical load is placed on a circuit, an excessive amount of current flows and the wiring overheats. The temperature may become high enough to ignite the insulation. The fuses and circuit breakers that are installed in electric circuits will prevent this condition. However, if these safety devices are not maintained properly, their failure may result in a fire.

- *Arcing.* An arc is pure electricity jumping across a gap in a circuit. The gap may be caused intentionally (as by opening a switch) or accidentally (as when a contact at a terminal becomes loose). In either case, there is intense heating at the arc. The electrical strength of the arc and amount of heat produced depend on the current and voltage carried by the circuit. The temperature may easily be high enough to ignite any combustible material near the arc, including insulation. The arc may also fuse the metal of the conductor. Then, hot sparks and hot metal may be thrown about and set fire to other combustibles.

4.3 Hazards of Electrical Fires

- *Electric Shock.* Electric shock may result from contact with live electrical circuits. It is not necessary to touch one of the conductors of a circuit to receive a shock. Any conducting material that is electrified through contact with a live circuit will suffice. Thus, firefighters are endangered in two ways: First, they may touch a live conductor or some other electrified object while groping about in the dark or in smoke. Second, a stream of water or foam can conduct electricity to firefighters from live electrical equipment. Moreover, when firefighters are standing in water, both the chances of electric shock and the severity of shocks are greatly increased.
- *Burns.* Many of the injuries suffered during electrical fires are due to burns alone. Burns may result from direct contact with hot conductors or equipment, or from sparks thrown off by these devices. Electric arcs can also cause burns. Even persons at a distance from the arc may receive eye burns.

4.4 Locations of Electrical Equipment Onboard

Electric power is essential to the operation of a vessel. The equipment that generates, controls and delivers this power is found throughout the vessel. Some of this equipment, such as lighting devices, switches and wiring, is common and easily recognized.

- *Engine Room.* The source of the vessel's electric power is its generators. At least two generators are located in the engine room and often three or four generators are fitted. While the others are operating, one is always held in reserve for backup duty. The generators supply power to the main electrical switchboard, which is typically in the same area as the generators in the engine room. The switchboard houses the generator control panels, as well as a distribution section. If a fire breaks out in the vicinity of the generator switches or the main switchboard, the vessel's engineer can stop the generator by mechanical means. This will de-energize the panel board and switches. Also nearby is the engine room console, which contains controls for the fire pumps, ventilating fans, engineer's signal alarm panel, temperature detection system and other engine room equipment.
- *Emergency Generator Room.* An emergency generator and switchboard are available for use on most vessels in case the main generator fails. It will provide power for emergency lighting and equipment only. They are located in the emergency generator room, which is outside the main engine room.
- *Passageways.* Electrical distribution and lighting panel boards are located along passageway bulkheads. Much of the vessel's electrical wiring is placed in the passageway overheads. Access panels are provided in these overheads to allow work on the wiring, and these panels can be removed to check the area for fire extension.
- *Other Locations.* The bridge contains much electrical equipment, including the radar apparatus, bridge console, smoke detector indicating panel and lighting panel boards. Below decks, in the bow and stern, are electrical control panels for the capstan and winch motors. A power panel board in the machine shop controls the electric-arc-welding machine, buffer and grinder, drill press and lathe. There is still much more electrical equipment located throughout every vessel. The important point is that the hazards of live electrical equipment must be considered whenever a shipboard fire is being fought.

4.5 Extinguishment of Class “C” Fires

When any type of electrical equipment is involved with fire, its circuit should be de-energized. However, recognizing that the circuit may not be de-energized, the fire must be extinguished using a non-conducting agent, such as CO₂ or dry chemical. In considering the application of a fire extinguishing agent, an electrical circuit or panel should always be considered energized.

5 Class “D” Fires

Metals are commonly considered to be non-flammable. However, they can contribute to fires and fire hazards in a number of ways. Sparks from the ferrous metals, iron and steel, can ignite nearby combustible materials. Finely divided metals are easily ignited at high temperatures. A number of metals, especially in finely divided form, are subject to self-heating under certain conditions; resulting in fires. Alkali metals such as sodium, potassium and lithium react violently with water, liberating hydrogen, and sufficient heat is generated in the process to ignite the hydrogen. Most metals in powder form can be ignited as a dust cloud, and violent explosions have resulted. In addition to all this, metals can injure firefighters through burning, structural collapse and toxic fumes.

Many metals, such as cadmium, give off noxious gases when subjected to the high temperatures of a fire. Some metallic vapors are more toxic than others. However, breathing apparatus should be used whenever fires involving metals are fought.

5.1 Hazards/Characteristics of Specific Metals

- *Aluminum.* Aluminum is a light metal with good electrical conductivity. In its usual forms it does not present a problem in most fires. However, its melting point of 660°C (1220°F) is low enough to cause the collapse of unprotected aluminum structural members. It is for this reason that aluminum is not permitted to be used in a fire main, even on an aluminum vessel. Aluminum chips and shavings have been involved in fire, and aluminum dust is a severe explosion hazard. Aluminum does not ignite spontaneously and is not considered to be toxic.

In addition, if aluminum is mixed with or smeared into iron oxide (rust) and then struck, a spark can be generated which can ignite an existing flammable vapor. This is the reason that the Rules prohibit the use of aluminum paint within hazardous areas, such as those on oil carriers.

- *Iron and Steel.* Iron and steel are not considered combustible. In the larger forms, such as structural steel, they do not burn in ordinary fires. However, fine steel wool or dust may be ignited, and iron dust is a fire and explosion hazard when exposed to heat or flame. Iron melts around 1535°C (2795°F) and ordinary structural steel around 1430°C (2606°F).
- *Magnesium.* Magnesium is a brilliant white metal that is soft, ductile and malleable. It is used as a base metal in light alloys for strength and toughness. Its melting point is 649°C (1200°F). Dust or flakes of magnesium are easily ignited, but in solid form it must be heated above its melting point before it will burn. It then burns fiercely with a brilliant white light. When heated, it reacts violently with water and all moisture.
- *Titanium.* Titanium is a strong white metal, lighter than steel, which melts at 2000°C (3632°F). It is mixed with steel in alloys to give high working temperatures. It is easily ignited in smaller forms (titanium dust is very explosive), though larger pieces offer little fire hazard. Titanium is not considered toxic.

5.2 Locations of Class “D” Materials Onboard

The metal principally used in the construction of vessels is steel. However, aluminum, its alloys and other lighter metals are used to build the superstructures of some vessels. The advantage of aluminum lies in the reduction of weight. A disadvantage, from the fire-fighting viewpoint, is the comparatively low melting point of aluminum as compared to that of steel.

In addition to the material used for the vessel itself, metals are carried in most forms as cargo. Generally, there are no stowage restrictions regarding metals in solid form. On the other hand, the metallic powders of titanium, aluminum and magnesium must be kept in dry, segregated areas. The same rules apply to the metals potassium and sodium.

It should be noted here that the large containers used for shipping cargo are usually made of aluminum. The metal shells of these containers have melted and split under fire conditions, exposing their contents to the fire.

5.3 Extinguishment of Class “D” Fires

Metals that form a fire risk are usually carried as cargoes and fall under the category of dangerous goods. Frequently there is a violent reaction with water, which may result in the spreading of the fire and/or explosion. No one method of extinguishment has proven effective for all fires involving metals. Sand, graphite, various other powder extinguishing agents and salts of different types have been applied to metallic fires with varying success.

Recognizing the unique fire risks that individual dangerous goods present, the International Maritime Organization has established emergency procedures for such products. These emergency procedures typically identify the particular type of extinguishing agent to be used in the case of a fire involving these products and are found in appendices to the IMDG Code (International Maritime Dangerous Goods Code), as well as the IMO Bulk Cargo Code (Code of Safe Practice for Solid Bulk Cargoes). In reviewing the fire fighting arrangements for a vessel intended to carry particular cargoes considered to be a Class “D” fire hazards, the above emergency procedures should be consulted.

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SECTION **3 Fire Main Systems**

1 General Principles of the Fire Main System

The fire main is a system consisting of sea inlet(s), suction piping, fire pumps and a distributed piping system supplying fire hydrants, hoses and nozzles located throughout the vessel. Its purpose is to provide a readily available source of water to any point throughout the vessel which can be used to combat a fire and is considered the backbone of the fire fighting systems onboard a vessel. Through the fire main system, the firefighter is provided with a reliable and versatile system capable of providing a number of different methods with which to engage a fire. Water can be supplied as a straight stream for combating deep seated fires, as a spray for combating combustible liquid fires where cooling and minimum agitation is desired or as a means to protect personnel where cooling is the primary effect desired.

2 Extinguishing Capabilities of Water

Water primarily extinguishes a fire by the removal of heat (see 1/5.3). It absorbs heat more effectively than any other commonly used extinguishing agent due to its good thermal conductivity and its high latent heat of vaporization. It is most effective when it absorbs enough heat to raise its temperature to 100°C (212°F). At that temperature, water absorbs additional heat as it goes through the transition from a liquid to a vapor (i.e., steam).

In the process of heating the water from normal temperatures, up through its conversion into steam, water absorbs approximately 2.6 kilo-joules of heat per gram (1117 BTU/lb) of water, which is a much higher heat absorption value than any other agent. This absorption of heat reduces the temperature of the burning vapors and also reduces the amount of vapor being generated by the cooling of the fuel surface. With adequate cooling, there is insufficient heat to maintain the self-supporting combustion process and the fire goes out.

Water also has an important secondary effect. When it turns to steam, it expands about 1600 times in volume at atmospheric pressure. As a result, one cubic meter (cubic foot) of water can generate up to 1600 cubic meters (cubic feet) of steam vapor. This great cloud of steam surrounds the fire, displacing the air that supplies oxygen for the combustion process. Thus, water provides a smothering action as well as cooling.

3 Moving Water to the Fire

The purpose of the fire main system is simply to move the water to the locations needed at sufficient capacity and pressure so that it can be used as an effective extinguishing medium. At sea, the supply of water is limitless. However, moving the water is another matter. The amount of water that can be moved to a shipboard fire depends on the number and capacity of the fire pumps installed and the design of the fire main piping system. Even when water is available in huge quantities, it still must be used economically and wisely. If it is not, its weight can affect the equilibrium of the vessel. This is especially true if large amounts of water are introduced into, and remain at, high points in the vessel. The weight of the water raises the center of gravity of the vessel and can impair the vessel's stability.

Even water that is not confined, but can run to lower portions of the vessel, may affect the buoyancy of the vessel. Vessels have capsized and sunk because excessive amounts of water were used during fire-fighting efforts. Each 1 m³ (35 ft³) of water weighs approximately one tonne (0.98 ton).

Aboard a vessel, water is moved to a fire in two ways:

- i) Via the fire main system, through hose lines that are manipulated by the vessel's personnel
- ii) Through piping systems that supply fixed manual or automatic sprinkler or spray systems

Both are reliable methods for bringing water to bear on a fire, provided the pumps, piping and all components of the system are properly designed and maintained. The first method of distribution, the fire main system, is discussed in this Section. Water sprinkler and water spray systems will be discussed in Section 5.

The fire main system is a vital part of the various fire-fighting systems installed onboard vessels. Since the hose and the nozzle complete the job of moving the water to the fire, it is equally important to understand the effects of the various operations of a hose line and the nozzles.

3.1 Straight Streams

The straight stream, sometimes called the solid stream, is a valuable form of water for fire-fighting. The straight stream is formed by a nozzle that is specially designed for that purpose. The nozzle from which the water is thrown is tapered to increase both the velocity of the water at the discharge and the reach.

3.1.1 Efficiency of Straight Streams

The distance that a straight stream travels before breaking up or dropping is called its reach. Reach is important when it is difficult to approach close to a fire. Actually, despite its name, a straight stream is not really straight. Like any projectile, it has two forces acting upon it. The velocity imparted by the nozzle gives it reach, either horizontally or at an upward angle, depending on how the nozzleman aims the nozzle. The other force, gravity, tends to pull the stream down where it encounters the deck. Accordingly, the stream is an arch. The maximum horizontal reach is then attained with the nozzle held at an upward angle of 35 to 40 degrees from the deck. Section 3, Tables 1 and 2 provide information about the throw capability of individual nozzle sizes at various pressures/directions.

Probably less than 10% of the water from a straight stream actually absorbs heat from the fire. This is because only a small portion of the water surface actually comes in contact with the fire, and only water that contacts the fire can absorb heat. The rest runs off, sometimes over the side; but more often the runoff becomes free-surface water and is a problem for the vessel.

3.1.2 Using Straight Streams

A straight stream should be directed into the seat of the fire. This is important since for maximum cooling, the water must contact the material that is actually burning. A solid stream that is aimed at the flames is ineffective. In fact, the main use of solid streams is to break up the burning material and penetrate to the seat of a Class "A" fire.

It is often difficult to hit the seat of a fire, even with the reach of a solid stream. Aboard a vessel, bulkheads with small openings can keep firefighters from getting into proper position to aim the stream into the fire. In some instances, there may be an obstruction between the fire and the nozzleman. In these cases, frequently the stream can be bounced off a bulkhead or the overhead to get around the obstacle. This method can also be used to break a solid stream into a spray-type stream, which will absorb more heat. It is useful in cooling an extremely hot passageway that is keeping firefighters from advancing toward the fire.

The following are the basic characteristics of a straight stream:

- Can be aimed accurately
- Has good reach
- Must hit seat of fire to cool effectively
- Run-off of water may be excessive
- Generates very little steam

TABLE 1
Water Discharge Rates

Note: Theoretical discharge may be taken using this table. Please note that 2½" hydrant/hose normally corresponds to a 7/8" smooth bore nozzle and a 1½" hydrant/hose normally corresponds to a 5/8" smooth bore nozzle.

Rate (psi)	Gallons of Water Flowing Per Minute at Various Nozzle Pressures and Sizes												
	Nozzle Sizes (inch)												
	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/8
30	63	91	124	162	205	253	307	365	429	498	572	651	826
32	65	94	129	167	212	261	317	377	443	514	591	673	854
34	67	97	133	172	218	269	327	389	457	530	610	693	880
36	69	100	137	177	224	277	336	400	470	546	627	713	905
38	71	103	140	182	231	285	345	411	483	561	645	733	930
40	73	106	144	187	237	292	354	422	496	575	661	752	954
42	75	108	147	192	243	299	363	432	508	589	678	770	978
44	77	111	151	196	248	306	372	442	520	603	694	788	1000
46	79	113	154	200	254	313	380	452	531	617	710	806	1021
48	80	116	158	205	259	320	388	462	543	630	725	824	1043
50	82	118	161	209	265	326	396	472	554	643	740	841	1065
52	84	121	164	213	270	333	404	481	565	656	754	857	1087
54	85	123	167	217	275	339	412	490	576	668	769	873	1108
56	87	125	170	221	280	345	419	499	586	680	782	889	1129
58	88	127	173	225	285	351	426	508	596	692	796	905	1149
60	90	130	176	229	290	357	434	517	607	704	810	920	1168
62	91	132	179	233	295	363	441	525	617	716	823	936	1187
64	93	134	182	237	299	369	448	533	627	727	836	951	1206
66	94	136	185	240	304	375	455	542	636	738	848	965	1224
68	96	138	188	244	308	381	462	550	646	750	862	980	1242
70	97	140	190	247	313	386	469	558	655	761	875	994	1260
72	98	142	193	251	318	391	475	566	665	771	887	1008	1278
74	100	144	196	254	322	397	482	574	674	782	900	1023	1296
76	101	146	198	258	326	402	488	582	683	792	911	1036	1313
78	102	148	201	261	330	407	494	589	692	803	924	1050	1330
80	104	150	204	264	335	413	500	596	700	813	935	1063	1347
82	105	151	206	268	339	418	507	604	709	823	946	1076	1364
84	106	153	208	271	343	423	513	611	718	833	959	1089	1380
86	108	155	211	274	347	428	519	618	726	843	970	1102	1396
88	109	157	213	277	351	433	525	626	735	853	981	1115	1412
90	110	159	216	280	355	438	531	633	743	862	992	1128	1429

For smaller and larger size nozzles (also, straight bore type), use the following table:

N.P.	1/4"	5/16"	3/8"	1/2"		N.P.	2 1/2"	3"
30	10	16	23	41		30	1017	1464
32	11	16	24	42		32	1050	1512
34	11	17	24	43		34	1082	1558
36	11	17	25	45		36	1114	1604
38	11	18	26	46		38	1144	1648
40	12	18	26	47		40	1174	1691
42	12	19	27	48		42	1203	1732
44	12	19	28	49		44	1231	1773
46	13	20	28	50		46	1259	1813
48	13	20	29	51		48	1286	1852
50	13	21	30	53		50	1313	1890
52	13	21	30	54		52	1339	1928
54	14	21	31	55		54	1364	1964
56	14	22	31	56		56	1389	2000
60	14	22	32	57		60	1438	
70	16	24	35	62		70	1553	
80	17	26	37	66		80	1660	
90	18	28	40	70		90	1761	
100	19	29	42	74		100	1856	

TABLE 2
Horizontal Reach of Water Streams

For smooth bore nozzles 5/8" with 1 1/2" hose and 7/8" with 2 1/2" hose in still air conditions, horizontal reach can be estimated about 0.3 meter (1 foot) per 0.07 bar (1 psi) Pitot pressure, being 14 and 15.9 meters (47 and 52 feet) correspondingly at 3.5 bar (50 psi).

For protection of Class "B" fires (flammable liquids), where spray pattern is used, the range to be estimated at about 6-7.5 m (20-25 feet) in still air at 3.5 bar (50 psi) pressure.

For smooth bore lines with 2 1/2" hose lines, the following table may be used for reference.

<i>Hose Streams Throw (in fee.) for smooth bore lines with 2 1/2" Hose Lines</i>												
Rate (psi)	Nozzle Sizes (inch)											
	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2
30	18	25	35	45	57	70	85	101	118	138	158	180
32	19	27	37	48	61	75	91	108	126	147	168	192
34	20	29	39	51	65	80	97	115	134	156	180	204
36	21	31	41	54	68	85	102	121	142	165	190	216
38	22	32	44	57	72	90	108	128	150	174	200	228
40	23	34	46	60	76	94	113	135	158	184	210	240
42	25	36	48	63	80	99	119	142	166	192	221	252
44	26	37	50	66	84	103	124	148	174	202	232	264
46	27	39	53	69	88	108	130	155	182	211	242	276
48	28	41	55	72	91	112	136	162	190	220	253	288
50	29	42	58	75	95	117	141	168	198	229	263	300

TABLE 2 (continued)
Horizontal Reach of Water Streams

<i>Hose Streams Throw (in feet) for smooth bore lines with 2 1/2" Hose Lines</i>												
<i>Rate (psi)</i>	<i>Nozzle Sizes (inch)</i>											
	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2
52	31	44	60	78	99	122	147	175	206	239	274	312
54	32	45	62	81	102	126	153	182	214	248	285	324
56	33	47	64	84	106	131	158	189	221	256	295	336
58	34	49	66	87	110	136	164	196	229	266	305	348
60	35	51	69	90	114	141	170	202	237	275	316	360
62	36	53	71	93	118	145	176	209	245	284	326	372
64	38	54	73	96	122	150	181	216	253	293	337	384
66	39	56	76	99	125	155	187	223	261	303	347	396
68	40	58	78	102	129	160	193	230	270	314	359	409
70	41	59	80	105	133	164	199	237	277	322	370	421
72	42	61	83	108	137	169	204	244	285	331	380	433
74	44	63	85	111	141	174	210	250	294	340	390	445
76	45	65	87	114	144	179	216	257	301	350	402	456
78	46	66	90	117	148	183	222	264	309	360	412	469
80	47	68	92	120	152	188	227	270	317	358	422	480
82	48	70	94	123	156	193	233	277	325	377	432	492
84	49	71	96	126	159	197	238	284	333	386	444	505
86	50	73	99	129	163	202	244	291	340	395	454	518
88	52	75	101	132	167	207	250	297	348	405	465	529
90	53	76	103	135	171	212	255	304	357	415	475	540
92	54	78	106	138	175	216	262	311	365	423	485	552
94	55	80	108	141	179	220	267	318	372	432	495	565
96	56	82	110	144	182	226	272	325	380	441	506	578
98	57	83	112	147	186	230	278	332	389	451	517	590
100	59	85	115	150	190	235	284	338	397	460	530	600

3.2 Fog Streams

The fog (or spray) nozzle breaks the water stream into small droplets. These droplets have a much larger total surface area than a solid stream. Thus, a given volume of water in fog form will absorb much more heat than the same volume of water in a straight stream due to the larger exposed surface area.

The greater heat absorption of fog streams is important. Less water needs to be applied to remove the same amount of heat from a fire. In addition, more of the fog stream turns into steam when it hits the fire. Consequently, there is less runoff, less free-surface water and less of a stability problem for the vessel. The cloud of steam surrounding the fire displaces the air that supplies oxygen for the combustion process. Thus, the fog stream helps to provide a smothering action as well as cooling.

The following are the basic characteristics of a fog stream:

- Difficult to aim
- Limited reach
- Excellent cooling abilities

- Generates steam
- Has small amount of run-off
- Pushes smoke and fire
- Does not have to hit seat of fire to be effective

There are basically two different types of fog streams that are used onboard a vessel: the high velocity fog stream and the low velocity fog stream. Both can be used very effectively in combating a fire but serve different functions, as discussed below.

3.2.1 High-velocity Fog Streams

High velocity fog streams are created by a specially designed hose nozzle. In addition to the direct cooling of the flame, the high velocity fog stream can be used effectively to reduce heat in compartments, cabins and cargo spaces. High velocity fog streams can also be used to move air in passageways and to drive heat and smoke away from advancing firefighters.

3.2.2 Low-velocity Fog Streams

Low velocity fog is obtained by using a special applicator along with a combination nozzle. Applicators are tubes or pipes that are angled at 60° or 90° at the water outlet end. They are stowed for use with the low velocity head already in place on the pipe. Some heads are shaped somewhat like a pineapple, with tiny holes angled to cause minute streams to bounce off one another and create a mist. Some heads resemble a cage with a fluted arrow inside. The point of the arrow faces the opening in the applicator tubing. Water strikes the fluted arrow and then bounces in all directions, creating a fine mist.

Low velocity fog is effective in combating Class “B” fires in spaces where entry is difficult or impossible. Applicators can be poked into areas that cannot be reached with other types of nozzles. They are also used to provide a heat shield for firefighters advancing with foam or high-velocity fog. Low-velocity fog can be used to extinguish small tank fires, especially where the mist from the applicator can cover the entire surface of the tank. However, other extinguishing agents, such as foam and carbon dioxide, are usually more effective.

SOLAS (2000 Amendments) – Footnote to II-2/10.5.5 concerning water fog applicators

A water fog applicator might consist of a metal L-shaped pipe, the long limb being about 2 m in length capable of being fitted to a fire hose and the short limb being about 250 mm in length, fitted with a fixed water fog nozzle or capable of being fitted with a water spray nozzle.

3.2.3 Limitations of Fog Streams

Fog streams do not have the accuracy or reach of straight streams. While they can be effectively used on the surface of a deep-seated fire, they are not as effective as solid streams in breaking through and reaching the heart of the fire.

3.2.4 Combination Nozzle Operation

The combination or dual purpose nozzle typically has a handle which is perpendicular to the plane of the nozzle and will produce either a straight stream or high velocity fog, depending on the position of its handle. Combination nozzles are available for use with 3.8 cm (1½") and 6.4 cm (2½") hoses. Reducers can be used to attach a 3.8 cm (1½") nozzle to a 6.4 cm (2½") hose. A straight stream is obtained by pulling the handle all the way back to the operator. A fog stream is obtained by pulling the handle back half way. The nozzle is shut down, from any open position by pushing the handle forward as far as it will go.

In addition, combination nozzles typically have the means to attach a low velocity applicator.

3.2.5 Conclusion

Straight stream and fog streams can be very effective against Class “A” fires as they have the ability to penetrate the fire and cool the fuel surface. Fog streams can be used on Class “A” fires to cool the flame and surrounding environment, but can also be effectively against Class “B” fires.

4 ABS Requirements for Fire Main Systems

The following information is provided as general guidance on the ABS requirements for fire main systems as required by the *Rules for Building and Classing Steel Vessels* (SVR) and *Rules for Building and Classing Steel Vessels Under 90 meters (295 feet) in Length* [SVR(L<90m)]. However, reference should always be made to the Rules applicable to the specific vessel concerned for the complete set of requirements.

4.1 Main Fire Pumps

4.1.1 Number Required

In accordance with SVR 4-7-3/1.5.1, each vessel is to be provided with at least two main fire pumps. For vessels 1000 gross tons and above, each main fire pump is to be independently power-driven. The phrase “independently power driven” should be understood to require that the driving power for each pump is not supplied from the vessel’s propulsion unit and also that the driving mechanism for each pump is independent of the other pump(s) driving mechanisms.

4.1.2 Arrangements

Unless an emergency fire pump is provided, the locations, as well as the arrangements, for access, power supplies, fuel supplies, sea suction, suction and discharge piping and supporting environmental services (lighting, ventilation, etc.) for the two main fire pumps must be arranged so that a fire in a space containing any one of the main fire pumps will not render both pumps inoperable, as specified in SVR 4-7-3/1.5.4. The following identifies the minimum requirements for access arrangements; separation and services supplying the two main fire pumps, as specified in SVR 4-7-3/1.5.4.

4.1.2(a) General Arrangement and Common Boundaries. The pumps are to be in separate rooms, completely isolated and independent from one another. It is usually necessary to confirm the arrangements to identify common entrances, passages and structural isolation of common boundaries. Only one common boundary is permitted between the spaces containing the two main fire pumps and this single common boundary must be a class “A-0” boundary or higher, as specified in SVR 4-7-3/1.5.4. Multiple common boundaries are not permitted.

4.1.2(b) Access. No direct access should be permitted between the spaces unless this is determined to be “impracticable”. Where so determined to be “impracticable,” SVR 4-7-3/1.5.4 indicates that a direct access may be considered. However, arrangements must comply with one of the arrangements specified in SVR 4-7-3/1.5.3vii), which are outlined in the following:

- i) An arrangement where the access is by means of an airlock. One of the doors of the machinery spaces is to be of A-60 class standard and the other is to be of steel, both reasonably gastight, self-closing and without any hold-back arrangements, or

- ii) An access through a watertight door. This door is to be capable of being operated from a space remote from the machinery space of category “A” and the spaces containing the fire pumps. The remote control must also be located at a point that is unlikely to be cut off in the event of fire in those spaces and for unattended propulsion machinery space operation, the door is to be remotely operable from the fire-fighting station (see SVR 4-9-4/21.3). As the door is a watertight door, controls from either side of the bulkhead are also required, in accordance with SVR 3-2-9/9.1.
- iii) Where direct access is provided in accordance with the arrangements specified in i) or ii) above, a second means of access must be provided to the spaces containing the main fire pumps. The second means of access to each space must be totally independent of the space containing the other fire pump.

4.1.2(c) Power Supplies. Power supplies for the two main fire pumps must be totally independent. If electrical, the review needs to confirm that the power is supplied from different sources (typically, one must be from the emergency generator), with the feeder cables being separated in all ways as far as practicable. Routing of the electric supply cable through the space containing the other fire pump or through high fire risk areas (category “A” machinery spaces) would not be acceptable. If diesel-driven, then arrangements for starting, fuel supply, air and exhaust piping, etc., are to be completely independent. Similarly, hydraulically-driven pumps are to have independent power units and controls without interconnections.

4.1.2(d) Water Supply. The sea chest, suction piping and discharge piping arrangements to the fire main, as well as the pump and valve controls, must be arranged so as to be totally independent from the other pump and are not to be located in or enter into the space containing the other pump, in accordance with SVR 4-7-3/1.5.4.

The sea chest and suction pipe for one of the main fire pumps (or the emergency fire pump), which is located outside of the machinery space, may be located in the machinery space provided the conditions outlined in SVR 4-7-3/1.5.3vi) are satisfied.

It should be noted that if the suction or discharge piping is permitted to be within a category “A” machinery space, the piping is to be all welded except for flange connections to the sea inlet valve.

4.1.2(e) Environmental Systems. The arrangements of environmental systems (e.g., lighting, ventilation, etc.) are to be completely independent for both pump locations. If the information available on hand is not sufficient to verify these arrangements, a comment should be made relative to the drawing and the installation verified by the attending Surveyor.

4.1.3 Pump Type, Relief, etc.

4.1.3(a) Suitability. It is important to know certain details regarding the pumps (NPSH requirements, discharge characteristics, type of pump, etc.) being proposed for installation in order to verify the pump’s suitability for fire main service. Part of determining the suitability of the pumps involves the recognition that fire pumps must operate over a wide range of flow rates, from minimal a flow rate while supplying a single nozzle to full flow. With this wide range of operating flow rates, the resulting pressures developed by the pump must stay within an appropriate and safe range. Some pumps may be capable of providing the high flow rate at the minimum required pressure, but may develop excessive pressures when delivering only the flow for a single nozzle. Such excessive pressures can make handling the hose very difficult, and can actually present a danger if the pressure is too high and the hose gets loose. This issue is specifically addressed in SVR 4-7-3/1.7.3, which indicates that the maximum pressure at any hydrant is not to exceed that at which effective control of a fire hose can be demonstrated. The pump characteristics play an important part in establishing compliance with this requirement.

Other pumps may be able to provide suitable pressures at minimum flow rates but be unable to maintain the required pressures specified in SVR 4-7-3/1.7.2 when delivering at the required full capacity flow rates. As a result of the need to supply a wide capacity range over a relatively narrow pressure band, centrifugal pumps with flat or very shallow head/capacity curves are usually proposed. Such pumps are capable of supplying minimal flow rates (i.e., approaching shut-off head) without creating excessive and dangerous pressures, yet are also capable of providing large flow rates while maintaining the required pressures at the most remote nozzles. Appropriate details verifying the suitability of the pumps should be requested and verified.

4.1.3(b) Relief Valves. In addition to the concern associated with the possibility of danger in having excessive pressure for hose handling, many pumps are also capable of exceeding the maximum working pressures of the piping system components at shut-off pressures. Accordingly, SVR 4-7-3/1.5.6 requires relief valves to be provided in conjunction with all fire pumps if the pumps are capable of developing a pressure exceeding the design pressure of the water service pipes, hydrants and hoses. These relief valves are to be so placed and adjusted as to prevent excessive pressure in any part of the fire main system.

4.1.3(c) ABS Certification. In accordance with SVR 4-7-3/1.5.1 and item 4 of SVR 4-1-1/Table 6, fire pumps are to be provided with ABS certificates. The certificates must be available for presentation to the attending Surveyor.

4.1.3(d) Multiple Service Applications. As noted in SVR 4-7-3/1.5.2, the pumps are not required to be dedicated for fire services only. They may be utilized for other purposes and designated accordingly (e.g., fire and ballast, fire and bilge, general service pump, etc.). However, at least one pump is to be available for fire use at all times. In addition, fire pumps should not be connected to systems normally used for transfer of oil. The Rules do permit occasional, short-term oil duties for the pump. However, if so designated, there must be suitable positive changeover arrangements (e.g., elbow and blank flange) and a notice to assure the pump's connection to fire main after such use. Because of pumps' designation and use for other than fire services and the need for ready capability of the fire water supply, the pumps should have simple and reliable means to switch them to fire services. The most common arrangement is to manifold valves at the pumps. In addition, there may be certain arrangements where the fire pumps also serve other fire-fighting services (e.g., sprinkler system, etc.) which must be immediately available. In such cases, isolation arrangements, such as swing elbows and blank flanges, would not be suitable.

4.1.4 Main Fire Pump Capacities

4.1.4(a) Total Pump Capacity. In accordance with SVR 4-7-3/1.3.1, the combined output of the main fire pumps is to be sufficient to deliver for fire-fighting purposes a quantity of water not less than four-thirds of the quantity required to be handled by each independent bilge pump as calculated in accordance with SVR 4-6-4/5.3.2. However, the total required capacity of the fire pumps need not exceed 180 m³/hr (792 gpm), insofar as classification requirements are concerned. In order to verify this requirement, the required independent bilge pump capacity must be established. Then the combined capacity of the fire pumps, while delivering at the pressure necessary to meet the requirements of SVR 4-7-3/1.7.2 at the most remote hydrants (i.e., pressure drops associated with flowing through the main must be considered), must not be less than four-thirds of that value.

4.1.4(b) Individual Pump Capacity. In accordance with SVR 4-7-3/1.3.2, each of the main fire pumps is required to have a capacity of not less than the greater of:

- i) 80% of the total required capacity divided by the number of required fire pumps,
- ii) 25 m³/hr (110 gpm), or
- iii) The capacity required to deliver at least the two jets of water.

SVR 4-7-3/1.3.2 indicates that these fire pumps are to be capable of supplying the fire main system under the required conditions, which should be understood to be those pressures specified in SVR 4-7-3/1.7.2.

SVR 4-7-3/1.3.2 actually identifies two interrelated requirements: flow rate at a required pressure. Therefore, when evaluating the individual fire pump capacity, the review should establish that each fire pump is capable of delivering the largest of the above required flow rates through the most hydraulically remote hydrants while maintaining the pressures specified in SVR 4-7-3/1.7.2 at the nozzles. In the case of the third requirement, the largest size nozzles to be used should be taken into considered.

In a few instances more than two pumps might be designated for fire services. The Rules leave this situation to special consideration. For example, provision of two smaller capacity pumps arranged together to make up the capacity of one of the required pumps will satisfy the intent of the Rules, provided they are arranged with common suction/discharge valves, power supply, start/stop controls, etc., and are interconnected in such a way as to perform the functions of the required pump.

In accordance with SVR 4-7-3/1.3.2, each pump for fire extinguishing which is installed in addition to the required number of pumps should have a capacity of at least 25 m³/h (110 gpm) and should be capable of delivering at least the two jets of water required in SVR 4-7-3/1.9.

4.1.5 Ready Availability of Water Supply

It should be noted that SVR 4-7-3/1.5.5 requires that cargo vessels be provided with the means to ensure the ready availability of water supply for spaces intended for centralized or unattended operation.

4.1.6 Connections to Fire Main from Another Engine Room Pump

The Rules also require that in addition to the main and emergency fire pumps, on a cargo vessel where other pumps (such as general service, bilge and ballast, etc.) are fitted in a machinery space, arrangements are to be made to ensure that at least one of these pumps, having the capacity and pressure required by SVR 4-7-3/1.3.2 and 4-7-3/1.7.2, is capable of providing water to the fire main.

4.2 Emergency Fire Pump

If the arrangements for the two main fire pumps are such that a fire in one space can put both main fire pumps out of service, an emergency fire pump is required to be provided, as per SVR 4-7-3/1.5.3. The emergency fire pump is required to be a fixed independently-driven pump and the requirements for the pump and its location are identified in SVR 4-7-3/1.5.3. These requirements are summarized below:

4.2.1 Arrangement (Independent Systems)

As per SVR 4-7-3/1.5.3, the emergency fire pump system, including the power source, fuel oil supply, electric cables, etc., as well as the lighting and ventilation for the emergency fire pump space are to be independent of the main fire pumps, so that a fire in any one compartment will not render both the main and emergency fire pumps inoperable. These items are to be verified during plan review whenever possible.

If the fire pump is electrically-driven, the power is to be supplied from the emergency generator and the feeder cable routed outside of high fire risk areas (category “A” machinery spaces). In addition, the electrical power and control cables for the emergency fire pump and valves are to also be widely separated from any electrical and control cables associated with the main fire pumps.

4.2.2 Capacity

In association with the requirements specified in the initial paragraph of SVR 4-7-3/1.5.3, as well as SVR 4-7-3/1.5.3i), the capacity of the pump is not to be less than 40% of the total capacity of the fire pumps required per SVR 4-7-3/1.3.1, and in any case, not less than the following:

- i) For cargo vessels of 2000 gross tonnage and upward: 25 m³/h (110 gpm), and
- ii) For cargo vessels less than 2000 gross tonnage: 15 m³/h (66 gpm).

Where applicable, the emergency fire pump is also to be capable of simultaneously supplying the amount of water needed for any fixed fire-extinguishing system protecting the space containing the main fire pump.

The emergency fire pump must also be suitable for the service and be provided with adequate protection against overpressurization (see 3/4.1.3).

4.2.3 Pressure

Per SVR 4-7-3/1.5.3ii), when the pump is delivering the quantity of water discussed above, the pressure at any hydrant is to be not less than the minimum pressures given in SVR 4-7-3/1.7.2. Verification of compliance with this requirement must be based upon considering the worst-case situation. See 3/4.1.4(b) of these Guidance Notes for a discussion regarding verification of the combined pressure/capacity requirement.

4.2.4 Starting Arrangements

In accordance with SVR 4-7-3/1.5.3iii), any diesel-driven power source for the pump is to be capable of being readily started in its cold condition down to a temperature of 0°C (32°F) by hand (manual) cranking. If this is impracticable, or if lower temperatures are likely to be encountered, heating arrangements are to be provided so that ready starting will be assured. If hand (manual) starting is impracticable, other means of starting may be considered. These means are to be such as to enable the diesel-driven power source to be started at least six (6) times within a period of 30 minutes and at least twice within the first 10 minutes. Diesel engines exceeding 15 kW (20 hp) are to be equipped with an approved auxiliary starting device (e.g., starting battery, independent hydraulic starting system or independent starting air system).

Also, any internal-combustion engine driving an emergency fire pump is to be capable of being readily started in its cold condition down to a temperature of 0°C (32°F). If this is impracticable, or if lower temperatures are likely to be encountered, heating arrangements are to be provided for ready starting of generator sets.

4.2.5 Fuel Supply

In accordance with SVR 4-7-3/1.5.3iv), any service fuel tank is to contain sufficient fuel to enable the pump to run on full load for at least three hours and sufficient reserves of fuel are to be available outside the main machinery space to enable the pump to be run on full load for an additional 15 hours.

4.2.6 Suction

The total suction head and net positive suction head of the pump are to be such that the requirements of SVR 4-7-3/1.5.3i), 4-7-3/1.5.3ii) and 4-7-3/1.7.2 are obtained under all conditions of list, trim, roll and pitch likely to be encountered in service, as per SVR 4-7-3/1.5.3v). (This excludes the docking condition of the vessel.) In addition, the sea valve is to be operable from a position near the pump.

4.2.7 Arrangement (Boundaries)

As per SVR 4-7-3/1.5.3vi), the space containing the emergency fire pump is not to be contiguous to the boundaries of category “A” machinery spaces or those spaces containing main fire pumps. Where this is not practicable, the common bulkhead between the two spaces is to be insulated to a standard of structural fire protection equivalent to that required for a control station. The common bulkhead is to be constructed to “A-60” class standard and the insulation is to extend at least 450 mm (18 in.) outside the area of the joint bulkheads and decks. The structural fire protection arrangements of the compartment containing the emergency fire pump should also be verified.

4.2.8 Supply and Delivery Piping

The emergency fire pump including seawater suction and delivery pipes is to be located outside the compartment containing the main fire pumps. The sea chest with valve and main part of the suction piping should be, in general, outside the machinery spaces containing the main fire pumps. If this arrangement is impractical, the sea chest may be fitted in the machinery spaces containing the main fire pump on the condition that the suction valve is remotely controlled from a position near the pump in the same compartment and that the suction pipe is as short as possible. Only short lengths of suction and discharge piping may penetrate the machinery spaces if enclosed in a steel casing, as discussed in 3/4.1.2(d) of these Guidance Notes and in SVR 4-7-3/1.5.3vi).

4.2.9 Access

Similar to the requirements discussed above for the access arrangements between the main fire pumps, no direct access is to be permitted between the machinery space of category “A” and the space containing the emergency fire pump and its source of power. This requirement assumes that the main fire pumps will be located in a category “A” machinery space. Accordingly, in the event that the main fire pumps are not located in a category “A” machinery space, it should be noted that direct access between the space containing the emergency fire pump and the main fire pump(s) also would be unacceptable. However, like the arrangements for main fire pumps, where this is unavoidable, the Rules do permit the following arrangements to be considered, in accordance with SVR 4-7-3/1.5.3vii):

- i) *Via Airlock.* An arrangement where access is provided by means of an airlock may be considered. For such an arrangement one of the doors of the machinery spaces is to be of A-60 class standard and the other is to be of steel, both reasonably gastight, self-closing and without any hold back arrangements.
- ii) *Via Watertight Door.* An access through a watertight door may also be considered. This door is to be capable of being operated from a space remote from the machinery space of category A and the space containing the emergency fire pump and is to be unlikely to be cut off in the event of fire in those spaces.
- iii) *Via Second Means of Access.* Where direct access is provided in accordance with the arrangements specified in i) or ii) above, a second means of access must be provided to the spaces containing the emergency fire pumps. The second means of access must be totally independent of the space containing the main fire pumps.

Related ABS Interpretation/Instruction

Note: Where an emergency fire pump room (EFPR) is accessible from the steering-gear room (SGR), and access to the SGR is from a machinery space of category A or a space containing the main fire pumps, the arrangement will be acceptable based on the following conditions.

- a) *An ABS Technical Office is to be satisfied with the shipyard’s or designer’s technical explanation that the EFPR arrangement described above is unavoidable (i.e., impracticable for the EFPR to be located elsewhere).*
- b) *The requirements of SVR 4-7-3/1.5.3vii) are to be satisfied.*

- c) *A-60 insulation with 450 mm overlap is to be provided to contiguous boundaries between EFPR and machinery spaces of category A or those spaces containing main fire pumps.*
- d) *Where the second protected means of access required per SVR 4-7-3/1.5.3vii) is provided from EFPR to directly outside of the SGR (i.e., via an escape trunk), then A-0 insulation is acceptable between SGR and machinery spaces of category A or those spaces containing main fire pumps. However, the protected escape trunk is to be at least A-60.*

Where the second means of escape is provided from the EFPR to SGR and then from SGR to outside of SGR, the above A-0 insulation is to be replaced by A-60 insulation.
- e) *EFPR ventilation may be common with SGR, provided SGR ventilation is completely separate and independent from the ventilation for the machinery spaces of category A or those spaces containing main fire pumps.*

Related IACS Unified Interpretation

UI SC 114 re. SOLAS Chapter II-2, Regulation 4.3.3.2.9, (SOLAS 2000 II-2/10.2.2.3.2.1)

When a single access to the emergency fire pump room is through another space adjoining a machinery space of category A or the spaces containing the main fire pumps, class A-60 boundary is required between that other space and the machinery space of category A or the spaces containing the main fire pumps.

4.2.10 Ventilation

Ventilation arrangements to the space containing the independent source of power for the emergency fire pump are to be such as to preclude, as far as practicable, the possibility of smoke from a machinery space fire entering or being drawn into that space. The space is to be well ventilated and power for mechanical ventilation is to be supplied from the emergency source of power, in accordance with SVR 4-7-3/1.5.3viii). This should be verified by plan review or the attending Surveyor requested to verify the compliance.

4.2.11 Priming

SVR 4-7-3/1.5.3i) requires that the emergency fire pump is to be of the self-priming type and the same should be confirmed at the plan review.

4.2.12 ABS Certification

The requirement for ABS certification of fire pumps, as discussed in 3/4.1.3(c) is also applicable to emergency fire pumps.

4.3 Fire Main Sizing and System Pressures

The ability of the fire main system to provide adequate quantities of water through a sufficient number of fire hoses at the necessary pressures is critical to the effectiveness and usefulness of system. Accordingly, SVR 4-7-3/1.7.1 and 4-7-3/1.7.2 specify the following:

Quote:

4-7-3/1.7.1 Fire main diameter

The diameter of the fire main and water service pipes is to be sufficient for the effective distribution of the maximum required discharge from two fire pumps operating simultaneously. However, the diameter need only be sufficient for the discharge of 140 m³/hour (616 gpm).

4-7-3/1.7.2 Fire main pressure

With the two pumps simultaneously delivering through nozzles specified in 4-7-3/1.15, the quantity of water specified in 4-7-3/1.7.1, through any adjacent hydrants, the following minimum pressures are to be maintained at all hydrants:

- i) vessels of 6,000 gross tonnage and upwards: 0.27 N/mm² (40 psi)
- ii) vessels of 1,000 gross tonnage and upwards, but under 6,000 gross tonnage: 0.25 N/mm² (37 psi)

Unquote

In examining the requirements of SVR 4-7-3/1.7, there are a number of interrelated issues involved with these requirements, including:

- i) Total required flow rate for the fire main system
- ii) Pressure drops associated with the fire main distribution system
- iii) Particular hydrants being considered
- iv) Sizes of the hose nozzles used
- v) Performance characteristics of the pumps

Each of these issues impacts the ability of the system to perform as required, and the interrelationship of these items needs to be well understood when evaluating the system.

4.3.1 Required Quantity of Water Discharged

The first item is the total required amount of water that the system must be capable of discharging from the fire main. A certain amount of clarification is needed. First, the requirement in SVR 4-7-3/1.7.2 references the quantity of water identified in SVR 4-7-3/1.7.1. Next, the quantity of water identified in SVR 4-7-3/1.7.1 is the “maximum required discharge from two fire pumps operating simultaneously.”

Defining the term “maximum required discharge from two fire pumps operating simultaneously” should be considered as the greater of the following:

- i) The total required capacity of the combined fire main pumps calculated in accordance with SVR 4-7-3/1.3.1 [see 3/4.1.4(a) of these Guidance Notes to determine this amount]; or
- ii) The combined capacities of the individual fire pumps where each individual fire pump capacity is determined in accordance with SVR 4-7-3/1.3.2 [see 3/4.1.4(b) of these Guidance Notes to determine this amount].

However, SVR 4-7-3/1.7.1 does place a limit on the capacity required by indicating that the diameter of the fire main and distribution system need only be sufficient for the discharge of 140 m³/hour (616 gpm), similar to the provisions of SOLAS. Accordingly, the required amount of water that the system must be capable of continuously discharging is the lesser of the “maximum required discharge from two fire pumps operating simultaneously” or 140 m³/hour (616 gpm). However, it should be noted that there are certain Flag Administrations that do not recognize the upper limit specified in SOLAS.

4.3.2 Fire Main Diameter/Pressure Drop

In association with other items, the pressure drop within the fire main when discharging the quantity of water discussed above is dependent upon the diameter, length, etc., of the fire main distribution piping, size and length of the hoses, nozzle sizes and elevation of hydrants. The requirements for the sizing of the fire main distribution piping are provided in SVR 4-7-3/1.7.1, which specifies, “The diameter of the fire main and water service pipes is to be sufficient for the effective distribution of the maximum required discharge from two fire pumps operating simultaneously.” Accordingly, the fire main piping must be sized to effectively deliver the “maximum required discharge from two fire pumps operating simultaneously.” As noted above, SVR 4-7-3/1.7.1 does place a limit on the capacity requirement by indicating that the diameter of the fire main and distribution system need only be sufficient for a maximum discharge of 140 m³/hour (616 gpm).

4.3.3 Hydrants Involved

SVR 4-7-3/1.7.2 indicates that the pressures stated therein must be maintained at “all” hydrants when discharging the total quantity of water through adjacent hydrants. To ensure that the minimum pressure will be available at “all” hydrants, the review must consider the worst case scenario. This would be at that hydrant which is the most hydraulically remote from the pumps. The “most hydraulically remote” hydrant is that hydrant in the system which would result in the largest pressure drop for the system when discharging the total required flow rate through the adjacent nozzles. In considering this requirement, one needs to recognize that the most hydraulically remote hydrant may be the hydrant located the farthest distance from the pump. However, it could also be the hydrant located highest on the superstructure or it may be a hydrant located at the end of a poorly sized branch line. It is a function of the pressure drop (at the required flow rate) in the piping to that hydrant which of course is a function of the distance, height and sizing of the fire main system leading to that hydrant. During the review of the fire main system, one should verify that with the total required quantity of water flowing through the nozzles of hoses attached to adjacent hydrants, the minimum specified pressure is maintained at all hydrants, including the most hydraulically remote hydrant.

4.3.4 Hose Nozzles

As indicated in SVR 4-7-3/1.7.2, the quantity of water involved must be discharged through hose nozzles that are sized in accordance with SVR 4-7-3/1.15. This is important to note, since the size of the nozzles to be used will impact the pressure drop through the system. A larger nozzle orifice will have a smaller pressure drop than a small nozzle when trying to flow the same amount of water. This requirement is also important in establishing that the discharge of the water through the adjacent hydrants must be through hoses which are attached to the hydrants being used to discharge the required flow rate. Thus, any calculations must take into account resistance of fire hoses with attached nozzles.

4.3.5 Pump Performance

The heart of the system is clearly the fire pump. Accordingly, the performance characteristics of the fire pumps at the required flow rates will be one of the major factors in the ability of the fire main system to provide the required minimum pressures. At least basic details of the type of pump and copies of the pump curves are necessary to verify compliance with SVR 4-7-3/1.7.1 and 4-7-3/1.7.2.

4.3.6 Conclusion

Typically, calculations are required to verify compliance with SVR 4-7-3/1.7.1 and 4-7-3/1.7.2. The calculations should establish that the fire main system, which includes the pumps, fire main distribution piping, hoses and nozzles, are properly selected and sized in order to supply the required total flow rate to the most hydraulically remote hydrants while maintaining the required pressure at every hydrant. The review of the calculations should ensure that the designer truly understands the requirements and also allows the Engineer to identify any problem areas before the system is built. However, even if verified by calculations, the ability of the system to meet the requirements of SVR 4-7-3/1.7.2 should also be demonstrated to the satisfaction of the attending Surveyor.

4.4 Fire Hose Reaction

SVR 4-7-3/1.7.3 indicates that the maximum pressure at any hydrant is not to exceed that at which the effective control of a fire hose can be demonstrated. Accordingly, the maximum pressure at any hydrant is to be limited to a pressure for which effective control of the fire hose can be maintained. The following provides a method for estimating the reaction forces from a discharging hose. Typically, forces from the nozzle with pitot tube pressures up to 6.9 bar (100 psi) would not be considered to produce excessive reactions.

Acceleration of water discharged from the smooth bore nozzle creates a reaction force:

$$F = 1.57 D^2 p \quad \text{lbf}$$

$$F = 0.157 D^2 p \quad \text{N}$$

where

F = reaction force, N (lb)

D = orifice diameter, mm (in.)

p = Pitot pressure, bar (psig)

The maximum pressure at any hydrant and the associated reaction forces should be investigated during the review of the calculations under all operating scenarios. This may require additional calculations since during the calculations discussed in 3/4.3 of these Guidance Notes are based upon full flow calculations at the most remote hydrants. However, the maximum hydrant discharge pressure will typically exist with a single nozzle discharging at the hydrant hydraulically closest to the pumps.

4.5 Isolation Valves and Routing Arrangements

In accordance with SVR 4-7-3/1.11.3, isolating valves are to be fitted in the fire main risers leading from those fire pumps located within Category “A” machinery spaces, as well as in any fire main branch piping which is routed back into Category “A” machinery spaces. Because of the uncertain conditions/intensity of fire in such spaces, the presumption is that the space is inaccessible, equipment inoperable and the main is left open-ended (e.g., damage, maintenance, etc.). As a result, water supply from the fire pump or pumps will not be able to build up the required pressure at hydrants and, further, such conditions will result in uncontrolled flooding of the space unless accessible isolation arrangements are available. Therefore, the Rules require accessible (i.e., located outside of the category “A” machinery space) valves be fitted so that damaged or open sections of the fire main piping located within the category “A” machinery spaces can be isolated to eliminate the pressure loss in the system.

In considering the fire main system design, particular attention should be paid to the way the fire main branches are routed. SVR 4-7-3/1.11.3 requires that the fire main and branches are to be so arranged that when the isolating valves are shut, all the hydrants on the vessel, except those into any particular category “A” machinery space, can be supplied with water by a fire pump not located in this machinery space and through pipes which do not enter the isolated space. This allows isolation of the piping within the space and use of the hydrants nearby to fight the fire. Therefore, the isolation valves must be located:

- i) Where the fire main risers leave the category “A” machinery spaces containing the fire pumps
- ii) Upstream of the point where any fire main branch piping re-enters the space.

As a result, no branch downstream of the riser piping isolation valve(s) should re-enter the space without an isolation valve, and no branch from the isolated space should project outside or into an adjacent compartment without an isolation valve and second source of supply.

4.6 Fire Main Piping Components/Materials

All valves, fittings and piping are to comply with the applicable requirements of SVR Sections 4-6-1 and 4-6-2. Accordingly, all valves and fittings are to be designed and constructed in accordance with a recognized standard, be suitable for the intended pressures and comply with all other requirements in SVR Section 4-6-2. A submitted drawing should include a complete Bill of Materials that provides the material specifications, standards of construction, pressure ratings and types of all valves and fittings, as well as the material specification, sizes and wall thickness of the piping, in accordance with SVR 4-6-1/9.3. The drawing should also identify the maximum system pressure and provide adequate information to identify the layout and arrangement of the system(s).

In addition to the common requirements and limitations in SVR Sections 4-6-1 and 4-6-2, the materials used in the system are not to be rendered ineffective by heat, unless the components are adequately protected, in accordance with SVR 4-7-3/1.11.1. This requirement is important to ensure that the fire main system will remain intact and functional even if one portion of the fire main piping is actually within the immediate vicinity of the fire. In order to be considered not “readily rendered ineffective by heat,” a component is to be certified as having passed an acceptable recognized fire test or the material is to have a melting temperature higher than the test temperature specified in an acceptable fire test. Insofar as classification requirements are concerned, the fire test requirement may be waived, provided that shipyards/manufacturers/designers (as appropriate) document that all components used in fire mains have a solidus melting temperature above the minimum temperature specified in an acceptable fire test. The requirement for the fire main material not to be rendered ineffective by heat extends from the pumps throughout the system to the fire station hydrant valves. The hoses and nozzles are not required to meet the above criteria as it is assumed that the integrity of the system will be maintained by the hydrant valve, but are required to be of approved non-perishable material, as discussed below.

The integrity of the valves to maintain closure is also critical to avoid losses of fire main pressure. For this reason, resiliently seated valves may be considered for use in fire main systems, provided they are capable of passing an appropriate fire test acceptable to the Bureau and can be effectively closed with the resilient seat damaged or destroyed such that leakage through the closed valve is insignificant.

No hose connections, non-metallic expansion joints and similar provisions are allowed. Frequently used rubber (cloth inserted) gaskets are also not permitted, as their destruction under the fire could lead to the loss of pressure in the system.

For Regulatory compliance, criteria stipulated by Flag Administration must be satisfied and may differ in criteria from that stated above.

4.7 Hydrant Locations and Fire Hoses/Nozzles

4.7.1 Hydrant Locations

SVR 4-7-3/1.9 requires that the number and position of the fire hydrants be such that at least two jets of water not emanating from the same hydrant (one of which is to be from a single length of hose) may reach any part of the vessel normally accessible to the passengers or crew while the vessel is being navigated and any part of any cargo space when empty, any ro-ro cargo space or any special category space (in which latter case the two jets are to reach any part of such space, each from a single length of hose). Furthermore, such hydrants are to be positioned near the accesses to the protected spaces.”

SVR 4-7-2/5.3.2(a) also requires that at least two combination solid stream and water spray nozzles and hoses sufficient in length to reach any part of the helicopter deck be provided at any helicopter facilities, which would include landing as well as winching facilities.

In addition to the spacing to facilitate hose access, SVR 4-7-3/1.11.1 specifies that the piping and hydrants are to be so placed that the fire hoses may be easily coupled to them. Also where deck cargo is carried, hydrants are to be located such as to avoid damage during cargo operations, but at the same time to remain easily accessible at all times.

Verification that the arrangements of the hydrants comply with the above requirements during plan review can be very difficult as the actual structural arrangements, location of equipment, etc., makes this approach much less reliable, and therefore, is typically included in those items to be verified by the Surveyor. However, the layout and arrangement of the fire stations, as provided in the drawing, in conjunction with the proposed hose lengths should be reviewed and any areas of concern identified. For those areas which are questionable or where the details provided on the drawings are insufficient to verify compliance, appropriate comments should be made in order to the issue to the Surveyor’s attention.

Related IMO MSC Circular 847 Interpretation***SOLAS Ch. II-2/4.5.1 (SOLAS (2000 Amendments) Ch. II-2/10.2.1.5.1) "Location of hydrant in machinery spaces"***

At least one hydrant with hose, nozzle, and coupling wrench should be provided in machinery spaces of category A.

4.7.2 Hydrant Valves

In accordance with SVR 4-7-3/1.11.2, a valve is required to be fitted at a fire station to serve each fire hose so that any fire hose may be removed while the fire pumps are at work. Normally, each hydrant is fitted with an individual valve, but the drawing should be reviewed to verify such compliance and the hose valve determined to be of a design and material which will not be rendered ineffective by heat.

4.7.3 Fire Hoses

4.7.3(a) Hose Approval. Fire hoses are required by SVR 4-7-3/1.13.1 to be of approved non-perishable material. Documentation to verify the material as non-perishable must be via certified to recognized standard by competent independent testing laboratory. In addition, fire hoses are to be ABS certified, in accordance with item 4 of SVR 4-1-1/Table 6.

4.7.3(b) Hose Length. Hoses are to be sufficient in length to project a jet of water to any of the spaces in which they may be used, but they are to have a length of at least 10 m (33 ft), as per SVR 4-7-3/1.13.1.

Fire hoses should not have a length greater than:

- 15 meters (49 feet) in machinery spaces
- 20 meters (66 feet) in other spaces and open decks
- 25 meters (82 feet) on open decks with a maximum breadth in excess of 30 meters (98 feet)

The limitation on the length of hose is due to difficulties in unfolding, kinking and handling of hoses.

4.7.3(c) Number of Hoses. The Rules do not specifically require a hose to be provided at each fire hydrant location. The minimum number of hoses to be provided on vessels of 1,000 gross tonnage and upwards is at least one for each 30 m (100 ft) length of the vessel and one spare, but in no case less than five in all. Also, this number does not include any hoses required in any engine or boiler room. The number of hoses in the machinery space(s) is not specified, but must be in compliance with the relevant governmental authorities.

However, while the Rules do not require a hose to be provided at each fire hydrant location, SVR 4-7-3/1.11.1 does indicate that unless one hose and nozzle is provided for each hydrant on the vessel, there is to be complete interchangeability of the hose couplings and nozzles.

Vessels carrying dangerous goods should be provided with three (3) additional hoses and three (3) additional nozzles, in accordance to SVR 4-7-3/1.13.2.

4.7.4 Nozzles

SVR 4-7-3/1.15.1 indicates that the standard nozzle sizes are to be 12 mm (0.5 in.), 16 mm (0.625 in.) and 19 mm (0.75 in.) or as near thereto as possible. Larger diameter nozzles may be permitted, provided the system can maintain the required pressures specified in SVR 4-7-3/1.7.2.

For nozzles for accommodation and service spaces, SVR 4-7-3/1.15.2 indicates that a nozzle size greater than 12 mm (0.5 in.) need not be used. For machinery spaces and exterior locations, SVR 4-7-3/1.15.3 indicates that the nozzle sizes are to be such as to obtain the maximum discharge possible from two jets at the pressure mentioned in SVR 4-7-3/1.7.2 from the smallest pump, provided that a nozzle size greater than 19 mm (0.75 in.) need not be used.

All nozzles are to be of a dual purpose type (i.e., combination spray/jet type) incorporating a shut-off in accordance with SVR 4-7-3/1.15.4. In addition, SVR 4-7-3/1.15.4 indicates that all nozzles are to be of an approved type (which implies approval by a competent authority) for the intended service. Also, nozzles made of plastic material such as polycarbonate may be accepted subject to review of their capability and serviceability as marine use fire hose nozzles.

Related IACS Unified Interpretation

UI SC146 - SOLAS Reg. II-2/4.7 & 4.8 (SOLAS 2000 Reg. II-2/10.2.3 & 10.2.3)

Aluminum alloys may be used for fire hose couplings and nozzles, except in open deck areas of oil tankers and chemical tankers.

4.7.5 Miscellaneous

SVR 4-7-3/1.13.1 also requires each hose to be provided with a nozzle and the necessary couplings, and that the fire hoses together with any necessary fittings and tools are to be kept ready for use in conspicuous positions near the water service hydrants or connections. Details of the fire stations normally provide sufficient details to verify compliance with this requirement.

4.8 International Shore Connection Arrangements

In accordance with SVR 4-7-3/1.19.1 and 4-7-3/1.19.2, each vessel is required to be provided with at least one international shore connection and arrangements are to be provided to enable the connection to be used on each side of the vessel. The purpose of the connection is to provide a uniform piping joint, which allows water supply to the vessel's fire main from another vessel or shore facility. For this purpose, at least one hydrant on either side of the vessel, suitable for such connection, should be designated an international shore connection station. Provision of dedicated port/starboard hydrants with shore connections permanently fixed to them is an acceptable arrangement.

SVR 4-7-3/1.19.3 and 4-7-3/1.19.4 addresses the dimensions and design of the international shore connection. The standard dimensions of flanges for the international shore connection are required to be in accordance with SVR 4-7-3/Table 1. A copy of this table is provided in Section 3, Table 3, below.

In addition, SVR 4-7-3/1.19.4 indicates that the connection is to be of steel or other suitable material and is to be designed for 10 bar (150 psi) services. The flange is to have a flat face on one side and on the other is to be permanently attached to a coupling that will fit the vessel's hydrant and hose. The connection is to be kept aboard the vessel together with a gasket of any material suitable for 10 bar (150 psi) services, together with four 16 mm (⁵/₈ in) bolts, 50 mm (2 in.) in length and eight washers.

The connection is to be accompanied with a gasket, bolts, nuts and washers. The shore connection is to be located in a readily accessible location.

TABLE 3
Dimensions of International Shore Connection

	<i>SI and MKS units</i>	<i>U.S. units</i>
Outside diameter	178 mm	7 in.
Inside diameter	64 mm	2.5 in.
Bolt circle diameter	132 mm	5.2 in.
Slots in flange	4 holes – 19 mm in diameter spaced equidistantly on a bolt circle of the above diameter slotted to the flange periphery.	4 holes – 0.75 inches in diameter spaced equidistantly on a bolt circle of the above diameter slotted to the flange periphery.
Flange thickness	14.5 mm minimum	0.57 in. minimum
Bolts and nuts	4 each of 16 mm diameter, 50 mm in length	4 each of 0.63 in. diameter, 1.97 inches in length

4.9 Cold Weather Protection

SVR 4-7-3/1.11.1 indicates that the arrangements of the fire main piping and hydrants are to be such as to avoid the possibility of freezing. Accordingly, those sections of the fire main, which may be subject to freezing temperatures, are required to be provided with adequate protection. Examples of acceptable arrangements would be heat tracing, installation of isolation valves inside the superstructure, provision of drain valves (for non-pressurized system), etc.

4.10 Additional Requirements for Vessels with Automation Notations

In vessels with a periodically unattended machinery space or when only one person is required on watch, SVR 4-7-3/1.5.5 requires that there be immediate water delivery from the fire main system at a suitable pressure. This can be accomplished by either the remote starting of one of the main fire pumps from the navigation bridge and fire control station, if any, or permanent pressurization of the fire main system by one of the main fire pumps. This requirement may be waived for cargo vessels of less than 1,600 gross tonnage, provided the arrangement of the machinery space access makes it unnecessary.

Where the option of remote starting is selected, the remote operation of any and all valves necessary to allow the remotely started fire pump to supply the fire main should be included (e.g., open those valves to the fire main and to close those to the other systems, sea water supply valves, etc.).

The above requirement is expanded upon in SVR 4-9-3/15.5.2 for vessels seeking the **ACC** notation. SVR 4-9-3/15.5.2 requires provisions be made for remotely starting one of the main fire pumps at the navigation bridge, unless the fire main is permanently pressurized, but also requires means to be provided for the starting of one of the main fire pumps at the fire control station, if fitted. As an alternative, means may be provided at fire fighting station to start the emergency fire pump, as in SVR 4-9-4/21.3viii), to satisfy this requirement.

For vessels seeking the **ACCU** notation, a fire-fighting station is required to be provided, in accordance with SVR 4-9-4/21.3viii). Starting one of the fire pumps located outside the propulsion machinery space, including operation of all necessary valves, to pressurize the fire main from the fire-fighting station is required. However, starting of one of the main fire pumps is still required to be provided on the navigation bridge, as per SVR 4-9-3/15.5.2.

When the fire main is permanently pressurized by one of the fire pumps and the pump is arranged to start automatically upon the loss of pressure in the system (caused by opening a hydrant), no additional pump starting arrangements would be required.

4.11 Alternative Requirements for Steel Vessels Under 90 Meters in Length and less than 1000 Gross Tons

The following identifies alternatives to certain requirements discussed above:

4.11.1 Fire Pumps

The number of pumps required is still the same, i.e., two pumps. However, only one of the pumps is required to be independently operable, as indicated in SVR 4-7-3/1.5.1.

4.11.2 Fire Main Pressure

For vessels of less than 1,000 gross tones, the minimum fire main pressure is to be sufficient to produce two 12 m (40 ft) jet throws through any adjacent hydrants to any part of the vessel, per (SVRL<90m) 4-5-2/5.1.4.

4.11.3 Hoses

In cargo vessels of less than 1,000 gross tones, the number of fire hoses should be calculated in accordance with the provisions of SOLAS (2000 Amendments) II-2/10.2.3.2.3.1. However, the number of hoses should in no case be less than three.

4.12 Additional Requirements for Oil and Fuel Oil Carriers

The following requirements are in addition to those discussed in 3/4.1 through 3/4.11:

On oil carriers and fuel oil carriers, SVR 4-7-3/1.5.7 requires additional isolation valves to be fitted in the fire main at the poop front in a protected position and on the tank deck at intervals not more than 40 m (131 ft) to isolate damaged sections of the fire main. These isolation valves should be located immediately forward of any hydrant position which will allow the ability to isolate a damaged portion of the main forward of a hydrant and still be able to use the closest intact hydrants.

Related IACS Unified Interpretation

UI SC146 - SOLAS Reg. II-2/4.7 & 4.8 (SOLAS 2000 II-2/10.2.3 & 10.2.3.3)

Aluminum alloys may be used for fire hose couplings and nozzles, except in open deck areas of oil tankers and chemical tankers.

4.13 Additional Requirements for Passenger Vessels

Passenger vessels present a very unique risk insofar as fire hazards are concerned. Unlike the situation of a cargo vessel where the crew are the only personnel onboard and are typically well-trained, a passenger vessel will be carrying a large number of untrained, and sometimes less mobile, people than the personnel normally found onboard. Accordingly, the risk of loss of life is great, and therefore, passenger vessels are required to meet special, more demanding fire main system requirements.

The fire pumps, fire mains, hydrants and hoses for passenger vessels are to be in accordance with requirements specified in Section 6 of the ABS *Guide for Building and Classing Passenger Vessels* (PVG)

The following requirements are in addition to those discussed in 3/4.1 through 3/4.11 of these Guidance Notes, SVR 4-7-3/1 and SVR Part 4, Chapter 9.

4.13.1 Fire Pumps

4.13.1(a) Number of Fire Pumps. Vessels of 4,000 tons gross tonnage and over are to be provided with at least three independently driven fire pumps and vessels of less than 4000 tons gross tonnage are to be provided with at least two independently driven fire pumps in accordance with PVG 6/5.1.2(a).

4.13.1(b) Capacity of Fire Pumps. In accordance with PVG 6/5.1.2(b), the fire pumps required by PVG 6/5.1.2(a) are to be capable of delivering for fire-fighting purposes a quantity of water not less than two thirds that required to be dealt with by the bilge pumps when employed for bilge pumping at the appropriate pressure specified in PVG 6/5.1.6(b). This should be verified by ensuring that the combined discharge capacity of the proposed fire pumps is at least two thirds of the combined capacities of the required bilge pump (3 or 4 bilge pumps, depending on the criterion number).

4.13.1(c) Arrangement of Fire Pumps and Power Sources. In accordance with PVG 6/5.1.2(c), sea connections, fire pumps and their source of power are to be located aft of the collision bulkhead and are to ensure that:

- i) In vessels of 1,000 tons gross tonnage and upwards, a fire in any one compartment will not put all the fire pumps out of action.
- ii) In vessels of less than 1,000 tons gross tonnage, if a fire in any one compartment could put all pumps out of action, an emergency fire pump complying with PVG 6/5.1.2(d) is to be provided.

4.13.1(d) Arrangement of Fire Water Supply. The arrangements for the ready availability of water supply are to comply with the following, in accordance with PVG 6/5.1.4

- i) In vessels of 1,000 tons gross tonnage and upwards, at least one effective jet of water is to be immediately available from any hydrant in an interior location and so as to ensure the continuation of the output of water by the automatic starting of a required fire pump;
- ii) In vessels of less than 1,000 tons gross tonnage, an effective stream is to be readily available, either by the automatic starting of at least one fire pump or by remote starting of at least one fire pump from the navigation bridge;
- iii) If fitted with periodically unattended machinery spaces, provisions for fixed water fire-extinguishing arrangement for such spaces equivalent to those required for normally attended machinery spaces are to be provided.

4.13.2 Fire Mains

4.13.2(a) Size. In accordance with PVG 6/5.1.6, the diameter of the fire main and water service pipes is to be sufficient for the effective distribution of the maximum required discharge from two fire pumps operating simultaneously. If the fire pump capacities differ, the largest two should be selected in determining compliance.

4.13.2(b) Pressure. In accordance with PVG 6/5.1.6(b), with the two pumps simultaneously delivering through nozzles the quantity of water specified in PVG 6/5.1.6(a), through any adjacent hydrants, the following minimum pressures are to be maintained at all hydrants:

- i) 4,000 tons gross tonnage and upwards 4 bar (58 psi)
- ii) Less than 4,000 tons gross tonnage 3 bar (44 psi)

However, the maximum pressure at any hydrant is not to exceed that at which the effective control of a fire hose can be demonstrated.

See 3/4.3 of these Guidance Notes regarding the various issues involved in determining compliance with this requirement.

Related IMO MSC Circ 847 Interpretation

SOLAS Reg. II-2/4.3.4.1 (SOLAS 2000 II-2/10.2.1.2.1.1), "Automatic starting of fire pumps and prevention of freezing in pipes"

Special attention should be given to the design of the continuously pressurized pipelines for prevention of freezing in pipes in vessels entering areas where low temperatures may exist.

4.13.3 Hydrants

In accordance with PVG 6/5.1.7(a), the number and position of hydrants are to be such that at least two jets of water not emanating from the same hydrant (one of which is to be from a single length of hose) may reach any part of the vessel normally accessible to the passengers or crew while the vessel is being navigated, and any part of any cargo space when empty, any ro-ro cargo space or any special category space (in which latter case the two jets will reach any part of such space, each from a single length of hose). Furthermore, such hydrants are to be positioned near the accesses to the protected spaces.

In accordance with PVG 6/5.1.7(b), for installations in the accommodation, service and machinery spaces, the number and position of hydrants are to be such that the requirements of PVG 6/5.1.7(a) are to be complied with when all watertight doors and all doors in main vertical zone bulkheads are closed.

In accordance with PVG 6/5.1.7(c), where access is provided to a machinery space of Category "A" at a low level from an adjacent shaft tunnel, two hydrants are to be provided external to, but near the entrance to, that machinery space. Where such access is provided from other spaces, in one of those spaces, two hydrants are to be provided near the entrance to the machinery space of Category "A". Such provision need not be made where the tunnel or adjacent spaces are not part of the escape route.

4.13.4 Fire Hoses

At interior locations in vessels carrying more than 36 passengers, the fire hoses are to be connected to the hydrants at all times.

There is to be at least one fire hose for each hydrants required by PVG 6/5.1.8(b), and these hoses are to be used only for the purposes of extinguishing fires or testing the fire-extinguishing apparatus at fire drills and surveys.

Vessels are to be provided with fire hoses the number of and diameter of which are to be to the satisfaction of the Bureau.

4.13.5 Nozzles

In vessels carrying more than 36 passengers, each machinery space of Category "A" is to be provided with at least two suitable water fog applicators.

4.13.6 Location/Arrangement of Water Pumps for Other Fire-Extinguishing Systems

In accordance with PVG 6/5.1.11, pumps required for the provision of water for other required fire-extinguishing systems, their sources of power and their controls are required to be installed outside the space or spaces protected by such systems and are to be so arranged that a fire in the space or spaces protected will not put any such system out of action.

4.14 Additional/Alternative Requirements for Ro-Ro Vessels

Due to the hazards associated with carrying vehicles with fuel remaining in their tanks, as well as the potential for additional amounts of combustibles in the vehicle construction and their cargo, the Rules provide for certain requirements in addition to those covered by SVR 4-7-3/1, SVR Part 4, Chapter 9 and those discussed in 3/4.1 through 3/4.11 of these Guidance Notes.

4.14.1 Locations of Hydrants

In accordance with SVR 4-7-3/1.9, the number and position of the fire hydrants on any vessel are to be such that at least two jets of water not emanating from the same hydrant (one of which is to be from a single length of hose) may reach any part of the vessel. Normally for ro-ro vessels, SVR 4-7-3/1.9 also requires that two jets of water, each from a single length of hose, are to be capable of reaching any part of ro-ro cargo space. Plan review should verify that the hydrant locations within the ro-ro spaces comply with this requirement.

4.14.2 Low Velocity Water Fog Applicators

In accordance with SVR 5-10-4/3.3.4, each ro-ro cargo space intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion is to be provided with at least three water fog applicators. The plan review of the fire main system should confirm that the appropriate number of water fog applicators is provided for each ro-ro space.

4.15 Additional/Alternative Requirements for Gas Carriers

4.15.1 Application

In accordance with SVR 5-8-11/2.1, all vessels, irrespective of size, carrying products which are subject to the requirements of SVR Section 5-8-11 are to comply with the requirements of regulations II-2/4 and II-2/7 of the 1983 SOLAS amendments. Basically, the requirements in SOLAS Reg. II-2/4 have been incorporated into SVR 4-7-3/1.

Accordingly, the review of the fire main system should verify compliance with the requirements of SVR 4-7-3/1, as discussed in 3/4.1 through 3/4.11 of these Guidance Notes, in association with the additional or alternative requirements specified in SVR 5-8-11/2 and outlined herein.

4.15.2 Fire Pump/Fire Main Sizing

When the fire pump and fire main are used as part of the water spray system as permitted by SVR 5-8-11/3.3, the required fire pump capacity and fire main and water service pipe diameter should not be limited by the provisions of regulations II-2/4.2.1 and II-2/4.4.1 of the 1983 SOLAS amendments. Accordingly, where the fire pump and fire main are used as part of the water spray system pressure, the calculations should be based upon both systems operating simultaneously, each at their required maximum discharge capacity.

4.15.3 Pressure

SVR 5-8-11/2.1 specifies that the discharge pressure requirements of SOLAS II-2/4.4.2 should be met at a pressure of at least 5.0 bar (72 psi) gauge. The discharge pressures specified in SVR 4-7-3/1.7.2 are identical to those found in SOLAS II-2/4.4.2. Accordingly, the values indicated in SVR 4-7-3/1.7.2 should be replaced with a pressure of at least 5.0 bar (72 psi) gauge and the system pressure calculations reviewed accordingly.

4.15.4 Arrangements

As required by SVR 5-8-11/2.2, the arrangements are to be such that at least two jets of water can reach any part of the deck in the cargo area and those portions of the cargo containment system and tank covers above the deck. Further, the locations of the fire hydrants are to satisfy the above requirement, as well as the requirements in Regulations II-2/4.5.1 (SVR 4-7-3/1.9) and II-2/4.8 (SVR 4-7-3/1.15), with a hose length not exceeding 33 m. The review should seek to verify the same, but frequently the need for Surveyor verification of this item is needed.

4.15.5 Isolation Valves

In accordance with SVR 5-8-11/2.3, stop valves are required to be fitted in any crossover line for the fire main. In addition, stop valves are also to be fitted in the fire main or mains at the poop front and at intervals of not more than 40 m between hydrants on the deck in the cargo area for the purpose of isolating damaged sections of the main. Plan review should verify the same.

4.15.6 Nozzles

All water nozzles provided for fire-fighting use are required by SVR 5-8-11/2.4 to be of an approved dual-purpose type capable of producing either a spray or a jet.

4.15.7 Piping Materials

All pipes, valves, nozzles and other fittings in the fire-fighting systems are required to be resistant to corrosion by seawater (for which purpose galvanized pipe, for example, may be used) and to the effect of fire. Refer to SVR 5-8-11/2.4.

4.15.8 Remote Operations

Where the vessel's engine-room is unattended, SVR 5-8-11/2.5 requires that arrangements be made to start and connect at least one fire pump to the fire main by remote control from the navigation bridge or other control station outside the cargo area. Details regarding this arrangement should be verified during plan review or a statement made requesting the Surveyor to verify the same.

4.16 Steel Vessels Under 90 Meters (295 feet) in Length

Certain provisions are made for vessels less than 90 meters (295 feet) in length in consideration of their unique services and arrangements. The requirements applicable to steel vessels under 90 meters in length and being classed for unrestricted service are discussed noted below.

4.16.1 Vessels > 500 Gross Tons and Unrestricted Service

The fire main system of vessels under 90 meters and over 500 gross tons which are to be classed for unrestricted service are to comply with the requirements identified in SVR(L<90m) 4-5-1/3 and 4-5-2/1 through 4-5-2/7.

In general, the requirements for the fire main systems of vessels under 90 meters are very similar to the requirements discussed above for vessels greater than 90 meters. Therefore, the discussion provided in 3/4.1 through 3/4.10 of these Guidance Notes (for vessels greater than 90 meters) is applicable, along with certain clarifications or modifications as provided below. For convenience, Section 3, Table 4 below provides a cross-reference between the references in the *Under 90 Meter Rules* and the sections above discussing each subject.

TABLE 4
Cross-reference of Under 90 Meter Rules Requirements

<i>Under 90 Meter Rules References</i>	<i>Section No. in These Guidance Notes</i>
4-5-1/3.1 – Materials	3/4.6
4-5-1/3.3 and 4-5-2/5.1 – Main Fire Pumps	3/4.1
Clarification: 4-5-1/3.3.4 indicates the relief valve is to be set at a pressure no greater than 25 psi above the pump pressure necessary to achieve that required by either 4-5-1/3.3.3	
Clarification: 4-5-2/5.1.4 requires the pressure at the nozzles to be 2.5 bar (37 psi) for any vessel 1,000 gross tons or greater.	
4-5-2/5.1.7 – Isolation	3/4.5
4-5-2/5.3 – Emergency Fire Pump	3/4.2
4/9.3.3 and 4/9.14 – Fire Main	3/4.3
4-5-1/3.7 through 4-5-1/3.11 – Hydrants, Fire Hoses and Nozzles	3/4.7
Clarification: One fire hose with the couplings and nozzles is required to be provided at each hydrant plus one additional spare – 4-5-1/3.9.3	
4-5-2/7 – International Shore Connection	3/4.8

4.16.2 Vessels < 500 Gross Tons

The fire main system of vessels under 90 meters and less than 500 gross tons which are to be classed for unrestricted service are to comply with the requirements identified in SVR(L<90m) 4-5-1/3 and 4-5-3/1. In general, these requirements are the same as the requirements outlined above for vessels 500 gross tons or more with the following exceptions:

4.16.2(a) Fire Pumps. Power driven fire pumps must be capable of producing a 12 meter (40 foot) jet throw through any two adjacent hydrants and only one of the pumps needs to be independently power driven. For vessels less than 20 meters (65 feet), one power driven pump, which may be an attached pump, is required along with one hand pump. The hand pump is to have a capacity of at least 1.1 m³/hr (5 gpm). Section 3, Table 5 lists the capacity of the power driven pumps:

TABLE 5
Pump Capacities

<i>Length of Vessel</i>	<i>Minimum Pump Capacity</i>
Less than 20 m (65 ft)	5.5 m ³ /hr (25 gpm)
20 m (65 ft) or greater, but less than 30.5 m (100 ft)	11.0 m ³ /hr (50 gpm)
30.5 m (100 ft) or greater, but less than 61 m (200 ft)	14.3 m ³ /hr (66.6 gpm)
Greater than 61 m (200 ft)	Refer to 4-5-2/5.1 – Under 90 m Rules

4.16.2(b) Fire Main. The fire main is to be sized for the effective distribution of the maximum required discharge of the pump(s) as per SVR(L<90m) 4-5-3/Table 1.

4.16.2(c) Hoses and Nozzles. Hoses and nozzles are to be in compliance with the above noted requirements, except that one fire hose with couplings and nozzles is to be provided for each hydrant and one spare hose is to be carried onboard. Further, hose diameters need not exceed 38 mm (1.5 inches). In addition, hoses for vessels less than 20 meters (65 feet) may be of good commercial grade having a diameter of not less than 16 mm (0.625 in.) and are to have a minimum test pressure of 10.3 bar (150 psi) and a minimum burst pressure of 31.0 bar (450 psi).

4.17 High Speed Craft

The fire main system requirements for high speed craft are found in Section 4/9 of the 2001 ABS *Guide for Building and Classing High Speed Craft* (HSCG).

Cargo craft (Refer to HSCG 4/1.17.11 for definition of “cargo craft”) which proceed more than 8 hours from a place of refuge are required to comply with either SVR Part 4, Chapter or SVR(L<90m) Part 4, Chapter 5. However, high speed craft which do not proceed, in the course of their voyage, more than 8 hours, at operational speed, from a place of refuge can comply with alternative requirements provided in HSCG Section 4/9. Accordingly, this distinction must be established prior to conducting the review of the fire main system on high speed craft.

4.17.1 Materials

As indicated in HSCG 4/9.3.1, materials readily rendered ineffective by heat are not to be used for fire mains unless adequately protected. In order to be considered not “readily rendered ineffective by heat”, a component is to be certified as having passed an applicable recognized fire test, or the material is to have a melting temperature higher than the test temperature specified in an applicable fire test.

For more information, refer to 3/4.6 of these Guidance Notes.

4.17.2 Fire Pumps

4.17.2(a) Number of Pumps. In accordance with HSCG 4/9.3.2a, all craft are to have at least two fire pumps. For craft of 500 gross tons and above, the pumps are to independently power-driven. For craft less than 500 gross tons, only one of the pumps need be independently power-driven and one of the pumps may be attached to the propulsion unit. For craft less than 20 m (65 ft) in length, one power driven pump, which may be an attached unit, and one hand operated fire pump are permitted.

4.17.2(b) Type of Pumps. Similar to the requirements for other vessels, HSCG 4/9.3.2b indicates that sanitary, ballast, bilge or general service pumps may be accepted as fire pumps, provided that they are not normally used for pumping oil. If the pumps are subject to occasional duty for the transfer or pumping of fuel oil, changeover arrangements that prevent operation for fire fighting when configured for fuel transfer are to be fitted.

4.17.2(c) Pump Capacity

- i) Craft of 500 Gross Tons and Above.* Each of the power-driven fire pumps required by HSCG 4/9.3.2a is to have a capacity of not less than two-thirds of the quantity required under HSCG 4/6.35.3 to be dealt with by each of the independent bilge pumps, but not less than 25 m³/hr (110 gpm), and in any event is to be capable of delivering at least the two required jets of water. These pumps are to be capable of supplying the water under the required conditions. Where more pumps than required are installed, their capacity will be subject to special consideration.
- ii) Craft Less Than 500 Gross Tons.* The capacity of each power-driven fire pump is to be in accordance with the above or HSCG Table 4/9.3, whichever is less. Hand pumps, where permitted, are to have a minimum capacity of 1.1 m³/hr (5 gpm).

4.17.2(d) Pressure. HSCG 4/9.3.2d requires all power-driven fire pumps to have sufficient pressure to simultaneously operate the adjacent hydrants required by HSCG 4/9.3.4a.

4.17.2(e) Relief Valves. In conjunction with all fire pumps, relief valves are to be provided if the pumps are capable of developing a pressure exceeding the design pressure of the water service pipes, hydrants and hoses. These valves are to be placed and adjusted so as to prevent excessive pressure in any part of the fire main system. In general, the relief valve is to be set to relieve at no greater than 1.7 bar (25 psi) in excess of the pump pressure necessary to maintain the requirements of HSCG 4/9.3.2c.

4.17.3 Arrangement

4.17.3(a) Standard Arrangement. For craft of 500 gross tons and above, the two main fire pumps (including their power source, fuel supply, electric cable and lighting and ventilation for the spaces in which they are located) are to be in separate compartments so that a fire in any one compartment will not render both main pumps inoperable. Only one common boundary is allowed between the compartments in which case the single common boundary is to be at least to A-0 standard.

No direct access is allowed between the compartments, except that where this is impracticable, an access meeting the requirements in 3/4.17.3(b) may be considered.

4.17.3(b) Alternative Arrangement. Where it is impracticable to do otherwise, a direct access between the compartments containing the main fire pumps may be considered provided:

- i)* A watertight door capable of being operated locally from both sides of the bulkhead and from a safe and accessible location outside of these spaces is provided. The means for the latter operation is expected to be available in the event of fire in these spaces; or

- ii) An air lock consisting of two gas-tight steel doors. The doors are to be self-closing without any hold back arrangements.
- iii) In addition to the arrangements specified in i) or ii) above, a second protected means of access is to be provided to the space containing the fire pumps.

4.17.4 Isolation

For craft of 500 gross tons and above, isolating valves and other arrangements, as necessary, are to be provided so that if a fire pump and its associated piping within its compartment are rendered inoperable, the fire main can be pressurized with a fire pump located in another compartment.

4.17.5 Fire Main

4.17.5(a) Size. HSCG 4/9.3.3a requires the diameter of the fire main and water service pipes to be sufficient for the effective distribution of the maximum required discharge from two fire pumps operating simultaneously, except that the diameter need only be sufficient for the discharge of 140 m³/hr (616 gpm).

Refer to 3/4.3 of these Guidance Notes for related discussion concerning the sizing of the fire main and the required calculations.

4.17.5(b) Valves. HSCG 4/9.3.3b requires that a valve be fitted to serve each fire hose so that any fire hose may be removed while the fire pumps are at work. These would be the hydrant valves.

4.17.5(c) Cold Weather Protection. Clearly, portions of the fire main which will be exposed to environmental conditions can be subject to freezing, and therefore, HSCG 4/9.3.3c requires fire main systems to be provided with drains, circulation loops or other means for cold weather protection.

4.17.6 Hydrants

4.17.6(a) Number and Position. HSCG 4/9.3.4a indicates that the number and position of the hydrants are to be such that at least two jets of water not emanating from the same hydrant (one of which is to be from a single length of hose) may reach any part of the craft. A review of the drawings by the Engineer may be able to verify compliance but typically verification by the Surveyor is required.

4.17.6(b) Materials. Similar to the requirement stated in 3/4.16.2 of these Guidance Notes, materials of the hydrants are not to be readily rendered ineffective by heat. Refer to HSCG 4/9.3.4b.

4.17.6(c) Installation. The pipes and hydrants are to be placed so that the fire hoses may be easily coupled to them. In craft where deck cargo may be carried, the positions of the hydrants are to be such that they are always readily accessible and the pipes are to be arranged to avoid risk of damage by such cargo. Refer to HSCG 4/9.3.4b.

4.17.7 Hoses

HSCG 4/9.3.5a requires that the fire hoses are to be of a type certified by a competent independent testing laboratory as being constructed of non-perishable material to a recognized standard. The hoses are to be sufficient in length to project a jet of water to any of the spaces in which they may be required to be used. The maximum length of hose is not to exceed 23 m (75 ft).

HSCG 4/9.3.5a also requires each hose to have a nozzle and the necessary couplings. Fire hoses, together with any necessary fittings and tools, are to be kept ready for use in conspicuous positions near the hydrants.

4.17.7(a) Diameter. HSCG 4/9.3.5b indicates that the hoses are not to have a diameter greater than 38 mm (1.5 in.). However, for craft under 20 m (65 ft) in length, a hose of good commercial grade having a diameter of not less than 16 mm ($\frac{5}{8}$ in.), a minimum test pressure of 10 bar (150 psi) and a minimum burst pressure of 31 bar (450 psi) would be permitted.

4.17.7(b) Number. HSCG 4/9.3.5c requires that one fire hose with the couplings and nozzle is to be provided for each hydrant. Additionally, at least one spare hose is to be kept onboard. Compliance with these items should be verified during plan review.

4.17.8 Nozzles

In accordance with HSCG 4/9.3.7a, the standard nozzle sizes are to be 12 mm (0.5 in.), 16 mm (0.625 in.) and 19 mm (0.75 in.), or as near thereto as possible. Larger diameter nozzles may be permitted, subject to compliance with HSCG 4/9.3.2c. For accommodation and service spaces, a nozzle size greater than 12 mm (0.5 in.) need not be used. For machinery spaces and exterior locations, the nozzle size is to be such as to obtain the maximum discharge possible from the two jets at the pressure mentioned in HSCG 4/9.3.2c from the smallest pump. However, a nozzle size greater than 19 mm (0.75 in.) need not be used.

All nozzles are to be of an approved dual-purpose type (i.e., spray and jet type) incorporating a shut-off as indicated in HSCG 4/9.3.7a. Fire hose nozzles of plastic type material such as polycarbonate may be accepted, subject to review of their capacity and serviceability as marine fire hose nozzles.

4.18 Cargo Vessels for River Service

Fire main systems installed on vessels intended to operate only on rivers and intracoastal waterways, and receiving the classification notation for the restricted service, are required to comply with Part 4, Section 7 of the *Rules for Building and Classing Steel Vessel for Service on Rivers and Intracoastal Waterways* (RR).

4.18.1 Fire Pumps

As indicated by RR 4/7.9.1a, all self-propelled vessels are to be fitted with at least one fire pump. For vessels over 20 meters (65 feet) in length, the pump is to be power-driven, but for vessels 20 meters (65 feet) in length and under, the pump may be hand-operated. Where the fire pump is allowed to be hand-operated, it must have a capacity of at least 1.1 m³/hr (5 gpm) and is to be equipped with suitable suction and discharge hoses for use on fire fighting.

Sanitary, ballast, bilge and general service pumps may be accepted as fire pumps in accordance with RR 4/7.9.2a. However, each pump is required to be capable of providing a full supply of water to the fire hoses whereby at least two powerful streams throw of 12 meters (40 feet) can be rapidly and simultaneously directed into any part of the vessel.

4.18.2 Relief valves

Relief valves are required to be fitted on power-driven fire pumps in accordance with RR 4/7.9.3, unless it can be shown that the arrangements are such as to prevent excessive pressure in any part of the fire main system.

4.18.3 Fire Main

The vessel is required by RR 4/7.11.1 to be fitted with a fixed fire main system and it should be sized for the simultaneous operation of at least the two fire hoses in RR 4/7.9.2a.

4.18.4 Locations of Hydrants

In accordance with RR 4/7.13.1a, the number and position of the fire hydrants are to be such that at least two streams of water not emanating from the same hydrant may reach any part of the vessel. One of the streams is to be from a single length of hose not more than 23 meters (75 feet) long for 38 mm (1½") hose or 15 meters (50 feet) long for 63 mm (2½") hose.

In addition, RR 4/7.13.1a specifies that the piping and hydrants are to be placed so that fire hoses may be easily coupled to them, and where deck cargo is carried, hydrants are to be located such as to avoid damage during cargo operations, but at the same time to remain easily accessible.

Verification that the arrangements of the hydrants comply with the above requirements during plan review can be very difficult as the actual structural arrangements, location of equipment, etc., makes this approach much less reliable. Therefore, the arrangements of the hydrants are to be verified by the Surveyor. However, the layout and arrangement of the fire stations as provided in the drawing, in conjunction with the proposed hose lengths, should be reviewed and any areas of concern identified. For those areas which are questionable or where the details provided on the drawings are insufficient to verify compliance, appropriate comments should be made to issue to the Surveyor's attention.

4.18.5 Materials

RR 4/7.13.1a also indicates that the materials used in the system are not to be rendered ineffective by heat, unless the components are adequately protected in accordance with SVR 4-7-3/1.11.1. This requirement is important to ensure that the fire main system will remain intact and functional even if one portion of the fire main piping is actually within the immediate vicinity of the fire. For more information about this issue, see 3/4.5 of these Guidance Notes.

4.18.6 Hydrant Valves

In accordance with RR 4/7.11.2, a valve is required to be fitted to serve each fire hose so that any fire hose may be removed while the fire pumps are at work. Normally, each hydrant is fitted with an individual valve, but the drawing should be reviewed to verify such compliance and the hose valve determined to be of a design and material which will not be rendered ineffective by heat.

4.18.7 Fire Hoses

As per RR 4/7.13.2, fire hoses are to be of approved material. In addition, the minimum hose diameter for all vessels over 21 m (65 ft) in length is to be not less than 38 mm (1.5 in.) diameter. For vessels 20 m (65 ft) and under, 19 mm (0.75 in.) diameter hose may be used. The hoses are to be sufficient in length to project a jet of water to any of the spaces in which they may be required, but the maximum length of hose is not to exceed 23 m (75 ft).

The Rules do not require a hose to be provided at each fire hydrant location. The minimum number of hoses to be provided is at least one for each 30 m (100 ft) length of the vessel and one spare. Also, this number does not include any hoses required in any engine or boiler room. The number of hoses in the machinery space(s) is not specified, suggesting this is to be in compliance with the relevant governmental authorities.

Each hose is to be provided with a nozzle and necessary couplings. Unless one hose and nozzle is provided for each hydrant on the vessel, there is to be complete interchangeability of the hose couplings and nozzles, in accordance with RR 4/7.13.2.

4.18.8 Nozzles

As indicated in RR 4/7.13.3, the minimum internal diameter of any hose nozzle is not to be less than 16 mm ($5/8$ in.), except as discussed below. Nozzles for hoses attached to hydrants serving machinery spaces are required to be suitable for spraying water on oil, or alternatively, they are to be of the dual purpose type. For vessels of 100 gross tons and under, the minimum internal diameter of the nozzles may be 8 mm ($5/16$ in.). For vessels of less than 20 m (65 ft), garden-type hoses can be used.

4.19 Additional Requirements for Passenger Vessels in River Service

In addition to the requirements discussed in 3/4.18, river vessels involved in passenger service must comply with the following:

4.19.1 Fire Pumps

Two independently power-driven fire pumps are required for passenger vessels, one of which is to be dedicated to fire fighting duties at all times. Arrangement of the pumps, sea suction and sources of power is to be such as to ensure that a fire or causality in any one space would not render both pumps inoperable. Where the arrangements are such that a fire would put both main fire pumps out of service, an emergency fire pump is to be fitted. Where an emergency fire pump is fitted, it is to be a fixed independently-driven pump with a capacity of not less than 25 m³/hr (110 gpm) and be capable of simultaneously delivering 12 m (40 ft) jet throw from any two adjacent hydrants. The arrangements for the sea connections are to be outside the machinery space.

The required pumps are to be capable of delivering at a pressure of at least 3.0 bar (44 psi) a quantity of not less than $2/3$ the quantity required to be dealt with by the bilge pumps.

4.19.2 Location of Hydrants

The number and position of hydrants is to be such that at least two streams of water, not emanating from the same hydrant may be directed at any part of the vessel normally accessible to the passengers and crew, any part of the cargo space, any ro-ro space and any special category space. Each stream is to be from a single length of hose. Furthermore, hydrants are to be located near the accesses to protected spaces.

In accommodation, service and machinery spaces, the number and position of hydrants are to be such that the above requirement can be complied with when all watertight doors and all doors in main vertical bulkheads are closed.

4.19.3 Fire Hoses

For passenger vessels carrying more than 36 passengers, fire hoses are to be connected to the hydrants at all times in interior locations.

4.19.4 Nozzles

Standard nozzle sizes are to be 12 mm (0.5 in.), 16 mm (0.625 in.) and 19 mm (0.75 in.), or as near to as possible. For accommodation and service spaces, a nozzle size greater than 12 mm (0.5 in.) need not be used. For machinery spaces and exterior locations, the nozzle size is to be such as to obtain the maximum discharge possible from two jets at the referenced pressures in SVR 4-7-3/1.7.2 from the smallest pump. However, a nozzle size greater than 19 mm (0.75 in.) need not be used.

4.20 Motor Pleasure Yachts

The fire main system requirements for motor pleasure yachts are found in Section 22 of the 2000 *Guide for Building and Classing Motor Pleasure Yachts* (MPY).

4.20.1 Fire Pumps

MPY 22.1.1 requires two fire pumps. However, only one of these pumps need be independently power-driven, and therefore, one of the fire pumps may be attached to the propulsion unit.

Where yachts are less than 20 m (65 ft), MPY 22.1.1 allows the use of one power-driven pump, which may be an attached unit (driven by propulsion engine) and one hand operated fire pump.

MPY 22.1.1 also indicates that sanitary, bilge and general service pumps may be accepted as fire pumps.

4.20.2 Fire Pump Capacity

In accordance with MPY 22.1.2, the fire pump capacity is to be in accordance with the following:

- $L < 20$ m (65 ft) 5.50 m³/hr (25 gpm)
Hand pump: 1.1 m³/hr (5 gpm)
- 20 m (65 ft) $< L < 30.5$ m (100 ft) 11.0 m³/hr (50 gpm)
- $L > 30.5$ m (100 ft) 14.3 m³/hr (67.6 gpm)

Power-driven fire pumps are to produce sufficient pressure to supply the effective stream required by MPY 22.3 from any hydrant on the yacht. An effective stream is normally considered to be a 12 m (40 ft) throw through the nozzle and hose provided.

4.20.3 Fire Main

The above fire pumps should normally supply the water through a fixed fire main system. However, MPY 22.1.2 indicates that if a fixed fire extinguishing system in excess of that required by MPY 22.5 is installed in the machinery spaces, a fire main may not be required for yachts below 20 m (65 ft) and a reduced pump capacity will be considered for larger yachts.

4.20.4 Hoses, Nozzles and Hydrants

In accordance with MPY 22.3, hoses are not to have a diameter greater than 38 mm (1.5 in.). Hoses for vessels under 20 m (65 ft) in length may be of a domestic service type of good commercial grade having a diameter of not less than 16 mm (0.625 in.).

Nozzle sizes are to be in accordance with the requirements identified in SVR 4-7-3/1.15 and discussed in 3/4.7.4 of these Guidance Notes. The nozzles attached to hydrants serving machinery spaces of yachts over 20 m (65 ft) are to be of the type suitable for spraying water on oil or dual-purpose nozzles.

The fire hydrants are to be of sufficient number and so located that any part of the yacht may be reached with an effective stream of water from a single length of hose not exceeding 15 m (50 ft). The review of the fire hydrant locations and hoses should try to establish the same and comment made in the review letter requesting Surveyor verification were necessary.

While not specifically indicated in the MPY Guide, the materials of the fire main system should not be rendered ineffective by heat. In addition, isolation valves are not specifically required on the fire main. However, installation of isolation valves is highly desirable in controlling the fire water supply.

4.21 Fishing Vessels

The requirements for the classification of fishing vessels are outlined in SVR(L<90m) Section 5-14-1. However, the Rules do not provide any specific requirements for the fire main system. In spite of this, the attention of owners, designers and builders is directed to the regulations of governmental and other authorities dealing with active fire protection for fishing vessels.

Where authorized by the Administration of a country signatory to the International Conference on Safety of Fishing Vessels, 1977/1993 Protocol, and upon request of the Owners of an existing vessel or a vessel under construction, the Bureau can review plans and survey the vessel for compliance with the provisions of this Convention/Protocol and certify thereto in the manner prescribed in the Convention/Protocol. In such cases, the IMO Torremolinos International Convention for the Safety of Fishing Vessels, 1977, as modified by the Torremolinos Protocol of 1993 is to be consulted as follows:

- Chapter V – Fire Protection, Fire Detection, Fire Extinction and Fire Fighting
- Part A – General
- Part B – Fire safety measures in vessels of 60 meters (197 ft) in length and over
- Part C – Fire safety measures in vessels of 45 meters (148 ft) in length and over but less than 60 meters (197 ft) in length

4.22 Accommodation Barges and Hotel Barges

One effective jet of water must be immediately available from any hydrant in an interior location and so as to ensure the continuation of the output of water by the automated starting of a required fire pump. Two independently power-driven fire pumps are required, each arranged to draw directly from the sea and discharge into a fixed fire main. However, where there are high suction lifts, refer to 4.7.2a of the *Preliminary Rules for Building and Classing Accommodation Barges and Hotel Barges* (hereafter referred to as the “*Preliminary Rules*”). One of the required pumps is to be dedicated to fire-fighting duties at all times. Arrangement of the pumps, sea suction and sources of power are to be such as to ensure that a fire or casualty in any one space would not render both pumps inoperable. Where shore supply of water is available for fire-fighting purposes, the requirements for fire pumps may comply with Appendix A, Section A.2.2 of the *Preliminary Rules*.

Related ABS Interpretation/Instruction (I/I)

Note 1: For accommodation barges that are to be supplied with shore-side water for fire fighting purposes, it is required that 2 sources of water be provided. As such, in applying Appendix A, Section A.2.2 of the Preliminary Rules, an independently driven emergency fire pump of the capacity specified in 4.7.2 of these Rules is to be provided regardless of the supplied shore-side pressure.

Note 2: An emergency fire pump, as required by Section A.2.2 of the Preliminary Rules, can be replaced by dedicated shore side fire department facilities provided the alternative arrangements listed below are complied with:

- a) The fire department facilities are dedicated to the Naval base that the barge is located in, they are no more than one and one-half (1½) miles from the barge, and the response time of the fire department (the time between the activation of the alarm and the arrival of the fire truck at the location of the barge) is to be no more than five (5) minutes.*
- b) The fire truck is to have a pump capacity and the equipment necessary to meet the Preliminary Rules requirements of 4.7.2d and 4.7.2e at the most extreme locations of the barge.*
- c) The fire truck is to be capable of using sea water as an alternative water supply to the shore hydrant connection.*
- d) The fire truck is to be capable of connecting directly to the barge's fire main.*
- e) The fire hydrants on the pier are to be spaced no more than 15.25 meters (50 ft) apart and are to have a dedicated water supply.*
- f) While the barge is moored to a pier it will be connected to the pier fire main, which will be capable of continuously providing 6.2 bar (90 psi) water to the barge fire main.*

- g) *Should the pier fire main water pressure drop below 6.2 bar (90 psi) while the barge is manned, an alarm is to sound in the control station and the dedicated shore based fire department is to be notified and put on stand-by status.*
- h) *The shore side fire hydrants are to be fitted with bleeder valves to maintain the flow of water in freezing conditions.*
- i) *A non-return valve is to be fitted to prevent water pumped from the fire truck into the barge fire main from flowing back into the shore water supply piping.*
- j) *A clear description of the secondary fire fighting arrangements is to be posted in the control station and included on the fire safety plan.*
- k) *The subject barges are to be Classed "Accommodation Barge - Restricted Service" and the Record entry is to include note 26, which states "Certain systems and arrangements accepted at the request of the U.S. Government."*

Note 3: For an accommodation barge or a hotel barge tied up at a pier/river bank/land mass or attached to a series of other barges, a "Dry" fire main system without an automatically starting fire pump is acceptable as a special modified system for limited or restricted service under the provisos of 1.19.2 and A.1 of the Preliminary Rules subject to compliance with the following list:

- a) *The barge is classed for river service and so distinguished in the Record.*
- b) *The fire fighting system complies with the published requirements of the governmental authority in which the vessel is registered.*
- c) *Pipe, pump and valve arrangements are to ensure an immediate supply of water at the required pressure from any hydrant in an interior location by suitably placed remote starting arrangements of a required fire pump.*
- d) *A ready means of escape (e.g., gangway or equivalent) from the barge is provided for safe egress of personnel.*
- e) *A public address system or other effective means of communication is available throughout the accommodation, service spaces and control stations.*
- f) *An efficient patrol system is maintained so that an outbreak of fire may be promptly detected.*
- g) *Fixed fire detection and fire alarm systems are provided as per 4.13 of the Preliminary Rules.*

4.22.1 Pump Requirements

The required pumps must meet the following:

- i) *Total capacity must comply with 4.7.2d of the Preliminary Rules.*
- ii) *Each pump's capacity must comply with 4.7.2e of the Preliminary Rules.*
- iii) *Remote start-up of the required pumps and remote operation of the suction and discharge valves are necessary where either pump is located in a space not normally manned and is relatively far from working areas, as per 4.7.2f of the Preliminary Rules.*
- iv) *Other pumps may be accepted as fire pumps, provided that they are not normally used for pumping oil and one pump is always dedicated to fire fighting duties.*
- v) *Non-return valves must be fitted on every centrifugal pump which is connected to the fire main.*
- vi) *Relief valves are needed as per 4.7.2i of the Preliminary Rules.*

4.22.2 Fire Main and Pressure

A fixed fire main is to be provided and be so equipped and arranged as to meet the following requirements and the requirements of 4.7.2c of the *Preliminary Rules*:

- i) *The fire main must be of sufficient diameter to comply with 4.7.3b of the Preliminary Rules.*
- ii) *Adequate pressure must be maintained as per 4.7.3c of the Preliminary Rules.*

- iii) Isolating valves are to be provided and located so as to permit optimum utilization in the event of physical damage to any part of the main.
- iv) No connections other than those necessary for fire fighting purposes are allowed.
- v) Precautions against freezing must be taken, as per 4.7.3f of the *Preliminary Rules*.
- vi) Materials readily rendered ineffective by heat are not to be used for fire mains unless adequately protected. The pipes and hydrants are to be in locations which are easily accessible and fire hoses may be easily coupled to them.
- vii) A cock valve is to be fitted to serve each fire hose so that any fire hose may be removed while the fire pumps are at work.
- viii) The location of pumps, sea suction and power sources for fire pumps are to be such that a fire or other casualty in one space will not render both main pumps inoperable.

4.22.3 Hydrant Locations/Arrangements

The number and position of hydrants is to be such that at least two jets of water, not emanating from the same hydrant (one of which is to be from a single length of fire hose) may reach any part of the unit normally accessible to those onboard. A hose is to be provided for every hydrant. Fire hoses are to be of material approved and be sufficient in length so the jet of water can reach any space for which it is intended to be used. The hose length must not exceed 23 m (75 ft). Dual purpose nozzles and necessary couplings are to be provided as per 4.7.4b of the *Preliminary Rules*. Any necessary fittings and tools must be kept ready for use in conspicuous positions near the hydrants or connections. At interior locations, fire hoses are to be connected to the hydrants at all times.

4.22.4 Nozzles

Standard nozzle sizes are to be 12 mm (0.5 in.), 16 mm (0.625 in.) and 19 mm (0.75 in.), or as near to as possible. For accommodation and service spaces, a nozzle size greater than 12 mm (0.5 in.) need not be used. For machinery spaces and exterior locations, the nozzle size is to be such as to obtain the maximum discharge possible from two jets at the referenced pressures in 4.7.2e of the *Preliminary Rules* from the smallest pump. However, a nozzle size greater than 19 mm (0.75 in.) need not be used.

4.22.5 International Shore Connection

The barge should be provided with at least one international shore connection complying with Regulation II-2/10.2.1.7 of the SOLAS 2000. Facilities should be available enabling such a connection to be used on any side of the barge.

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SECTION 4 Fixed Gas Fire Extinguishing Systems

1 Principles of Fixed Gas Fire-extinguishing Systems

Fixed gas fire-extinguishing systems typically suppress fires by reducing the available oxygen in the atmosphere to a point where combustion can no longer take place or by interrupting the chemical reaction necessary for the progression of the fire.

Advantages of fixed gas systems over water-based systems are that:

- Damage to sensitive equipment can be avoided, especially in the case of electronic equipment.
- Clean up time and equipment down time is substantially reduced.

Disadvantages are that:

- Some gaseous agents are hazardous to personnel.
- Cooling effect of gas systems is significantly less than water-based systems.
- Unlike the unlimited supply of water for fire-fighting systems, the quantity of gas available is limited to that carried in the cylinders protecting the space.

Due to the above disadvantages, it is essential that fixed gas fire-fighting systems be deployed as quickly as possible to minimize heat buildup. Also, care should be taken to avoid the possibility of a fire being restarted due to dissipation of the fire-extinguishing gas and the introduction of fresh air from protected compartments being prematurely opened after a fire.

In new installations, the most common fixed gas extinguishing systems encountered are either high/low pressure CO₂ systems or those utilizing Halon “alternatives”.

2 CO₂ Fire-extinguishing Systems

2.1 Agent Characteristics

CO₂ is a compound of carbon and oxygen. At atmospheric pressures and temperatures, CO₂ is a colorless, odorless and electrically non-conductive gas. It is approximately 50% heavier than air. CO₂ provides a desirable (although very limited) cooling effect. The gas dissipates into the atmosphere after its discharge and leaves no residue.

Because CO₂ reduces the available oxygen in the atmosphere, it will not support life. A concentration of 6% to 7% is considered the threshold level at which harmful effects become noticeable in humans, at concentrations below 10%, most people lose consciousness within a short time. Because of the hazard involved, particular care must be taken to ensure that all personnel are evacuated from the protected space prior to discharging the system.

2.2 Effectiveness

CO₂ gas is an effective agent for class “A” (wood, paper, etc.), class “B” (flammable liquids and gases) and class “C” (electrical equipment) hazards as it displaces the oxygen necessary for combustion. The CO₂ concentration must be maintained for a sufficient period to allow the maximum temperature to be reduced below the auto-ignition temperature of the burning material. Reduction of oxygen content to 15% is sufficient to extinguish most fires. Developing a CO₂ concentration of 28.5% in the atmosphere will reduce the oxygen content to about 15%. However, the concentrations required normally exceed this amount in order to allow for possible escape of gas or infiltration of air, as well as to provide an adequate margin of safety.

Carbon dioxide cannot be used on Class “D” (reactive metals, metal hydrides and chemicals containing their own oxygen supply) hazards, such as magnesium, potassium, sodium and cellulose nitrate. These Class “D” fires can only be controlled by special extinguishing agents and procedures.

2.3 CO₂ System Applications

CO₂ systems are “total flooding” systems and must displace sufficient amounts of air to reduce the oxygen concentration to a level which will not support combustion.

2.3.1 Machinery Space Systems

As indicated above, fires in machinery spaces, cargo pump rooms and similar spaces are generally Class “B” (flammable liquids) type fires. In this type of fire, ignition of flammable sources can spread quickly, since such fires normally involve pool fires or jet or spray fires from pressurized fuel or lube oil lines. Accordingly, the heat build-up is rapid. It is important to introduce the required quantities of CO₂ quickly in order to minimize the growth of the fire. This prevents the build-up of heat from possibly causing failure of the structural integrity of the space, making it impossible to maintain the CO₂ concentration and also prevents heat updraft created by the fire from carrying away the carbon dioxide, as well as allowing for quicker cool-down periods.

2.3.2 Cargo Hold Systems

Fires in ordinary cargo holds normally involve class “A” combustibles and generally start with some smoldering and production of large quantities of smoke. Only when sufficient heat is developed to reach the “flash-over” or ignition temperature (temperature at which solid combustibles give off sufficient gases to support continued rapid burning) will rapid burning occur. Extinguishing a class “A” fire is difficult due to the thermal insulating properties of the material. Typically, the hold is kept closed until the vessel reaches a port where the cargo is removed from adjacent spaces not involved in the fire. The cargo hold involved in the fire is then opened, with charged fire main nozzles at the ready and the cargo is unloaded, cooled with water or broken open if necessary to extinguish any remaining fire.

3 ABS Requirements for Fixed Gas Extinguishing Systems

The following information is provided as general guidance regarding the ABS requirements for fixed gas fire-extinguishing systems as required by the *Rules for Building and Classing Steel Vessels* and *Rules for Building and Classing Steel Vessels 90 Meters in Length*. However, reference should always be made to the Rules applicable to the specific vessel concerned for the complete set of requirements.

3.1 General Requirements

3.1.1 Information to be Submitted

The drawings and details to be reviewed should include a system's diagrammatic arrangement, calculations regarding quantity and discharge time of the gas and a complete bill of materials. The bill of materials should include material specifications, sizes and wall thickness of the piping; type of fittings (including material specifications), pressure ratings and standards of construction for the piping components, along with manufacturer's information regarding specialized system components. Certain additional information normally required to be verified on electrical and structural arrangements may also be provided.

3.1.2 Non-Permitted Extinguishing Medium

In accordance with SVR 4-7-3/3.1.1, the use of a fire-extinguishing medium which gives off toxic gases in such quantities as to endanger persons is not to be permitted. In addition, the new installation of Halon fire-extinguishing systems is no longer permitted as a fire-extinguishing medium, as specified in SVR 4-7-3/3.1.1 [and SOLAS (2000 Amendments) Ch. II-2/10.4.1.2], due to the damage halogenated hydrocarbons inflict upon the ozone layer of the atmosphere.

3.1.3 System Components and Materials

Piping, joints and fittings are to comply with the requirements in SVR Sections 4-6-1 and 4-6-2 and be suitable for the system's pressure rating. Manifolds and associated piping from the cylinders downstream and including the last valve (time delay) are to be suitable for the cylinders' maximum storage pressure.

3.1.3(a) Materials. Materials are to be suitable for the intended service. Ordinary cast iron, steel pipe ASTM A-120 and non-metallic pipes are not to be used. In addition, the components are not to be rendered ineffective by heat, suggesting they be equivalent to steel. For example, aluminum pipes or discharge nozzles are not allowed as their failure could eliminate the system's ability to function.

3.1.3(b) Non-metallic Flexible Hoses. Flexible hoses used at the cylinders are to comply with SVR 4-6-2/5.7.1 and should be supplied by the system manufacturer.

3.1.3(c) Certification of Piping Components. Piping system components are to be certified in accordance with SVR 4-6-1/7 and the requirements outlined in SVR 4-1-1/Table 6, as appropriate. The requirements in SVR 4-1-1/Table 4 should also be applied to specialized system components, such as the control and release valves, cylinder heads, delay timers, nozzles, etc., and compliance verified during plan review.

3.1.3(d) Minimum Pipe Wall Thickness. Piping used in fixed fire-extinguishing systems must comply with minimum wall thickness requirements specified in SVR 4-7-3/Table 2. For piping from storage containers to the distribution station, minimum wall thickness of the piping is given in Column "A" of SVR 4-7-3/Table 2. Minimum wall thickness of the piping from the distribution station to the nozzles is listed in column "B" of SVR 4-7-3/Table 2. The content and notes of SVR 4-7-3/Table 2 are provided in Section 4, Table 1 of these Guidance Notes. Verification of compliance with the minimum wall thickness requirements specified in Section 4, Table 1 should be verified during plan review.

TABLE 1
Minimum Pipe Wall Thickness of Gas Medium Distribution Piping

<i>Nominal Bore, mm</i>	<i>OD mm</i>	<i>A mm</i>	<i>B mm</i>	<i>Nominal Bore inch</i>	<i>OD inch</i>	<i>A inch</i>	<i>B Inch</i>
15	21.3	2.8	2.6	1/2	0.840	0.110	0.102
20	26.9	2.8	2.6	3/4	1.050	0.110	0.102
25	33.7	4.0	3.2	1	1.315	0.157	0.126
32	42.4	4.0	3.2	1 1/4	1.660	0.157	0.126
40	48.3	4.0	3.2	1 1/2	1.9	0.157	0.126
50	60.3	4.5	3.6	2	2.375	0.177	0.142
65	76.1	5.0	3.6	2 1/2	2.875	0.197	0.142
80	88.9	5.5	4.0	3	3.5	0.220	0.157
90	101.6	6.03	4.0	3 1/2	4.0	0.248	0.157
100	114.3	7.1	4.5	4	4.5	0.280	0.177
125	139.7	8.0	5.0	5	5.563	0.315	0.197
150	168.3	8.8	5.6	6	6.625	0.346	0.220

Notes:

- 1 The above minimum thicknesses are derived from those thicknesses available in ISO 4200 Series 1 (OD), JIS (N.P.S.), or ASTM (N.P.S.). Diameter and thickness according to other recognized standards will be accepted. Accordingly, slight variations in the minimum wall thickness may be considered if the minimum wall thickness values from the standard to which the pipe is manufactured do not match up directly with the tabulated values.
- 2 For threaded pipes, where approved, the thickness is to be measured to the bottom of the thread. This item is very important to check during the plan review stage.
- 3 The internal surface of pipes outside the engine room is to be galvanized and should also be verified during plan review.

3.1.3(e) Design of Fire-extinguishing Medium Containers. In accordance with SVR 4-7-3/3.1.11, containers for the storage of fire-extinguishing medium and associated pressure components are to be designed in accordance with requirements for pressure vessels in SVR Section 4-4-1. Past practice has been to base the design upon a maximum ambient temperature of 55°C (131°F).

At 21°C (70°F), pressure in CO₂ containers is about 58.7 bar (850 psi). However, the cylinder pressure can rise rapidly with an increase in temperature. To flatten the pressure vs. temperature characteristics during the storage, gas in cylinders is limited to maximum fill densities.

High pressure CO₂ cylinders are normally single-piece extruded seamless cylinders (e.g., manufactured without welding). In accordance with SVR 4-4-1/1.11.4, these types of mass-produced cylinders are to be designed, manufactured and tested in accordance with a recognized standard for this type of pressure vessel. Their acceptance can be based on their compliance with the standard as verified by either the Bureau or an agency recognized by a national authority (in the country of manufacture) having jurisdiction over the safety of such pressure vessels. The certificate of compliance, traceable to the cylinder's serial number, is required by SVR 4-4-1/1.11.4 to be presented to the Surveyor for verification in each case.

If welded cylinders are encountered, they would be required to be ABS certified in accordance with the requirements specified in SVR 4-4-1/Table 2. Appropriate ABS certificates must be made available to the Surveyor.

3.1.4 Marking of Control Valves

As required by SVR 4-7-3/3.1.2, suitable provisions are to be made to prevent the inadvertent admission of an extinguishing medium to any space. Accordingly, the pipes necessary for conveying the fire-extinguishing medium into protected spaces are to be provided with control valves and the control valves are to be clearly marked, indicating the spaces to which the pipes are led.

In association with the above requirement, it is important to remember that the piping arrangements within the storage room can be quite complex, especially when the same storage bank is protecting multiple spaces. In an emergency, there is no time to trace out the piping system to identify which valves must be opened to release the medium into a particular space. Accordingly, the clear marking and identification of the control and directional valves is critical, especially when it is recognized that there is typically only one charge of extinguishing medium, and the accidental release of extinguishing medium into the wrong space may deplete the only source of extinguishing medium.

3.1.5 Distribution Piping

The piping for the distribution of fire-extinguishing medium is to be arranged and discharge nozzles positioned such that a uniform distribution of medium is obtained, as indicated in SVR 4-7-3/3.1.2. The sizing of the piping and nozzles is critical for the proper operation of the system in the discharge time permitted and calculations are normally required to verify the same. As far as practicable, piping should not pass through accommodation areas. Where it is not practicable to insist the piping not pass through accommodations areas, the pipelines may pass through accommodations provided that they are of substantial thickness and that their tightness is verified with a pressure test, after installation, at a pressure head not less than 50 bar (725 psi). In addition, pipes passing through accommodation areas should be joined only by welding and should not be fitted with drains or other openings within the spaces. The pipes should not pass through refrigerated spaces.

SVR 4-7-3/3.1.2 also indicates that where a cargo space, which is fitted with a gas fire-extinguishing system, is used as a passenger space, the gas connections are required to be blanked during such use. If the possibility exists that a cargo space could be used as a passenger space, arrangements for blanking are to be indicated on the plans and verified by the Surveyor.

3.1.6 Nozzle Distribution

SVR 4-7-3/3.1.2 requires the discharge nozzles to be positioned such that a uniform distribution of medium is obtained. However, it is important to note that the nozzles should not be positioned in a way that might endanger personnel engaged in maintenance of equipment or using access ladders, escapes and similar locations. Also, the nozzles should not be located near ventilation or other openings, as there is a relatively greater chance of CO₂ being forced out of the opening.

In enclosed spaces, such as aboard a vessel, the location of the system nozzles is not as critical as the location of foam and water spray systems nozzles. The gas of a fixed gas extinguishing system will disperse to all portions of the hazard within a relatively short period. However, reasonable spacing of the nozzles in some uniform pattern does reduce the time necessary for the gas to mix with the air and completely inert the space. When considering CO₂, which is heavier than air, it will tend to remain in the lower portions of the space and the air forced out the top will contain little CO₂. (During fire conditions, updraft from fire will tend to carry CO₂ away, making prompt action and closure of openings essential.)

3.1.7 Means to Close All Openings and Stop Ventilation Fans

Closure of all openings which may admit air into or allow the extinguishing medium to escape from a protected space prior to the release of the CO₂ is critical to ensure that the required CO₂ concentration will be maintained. This includes means of closing all doorways, ventilators, annular spaces around funnels and other openings to the protected space. If the ventilation is power operated, then manual override is to be provided. Likewise, stopping of ventilating fans prior to the discharge of CO₂ is necessary. The ability to stop ventilating fans serving machinery spaces, pump rooms and cargo spaces, as well as the ability to close all doorways, ventilators, annular spaces around funnels and other openings to the protected space, as required by SVR 4-7-2/1.9.5, 4-7-2/1.9.6, 4-7-3/3.1.3 and 4-8-2/11.9, is typically noted in the review letter and verified by the attending Surveyor.

3.1.8 Air Reservoirs

As discussed above, maintaining the concentration of the fixed gas extinguishing medium is critical. Accordingly, SVR 4-7-3/3.1.4 requires that the volume of free air contained in air reservoirs be considered. For this purpose, the volume of free air contained in all air receivers is to be taken into account and is to be added to the volume of the spaces to be protected, unless their safety relief valves or other pressure relief devices are discharging outside the protected spaces.

3.1.9 Medium Release Warning Alarm

Means are required to be provided for automatically giving audible warning of the release of fire-extinguishing medium into any space in which personnel normally work or to which they have access, in accordance with SVR 4-7-3/3.1.5. The alarm is required to operate for the period of time necessary to evacuate the space, but not less than 20 seconds before the medium is released, and should be capable of being heard in any part of the protected space with the machinery operating under normal conditions.

Alarms may be pneumatically (by the extinguishing medium or by air) or electrically operated. If electrically operated, the alarms are to be supplied with power from the main and an emergency source of power. If pneumatically operated by air, the air supplied is to be dry and clean and the supply reservoir is to be fitted with a low pressure alarm. The air supply may be taken from the starting air receivers. Any stop valve fitted in the air supply line is to be locked or sealed in the open position. Any electrical components associated with the pneumatic system are to be powered from the main and an emergency source of electrical power.

Considering the extreme hazard any discharge of CO₂ presents to personnel in the protected space, verification that the alarms and the release delay will operate properly is vital in ensuring that personnel will have the opportunity to evacuate the protected space prior to the CO₂ discharge. As noted above, the alarm and associated delay in the discharge must continue for at least 20 seconds. However, larger engine rooms may require a system with a longer delay to ensure that individuals have an opportunity to evacuate. Verification that the time delay unit is located properly within the system design and will in fact prevent an immediate release must be verified during plan review. It is also important to note that individuals react distinctively differently under the stress and pressure of an emergency, and therefore, any method of delayed release which relies upon individual timing or counting out is not considered acceptable. The time delay unit must be an automatic device that is incorporated into the system.

SVR 4-7-3/3.1.5 indicates that conventional cargo holds need not have a pre-discharge alarm, since personnel are not expected to normally enter into ordinary cargo holds. However, ro-ro cargo spaces and other spaces (e.g., reefer container holds, etc.) where personnel can be expected to enter and where convenient accesses, such as doors or hinged hatches, are provided are to comply with this requirement.

In addition, SVR 4-7-3/3.1.5 indicates that small spaces, such as small compressor rooms, paint lockers, etc., where speedy egress is possible, need not be fitted with pre-discharge alarms. Multi-level spaces, spaces with vertical exits/ladders and spaces where personnel could not be expected to easily escape should not be considered as providing speedy egress and appropriate pre-discharge alarms should be provided.

SVR 4-7-3/3.1.5 requires that the pre-discharge alarm shall be automatically activated, e.g., by opening of release cabinet door. The alarm shall operate for the length of time needed to evacuate the space, but in no case less than 20 seconds before the medium is released.

Related IMO Resolution

Resolution A.686(17), paragraph 4.2

The fire-extinguishing medium alarm should have a characteristic which can be easily distinguished from any other audible alarm or call installed in the space(s) concerned, and should not be combined with any other audible alarm or call.

In association with the above discussions, it should be noted that certain administrations, such as UK MSA, do not allow time delays to be fitted in fixed gas fire-extinguishing systems. For such situations where the Rules may be in conflict with specific flag state regulations, SVR 4-7-1/1 indicates that consideration can be given to fire-extinguishing systems that comply with the published requirements of the governmental authority of the country whose flag the vessel is entitled to fly as an alternative or addition to the requirements. Accordingly, if the flag administration has “published” regulations specifically prohibiting time delays, arrangements without the delays can be accepted for classification.

3.1.10 Location of Controls for Extinguishing Medium Release

SVR 4-7-3/3.1.6 requires that the means of control of any fixed gas fire-extinguishing system are to be:

- i) Readily accessible,
- ii) Simple to operate, and
- iii) Grouped together in as few locations as possible at positions not likely to be cut off by a fire in a protected space.

While SVR 4-7-3/3.1.6 indicates that the number of the release stations is to be limited to as few as possible, at least two “independent” release stations are required. One release station is to be installed outside of the protected space in a location not likely to be cut off by a fire in the protected space and the second means of release for the system is to be within the cylinder storage compartment. One system actuation control at the storage location is acceptable for protection of cargo and ro-ro spaces.

SVR 4-7-3/3.1.6 also requires each release station to be clearly marked and identified as to which space it is protecting. In addition, at each location there are to be clear instructions relating to the operation of the system with regard to the safety of personnel.

In reviewing the system drawing, the design of the remote control system should be carefully considered. Frequently the remote control operation is accomplished by a cable system. A lever is pulled at the remote station, and this force is transmitted via the cable to the cylinder location where cylinders or valves are operated. Operation of the remote pulls should not require more than 178 N (40 lbf) pull or more than 35.6 cm (14 inches) movement to accomplish its purpose. Although the system may operate satisfactorily when new, kinks in the cable due to being kept in one position, or possible deterioration of pulleys, etc., may make the system more difficult, or impossible, to operate in the future. For this reason, excessive lengths of control cable should not be used, and cables and other operating mechanisms should never be installed in locations where they will be subject to the effect of weather, corrosion, etc. In addition, actuation cables and tubing should not run through the protected spaces. Pneumatic release arrangements, typically using small nitrogen-charged cylinders, can be used where cable actuation arrangements are not suitable or desired. However, it must be verified that the pneumatic release arrangements continue to comply with the requirements outlined above.

3.1.11 Automatic Release of Fire-extinguishing Medium

Controls to actuate the system must be of the manual actuation type. Automatic actuation of the system (e.g., upon the fire detection signal, temperature rise devices, etc.) is not permitted by SVR 4-7-3/3.1.7, except as may be specifically approved based on the use of an extinguishing medium that not give off toxic gases, liquid or other substances that would endanger personnel.

3.1.12 Systems Protecting More Than One Space

Where the quantity of extinguishing medium is required to protect more than one space, SVR 4-7-3/3.1.8 indicates that the quantity of medium available need not be more than the largest quantity required for any one space so protected.

3.1.13 Storage of Medium Containers

3.1.13(a) General Arrangements. The requirements for the storage of the extinguishing medium cylinders are found in SVR 4-7-3/3.1.9. The gas cylinders are to be located in a dedicated storage room located outside of the protected space that is safe and readily accessible. The room is to have readily available access independent from the protected space (e.g., not subject to being cut off in the event of a fire), preferably from the open deck.

In addition, the access door is to open outwards, so that in the event of an inadvertent release of gas within the space, personnel will not be trapped inside the storage room. If the door was permitted to open into the space, even a moderate over-pressurization within the compartment would make it impossible for anyone inside the space to open the door.

If adjacent to other spaces, its common boundaries, including doors and other openings, are to be gas tight.

Spaces which are located below deck or spaces where access from the open deck is not provided are to be fitted with a mechanical ventilation system designed to take exhaust air from the bottom of the space and sized to provide at least 6 air changes per hour. Access doors are to open outwards, and bulkheads and decks including doors and other means of closing any opening therein which form the boundaries between such rooms and adjoining enclosed spaces are to be gastight. The boundaries of the room are to have fire-rated integrity equivalent to that of a control station.

3.1.13(b) Ventilation Arrangements. Spaces containing the cylinders should also be designed and ventilated so as to preclude an ambient temperature in excess of 50°C (130°F). This is to prevent the pressure in the cylinders from rising and possibly breaking the rupture disc which protects the cylinder from overpressure. In such a situation, rupture of the overpressure disc would fill the cylinder room with gas, leaving none to fight the fire. The inadvertent release could also endanger any personnel that may be within the storage room.

3.1.13(c) Insulation Requirements of Boundaries. A similar overpressure situation might arise if cylinders are located immediately adjacent to the space that they protect. Heat from a fire in the protected space might readily be conducted through the bulkhead, elevating the temperature in the storeroom and overpressuring the cylinders. This situation could easily occur if the fire has gained a considerable head start before discovery. To avoid such a situation, the cylinder bank should be located in a space that is not contiguous with the space protected. If this not possible, then the common boundaries (bulkheads and decks) between the spaces are to be insulated. For insulation requirements, see Tables 9 in SOLAS 2000 Reg. II-2/9. In determining the insulation requirements, storage rooms are to be considered as Control Stations, as specified in SVR 4-7-3/3.1.9

Related ABS Interpretation/Instruction (I/I):

Note: (Regarding fixed gas system protection for paint lockers.) Because the number of bottles required to provide an adequate volume of agent to extinguish a fire within the paint locker is small and the system is to be considered as local, the storage space need not be considered a control station. This is providing that the extinguishing medium is located nearby the paint locker with controls readily accessible, and in general the volume of CO₂ required is not to exceed 300 pounds, or equivalent for other mediums.

3.1.13(d) Ventilation. The ventilation system for the gas medium storage room is to be independent of all other spaces, and details regarding the ventilation system should be checked for any other interconnections to verify that the gas, in case of leakage, would not propagate into other spaces. If the submitted information is not available/sufficient, the compliance with the above may be left to the satisfaction of the attending Surveyor and so noted in the review letter.

3.1.14 Medium Quantity Check

In order to provide the crew with the means to ensure that there has been no leakage of gas and that the system is fully charged with the required quantity of CO₂, SVR 4-7-3/3.1.10 requires that means are to be available to periodically monitor the quantity of medium in the cylinders. Typically, this is accomplished by weighing the cylinders, thus a suitable scale should be listed in the Bill of Materials and a rail is to be suitably arranged for this purpose or a note on the drawing indicating such arrangements will be provided.

Means for checking the quantity of medium in containers are to be provided, in accordance with SVR 4-7-3/3.1.10.

3.2 Additional Requirements for Fixed CO₂ Gas Extinguishing Systems

Classification requirements specific to fixed CO₂ fire-extinguishing systems are found in SVR 4-7-3/3.3 and requirements for low pressure CO₂ systems are contained in SVR 4-7-3/3.5.

3.2.1 Quantity of CO₂ Required

3.2.1(a) Cargo Spaces. SVR 4-7-2/7.1.1 requires the cargo spaces of dry cargo vessels 2,000 gross tonnage and upwards to be protected by a fixed gas fire-extinguishing system (unless protected by a fire-extinguishing system which gives equivalent protection). The only exceptions are those cargo spaces addressed in SVR 4-7-2/7.1.2 and 4-7-2/7.1.3. SVR 4-7-2/7.1.1 further indicates that the fixed gas system is to comply with the provisions of SVR 4-7-3/3.

For regular cargo spaces, SVR 4-7-3/3.3.1 requires that the quantity of carbon dioxide provided is to be sufficient to give a minimum volume of free gas equal to 30% of the gross volume of the largest cargo space so protected in the vessel. In ro-ro and cargo spaces (other than "Special Category" spaces) intended for carriage of motor vehicles with fuel in their tanks and capable of being sealed, the minimum required concentration is 45% of the gross volume of the space as indicated in SVR 5-10-4/3.3.1(a).

Gasketless hatch covers or hatch covers having narrow gaps between cover panels where the ratio of the total gap area, in m² (ft²), to the total volume of the cargo hold space, in m³ (ft³), is less than 0.098 (0.03) are considered to be non-tight hatch covers. For non-tight hatch covers, the amount of CO₂ is to be increased an appropriate amount to compensate for the amount of CO₂ that will be lost.

For dry cargo vessels of less than 2000 gt, the cargo spaces are exempted from the subject system requirements. In addition, the cargo spaces of vessels constructed solely for carrying ore, coal, grain, unseasoned timber, non-combustible cargoes or cargoes which constitute a low fire risk (see 5-3-7/3.3 or MSC/Circular 671 *List of solid bulk cargoes which are non-combustible or constitute a low fire risk or for which a fixed gas fire-extinguishing system is ineffective*) may be exempted, as indicated in SVR 4-7-2/7.1.3. However, such exemptions are only granted if the vessel is fitted with steel hatch covers and effective means of closing all ventilators and other openings leading to the cargo spaces.

It is also important to note that CO₂ fire-extinguishing systems are not permitted to be installed in “Special Category” spaces. “Special Category” spaces are defined as those enclosed spaces above or below the bulkhead deck intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion, into and from which such vehicles can be driven and to which passengers have access. The use of a CO₂ system would endanger the lives of passengers who may be inside the space and not understand the meaning of the alarms or the need to evacuate.

3.2.1(b) Machinery Spaces. The requirements in SVR 4-7-3/3.3.2 specify that the quantity of carbon dioxide gas for fire-extinguishing for machinery spaces is to be sufficient to give a minimum volume of free gas equal to the larger of the following volumes, either:

- i) 40% of the gross volume of the largest machinery space so protected, the volume to exclude that part of the casing above the level at which the horizontal area of the casing is 40% or less of the horizontal area of the of the space concerned taken midway between the tank top and the lowest part of the casing; OR
- ii) 35% of the gross volume of the largest machinery space protected, including the casing.

The above-mentioned percentages may be reduced to 35% and 30%, respectively, for cargo vessels of less than 2,000 gross tonnage.

For the purpose of the above paragraph, the volume of free carbon dioxide shall be calculated at 0.56 m³/kg (9 lb/ft³), as indicated in SVR 4-7-3/3.3.3.

Method of Calculating Quantity

Quantity of CO₂ to be provided can be calculated by the formula below:

$$W = (V/S) * (C/100)$$

where

- W = weight of gas agent required, kg (lb)
- V = volume of the protected space, m³ (ft³)
- C = concentration of gas upon release into space (%), as specified below
- S = specific volume of gas, m³/kg (ft³/lb); see Section 4, Table 2.

TABLE 2
CO₂ Requirements

<i>Specific Volume</i>	<i>Quantity of CO₂</i>
m ³ /kg	0.56
ft ³ /lb	9.00

Note: The above values are based on ambient temperature of 20°C (70°F).

As stated above, machinery spaces with a casing involved are required to have a concentration of at least 35% of the gross volume of the space including casing, or 40% of the gross volume of the space excluding the casing, whichever is greater. For cargo vessels of less than 2000 gt., the above percentages may be reduced to 30% and 35%, respectively.

Where several spaces are protected by the same system, the quantity of gas in the system storage need not exceed the amount required for the largest protected space (considering one space is on fire at any given moment). When machinery spaces are considered “entirely separate,” the quantity of carbon dioxide may be calculated from the gross volume of the largest space. If two or more machinery spaces are not entirely separate, then they are to be considered as forming one space and the gross volumes of these machinery spaces are to be included in determining the quantity of carbon dioxide to be provided.

Typically, the volume of the protected space(s) is specified in the required calculations.

3.2.2 Discharge Time, CO₂ Piping and Nozzle Sizing

SVR 4-7-3/3.3.4 requires that the fixed piping systems for machinery spaces is to be such that 85% of the gas can be discharged into the space within 2 minutes.

The manifold and distribution piping are to be reviewed to verify that:

- i) The pipe sizes are adequate to facilitate the discharge at the required amount of gas within the specified time frame,
- ii) That the maximum allowable working pressure and minimum thickness of piping comply with SVR 4-6-2/5, and
- iii) That the minimum wall thickness of steel pipes for carbon dioxide systems complies with SVR 4-7-3/Table 2. Further, the supply lines are to provide adequate supply to the nozzles without throttling.

3.2.3 Sizing of the Discharge Piping for Discharge Time

Proper sizing of the CO₂ nozzles is critical to the proper operation of the system. SVR 4-7-3/3.3.4 requires that for CO₂ systems protecting machinery rooms, 85% of gas is to be discharged within 2 minutes, and therefore, if there is not enough nozzle area, the required amount of gas will not be discharged within the required time. However, CO₂ will transform straight from a gas to a solid if the pressure within the discharge piping drops too low (due to its point of sublimation), which could result in the blockage of the piping. Therefore, the nozzles must be properly sized to ensure adequate back-pressure will be maintained in the distribution piping to maintain a pressure above the point of sublimation for CO₂.

Normally, the discharge times are confirmed by submitted calculations, which should be reviewed to verify compliance with the above requirements. However, in the absence of flow calculations for machinery space systems, documentation verifying that the pipes and nozzles are sized in accordance with Title 46CFR Table 95.15-5(d) may be considered in confirming that the system will discharge the required quantity of carbon dioxide in less than two minutes while still maintaining adequate back-pressure.

3.3 Additional Control Requirements for CO₂ Systems

As the inadvertent release of CO₂ would present a serious hazard to personnel, SVR 4-7-3/3.3.5 identifies additional requirements to prevent such a release of CO₂ into spaces that are normally manned. SVR 4-7-3/3.3.5 requires that for spaces normally manned, the controls complied with the following and the same should be verified during plan review:

3.3.1 Release Arrangements

Two separate controls are to be provided for releasing CO₂ into a protected space and to ensure the activation of the alarm. One control is to be used to discharge the gas from its storage containers. A second control is to be used to open the valve of the piping that conveys the gas into the protected space.

The two controls are to be located inside a release box clearly identified for the particular space. If the box containing the controls is locked, a key to the box is to be in a break-glass type enclosure conspicuously located adjacent to the box.

3.3.2 Storage of CO₂ Containers

The requirements for the storage of the extinguishing medium cylinders are found in SVR 4-7-3/3.1.9 and discussed in 4/3.1.13 of these Guidance Notes.

3.4 Additional Requirements for Low Pressure CO₂ Systems

Low pressure CO₂ storage systems utilize refrigeration units to maintain the CO₂ at temperatures below normal atmospheric temperatures. By reducing the temperature of the CO₂, the storage pressure is also reduced substantially below the equilibrium pressure seen in at atmospheric temperatures [approx. 57 vs. 21 bar (850 vs. 300 psi.)]. This reduction in the pressure makes it feasible to design and construct much larger CO₂ containers, and therefore, provides the ability to store large volumes of CO₂ in a single container.

The use of refrigerated CO₂ as a fire-extinguishing medium will typically be in the pressure range of 18 to 22 bar (260 to 320 psi) in the storage condition, and such systems are to be in accordance with the requirements discussed above and found in SVR 4-7-3/3.1 and 4-7-3/3.3, as well as the following additional requirements.

3.4.1 Plans and Data to be Submitted

In accordance with SVR 4-7-3/3.5.1, the following plans and data are to be submitted for review:

- System schematic arrangement
- CO₂ capacity and flow calculations
- System control and alarm arrangement
- Arrangement of CO₂ containers and refrigerating plant
- Construction details of CO₂ containers
- Manufacturer's specifications for compressor, condenser, receiver, evaporator, etc.
- Piping diagram for refrigerating system
- Electrical wiring diagrams

3.4.2 CO₂ Containers

The following requirements apply to CO₂ containers and are found in SVR 4-7-3/3.5.2. These requirements should be verified during plan review.

3.4.2(a) Capacity. The capacity of the CO₂ containers is to be such as to provide sufficient vapor space to allow for expansion of the liquid under the maximum expected storage temperature that can be encountered without exceeding the relief valve setting. The amount of liquid under such conditions is not to be in excess of 95% of the volume of the container.

3.4.2(b) Design and Construction. CO₂ containers are to be designed, constructed and tested in accordance with the requirements of SVR Section 4-4-1 (see in particular 4-4-1/1.11.4).

3.4.2(c) Instrumentation and Alarms. Each container is required to be fitted with the following instruments and alarms at the storage location:

- Pressure gauge
- High pressure alarm set at not more than 22 bar (320 psi) and not within 5% of relief valve setting
- Low pressure alarm, set at not less than 18 bar (260 psi)
- Level indicator, and low level alarm

A summary alarm for any of these alarm conditions is also to be given in the manned propulsion machinery space or the centralized control station (see SVR 4-9-3/7 and 4-9-4/9), as appropriate. In the case of unattended propulsion machinery space, an additional summary alarm is to be given in the engineers' accommodation area (see SVR 4-9-4/19).

3.4.2(d) Relief Valves. Two relief valves are to be fitted on each container, such that either one but not both can be shut off. The relief valves are to be set at not less than 22 bar (320 psi). The capacity of each valve is to be capable of preventing a pressure rise, due to exposure to fire, in excess of 20% above the relief valve setting. The discharge from the relief valve is to be led to the open air.

3.4.2(e) Insulation. The containers and piping which are always filled with liquid CO₂ are to be insulated so that the pressure will not exceed the relief valve setting when subjected to an ambient temperature of 45°C (113°F) for a period of 24 hours after the refrigerating plant is out of service. Where porous or fibrous insulation materials are used, they are to be protected by impervious sheaths from deterioration by moisture.

3.4.3 Refrigerating Plant

The refrigeration plant is critical to the safe and proper operation of the system. If the refrigeration plant would fail to operate, the temperature of the CO₂ in the container would gradually increase to atmospheric temperature. In the process, the safety or relief valves would open to relieve the resulting increase in pressure. As the safety valves relieved the excessive pressure, the majority of the CO₂ would be lost and there would be no CO₂ in the case of a fire. Accordingly, the Rules identify specific requirements regarding the refrigeration plant in SVR 4-7-3/3.5.3, as discussed below and the same should be verified during the review of the system.

3.4.3(a) Duplication of Plant. The CO₂ containers are to be served by two completely independent and automated refrigerating units dedicated for this service, each comprising its own compressor and prime mover, condenser, receiver, evaporator, etc. Provision is to be made for local manual control of the refrigerating plant. Upon failure or stoppage of the unit in operation, the other unit is to be put into operation automatically. This changeover is to be alarmed at the manned propulsion machinery space or the centralized control station, as appropriate, and in the case of unattended propulsion machinery space, at the engineers' accommodation. See also SVR 4-7-3/3.5.2(c). Each refrigerating unit is to be supplied from the main switchboard by a separate feeder.

3.4.3(b) Performance Criteria. Each refrigerating unit is to be capable of maintaining the liquefaction of the required quantity of CO₂ at the specified pressure, at a sea water temperature of 32°C (90°F) and an ambient temperature of 45°C (113°F). See also insulation requirement in SVR 4-7-3/3.5.2(e).

3.4.3(c) Cooling Water Supply. Where sea water is utilized for cooling, two sea water pumps are to be provided, one of which is to be standby and may be a pump used for other services. Both pumps are to be capable of drawing from at least two sea chests.

3.4.4 Piping

The piping and piping components must be suitable for the combination of the pressures and low temperatures to which they will be exposed and the same should be verified during plan review. Also, the following additional requirements regarding the piping are found in SVR 4-7-3/3.5.4 and should be verified during plan review.

3.4.4(a) General Piping Requirements. Pipes, fittings and pipe joints are to be designed, fabricated and tested, and are to be of materials according to the piping classes determined in accordance with in SVR 4-6-1/5.

3.4.4(b) CO₂ Distribution Piping. CO₂ flow from storage containers to the discharge nozzle is to be in liquid phase. The design pressure at the nozzle is not to be less than 10 bar (145 psi).

3.4.4(c) Safety Relief Valve. Safety relief devices are to be provided in each section of pipe that may be isolated by valves and in which there could be a build-up of pressure in excess of the design pressure of any of the components.

3.4.5 CO₂ Release Control

In addition to the requirements in SVR 4-7-3/3.1.6 and 4-7-3/3.3.5, the following requirements as found in SVR 4-7-3/3.5.5 are to be complied with, as appropriate.

3.4.5(a) Automatic Regulation of Gas. Where automatic means are provided to regulate the quantity of CO₂ discharged into the protected spaces, manual means of regulation are also to be provided.

3.4.5(b) Emergency Control. If an emergency release control is provided, in addition to the normal release control, it must not bypass the activation of alarm required by SVR 4-7-3/3.1.5. It may; however, bypass the automatic gas regulator [see SVR 4-7-3/3.5.5(a)], provided that it is possible at the emergency release control position to control the amount of gas to be released and to close the master valve, or equivalent, after the designated amount is released.

3.4.5(c) Multiple Spaces. If the system serves more than one space, the quantity of CO₂ to be discharged to each space is to be provided with means of control, e.g., automatic timer or accurate level indicators located at the control positions.

3.4.5(d) Instructions. Instructions for release control, as required by SVR 4-7-3/3.1.6, are to be posted at each location where gas can be released. This is to include instructions for manual means of regulating the amount of gas to be released into each of the protected spaces.

3.5 Additional Requirements for Vessels Receiving an “ACCU” Automation Notation

In addition to the system features as described above, vessels classed **ACCU** are required to have means to control the following systems from the fire-fighting station, per SVR 4-9-4/21.3, and should not depend upon power from inside the protected space:

- Shutdown of ventilation fans serving the machinery space.
- Shutdown of forced draft blowers of boilers, inert gas generators and incinerators, and of auxiliary blowers of propulsion diesel engines.
- Closing of propulsion machinery space skylights, openings in funnels, ventilator dampers and other openings.
- Closing of propulsion machinery space watertight and fire-resistant doors. Doors normally closed and self-closing doors may be excluded.
- Actuation of the fixed fire-extinguishing system for the propulsion machinery space.

While SVR 4-9-4/21.3 does provide other requirements for the remote control of various systems or devices from the dedicated fire-fighting station, the above identify those that would specifically impact the proper operation of a fixed gas fire-extinguishing system and should be verified during the plan review.

3.6 Governmental Authorization

While the above outlines the requirements for fixed gas fire-extinguishing systems insofar as ABS classification requirements are concerned, it is recognized that there may be Flag Administration requirements which directly contradict the requirements specified in the Rules and SOLAS, especially in the area of fixed gas fire-extinguishing systems. SVR 4-7-1/1 makes provisions for such situations specifying that consideration may be given to the published requirements of the governmental authority of the country in which the vessel is to be registered.

One example where alternative arrangements have been accepted in accordance with the provisions of SVR 4-7-3/3.1.7 is on certain flagged vessels, the Administration specifically accepts the installation of an automatic release. Such an arrangement would not normally be accepted based upon ABS and SOLAS requirements but may be considered based upon published Flag Administration requirements.

3.7 Steam Smothering Systems

As indicated in SVR 4-7-3/3.7, in general, the use of steam as a fire-extinguishing medium in fixed fire-extinguishing systems is not permitted. In exceptional cases, the use of steam may be permitted in restricted areas as an addition to the required fire-extinguishing medium providing that the boiler or boilers available for supplying steam have an evaporation of at least 1.0 kg (2.2 lb) of steam per hour for each 0.75 m³ (27 ft³) of the gross volume of the largest space so protected.

3.8 Halon Systems

While fixed fire-extinguishing systems utilizing Halon were very popular due to their ability to support life while still extinguishing a fire, based upon the Montreal Protocol, the Rules no longer permit the use of halogenated hydrocarbon systems for new installations, in accordance with SVR 4-7-3/3.1.1. Accordingly, no discussion regarding these types of systems is provided herein.

3.9 Requirements for Systems using Halon “Alternatives”

With the prohibition of Halon as a fire-extinguishing medium in association with the Montreal Protocol and the resulting SOLAS Amendment in 1992 due to its detrimental impact on the environment, a major void was created for extinguishing media that are not as dangerous to personnel as CO₂. Accordingly, there has been significant work in the development of Halon alternatives and the development of international testing criteria to verify their effectiveness as suitable extinguishing fires in shipboard applications.

Based upon significant work and testing conducted by a number of countries, including the U.S. Coast Guard, the International Maritime Organization (IMO) has established a minimum set of criteria for the testing of extinguishing agents and the design of the systems. These criteria are published in IMO Circulars 776 and 848.

For an extinguishing agent to be considered for Classification purposes, full compliance with requirements specified in IMO Circulars 776 and 848 would be required. In addition, approval of the medium by the Flag Administration would be required. The Bureau's acceptance of a Halon alternative agent without prior approval of an appropriate Administration is not permitted. This is to ensure that the environmental issues associated with the requirements in IMO Circulars 776 and 848 have been adequately addressed with the appropriate organization(s) of the Administration.

It is important to note that the criteria in IMO Circulars 776 and 848 require not only the agent to be tested and verified as an effective extinguishing medium, but also require the specific discharge nozzles to be included in the test, since different nozzles will generate different flow and distribution patterns. Accordingly, if a different nozzle is proposed to be used with a particular agent, the fire tests specified in IMO Circulars 776 and 848 would need to be repeated. Therefore, not only the particular extinguishing agent but also the hardware provided by the particular manufacturers/distributors must be verified as having passed the IMO testing.

Once an extinguishing medium and the hardware associated with a particular manufacturer/distributor have passed the fire testing requirements specified in IMO Circulars 776 and 848, and they have received approval by the cognizant Administration, the same can be considered for Classification purposes. Upon receipt and review of documentation verifying compliance with the above items, the actual system design can be reviewed for compliance with the requirements identified in IMO Circulars 776 and 848. This would include verification of compliance with all applicable system requirements identified in IMO Circulars 776 and 848, as well as in SOLAS Reg. II-2/5.1 (FSS Code Chapter 5/2.1), except as modified by the Guidelines, and NFPA 2001 Standard, which are referenced in IMO Circulars 776 and 848. Verification that the piping components also comply with the applicable ABS requirements specified in SVR Section 4-6-2 and 4-7-3/3 would also be required.

Currently there are several Halon alternatives that are on the market and some that have obtained ABS Type Approval. The Kidde-Fenwal FM-200 Marine ECS Series Fire Suppression System and the ANSUL Inergen system are now listed as the ABS Type Approved systems. See the ABS website <http://www.eagle.org/typeapproval/index.html> for further details. The ABS Type Approval listings will identify specific requirements applicable to the particular system.

3.10 Additional/Alternative Requirements for Special Locations

3.10.1 Oil Carrier Cargo Pump Rooms

Cargo pump rooms are a major source of fire risk onboard oil carriers due to the necessity to operate equipment such as cargo pumps, etc., in an atmosphere where flammable vapors frequently exist. Accordingly, cargo pump rooms are required to be provided with an approved fixed fire-extinguishing system controlled from a readily accessible position outside of the pump room in accordance with SVR 5-1-7/29.1i). Where a CO₂ system is provided to meet this requirement, the system is to comply with the requirements outlined in SVR 4-7-3/3 and discussed above, but special concerns exist due to the expected hazardous atmosphere within the pump room. Therefore special precautions are required as discussed below.

3.10.1(a) General. When carbon dioxide systems are released, the high pressure flow of carbon dioxide can create ice particles which are subject to establishing a static charge as they flow through the distribution piping. Since the pump room is a hazardous area with the potential of having a flammable atmosphere, the discharge of a charged particle against the structure could create a spark and introduces the potential for igniting the atmosphere. Accordingly, a notice is required by SVR 5-1-7/29.1i) to be exhibited at the controls stating that the system is only to be used for fire-extinguishing and not for inerting purposes, due to the electrostatic ignition hazard.

3.10.1(b) Pre-discharge Alarms. The audible alarms to warn of the release of the fire-extinguishing medium into pump rooms as required by SVR 4-7-3/5.1.5 may be of the electric or pneumatic type. However, special requirements as discussed below must be applied:

- *Electrically-operated Alarms.* When electrically-operated alarms are used, the arrangements are to be such that the electric actuating mechanism is located outside the space, and the alarms must be certified as being safe for use in flammable cargo vapor/air mixtures, as indicated in SVR 5-1-7/29.1i). Even while the alarm actuating mechanism is located outside the protected space, hazardous atmospheres exit on the open deck of oil carriers, and the review should ensure that the device is suitable for the location installed.
- *CO₂-operated Alarms.* Owing to the possibility of the generation of static electricity in the CO₂ cloud, CO₂-powered alarms should not be encouraged, as indicated in IACS UR F5. However, SVR 5-1-7/29.1i) does not specifically prohibit such alarms, and therefore, where the CO₂-powered alarms are utilized, special precautions regarding the testing of the alarms must be exercised. Where periodic testing of CO₂-operated alarms is required, SVR 5-1-7/29.1i) indicates that air and not CO₂ must be used. Accordingly, where such alarm arrangements are indicated on the drawing, a placard stating this requirement should be provided.
- *Air-operated Alarms.* Air-operated alarms may also be used. However, the air supplied is to be dry and clean, and the supply reservoir is to be fitted with a low pressure alarm. The air supply may be taken from the starting air receivers. Any stop valve fitted in the air supply line is to be locked or sealed in the open position. Any electrical components associated with the pneumatic system are to be powered from the main and an emergency source of electrical power.

3.10.1(c) Required Quantity of Fire-Extinguishing Medium. SVR 5-1-7/29.3 indicates that where the fire-extinguishing medium used in the cargo pump room system is also used in systems serving other spaces, the quantity of medium provided or its delivery rate need not be more than the maximum required for the largest compartment.

3.10.2 Gas Carrier Cargo Pump and Compressor Rooms

Similar to oil carrier pump rooms, gas carrier cargo compressor and pump rooms have equipment which operates in atmospheres where flammable vapors frequently exist. Accordingly, these spaces are required to be provided with an approved fixed CO₂ fire-extinguishing system controlled from a readily accessible position outside of the space, in accordance with SVR 5-8-11/5.1, and should comply with the requirements in SVR 4-7-3/3. However, once again special concerns exist, since these spaces will typically have hazardous atmospheres, and therefore, the following special precautions are applicable.

3.10.2(a) General. As discussed in 4/3.10.1 of these Guidance Notes, when carbon dioxide systems are released, the high pressure flow of carbon dioxide can create ice particles which are subject to establishing a static charge and introduce the potential for igniting the atmosphere. Accordingly, a notice is required by SVR 5-8-11/5.1 to be exhibited at the controls stating that the system is only to be used for fire-extinguishing and not for inerting purposes, due to the electrostatic ignition hazard.

3.10.2(b) Additional Quantity of Fire-Extinguishing Medium. In accordance with SVR 5-8-11/5.1, the amount of carbon dioxide gas carried should be sufficient to provide a quantity of free gas equal to 45% of the gross volume of the cargo compressor and pump rooms.

3.10.2(c) Pre-discharge Alarms

- *Electrically-operated Alarms.* When electrically-operated alarms are used, the arrangements are to be such that the electric actuating mechanism is located outside the space and the alarms must be certified as being safe for use in flammable cargo vapor/air mixtures. Even while the alarm actuating mechanism is located outside the protected space, hazardous atmospheres exit on the open deck of gas carriers, and the review should ensure that the device it is suitable for the location installed.
- *Pneumatically-operated Alarms.* In accordance with SVR 5-8-11/5.1.1(a), in those cases where the periodic testing of such alarms is required, CO₂-operated alarms should not be used, due to the possibility of the generation of static electricity in the CO₂ cloud. Air-operated alarms may be used. However, the air supplied is to be dry and clean, and the supply reservoir is to be fitted with a low pressure alarm. The air supply may be taken from the starting air receivers. Any stop valve fitted in the air supply line is to be locked or sealed in the open position. Any electrical components associated with the pneumatic system are to be powered from the main and an emergency source of electrical power.

3.10.3 Paint Locker and Flammable Liquid Lockers

Paint lockers and flammable liquid lockers are required to be protected by a fire-extinguishing system and CO₂ systems are frequently installed for this purpose. Where installed, the CO₂ system is to comply with the requirements discussed above and is to provide sufficient CO₂ to supply a free volume of gas equivalent to at least 40 % of the gross volume of the space.

For more information about acceptable fire-extinguishing arrangements for paint and flammable liquid lockers, see Section 9 of these Guidance Notes.

SECTION **5 Fixed Water Fire Extinguishing Systems**

1 General Principles of Fixed Water Fire-extinguishing Systems

Water is an ideal extinguishing medium for many shipboard applications. It is readily available, has great heat absorbing capabilities and can be used on a variety of fires. There are several mechanisms involved in the extinguishment of a fire with water. First, there is the cooling of the flame temperature when water passes through the combustion zone and absorbs heat through evaporation. Cooling of the flame temperature results in a reduction in the amount of radiant heat released by the fire, and therefore, a reduction in the amount of heat radiated back to the fuel surface. Secondly, there is the cooling effect of the fuel surface by the direct impingement of water droplets on the surface. With a reduction of the radiant heat received at the fuel surface and the additional cooling of the fuel surface by direct contact with the water droplets, there is a reduction in the amount of combustible gases released. With sufficient cooling of the flame temperature and/or the fuel, the rate of pyrolysis or vaporization of combustible vapors will be reduced to a point which combustion will no longer be self-supporting. Water has the important additional effect of when it evaporates it turns into steam. The steam, which is in the immediate vicinity of the chemical reaction, displaces the air that supplies oxygen for the combustion process and results in a smothering of the fire.

Fixed water extinguishing systems are normally considered to include *water spray*, *water sprinkler* and *water mist systems*. These systems utilize fixed piping systems with distributed arrays of nozzles located in the overhead, which are supplied from dedicated pump(s). However, the particular fire hazards and safety concerns vary depending on the particular type of space being protected. For example, in a machinery space, one would anticipate Class “B” combustibles to be involved, while in an accommodation space, one would anticipate the involvement of Class “A” combustibles. Even the degree of anticipated supervision has a role. There are many locations in the accommodation spaces and service spaces that are not continuously supervised (cabins, storage closets, etc.) and a small initial fire could easily go unnoticed by shipboard personnel. There are also certain differences in the extinguishing mechanisms at work for a water mist system as compared to those involved in a water spray or water sprinkler system. Accordingly, the system designs, as well as the requirements, vary depending upon the space to be protected and the type of system to be installed. The following provides a brief discussion regarding the individual types of systems.

1.1 Water Spray System

Water spray systems are manually operated, open “deluge” type systems and are typically used to protect open ro-ro spaces, “Special Category” spaces and cargo pump rooms. Water spray systems are also permitted for use in protecting machinery spaces, but such arrangements are seldom proposed due to the hazards involved and the availability of suitable alternatives. Like other types of fixed water extinguishing systems, the water spray system consists of pump(s), a fixed piping system and a distributed array of nozzles. However, the one distinctive characteristic of a water spray system is that it utilizes “open” type nozzles. When this type of system is activated, water will be discharged simultaneously through all of the branch nozzles, which can result in very high water demand rates. Also, these systems are normally required to be manually actuated, and therefore, personnel must initiate the discharge of the system.

1.2 Water Sprinkler Systems

Water sprinkler systems also utilize a distribution system consisting of fixed supply piping and overhead nozzles. However, unlike water spray systems, *water sprinkler systems* are designed for automatic activation. Since these systems are automatically actuated, the distribution system must be pressurized at all times. To accommodate the automatic release, the sprinkler nozzles used are of the “closed” type and fitted with individual heat sensitive links or bulbs that allow the nozzle to open when the temperature of the air in the vicinity of a particular nozzle exceeds a certain “activation” temperature. Since each individual nozzle has its own activation mechanism, only those nozzles in the immediate vicinity of the fire will see temperatures sufficient for activation and will open. Normally, the nozzles located directly above or next to the fire source, as well as the nozzles around the outside perimeter of the fire base, will be opened. Those nozzles located directly over or near the fire source serve to control the fire by wetting the flames and fuel source, while the nozzles around the perimeter of the fire serve to pre-cool any surrounding combustible materials. These systems are normally used to protect accommodation spaces and service spaces.

1.3 Water Mist Systems

Water mist technology has been around for some time. However, only in recent years have appropriate design and testing criteria been developed by the International Maritime Organization (IMO) for water mist systems in marine applications, permitting their consideration as acceptable alternatives to the required water spray and sprinkler systems.

Water mist systems have pumping and distribution piping system arrangements similar to those found with water spray and water sprinkler systems. However, the critical difference between this type of system and either a water sprinkler or water spray system is in the size of the water droplets discharged from the nozzles. The water droplets associated with a water mist system are typically much finer than those discharged from either a water spray or water sprinkler nozzle. For some water mist systems generating the smaller droplet sizes, the extinguishing medium discharged is similar to a thick fog.

A number of different techniques are used to generate the smaller water mist droplets, including impingement, pressure jet and twin fluid methods. The impingement method typically involves directing the water onto a spiral or spinning device which breaks up the stream into small, well-distributed droplets. The pressure jet method involves the acceleration and dispersion of small water droplets through swirling chambers or high pressure discharges through very small orifices. The twin fluid method atomizes the water by injecting the water jet and an atomizing gas together in such a way as to shear the water droplets into smaller particles, creating a mist. Depending upon the particular manufacturer’s design, water mist system pressures can range from very low pressure, 3-5 bar (43-72 psi) to quite high pressures, 100-150 bar (1450-2175 psi).

The actual size of the water mist droplets created will vary depending upon the particular technique used and the degree of nozzle refinement developed by the individual manufacturer. It is important to note that the actual size of the water droplet will impact the degree to which the various extinguishing mechanisms discussed in the first paragraph of this Section will be actively involved. To explore this issue further, one must note that water spray and sprinkler systems discharge relatively “large” water droplets. Due to the weight and/or inertia of these “large” droplets, they “fall” into the flames. As these “large” droplets pass through the flame, a certain amount of the droplet will evaporate. The evaporation absorbs heat from the flame, which results in a cooling of the flame temperature. A certain amount of steam is also generated. However, due to the “large” size, often a significant portion of the droplet will pass through the flame intact and then contact the fuel surface. The cooling of the fuel surface by the water droplet plays a major role in the control or extinguishment of the fire by a water spray or water sprinkler system.

In contrast to water spray or water sprinkler droplets, water mist droplets are typically much smaller. The reduced size of the droplet can significantly impact the extinguishing mechanisms at work. First, the smaller water mist droplets have minimal weight and their flow paths are more strongly affected by the fire plume convection currents. As a result, the water mist droplets do not typically pass through the flame due to their own weight and momentum, and in fact, may actually have difficulty reaching the flame due to the plume convection currents. Typically, the water mist droplets are actually carried into the fire with the air currents feeding the fire. These air currents normally enter the flame at the lower levels of the plume and the water mist droplets are pulled directly into the combustion zone with the air. This process provides a good distribution of the mist droplets within the combustion zone of the fire so long as the droplets are well entrained in the air currents feeding the fire.

The second impact on the extinguishing mechanisms is that since the water droplets are much smaller, a much greater surface area per volume of water is presented to the fire. This facilitates greater heat absorption and a higher evaporation rate for a particular volume of water. That is, for the particular volume of water actually entering in the flame region, the smaller water mist droplets will typically absorb more heat than the typical water spray or water sprinkler droplets due to the increased amount of exposed surface area. This results in a greater degree of cooling for the flame per unit volume of water, and therefore, a greater reduction in the amount of heat radiated back to fuel surface. This increase in heat absorption also increases the amount of evaporation and produces greater steam generation, and as a result, the smothering action of the fire by steam is increased.

There are, however, certain negative impacts associated with the reduced size of the water mist droplets. For spray and water sprinkler systems, the cooling of the fuel surface, especially in the immediate vicinity of the base of the fire, can play a very important role in the control and extinguishment of a fire. However, since the water mist droplets are not as large as the typical water spray or water sprinkler droplets, fewer of the water mist droplets are able to pass through the flame and impact the fuel surface within the base of the fire while still intact. Also, the lack of weight or significant inertia of the water mist droplet makes it more difficult to ensure that water droplets will follow a predictable path. Therefore, more of a “total flooding” effect is needed for spaces being protected with water mist applications utilizing smaller size droplets.

Water mist systems have been proposed for use in machinery spaces, as well as in accommodation and service spaces. In order to address such proposals, IMO developed fire test criteria for establishing the equivalency of a particular water mist manufacturer’s system to the water spray addressed in FSS Code Chapter 7 and the water sprinkler systems addressed in FSS Code Chapter 8. IMO MSC/Circular 668, as amended by IMO Circular 728, provides the testing criteria applicable to establish equivalence for use in machinery spaces and cargo pump rooms, while IMO Resolution A800(19) provides the testing criteria applicable to establish equivalence to a water mist system for use in accommodations and service spaces.

2 ABS Requirements for Fixed Water Spray, Water Sprinkler, and Water Mist Systems

The following information is provided as general guidance on the ABS requirements for water spray, water sprinkler and water mist systems. However, reference should always be made to the Rules applicable to the specific vessel concerned for the complete set of requirements.

2.1 General System Component Requirements

2.1.1 Pumps

Pumps associated with water sprinkler, water spray or water mist systems are considered to be the same as fire pumps and are required to be ABS certified in accordance with SVR 4-6-1/7.3.

2.1.2 Sprinkler System Piping Components and Materials

System piping components are to comply with the general requirements and limitations in SVR Sections 4-6-1 through 4-6-3. In addition, depending upon the pressure “Class” (refer to SVR 4-6-1/Table 1) of the system, the components may also be required to be certified in accordance with SVR 4-6-1/Table 2. A submitted drawing should include a complete Bill of Materials that provides the material specifications, standards of construction, pressure ratings and types of all valves and fittings, as well as the material specification, sizes and wall thickness of the piping, in accordance with SVR 4-6-1/9.3. The drawing should also identify the maximum system pressure and provide adequate information to identify the layout and arrangement of the system(s).

In addition to common requirements and limitations in SVR Sections 4-6-1 through 4-6-3, the materials used in the system are not to be rendered ineffective by heat. In order to be considered not “readily rendered ineffective by heat”, a component is to be certified as having passed an acceptable recognized fire test, or the material is to have a melting temperature higher than the test temperature specified in an acceptable fire test.

Resiliently seated valves may also be considered for use in a water spray, water sprinkler or water mist system, provided that the proposed valves are capable of passing an appropriate fire test acceptable to the Bureau and can be effectively closed with the resilient seat damaged or destroyed, such that leakage through the closed valve is insignificant. However, rubber (cloth inserted) gaskets are frequently proposed but are also not permitted, as their destruction under the fire could lead to the loss of system pressure and integrity.

In addition, particular attention is to be exercised regarding the arrangements of sea suctions, pumps’ suction and discharge outlets for compliance with SVR 4-6-2/9.13 and the arrangements required at the fire-fighting station for fixed fire-extinguishing systems in the propulsion machinery space by SVR 4-9-4/21.3ix).

For Regulatory compliance, criteria stipulated by the Flag Administration must be satisfied and may differ from the criteria stated herein.

2.1.3 Nozzles

The nozzles are a very critical component of any fixed pressure water spray, water sprinkler or water mist system and their proper operation are crucial to the system’s ability to control and/or extinguish a fire. Accordingly, the performance of nozzles should be verified through testing by an appropriate laboratory, agency or other recognized entity (Administration, the Bureau, etc.) to a suitable standard or procedure which is specifically designed to establish and verify the ability of the nozzle design to consistently provide the discharge spray density, droplet size, coverage pattern, etc., as advertised by the manufacturer.

In addition to the above, SVR 4-1-1/Table 4 also requires all fixed fire-extinguishing system components, which would include spray, sprinkler or mist system nozzles, to be covered under the ABS Certification Program. Accordingly, such nozzles must also meet the requirements specified in the table for either an “Individual Unit Certification” or the “ABS Type Approval Program”, as described in SVR Appendix 1-1-A3.

2.2 Fixed Water Spray Systems in Machinery Spaces

SVR 4-7-2/1.1.1iii) and 4-7-2/1.3i) recognize pressurized water spray systems as acceptable fixed fire-extinguishing arrangements for use in machinery spaces. The requirements for fixed water spray systems in machinery spaces are found in SVR 4-7-3/7 and are discussed below.

2.2.1 Nozzles

SVR 4-7-3/7.1 requires any required fixed pressure water-spraying fire-extinguishing system in machinery spaces to be fitted with spraying nozzles of an approved type. As discussed above, the approval of the nozzle by an appropriate laboratory or agency is very important in documenting the nozzle's performance and suitability for the intended service. Documentation verifying such approvals should be available.

2.2.2 Coverage Rate

SVR 4-7-3/7.1.2 requires the number and arrangement of the water spray system nozzles to be sufficient to provide an effective average distribution of water of at least 5 L/min/m² (0.12 gpm/ft²) over the protected area. It also requires nozzles to be fitted above bilges, tank tops and other areas over which oil fuel is liable to spread, as well as other specific fire hazards in machinery spaces. In reviewing the arrangement of the nozzles for a particular application, the spray density, recommended spacing and coverage pattern identified by the manufacturer for a particular nozzle should be compared to the proposed layout and spacing. The review must verify that the design will provide the required spray coverage rate to all portions of the protected space, as well as verify nozzles are fitted above bilges, tank tops and other areas over which oil fuel is liable to spread, as well as other specific fire hazards in machinery spaces.

It should be noted that FSS Code Chapter 7 also makes mention of the possible need to require increased application rates where considered necessary by the Administration.

Related IMO MSC Circular 847 Interpretation***SOLAS II-2/10.2(FSS Code Chapter 7) Areas for increased application rates***

An indication of areas for which increased application rates may be required is given below:

<i>Protected Area</i>	<i>Application Rate</i>
<i>Boiler fronts or roof, firing areas, oil fuel units, centrifugal separators (not oily water separators), oil purifiers and clarifiers</i>	<i>20 l/min</i>
<i>Hot oil fuel pipes near exhausts or similar heated surfaces on main or auxiliary diesel engines</i>	<i>10 l/min</i>

In reviewing the nozzle layout and spacing, it is a very important to recognize that the spray density and distribution pattern for a particular nozzle are functions of the nozzle height, as well as the water pressure at the nozzle inlet. While the height of the nozzles should be identified in the drawing, pressure drop calculations are normally necessary to establish pressure at the most hydraulically remote nozzle section. While it may be possible to calculate the system pressure drops for a simple "tree" water spray system, more elaborate tree systems, as well as "grid" or "looped" distribution piping systems, are normally used for larger water spray systems and pressure drop calculations for these systems become very complicated. Accordingly, the submission of pressure drop calculations from the designer is often necessary for all but the simplest of designs.

Once received, the pressure drop calculations should be reviewed for the analytical approach used, the initial criteria and values (e.g., friction factors, flow rates, pipe sizes, etc.), overall completeness of the analysis and the results. With more complex systems, most analyses will be computer-based. Without the actual program, it is often very difficult to completely verify all portions of such calculations. Therefore additional information to substantiate the validity of the computer program is also frequently necessary.

2.2.3 Division into Sections

Water spray systems in machinery spaces can be quite large. Accordingly, SVR 4-7-3/7.1.3 allows the system to be divided into sections. The distribution valves controlling the various sections are required to be operated from easily accessible positions outside the spaces to be protected and in a location which is not be readily cut off by a fire in the protected space.

2.2.4 Supply and Control Arrangements

Quick and ready operation is vital for any fire-fighting system, and especially one which is intended to protect a space containing the volume of combustibles normally found in a machinery space. Accordingly, SVR 4-7-3/7.1.4 requires the water spray system to be kept charged at the necessary pressure, and the pump supplying the water for the system is to be put automatically into action by a pressure drop in the system.

There are several points to consider with the above requirement.

First, the system will have open type nozzles, and therefore, the pressurization of the system will only be up to the zone valves. Second, the type of system selected to maintain the continuous pressure in the sprinkler main is important. The continuous pressurization of the system is normally provided through either an accumulator system or by a pump. However, if a pump is used, it is important to verify that its design will be appropriate for this service. Main system pumps are usually designed for large capacities and are not suitable for this pressure maintenance duty, since continuous operation at shut-off head will damage the pump. However, smaller capacity “jockey” pumps which cycle on and off to maintain the pressure in the sprinkler main can be used for this type of service. The third item to note is that the valving arrangement, on both the supply and discharge sides of the main pump, must be arranged to ensure that the appropriate valves will be open when the sprinkler pump is automatically brought into action so that the system will operate properly.

2.2.5 System Capacity Requirements

SVR 4-7-3/7.1.5 requires that the water spray pump be capable of simultaneously supplying at the necessary pressure all sections of the system in any one compartment to be protected. Since the nozzles are of the open type, all nozzles of a particular branch or zone will be brought into action when that branch or zone valve is opened. When considering all branches or zones within a particular machinery space, the result can be a substantial demand on the pumping and distribution system capacity. System flow and pressure drop calculations, as discussed above, are necessary to verify that the pump and distribution system are in compliance with this requirement.

2.2.6 Arrangements

SVR 4-7-3/7.1.5 also requires that the pump and its controls are to be installed outside the space or spaces to be protected and that the arrangements are such that a fire in the space or spaces protected by the water spray system will not render the system inoperative. Accordingly, the arrangements for the pump location, the power supply to the pump and controls, access and ventilation arrangements, etc., for the water spray system must be examined to ensure compliance.

2.2.7 Pump Prime Movers

SVR 4-7-3/7.1.6 addresses requirements for the prime mover of the system pump and indicates that the pump may be driven by independent internal combustion machinery. However, if the prime mover for the pump is dependent upon power being supplied from the emergency generator, the generator is required to be arranged to start automatically in the case of main power failure. This is to ensure that the power for the pump is immediately available.

Further to the requirements outlined in SVR 4-7-3/7.1.5, the requirements in SVR 4-7-3/7.1.6 specify that if the pump is driven by independent internal combustion machinery, then the arrangements are to ensure that a fire in the protected space will not affect the air supply to the machinery.

2.2.8 Protection from Clogging

SVR 4-7-3/7.1.7 requires precautions be taken to prevent the nozzles from becoming clogged by impurities in the water or corrosion of piping, nozzles, valves and pump. This is normally accomplished through the use of galvanized piping, in-line strainers and flushing/drainage arrangements.

2.3 Fixed Water Sprinkler Systems in Accommodation Spaces

For all vessels utilizing Method “IIC” construction (refer to SVR 4-7-2/3.1 for definitions) SVR 4-7-2/3.3.2 requires an automatic sprinkler system to be fitted in the accommodations spaces, galleys and other service areas. In addition, 6/3.3.1 of the *ABS Guide for Building and Classing Passenger Vessels* requires that all accommodations and service spaces on passenger vessels to be fitted with an automatic sprinkler system unless such spaces are fitted with an approved fixed fire detection and fire alarm system. The system requirements for the automatic sprinkler systems installed in the above spaces are found in PVG 6/5.9 and SVR 4-7-3/9 and are in line with the requirements found in FSS Code Chapter 8. These system requirements are discussed below.

2.3.1 General

SVR 4-7-3/9.1.1 provides the basic sprinkler system requirements and indicates that any required automatic sprinkler system is to be capable of immediate operation at all times and that no action by the crew is to be necessary to set it in operation. This Subparagraph further specifies that the system is to be of the wet pipe type (i.e., permanently filled with water under pressure from the freshwater tank), is to be kept charged at the necessary pressure and is to have provision for a continuous supply of water.

SVR 4-7-3/9.1.1 does permit small exposed sections of the system to be of the dry pipe type (i.e., not permanently filled with water), where this is a necessary precaution. It also requires that any parts of the system which may be subjected to freezing temperatures in service are to be suitably protected against freezing. Saunas should be fitted with a dry pipe sprinkler system. The operating temperature may be up to 140°C (284°F).

2.3.2 Visual and Audible Alarms

SVR 4-7-3/9.1.2 requires each section of sprinklers to include means for giving a visual and audible alarm signal automatically at one or more indicating units whenever any sprinkler comes into operation. The alarm systems are to also be capable of indicating if any fault occurs in the system. Such units are to indicate in which section served by the system a fire has occurred and are to be centralized on the navigation bridge. In addition, visible and audible alarms from the unit are to be located in a position other than on the navigation bridge, so as to ensure that the indication of fire is immediately received by the crew.

2.3.3 Zone Arrangements

SVR 4-7-3/9.3.1 requires sprinklers to be grouped into separate sections, each of which is to contain not more than 200 sprinklers. In this way, damage to piping within a particular zone or maloperation of a particular zone valve will not disable the entire sprinkler system. FSS Code Chapter 8 goes on to require that in passenger vessels, any section of sprinklers is not to serve more than two decks and is not to be situated in more than one main vertical zone, unless special acceptance is granted by the Administration.

2.3.4 Section Isolation Valves

SVR 4-7-3/9.3.2 provides requirements for section isolating valves and requires each section of sprinklers to be capable of being isolated by one stop valve only. The stop valve in each section is to be readily accessible and its location is to be clearly and permanently indicated. Means are to be provided to prevent the operation of the stop valves by any unauthorized person.

2.3.5 Pressure Gauges

SVR 4-7-3/9.3.3 requires that a pressure gauge, capable of indicating the pressure in the system, be provided at each section stop valve and at a central station. This allows the crew to verify that the system is pressurized and ready for operation.

2.3.6 Zone Arrangement Plan

To assist the crew in identifying the location of a fire quickly, SVR 4-7-3/9.3.4 requires a list or plan to be displayed at each indicating unit showing the spaces covered and the location of the zone in respect of each section. Suitable instructions for testing and maintenance are also required to be available.

2.3.7 Nozzles

In addition to the requirements for nozzles discussed in 5/2.1 of these Guidance Notes, SVR 4-7-3/9.5 specifically indicates that the sprinkler nozzles are to be resistant to corrosion by the marine atmosphere. Approval by an appropriate laboratory or agency for use in marine applications would be sufficient to verify compliance with this requirement.

Within accommodation and service spaces, SVR 4-7-3/9.5 requires that the sprinklers come into operation within the temperature range from 68°C (154°F) to 79°C (174°F). The one stated exception to this requirement is in locations such as drying rooms, where high ambient temperatures might be expected. For these applications, the operating temperature may be increased by not more than 30°C (86°F) above the maximum deckhead temperature.

The design, selection and proper operation of the sprinkler nozzles are critical to the effectiveness with which an automatic sprinkler system can control or extinguish a fire. The sprinkler nozzles must be located and installed in accordance with the manufacturer's recommendations. Certain nozzles are designed to be located near a side wall, while others are designed for a full pattern. In addition, there are upright, as well as pendent, sprinkler nozzles. As discussed in 5/2.2.2 of these Guidance Notes, the coverage pattern is influenced by the actual nozzle height and the pressure at the nozzle. Accordingly, such details and information must be considered when reviewing the placement of the nozzles.

2.3.8 Coverage Rate

SVR 4-7-3/9.5 requires sprinklers to be placed in an overhead position and spaced in a suitable pattern to maintain an average application rate of not less than 5 L/min/m² (0.12 gpm/ft²) over the nominal area (i.e., gross, horizontal projection of the area to be covered) covered by the sprinklers. However, the use of sprinklers providing an alternative amount of water suitably distributed so as to be not less effective may be considered.

Related IMO MSC Circular 847 Interpretation

SOLAS II-2/12.3, (FSS Code Chapter 8.2.5.2.3) "Definition of nominal area"

Nominal area is defined as being the gross, horizontal projection of the area to be covered.

2.3.9 Automatic Operation

The system must be capable of automatic operation in the event of a fire. In order to ensure that an adequate quantity of water at the necessary pressure is available at all times, SVR 4-7-3/9.7.1 requires the system to be fitted with a fresh water pressure tank. The tank is to contain a standing charge of fresh water, equivalent to the amount of water which would be discharged in one minute by the pump referred to in SVR 4-7-3/9.9.2, and the arrangements are to provide for maintaining an air pressure in the tank such as to ensure that when the standing charge of fresh water in the tank has been used, the pressure will be not less than the working pressure of the sprinkler, plus the pressure exerted by a head of water measured from the bottom of the tank to the highest sprinkler in the system. To accommodate the volume of air necessary to maintain the pressure throughout the one (1) minute discharge, the tank is required to have an actual volume equal to at least twice that of the charge of water specified above. In addition, suitable means of replenishing the air under pressure and of replenishing the fresh water charge in the tank are to be provided. Also, a glass gauge is required to be provided to indicate the correct level of the water in the tank.

2.3.10 Accumulator

The accumulator mentioned above is to be considered as a pressure vessel and it is to comply with the applicable requirements identified in SVR Section 4-4-1. These requirements will vary depending upon the maximum pressure involved. During the review of the system, the applicable requirements from SVR Section 4-4-1 should be identified and the submitter advised accordingly, unless ABS certification is already indicated on one of the drawing notes.

In order to prevent corrosion and the possibility of excessive sedimentation, SVR 4-7-3/9.7.2 requires that a means be provided to prevent the passage of seawater into the tank.

2.3.11 Sprinkler Pump

2.3.11(a) Automatic Operation. SVR 4-7-3/9.9.1 requires that an independent power pump be provided solely for the purpose of continuing the automatic discharge of water from the sprinklers. The pump is to be brought into action automatically by the pressure drop in the system before the standing fresh water charge in the pressure tank is completely exhausted. The system's control arrangement should be reviewed to verify compliance with this requirement.

2.3.11(b) Pump Performance. In accordance with SVR 4-7-3/9.9.2, the pump and the piping system are to be capable of maintaining the necessary pressure at the level of the highest sprinkler to ensure a continuous output of water sufficient for the simultaneous coverage of a minimum area of 280 m² (3050 ft²) at the application rate specified in SVR 4-7-3/9.5. The ability of the pump and the piping system to support this flow rate at the most remote section must be verified through a review of the pump curves and appropriate pressure drop calculations, as discussed in 5/2.2.1 of these Guidance Notes.

2.3.11(c) Pump Testing Arrangements. In accordance with SVR 4-7-3/9.9.3, a test valve with a short open-ended discharge pipe is to be fitted on the delivery side of the pump. The effective area through the valve and pipe is required to be adequate to permit the release of the required pump output while maintaining the pressure in the system specified in SVR 4-7-3/9.7.1.

2.3.11(d) Sea Inlet. As required by SVR 4-7-3/9.9.4, the sea inlet to the pump is to be in the space containing the pump wherever possible. In addition, the arrangement is to ensure that when the vessel is afloat it will not be necessary to shut off the supply of sea water to the pump for any purpose other than the inspection or repair of the pump.

2.3.11(e) Location. In order to protect the integrity of the sprinkler system, SVR 4-7-3/9.11 requires that the sprinkler pump and tank be located in a position reasonably remote from any machinery space of category A, since category A machinery spaces are high fire risk areas. It further requires that the sprinkler pump and tank are not to be located in any space that is required to be protected by the sprinkler system.

2.3.11(f) Source of Power. In accordance with SVR 4-7-3/9.13, there is to be not less than two sources of power supply for the seawater sprinkler pump. If the pump is electrically-driven, it is required to be connected to the main source of electrical power, which is to be capable of being supplied by at least two generators. Furthermore, for passenger vessels, an electric motor powering the sprinkler pump is to also be supplied with a feeder from the emergency switchboard as indicated in PVG 6/5.9.13. The feeders are to be arranged so as to avoid galleys, machinery spaces and other enclosed spaces of high fire risk, except insofar as it is necessary to reach the appropriate switchboards.

Where one of the sources of power for the pump is an internal combustion engine, in addition to complying with the provisions of SVR 4-7-3/9.11, the source is to be so situated that a fire in any protected space will not affect the air supply to the machinery.

2.3.12 Back-up Supply of Water

In order to provide a back up source of water, SVR 4-7-3/9.15 requires that the sprinkler system must have a connection from the vessel's fire main by way of a lockable screw-down non-return valve which will prevent a backflow from the sprinkler system to the fire main. While the interconnection for a backup source of water is required, this does not necessarily require the fire main pumps to be sized to supply the sprinkler system or the fire main and sprinkler system simultaneously.

2.3.13 System Testing Arrangements

Testing of the system is very important in ensuring that the sprinkler system will operate properly when needed. Accordingly, SVR 4-7-3/9.17.1 requires a test valve to be provided for testing the automatic alarm for each section of sprinklers by a discharge of water equivalent to the operation of one sprinkler. The test valve is required to be situated near the stop valve for that section.

In addition, a means for testing that the pump will operate automatically upon reduction of pressure in the system is to be provided in accordance with SVR 4-7-3/9.17.2. Switches are also required by SVR 4-7-3/9.17.3 to be provided at one of the indicating positions referred to in SVR 4-7-3/9.1.2 which will enable the alarm and the indicators for each section of sprinklers to be tested.

2.3.14 Spares

As previously discussed, the sprinkler nozzles are of the "closed" type and each individual nozzle is fitted with its own heat sensitive link or bulb which allows the nozzle to open when exposed to excessive heat. Accordingly, if one sprinkler head activation link or bulb breaks or otherwise allows the sprinkler head to open inadvertently, the entire zone must be shut down until the sprinkler head is replaced. Thus, it is very important to carry an adequate number of spare sprinkler heads onboard so that a defective head can be replaced and the particular sprinkler zone re-pressurized as soon as possible. It is also important to recognize that different locations are fitted with different types of heads or activation temperatures. SVR 4-7-3/9.19 requires that spare sprinkler heads are to be provided for each section of sprinklers. Spare sprinkler heads should include all types and ratings installed in the vessel, and should be provided as follows:

< 300 sprinkler heads	6 spare sprinkler heads
300 to 1000 sprinkler heads	12 spare sprinkler heads
> 1000 sprinkler heads	24 spare sprinkler heads

The number of spare sprinkler heads of any type need not exceed the number of heads installed of that type.

2.4 Fixed Water Spray Systems in Ro-Ro Spaces

The protection of ro-ro (roll-on/roll-off) spaces presents a unique challenge. There are frequently low flash point fuels (e.g., gasoline, etc.) in vehicle fuel tanks, large quantities of category “A” type combustibles and the possibility of passengers in the area on ferry type passenger vessels. However, to better understand the challenges, the differing requirements and where fixed water spray systems come into use, it is important to have an understanding of several important definitions. They are provided as follows:

2.4.1 Definitions

- *Ro-Ro Cargo Spaces* (Refer to SVR 5-10-1/3.5). Spaces not normally subdivided in any way and extending to either a substantial length or the entire length of the vessel, in which goods [packaged or in bulk, in or on road cars, vehicles (including road tankers), trailer containers, pallets, demountable tanks or in or on similar stowage units or other receptacles] can be loaded and unloaded normally in a horizontal direction.
- *Open Ro-Ro Cargo Spaces* (See SVR 5-10-1/3.7). Ro-Ro Cargo Spaces open at both ends or open at one end and provided with adequate natural ventilation effective over the entire length through permanent openings in the side plating or deck head to the satisfaction of the Administration.
- *Closed Ro-Ro Cargo Spaces* (See SVR 5-10-1/3.9). Ro-Ro Cargo Spaces which are neither Open Ro-Ro Cargo Spaces nor weather decks.
- *Vehicle Passenger Ferry* (See SVR 5-10-1/3.3). A vessel designed and fitted for the carriage of vehicles and more than twelve (12) passengers.
- *Special Category Spaces* (See SVR 5-10-1/3.13). Special Category Spaces are those enclosed spaces above or below the bulkhead deck intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion, into and from which such vehicles can be driven and to which passengers have access.

2.4.2 Ro-Ro Spaces on Cargo Vessels

The fire-extinguishing arrangements for a typical ro-ro space on a cargo (non-passenger) vessel are addressed in SVR 5-10-4/3. This Subsection requires ro-ro spaces which are capable of being sealed (i.e., closed ro-ro space) to be fitted with either a fixed gas fire-extinguishing system [SVR 5-10-4/3.3.1(a)] or a fixed pressure water spray system [SVR 5-10-4/3.3.1(b)]. However, for ro-ro spaces on such vessels that are not capable of being sealed (i.e., open ro-ro space), a fixed gas system would be totally ineffective since the concentration of gas could not be maintained, and therefore, a fixed pressure water spray system is required [SVR 5-10-4/3.3.1(b)]. For the requirements of the fixed pressure water spray system, SVR 5-10-4/3.3.1(b) refers to SVR 4-7-3/7 and IMO Resolution A.123(V) *Recommendation on Fixed Fire-Extinguishing Systems for Special Category Spaces*.

2.4.3 Ro-Ro Spaces on Passenger Vessels

As noted above, ferries present the additional concern of possibly having passengers in the ro-ro space when activation of the fire-extinguishing system is needed. Therefore, SOLAS and the Rules differentiate between those ro-ro spaces where passengers may have access and those which passengers will not have access. As defined above, those ro-ro spaces to which passengers may have access are called “Special Category Spaces”, and 5-10-4/3.3.2 requires that all such spaces be fitted with a pressure water spray system complying with SOLAS 2000 II-2/20.6.1.2, which refers to IMO Resolution A.123(V).

For those ro-ro spaces on passenger vessels which are not accessible by passengers, SOLAS 2000 II-2/20.6.1.1 permits the use of fixed fire-extinguishing systems similar to those permitted in cargo vessel ro-ro, e.g., fixed gas or fixed water spray systems.

As indicated above, fixed pressure water spray systems installed in ro-ro spaces are to comply with SVR 4-7-3/7 and IMO Resolution A.123(V) *Recommendation on Fixed Fire-Extinguishing Systems for Special Category Spaces*. Although the requirements of SVR 4-7-3/7 are discussed above, certain requirements are modified by the IMO Resolution. Accordingly, for the sake of clarity, the combined set of requirements is discussed below.

2.4.3(a) Nozzles. The water spray nozzles are to be of an approved type, in accordance with SVR 4-7-2/7.1, and ABS certified as per SVR 4-1-1/Table 4. In addition, paragraph (a) of IMO Res. A.123(V) requires the nozzles to be of the “full bore” type. Details of the nozzle to be used, as well as documentation verifying the appropriate approvals, should be verified.

2.4.3(b) Coverage Rate. Paragraph (a) of IMO Res. A.123(V) requires the nozzles to be arranged so as to secure an effective distribution of water in the spaces which are to be protected. For this purpose, paragraph (a) requires the system to be capable of providing water application at a rate of at least 3.5 L/min/m² (0.084 gpm/ft²) for spaces with a deck height not exceeding 2.5 meters (8.2) feet and a capacity of at least 5 L/min/m² (0.12 gpm/ft²) for spaces with a deck height of 2.5 meters (8.2 feet) or more.

In reviewing the arrangement of the nozzles for a particular application, the spray density, recommended spacing and coverage pattern identified by the manufacturer for a particular nozzle should be compared to the proposed layout and spacing. The review must verify that the design will provide the required spray coverage rate to all portions of the protected space.

As previously discussed, the spray density and distribution pattern for a particular nozzle are functions of the nozzle design, height and the water pressure at the nozzle inlet. Paragraph (b) of IMO Res. A.123(V) requires that the water pressure should be sufficient to secure an even distribution of water, and pressure drop calculations are normally necessary to ensure that adequate pressure will be available at the most hydraulically-remote nozzles to provide the proper spray pattern and coverage rate. Refer to 5/2.2.2 of these Guidance Notes concerning the review of pressure drop calculations.

2.4.3(c) Coverage Zones. Water spray systems in ro-ro spaces can be quite large. Accordingly, Paragraph (c) of IMO Res. A.123(V) allows the system to be divided into sections. This paragraph requires that the system should normally cover the full breadth of the vehicle deck and may be divided into sections (provided that they are of at least 20 meters (66 feet) in length), except that in vessels where the vehicle deck space is subdivided with longitudinal “A” Class divisions forming boundaries of staircases, etc., the breadth of the sections may be reduced accordingly. Compliance of the system arrangements with the above requirements is to be verified during the plan review.

2.4.3(d) Control Valves. Paragraph (d) of IMO Res. A.123(V) requires the distribution valves for the system to be situated in an easily accessible position adjacent to, but outside of, the space to be protected, which will not readily be cut off by a fire within the space. Paragraph (d) also requires that direct access to the distribution valves from the vehicle deck space and from outside that space should be provided and that adequate ventilation should be fitted in the space containing the distribution valves.

2.4.3(e) Pump(s). Paragraph (f) of IMO Res. A.123(V) requires that the water spray pump or pumps be capable of simultaneously supplying at the required pressure all nozzles in any one vehicle deck or at least two sections thereof. Calculations are necessary to verify that the pump and distribution system are in compliance with this requirement.

2.4.3(f) Pressurization of System. SVR 4-7-3/7.1.4 requires the water spray system to be kept charged at the necessary pressure and the pump supplying the water for the system to be put automatically into action by a pressure drop in the system. However, paragraph (g) of IMO Res. A.123(V) provides an alternative which allows for the principal pump or pumps to be capable of being brought into operation by remote control (which may be manually actuated) from the position at which the distribution valves are situated.

2.4.3(g) Back-up Water Supply. Paragraph (e) of IMO Res. A.123(V) indicates that the water supply to the system is to be provided by a pump or pumps other than the vessel's required fire pumps. However, it does require that there is to be an interconnection between the fire pumps and the spray system which is fitted with a lockable non-return valve that will prevent a back-flow from the system into the fire main. This interconnection should be verified on both the fire main and sprinkler system drawings.

2.4.3(h) Component Locations. SVR 4-7-3/7.1.5 also requires that the sprinkler pump(s) and associated controls are to be installed outside the space or spaces to be protected and that the arrangements are such that a fire in the space or spaces protected by the water-spraying system will not put the system out of action. Accordingly, the arrangements for the pump location, the power supply to the pump and controls, access and ventilation arrangements, etc., for the water spray system must be examined to ensure compliance.

2.4.3(i) Prime Mover Arrangements. SVR 4-7-3/7.1.6 addresses requirements for the prime mover of the system pump and indicates that the pump may be driven by independent internal combustion machinery. However, if the prime mover for the pump is dependent upon power being supplied from the emergency generator, the generator is required to be arranged so as to start automatically in the case of main power failure. This is to ensure that the power for the pump is immediately available.

Further to the requirements outlined in SVR 4-7-3/7.1.5, SVR 4-7-3/7.1.6 specifies that if the pump is driven by independent internal combustion machinery, the arrangements are to ensure that a fire in the protected space will not affect the air supply to the machinery.

2.4.3(j) Protection of Clogging. SVR 4-7-3/7.1.7 requires precautions be taken to prevent the nozzles from becoming clogged by impurities in the water or corrosion of piping, nozzles, valves and pump. This is normally accomplished through the use of galvanized piping, in-line strainers and flushing/drainage arrangements.

2.4.3(k) Stability Impacts. One important issue regarding water spray systems is the recognition that these types of systems can discharge large quantities of water into protected spaces in a relatively short period of time. This additional weight can seriously affect the stability of the vessel, especially if large quantities of water are introduced at higher levels in the vessel. The weight of the water raises the center of gravity of the vessel and the free surface effects can detrimentally affect the stability of the vessel, especially in large open areas, such as ro-ro decks, where the potential for large free surface effect exists. Accordingly, SVR 5-10-4/3.3.1(b) and SOLAS 2000 Reg. II-2/20.6.1.4 require that drainage and pumping arrangements are to be such as to prevent the build-up of free surfaces. If this is not possible, the adverse effect upon the stability of the added weight and free surface of water is to be taken into account in the approval of the stability information. This is an issue that must be addressed early on so that potential problems with drainage or stability are avoided.

2.5 Fixed Water Mist Systems in Machinery Spaces and Cargo Pump Rooms

With the prohibition of Halon-based extinguishing systems and the hazards associated with CO₂ systems, as well as water spray systems, in machinery spaces and cargo pump rooms, IMO recognized the need for consideration of alternative fire-extinguishing systems. For this reason, IMO developed MSC Circulars 668 and 728, which provide guidelines for the approval of alternative water-based fire-extinguishing systems as equivalent to the water spray systems referred to in FSS Chapter 7. It is through compliance with the design and testing requirements specified in IMO MSC Circulars 668 and 728 that manufacturers of water mist systems can establish that their system provides an equivalent level of safety, and therefore, an acceptable alternative to the water spray system discussed in FSS Chapter 7.

Paragraph 1 of the Annex to MSC/Circular 668 provides a general explanation of the purpose for the Circular. Paragraphs 2 through 8 of the Annex to MSC/Circular 668 provide a number of definitions associated with water-based fire-extinguishing system, and paragraphs 9 through 25 of the Annex to MSC/Circular 668 identify the general requirements for water mist systems. Appendix “A” to MSC/Circular 668 identifies the design and testing requirements applicable to water mist nozzles and Appendix “B” to MSC/Circular 668 identifies the fire tests which must be successfully completed for a manufacturer to qualify his system. A copy of MSC Circulars 668 and 728 should be available for any review involving a fixed water mist system to be installed in machinery space and cargo pump room.

The following provides a discussion regarding the requirements applicable to water mist systems being installed in machinery spaces and cargo pump rooms based upon the requirements of IMO MSC Circulars 668 and 728.

2.5.1 General

Water mist systems are specialized systems, and the characteristics of the systems (e.g., required minimum pressure, droplet size and velocity, minimum required discharge flow rate, etc.) will most likely vary substantially from manufacturer to manufacturer. As outlined in the general discussion above, there are a number of different approaches used to generate water mist. Some manufacturers use high pressure systems, while others low pressure; some use mechanical impingement, while others use jet discharge or atomization, etc. The design of the various systems’ nozzles differs dramatically depending upon the approach and they are specially designed to maximize the manufacturer’s particular method of mist generation. Accordingly, the nozzles are particularly critical to the proper operation and effectiveness of a water mist system.

2.5.2 Water Mist Nozzle and System Testing/Approval

Recognizing the critical role that the nozzles play, Appendix “A” of MSC/Circular 668 provides substantial design and testing requirements specifically for the water mist nozzles. The design criteria addresses numerous items regarding the nozzle, including body strength, threading, flow constant value calculations, etc., as well as specific tests, such as oven plunge, heat exposure, thermal shock, corrosion, impact and clogging tests, etc.

In addition to the nozzle design and testing requirements specified in Appendix “A”, Appendix “B” identifies a series of fire tests that are required to qualify the nozzle in particular, and the system in general, for suitability to extinguish a machinery space or cargo pump room fire. However, it is very important to note that the number and type of fire tests, as well as the test room sizes, differ depending upon the size of the engine room for which the water mist system is seeking approval. “Class 1” engine rooms are considered to be those with a net volume up to 500 m³, “Class 2” engine rooms are those with a net volume above 500 m³ but less than 3000 m³ and “Class 3” engine rooms are those with a net volume greater than 3000 m³. For a particular water mist system to be considered for installation in a machinery space of an ABS-classed vessel, the system must have passed the required fire tests for that particular “Class” or size of engine room.

As previously discussed, fixed fire-extinguishing system components are required to be ABS certified in accordance with SVR 4-1-1/Table 4. The review of the manufacturer's testing documentation for compliance with Appendices "A" and "B" is a very tedious and time consuming job. However, with the certification program, there should only be the need to perform this review once for a particular manufacturer's system and nozzle. The results of the review and details pertaining to the system's design and installation criteria should be recorded on the ABS certification report so that future reviewers will not have to repeat the job of reviewing the individual test results, etc. The certification report should only be issued after verifying compliance with all design and testing requirements specified in Appendices "A" and "B" of IMO MSC/Circular 668. The report should clearly indicate complete details regarding the basis of the system's approval, including any details which could possibly affect the system's performance. As a minimum, these details should include:

- i) The system's design parameters (e.g., Size/Class of machinery space for which it is approved, maximum enclosure height, models of nozzles, minimum nozzle pressures, nozzle flow rates particle size distribution, pumps and control valves used for the test, maximum ventilation condition, etc.);
- ii) Installation criteria used during the testing (e.g., nozzle spacing, minimum and maximum heights, required stand off distances, etc.); and
- iii) Any other special issues or requirements which could potentially affect the satisfactory performance of future installations.

The recording of this information is critical since compliance with such details must be verified during the review of a specific water mist system installation. The certification report should also list the various system drawings, schematics and other documentation used for the approval (complete with reference numbers, dates, etc.) so that it can be determined if future submittals are utilizing the same system design.

Further discussions regarding the detailed testing and approval procedures of the individual manufacturer's system and nozzles in Appendices "A" and "B" are beyond the scope of these Guidance Notes. However, it is important for the Engineer conducting the individual system review for a particular installation to understand that there are substantial design and testing requirements applicable to the water mist system and nozzles. The manufacturer's system must pass a series of fire tests applicable to the particular size machinery space simply to qualify for consideration, as specified in paragraph 10 of MSC/Circular 668. Further, the review of a particular system installation must verify compliance with all of the information/criteria included on the ABS issued certification report.

2.5.3 Release Arrangements

In accordance with paragraph 9 of MSC/Circular 668, the system is to be capable of manual release. In addition, paragraph 20 of MSC/Circular 668 requires that the system's operational controls are to be available at easily accessible positions outside the spaces to be protected and are not to be liable to be cut off by a fire in the protected space(s). Verification of compliance with the above should either be verified during plan review or a comment noted requesting the Surveyor to verify the arrangements.

2.5.4 Availability

The system is to be available for immediate use and capable of continuously supplying water for at least 30 minutes in order to prevent re-ignition or fire spread within that period of time. Systems which operate at a reduced discharge rate after the initial extinguishing period are to have a second full fire-extinguishing capability available within a five (5) minute period of initial activation.

2.5.5 Pressure Tank/Accumulator

In accordance with paragraph 11 of MSC Circular 688, the system is to also be provided with a pressure tank which meets the functional requirements stipulated in FSS Code Chapter 8.2.3.2. The minimum water capacity for the pressure tank is to be based upon the design criteria specified in paragraph 19 of MSC/Circular 668 plus the filling capacity of the piping. Accordingly, the system is to be provided with a charged accumulator capable for supplying the system serving the space demanding the greatest volume of water for a period of at least one minute at the required pressure.

2.5.6 Immediate and Continuous Supply

There are also several other points to consider with the requirements in paragraph 11. First, for the water mist system to be "...available for immediate use and capable of continuously supplying water...", the system must be kept charged at the necessary pressure and the pump supplying the water for the system must be arranged to come into action automatically by a drop of the pressure in the system. Second, the valving arrangement, on both the supply and discharge sides of the main pump must be arranged to ensure that the appropriate valves will be open when the sprinkler pump is automatically brought into action. Third, the accumulator is to be considered as a pressure vessel and must comply with SVR Section 4-4-1.

2.5.7 Design/Suitability of Components

Paragraph 12 of MSC/Circular 668 requires that the system and its components are to be suitably designed to withstand ambient temperature changes, vibration, humidity, shock, impact, clogging and corrosion normally encountered in machinery spaces or cargo pump rooms in vessels. Further, components within the protected spaces should be designed to withstand the elevated temperatures which could occur during a fire. Verification of compliance with these requirements should be verified by a review of the standards and approvals issued for the components during the review of the Bill of Materials.

Paragraph 13 of MSC/Circular 668 requires that the system and its components "...be designed and installed in accordance with international standards acceptable to the Organization and manufactured and tested to the satisfaction of the Administration in accordance with the appropriate elements of Appendices A and B". In this regard, a footnote is also provided which indicates the "Pending the development of international standards acceptable to the Organization, national standards as prescribed by the Administration should be applied."

As one reviews the design and testing requirements identified in MSC Circular 668 as amended by MSC/Circular 728, it becomes obvious that the requirements are focused on the nozzle as well as some overall system requirements. However, there are many areas of a water mist system which are not adequately addressed in the Circular. To address such concerns, the writers of Circular simply make reference to "international standards acceptable to the Organization". However, at this time no particular "international standards acceptable to the Organization" exist, and therefore, the footnote allows consideration of appropriate national standards. While other appropriate national standards may exist, the one national standard which is frequently used is NFPA 750, *Standard on Water Mist Fire Protection Systems*.

Accordingly, based upon the above-mentioned reference, the Engineer conducting the review should understand that in addition to compliance with the design and testing requirements specified in Appendices "A" and "B" of MSC/Circular 668, as amended by MSC Circular 728, the system, as well as its components, must also comply with the design and installation requirements specified in an appropriate national or international standard, such as NFPA 750. The review should verify compliance with all aspects of the same.

2.5.8 Nozzle Placement

In accordance with paragraph 14 of MSC/Circular 668, the nozzle location, type of nozzle and nozzle characteristics are to be within the limits tested during the Appendix “B” fire tests. This is part of the information which should be taken from the ABS certification report and compliance verified during plan review.

2.5.9 Electrical Arrangements

The next paragraph in MSC/Circular 668 concerns electrical equipment and arrangements. The electrical components of the pressure source for the system are required to have a minimum rating of IP 54. In addition, the system is to be supplied by both the main and emergency sources of power and should be provided with an automatic changeover switch. The emergency power supply should be provided from outside the protected machinery space.

2.5.10 Secondary Water Supply

The system is to be provided with a redundant means of pumping or otherwise supplying the water-based extinguishing medium. The system is to be fitted with a permanent sea inlet and is to be capable of continuous operation using sea water in accordance with paragraph 16 of MSC/Circular 668.

2.5.11 System Calculations

Paragraph 17 of MSC/Circular 668 requires that the system is to be sized in accordance with a hydraulic calculation technique. Accordingly, the distribution system must be properly analyzed to ensure that the required flow rates at the most hydraulically demanding system will be provided. System flow and pressure drop calculations are to be requested and reviewed (see above for a general discussion regarding this subject).

In accordance with paragraph 18 of MSC/Circular 668, systems capable of supplying water at the full discharge rate for 30 minutes may be grouped into separate sections within a protected space. However the sectioning of a system with such spaces must be specifically approved. In addition, paragraph 19 of MSC/Circular 668 indicates that regardless of the sectioning arrangements, the capacity and design of a system is to be based upon the complete protection of the space demanding the greatest volume of water. Accordingly, even if sectioning of the system within a particular space is permitted, the system still needs to be capable of supplying all nozzles within that space are the required pressure.

As indicated above, paragraph 19 of MSC/Circular 668 requires that the capacity and design of a system is to be based upon the complete protection of the space demanding the greatest volume of water. Accordingly, the calculations should evaluate the most hydraulically demanding space, as well as the space demanding the greatest volume of water.

2.5.12 System Component Locations

In accordance with paragraph 21 of MSC/Circular 668, the pressure source components (e.g., pump, controls, etc.) are to be located outside of the protected space. Accordingly, the arrangements for the pump and accumulator location, the power supply to the pump and controls, access and ventilation arrangements, etc., for the water mist system must be examined to ensure compliance.

2.5.13 Testing Arrangements

A means for testing the operation and flow of the system to assure the required pressure and flow is to be provided in accordance with paragraph 22 of MSC/Circular 668.

2.5.14 Audible and Visual Alarms

Activation of any water distribution valve is to give a visual and audible alarm in the protected space and at a continuously manned central control station. An alarm in the central control station is to indicate the specific valve activated paragraph 23 of MSC/Circular 668.

2.5.15 Operating Instructions

Operating instructions for the system are to be displayed at each operating position. The operating instructions are required to be in the official language of the flag State, and if the language is neither English nor French, a translation into one of these languages is to be included as per paragraph 24 of MSC/Circular 668.

2.5.16 Spares

Spare parts and operating and maintenance instructions for the system are to be provided as recommended by the manufacturer, in accordance with paragraph 25 of MSC/Circular 668.

2.6 Fixed Water Mist Systems in Accommodation and Service Spaces

Similar to the discussions in 5/2.5 of these Guidance Notes, IMO developed Resolution A.800(19), which provides guidelines for the approval of alternative water-based fire-extinguishing systems as equivalent to the water sprinkler systems complying with FSS Code Chapter 8. It is through compliance with the design and testing requirements specified in IMO Resolution A.800(19) that water mist systems may be considered as fire protection systems which can provide an equivalent level of safety and therefore an equivalent system to the water sprinkler systems discussed in FSS Code Chapter 8.

2.6.1 General

Water mist systems are specialized systems. The characteristics of these systems (e.g., required minimum pressure, droplet size and velocity, minimum required discharge flow rate, etc.) can vary substantially from manufacturer to manufacturer and there are numbers of different approaches used to generate water mist. The nozzles are particularly critical to the proper operation and effectiveness of a water mist system.

2.6.2 Water Mist Nozzle and System Testing/Approval

Similar to the water mist component and system requirements discussed above for machinery spaces, Appendix “1” of IMO Resolution A.800(19) provides substantial design and testing requirements specifically for the water mist nozzles. In addition, Appendix “2” identifies a series of fire tests that are required to qualify the nozzle, in particular, and the system in general, for suitability to extinguish a number of different types of fires involving accommodation and service spaces.

As previously discussed, fixed fire-extinguishing system components are required to be ABS certified in accordance with SVR 4-1-1/Table 4 and procedures similar to those discussed in 5/2.5.1 above should be followed for the certification of a water mist system and its components for use in accommodations and service spaces. The certification report should only be issued after verifying compliance with all design and testing requirements specified in appendixes “1” and “2” of IMO Resolution A.800(19). The report should clearly indicate complete details regarding the basis of the system’s approval including any details which could possibly affect the system’s performance.

As a minimum, these details should include:

- i) The system’s design parameters (e.g., Size/Class of machinery space for which it is approved, maximum enclosure height, models of nozzles, minimum nozzle pressures, nozzle flow rates particle size distribution, pumps and control valves used for the test, maximum ventilation condition, etc.);

- ii) Installation criteria used during the testing (e.g., nozzle spacing, minimum and maximum heights, required stand-off distances, etc.); and
- iii) Any other special issues or requirements which could potentially affect the satisfactory performance of future installations. The recording of this information is critical since compliance with such details must be verified during the review of a specific water mist system installation. The certification report should also list the various system drawings, schematics and other documentation used for the approval (complete with reference numbers, dates, etc.) so that it can be determined if future submittals are utilizing the same system design.

Further discussions regarding the detailed testing and approval procedures of the individual manufacturer's system and nozzles in Appendices "1" and "2" are beyond the scope of these Guidance Notes. However, it is important for the Engineer conducting the individual system review for a particular installation to understand that there are substantial design and testing requirements applicable to the water mist system and nozzles. The manufacturer's system must pass a series of fire tests applicable to the particular size machinery space simply to qualify for consideration as specified in paragraph 3.2 of IMO Resolution A.800(19). Review of a particular system installation must verify compliance with the information/criteria included on the ABS issued certification report.

2.6.3 Automatic Operation

The system is to operate automatically, with no human action necessary to set it into operation, in accordance with paragraph 3.1 of IMO Resolution A.800(19). Further, the system is required to be capable of both detecting the fire and acting to control or suppress the fire, in accordance with paragraph 3.2 of IMO Resolution A.800(19). The detection and automatic operation is normally accomplished by the use of nozzles with heat sensitive bulbs or links designed to allow the nozzles to open when the temperature in the vicinity of the nozzle reaches a certain activation temperature.

The system is required to be capable of continuously supplying the extinguishing medium for a minimum of 30 minutes and a pressure tank is to be provided to meet the functional requirements specified in FSS Code Chapter 8/2.3.2.1. Based upon the above requirement, the system must be capable of automatic operation in the event of a fire and the pump, pump controls, valving, etc., must be designed for such operation.

2.6.4 Accumulator Tank

In association with the above mentioned requirement, the system is to be fitted with a fresh water pressure tank to maintain the pressurized condition of the system. The tank is to contain a standing charge of fresh water, equivalent to the amount of water which would be discharged in one minute by the pump. In addition, arrangements are to provide for maintaining an air pressure in the tank such as to ensure that when the standing charge of fresh water in the tank has been used the pressure will be not less than the working pressure of the sprinkler plus the pressure exerted by a head of water measured from the bottom of the tank to the highest sprinkler in the system.

To accommodate the volume of air necessary to maintain the pressure throughout the one minute discharge, the tank is required to have an actual volume equal to at least twice that of the charge of water specified above. In addition, suitable means of replenishing the air under pressure and of replenishing the fresh water charge in the tank are to be provided. Also, a glass gauge is required to be provided to indicate the correct level of the water in the tank.

The accumulator tank addressed above is to be considered as a pressure vessel and it is to comply with the applicable requirements identified in SVR Section 4-4-1. These requirements will vary depending upon the maximum pressure involved. During the review of the system, the applicable requirements from SVR Section 4-4-1 should be identified and the submitter advised accordingly, unless ABS certification is already indicated on one of the drawing notes.

2.6.5 Wet Pipe System

The system is to be of a wet pipe design, but small exposed sections are allowed to be of the dry pipe, pre-action, deluge, antifreeze or other type, where determined necessary. See section 2 of IMO Resolution A.800(19) for appropriate definitions of these terms.

2.6.6 Design and Suitability of Components

In accordance with paragraph 3.6 of IMO Resolution A.800(19), the system and its components are to be suitably designed to withstand ambient temperature changes, vibration, humidity, shock, impact, clogging and corrosion normally encountered in vessels. Further, components within the protected spaces should be designed to withstand the elevated temperatures which could occur during a fire.

Paragraph 3.7 of IMO Resolution A.800(19) requires that the system and its components “...be designed and installed in accordance with international standards acceptable to the Organization and manufactured and tested to the satisfaction of the Administration in accordance with the appropriate elements of Appendices 1 and 2...” In this regard, a footnote is also provided which indicates that “Pending the development of international standards acceptable to the Organization, national standards as prescribed by the Administration should be applied.”

Like MSC Circular 668, IMO Resolution A.800(19) is focused on the design and testing requirements for the nozzle, as well as some overall system requirements. Accordingly, there are many areas of a water mist system which are not adequately addressed in the Resolution. To address such concerns, the Resolution makes reference to “international standards acceptable to the Organization”. However, at this time no particular “international standards acceptable to the Organization” exist, and therefore, the footnote allows consideration of appropriate national standards. While other appropriate national standards may exist, the national standard frequently used is NFPA 750, *Standard on Water Mist Fire Protection Systems*.

Accordingly, based upon the above-mentioned reference, the Engineer conducting the review should understand that in addition to compliance with the design and testing requirements specified in Appendices “1” and “2” of IMO Resolution A.800(19) for the system, as well as its components, the system and components must also comply with the requirements specified in an appropriate national or international standard, such as NFPA 750. The review should verify compliance with all aspects of the same.

2.6.7 Power Supply Arrangements

The system is to be provided with power from both the main and emergency sources of power in accordance with paragraph 3.8 of IMO Resolution A.800(19).

2.6.8 Redundant Pumping Arrangements

The system is to be provided with a redundant means of pumping or otherwise supplying the water-based extinguishing agent to the sprinkler system in accordance with paragraph 3.9 of IMO Resolution A.800(19).

2.6.9 Sea Inlet

The system is to be fitted with a permanent sea inlet and is to be capable of continuous operation using sea water, in accordance with paragraph 3.10 of IMO Resolution A.800(19).

2.6.10 Calculations

Paragraph 3.11 of IMO Resolution A.800(19) requires the system to be properly sized in accordance with a hydraulic calculation technique. This requires that the pressure sources and distribution system must be properly analyzed to ensure that the required flow rates at the most hydraulically demanding system will be provided. System flow and pressure drop calculations are to be requested and reviewed (refer to 5/2.2.1 of these Guidance Notes for a general discussion regarding this subject).

2.6.11 Zoning

The sprinklers are to be grouped into separate sections and no one section should serve more than two decks of one main vertical zone, as per paragraph 3.12 of IMO Resolution A.800(19).

2.6.12 Isolation Valves

Each sprinkler section is to be capable of being isolated by only one stop valve. The stop valve in each section is to be readily accessible and its location clearly and permanently indicated, in accordance with paragraph 3.13 of IMO Resolution A.800(19).

2.6.13 Dedicated System

The sprinkler system piping is not to be used for any other purpose, in accordance with paragraph 3.14 of IMO Resolution A.800(19). Accordingly, no connections for wash-down arrangements, deck showers or other non-potable water services are to be permitted.

2.6.14 System Component Locations

In accordance with paragraph 3.15 of IMO Resolution A.800(19), the sprinkler system supply components (e.g., pump, valves, controls, etc.) are to be located outside of any category "A" machinery spaces.

2.6.15 Testing Arrangements

Arrangements are to be provided which will allow testing of the automatic operation of the system and ensure that the required pressure and flow will be provided, in accordance with paragraph 3.16 of IMO Resolution A.800(19).

2.6.16 Visual and Audible Alarms

In accordance with paragraph 3.17 of IMO Resolution A.800(19), each sprinkler section is to be provided with the means to give a visual and audible alarm at a continuously manned central control station within one minute of flow from one or more sprinklers. Each sprinkler section is to also be fitted a check valve, a pressure gauge and a test connection with a means of drainage. An alarm in the central control station is to indicate the specific valve activated, in accordance with paragraph 23 of MSC/Circular 668.

2.6.17 Sprinkler Control Plan

A sprinkler control plan is to be displayed at each centrally manned control station, in accordance with paragraph 3.18 of IMO Resolution A.800(19).

2.6.18 Installation Plans and Operating Manuals

Installation plans and operating manuals for the system are required to be readily available onboard. A list or plan is to be displayed showing the spaces covered and the locations of the zones in respect to each other. Instructions for testing and maintenance are to also be available onboard. See paragraph 3.19 of IMO Resolution A.800(19).

2.6.19 Nozzles

In addition to the previously discussed requirements for nozzles, the sprinklers are to have fast response characteristics as defined in ISO 6182-1. See paragraph 3.20 of IMO Resolution A.800(19). Documentation verifying the same should be submitted.

Within accommodation and service spaces, paragraph 3.21 of IMO Resolution A.800(19) requires that the sprinklers are to have a nominal temperature range of 57°C (134°F) to 79°C (174°F), except that in locations such as drying rooms, where high ambient temperatures might be expected, the operating temperature may be increased by not more than 30°C (86°F) above the maximum deckhead temperature.

The nozzle location, type of nozzle and nozzle characteristics are to be within the limits tested during the Appendix “2” fire tests. This is part of the information which should be taken from the ABS certification report.

2.6.20 Total System Capacity Requirements

Similar to the requirements specified in FSS Code Chapter 8/2.3.3.2, paragraph 3.22 of IMO Resolution A.800(19) requires that the pumps and alternative supply components are to be sized so as to be capable of maintaining the required flow to the hydraulically most demanding area of not less than 280 m² (3012 ft²). However, paragraph 3.22 permits the use of alternative minimum coverage areas if the total protected area is less than 280 m² (3012 ft²). The ability of the pump and the piping system to support this flow rate at the most hydraulically remote section must be verified through a review of the pump curves and appropriate pressure drop calculations as discussed in 5/2.1 above.



SECTION 6 Foam Fire Extinguishing Systems

1 Foam

Foam is produced by the combination of three materials:

- Water
- Air
- Foam making agent

Foam is formed by first mixing the foam-making agent (*foam concentrate*) with water to create a *foam solution*. The actual foam bubbles are created by introducing air into the foam solution through an appropriate aerating device. The correctly chosen foam concentrate, when properly proportioned with water and expanded with air through an application device, will form a finished foam.

The foam concentrate is required to be thoroughly mixed with water at a particular concentration to produce the *foam solution* needed to create the desired foam. Two of the most common concentrations are 3% and 6% foams. These values are the percentages of the concentrate to be used in making the foam solution. Thus, if 3% concentrate is used, three (3) parts of concentrate must be mixed with 97 parts of water to make 100 parts of foam solution. If 6% concentrate is used, six (6) parts of concentrate must be mixed with 94 parts of water.

2 General Principals of Foam Extinguishing Systems

2.1 Extinguishing Effects of Foam

Firefighting foam is used to form a blanket on the surface of flaming liquids. The blanket prevents flammable vapors from leaving the surface and prevents oxygen from reaching the fuel. A fire cannot exist when the fuel and oxygen are separated, and therefore, a properly placed foam blanket will smother the fire. In addition, the water in the foam also has a cooling effect, which gives foam the ability to cool surrounding structure to help prevent flash back.

The ideal foam should flow freely enough to cover a surface rapidly, yet have adequate cohesive properties to stick together sufficiently to establish and maintain a vapor tight blanket. In addition, the solution must retain enough water to provide a long-lasting seal. Rapid loss of water would cause the foam to dry out and break down (wither) from the high temperatures associated with fire. The foam should also be light enough to float on flammable liquids, yet heavy enough to resist winds.

2.2 Foam Characteristics

Foam must contain the right blend of physical characteristics to be effective:

- *Knockdown Speed and Flow.* The ability of the foam blanket to spread across a fuel surface or around obstacles and wreckage in order to achieve complete extinguishment is very important. The foam must have good cohesion properties to maintain the blanket affect yet at the same time not be so viscous to hinder the ability of the foam to flow over the area and form a self-supporting blanket.

- *Heat Resistance.* The foam must be able to resist the destructive effects of heat radiated from any remaining fire from the liquid's flammable vapor and any hot metal wreckage or other objects in the area.
- *Fuel Resistance.* An effective foam minimizes fuel pick-up so that the foam does not become saturated and burn.
- *Vapor Suppression.* The vapor-tight blanket is a critical function of a foam's ability to extinguish a fire. The foam produced must be capable of suppressing the flammable vapors to break the fuel-oxygen-heat fire triangle and to minimize the risk of re-ignition.
- *Alcohol Resistance.* Due to alcohol's affinity to water and because a foam blanket is more than 90% water, foam blankets that are not alcohol-resistant will be destroyed if used on alcohol-based cargoes.

2.3 Types of Foams

There are two basic types of foam, chemical and mechanical.

2.3.1 Chemical Foam

Chemical foam is formed by mixing together a solution of an alkali (usually sodium bicarbonate), an acid (usually aluminum sulfate), water and a stabilizer. The stabilizer is added to make the foam tenacious and long-lived. When these chemicals react, they form a foam or froth of bubbles filled with carbon dioxide gas. The carbon dioxide in the bubbles has little or no extinguishing value. Its only purpose is to inflate the bubbles. From 7 to 16 volumes of foam are produced for each volume of water.

Premixed foam powders may also be stored in cans and introduced into the water during fire-fighting operations. For this, a device called a foam hopper is used. Or, the two chemicals may be premixed with water to form an aluminum sulfate solution and a sodium bicarbonate solution. The solutions are then stored in separate tanks until the foam is needed. At that time, the solutions are mixed to form the foam. Few chemical foam systems are still in use aboard vessels.

2.3.2 Mechanical (Air) Foam

Mechanical foam is produced by mixing a foam concentrate with water to produce a foam solution. The bubbles are formed by the turbulent mixing of air and the *foam solution*. As the name air foam implies that the bubbles are filled with air. Aside from the workmanship and efficiency of the equipment, the degree of mixing determines the quality of the foam. The design of the equipment determines the quantity of foam produced. There are several types of mechanical foams, similar in nature, but each has its own special fire fighting capabilities.

Types of mechanical foams include the following:

2.3.2(a) Protein Foam. Protein foams were the first types of mechanical foam to be marketed extensively and have been used since World War I.

These foams are usually produced by the hydrolysis of waste protein material, such as protein-rich animal waste (i.e., hoofs and horns) and vegetable waste that is hydrolyzed (subjected to a chemical reaction with water that produces a weak acid). In addition, stabilizing additives and inhibitors, such as mineral salts, are added to prevent corrosion, resist bacterial decomposition, to control viscosity and increase their resistance to withering from the heat of a fire.

At the time of a fire, the protein foam concentrates are mixed with fresh or seawater in 3% or 6% solutions. The foam concentrate can produce foam with all types of water, except water that is contaminated with oil. When antifreeze is added, foam can be produced in subfreezing temperatures down to -23.3°C (-10°F).

2.3.2(b) Fluoroprotein Foam (FP). Fluoroprotein foams are formed by the addition of special fluorochemical surfactants with protein foam (fluorinated compound bonded to the protein). This enhances the properties of protein foam by increasing foam fluidity (ease to flow) and improves the properties of regular protein foam by providing faster knockdown and excellent fuel tolerance. Fluoroprotein foam works well with dry chemical agents, and when the water is mixed with antifreeze, it produces foam in sub-freezing temperatures.

2.3.2(c) Film Forming Fluoroprotein Foam (FFFP). FFFPs are a combination of fluorochemical surfactants with protein foam. They are designed to combine the burnback resistance of a fluoroprotein foam with an increased knockdown power. These foams also release a film on the surface of the hydrocarbon.

2.3.2(d) Aqueous Film Forming Foam (AFFF). AFFFs are a combination of fluorochemical surfactants and synthetic foaming agents that create a unique characteristic – an aqueous film. This film is a thin layer of foam solution with unique surface energy characteristics that spreads rapidly across the surface of a hydrocarbon fuel causing dramatic fire knockdown.

The aqueous film is produced by the action of the fluorochemical surfactant reducing the surface tension of the foam solution to a point where the solution can actually be supported on the surface of the hydrocarbon.

AFFFs are more effective on hydrocarbons (fuels) with higher surface tensions, such as kerosene, diesel oil and jet fuels, and less effective on fuels with lower surface tensions, such as hexane and high octane gasolines.

AFFF's may drain foam solution (the water and foam concentrate mixture) rapidly from the foam bubble to produce optimum film formation for rapid fire extinguishment. To achieve these qualities, long term sealability and burnback resistance are sacrificed.

2.3.2(e) Alcohol Resistant-Aqueous Film Forming Foam (AR-AFFF). Alcohol resistant foams are produced from a combination of synthetic stabilizers, foaming agents, fluorochemicals and alcohol resistant membrane forming additives.

Polar solvents and water miscible fuels, such as alcohols, are destructive to non-alcohol resistant type foams. Alcohol aggressively mixes with the water in the foam and destroys the foam blanket and its fire-fighting properties.

Alcohol resistant foams act as a conventional AFFF on hydrocarbon fuels, forming an aqueous film on the surface of the hydrocarbon fuel. When used on alcohol type fuels, the membrane forming additives form a tough polymeric (sometimes called mucoloid) membrane which separates the foam from the alcohol and prevents the destruction of the foam blanket.

While some concentrates are designed for use on alcohol-type fuels at 6% and hydrocarbon fuels at 3%, today's newer formulations are designed to be used at 3% on both fuel groups. These newer formulations provide more cost effective protection of alcohol-type fuels, using half the amount of concentrate as a 3%/6% agent. The use of a 3 × 3 AR-AFFF also simplifies setting the proportioning percentage at an incident, since it is always 3%.

Overall, AR-AFFF's are the most versatile type of foam available today, offering good burnback resistance, knockdown and high fuel tolerance on both hydrocarbon and alcohol fuel fires.

2.3.2(f) Synthetic Foam. Synthetic detergent-base foam is made up of alkyl sulfonates. This form has less burnback resistance than protein formulas, but may be used with all dry chemicals. It foams more readily than the proteins and requires less water. This is important where the water supply is limited.

2.3.3 Low Expansion Foams

Low expansion foams are considered to be those foams with an expansion ratio of 12:1 when mixed with air. That is one volume of foam concentrate will create 12 volumes of foam. Low expansion foams are effective in controlling and extinguishing most flammable liquid (Class “B”) fires. Foams typically used on tanker deck foam systems are of the low expansion foam type.

2.3.4 Mid Low Expansion Foams

Mid expansion foams refer to those foams with an expansion ratio of between about 20:1 to 100:1. Few applications of mid expansion foams are found in shipboard applications.

2.3.5 High-Expansion Foams

High-expansion foams are those that expand in ratios of over 100:1. Most systems produce expansion ratios of from 400:1 to 1000:1. Unlike conventional foam, which provides a blanket a few inches over the burning surface, high-expansion foam is truly three dimensional; it is measured in length, width, height, and cubic feet.

High-expansion foam is designed for fires in confined spaces. Heavier than air but lighter than oil or water, it will flow down openings and fill compartments, spaces and crevices, replacing air in these spaces. In this manner, it deprives the fire of oxygen. Because of its water content, it absorbs heat from the fire and cools the burning material. When the high-expansion foam has absorbed sufficient heat to turn its water content to steam at 100°C (212°F), it has absorbed as much heat as possible, and then the steam continues to replace oxygen and thus combat the fire.

2.4 Limitations on the Use of Foam

Foams are effective extinguishing agents when used properly. However, they do have some limitations, including the following:

- i) Because they are aqueous (water) solutions, foams are electrically conductive and should not be used on live electrical equipment.
- ii) Like water, foams should not be used on combustible-metal fires.
- iii) Many types of foam must not be used with dry chemical extinguishing agents. AFFF is an exception to this rule and may be used in a joint attack with dry chemical.
- iv) Foams are not suitable for fires involving gases and cryogenic (extremely low temperature) liquids.
- v) If foam is placed on burning liquids (like asphalts) whose temperatures exceed 100°C (212°F), the water content of the foam may cause frothing, spattering or slopover. Slopover is different from boilover, although the terms are frequently confused. Boilover occurs when the heat from a fire in a tank travels down to the bottom of the tank and causes water that is already there to boil and push part of the tank’s contents over the side. Certain oils with a high water content, such as crude oil, have a notorious reputation for boilover. Slop-over occurs when foam, introduced into a tank of hot oil [surface temperature over 100°C (212°F)] sheds its water content due to the high heat. The water forms an emulsion of steam, air and the foam itself. The forming of the emulsion is accompanied by a corresponding increase in volume. Since tanks are three dimensional, the only place for the emulsion to go is over the sides of open tanks or into the vents of enclosed tanks.
- vi) Sufficient foam must be on hand to ensure that the entire surface of burning material can be covered. In addition, there should be enough foam to replace foam that is burned off and to seal breaks in the foam surface.

2.5 Advantages of Foam

In spite of its limitations, foam is quite effective in combating Class “B” and some Class “A” fires and has the following advantages:

- i)* Foam is a very effective smothering agent, and it provides cooling as a secondary effect.
- ii)* Foam sets up a vapor barrier that prevents flammable vapors from rising. The surface of an exposed tank can be covered with foam to protect it from a fire in a neighboring tank.
- iii)* Foam is of some use on Class “A” fires because of its water content. AFFF is especially effective, as are certain types of wet-water foam. Wet-water foam is made from detergents, and its water content quickly runs out and seeps into the burning material. It is not usually found aboard vessels; a more likely use is in protecting bulk storage in piers or warehouses.
- iv)* Foam is effective in blanketing oil spills. However, if the oil is running, an attempt should be made to shut down a valve, if such action would stop the flow. If that is impossible, the flow should be dammed. Foam should be applied on the upstream side of the dam (to extinguish the fire) and on the downstream side (to place a protective cover over any oil that has seeped through).
- v)* Foam is the most effective extinguishing agent for fires involving large tanks of flammable liquids.
- vi)* Foam can be made with fresh water or seawater, and hard or soft water.
- vii)* Foam does not break down readily, and it extinguishes fire progressively when applied at an adequate rate.
- viii)* Foam stays in place, covers and absorbs heat from materials that could cause re-ignition.
- ix)* Foam uses water economically.
- x)* Foam concentrates are not heavy, and foam systems do not take up much space.

2.6 Basic Guidelines for Foam

2.6.1 Storage

If manufacturer recommendations are followed, then protein or synthetic foam concentrates should be ready for active service even after many years of storage.

2.6.2 Water Temperature and Contaminants

Foams in general are more stable when generated with lower temperature water. Although all foam liquids will work with water in excess of 37.7°C (100°F), the typical concentrate works best with water in the temperature range between 1.7°C and 26.7°C (35°F and 80°F). Either fresh or sea water may be used. Water containing known foam contaminants, such as detergents, oil residues, or certain corrosion inhibitors, may adversely affect foam quality.

2.6.3 Combustible Products in Air

It is desirable to take clean air into the foam nozzle at all times, although the effect of contaminated air on foam quality is minor with low expansion foams.

2.6.4 Water Pressures

Nozzle pressures should be held between 3.4 bar and 13.8 bar (50 and 200 psi). If a proportioner is used, proportioner pressure should not exceed 13.8 bar (200 psi). Foam quality deteriorates at higher pressures. Range falls off at lower pressures.

2.6.5 Non-ignited Spills

Where flammable liquids have spilled, fires can be prevented by prompt coverage of the spill with a foam blanket. Additional foam may be necessary from time to time, to maintain the blanket for extended periods until the spill has been cleaned up.

2.6.6 Electrical Fires

Foam should be considered nearly the same as water when used on electrical fires, and is therefore not generally recommended for use on electrical fires. However, if the supply of current to the electrical circuits can be interrupted or broken, then foam can be used to extinguish such fires.

2.6.7 Vaporized Liquids

Foam is not recommended for use on materials that may be stored as liquids, but are normally vapor at ambient conditions, such as propane, butadiene and vinylchloride. Fire-fighting foam is not recommended for use on materials that react with water, such as magnesium, titanium, potassium, lithium, calcium, zirconium, sodium and zinc.

2.7 Foam System Equipment

As mentioned above, finished foam is a combination of foam concentrate, water and air. When these components are brought together in proper proportions and thoroughly mixed, foam is produced. The following is a discussion of the typical types of equipment used in the production of foam.

2.7.1 Proportioning Devices

All foam proportioners are designed to introduce the proper percentage of foam concentrate into the water stream. There are several varieties of proportioning systems available to the fire service today. The choices range from the more commonly-used and economical in-line eductors to Around-the-Pump systems to the sophisticated and more expensive Balanced Pressure systems.

2.7.1(a) Eductors. Eductors are the most common form of proportioning equipment. They are used for dedicated foam discharges and around-the-pump systems.

Eductors work on the Venturi principle. Water is introduced, under pressure, at the inlet of the eductor. The eductor reduces the orifice available for the water to pass through, so it must speed up to get through. This creates a pressure drop that, in turn, puts suction on the pick-up tube. As the foam concentrate is pulled up the tube, it passes through a metering valve that allows the correct percentage to be introduced into the water stream. In most cases, the metering valve can be adjusted to select a 1, 3, or 6% foam solution.

Eductors are extremely reliable and simple pieces of equipment. However, they do have certain limitations.

- *Educator GPM Flow Rate Restrictions.* All eductors have liters per minute (gallons per minute) solution flow rating. Typically, 227, 360, 473, 946 L/min (60, 95, 125, 250 gpm) models are available. The eductor must be matched with a nozzle that has the same flow rating. Eductor/Nozzle mismatches are the most common cause of fire service proportioning problems. Mismatches can result in a weak solution or a complete shut-down of foam concentrate pick-up.
- *Inlet Pressure Requirements.* Eductors establish their pressure drop at a fairly high energy cost. The loss between the inlet and outlet pressure of an eductor can be 40% or more. In order to accommodate this loss and still provide adequate nozzle pressure, relatively high eductor inlet pressures are necessary. Most manufacturers recommend inlet pressures at the eductor in the range of 12.4-13.8 bar (180-200 psi).

Most eductors will continue to pick up at lower inlet pressures. However, at these lower pressures, the solution flow drops. Under these conditions, it becomes impossible to accurately know the concentration of the foam solution being delivered to the fire.

- *Back Pressure Restrictions.* Too much back pressure on an eductor can shut down foam concentrate pick up. Therefore:

The nozzle and eductor must be matched.

The nozzle must be fully opened or fully closed. It cannot be in-between.

Prevent kinks in the hose line between nozzle and eductor.

The nozzle should not be elevated above the eductor.

The hose lay can not exceed manufacturer's recommendation.

Following these simple rules helps to eliminate excessive back pressure on the eductor.

- *Eductors Must Be Kept Clean.* Eductors must be thoroughly cleaned after each use. Failure to clean an eductor can result in clogging and blockage due to hardening foam concentrate residue. If this occurs, the eductor will not function properly, if at all.

When eductors are properly understood and maintained, they can accurately and reliably proportion foam at relatively low cost.

2.7.1(b) Around-the-Pump Systems. Another method of proportioning is the Around-the-Pump type system. In this case, an eductor is installed on the discharge side of the water pump. As before, water flow causes a vacuum that picks up and introduces the foam concentrate into the pump suction. An adjustable metering valve controls the flow of the foam concentrate.

Around-the-pump systems offer several advantages when compared to an in-line eductor:

- *Variable Flow Rate.* The discharge rate can be adjusted for the specific application. The rate is infinitely variable up to the maximum flow of the unit.
- *Variable Pressure.* The system operates at any pressure above 8.6 bar (125 psi). The pump operation is the same with foam or water.
- *No Back Pressure Restrictions.* The unit is not affected by hose length or elevation loss.
- *No Nozzle Restrictions.* The unit operates with any size or type of nozzle.

However, Around-the-Pump systems have their own limitations:

- Pump inlet pressure is limited to 0.7 bar (10 psi) to prevent a back pressure condition that will shut the system down.
- There is no choice of simultaneous flow of foam solution and plain water.
- An operator must continually calculate, set and monitor the foam proportioning metering valve to correspond with the volume [L/min (gpm)] being flowed.
- Clean-up time can be long since ALL discharges must be flushed, whether or not they were opened during the operation.

2.7.1(c) Balanced Pressure Foam Proportioners. Balanced pressure systems are extremely versatile and accurate. Most often these systems are associated with fixed systems and specialized mobile equipment. Their design and operation are complex.

The principle of operation is based on the use of a modified venturi proportioner commonly called a ratio controller. As water passes through a jet at the inlet of the ratio controller, it creates a reduced pressure area between the jet and a downstream section called a throat or receiver. This reduction in pressure causes foam concentrate to flow through a metering orifice and into the reduced pressure area.

As the water flow through the ratio controller jet increases, so does the level of pressure reduction, thereby affecting a corresponding pressure drop across the foam liquid metering orifice. This corresponding pressure drop results in a foam liquid flow which is proportionate to the water flow through the ratio controller. As both the water and foam liquid flow into a common reduced pressure area, it is necessary only to maintain identical water and foam liquid pressures at the inlets of the ratio controller.

Pressure sensing lines lead from the foam liquid and water lines upstream of the ratio controller water and foam inlets to the diaphragm valve. This valve automatically adjusts the foam liquid pressure to correspond to the water pressure. A duplex gauge monitors balancing of foam liquid and water pressures on a single gauge.

For manual operation, the diaphragm valve is not required. The pressure of the foam liquid is adjusted to correspond to the water pressure by means of a manually operated valve in the foam liquid bypass piping.

The pressure loss across the proportioner is approximately 1.7-2.1 bar (25-30 psi) at maximum flow, depending on the ratio controller size selected. The minimum flow for which this device will proportion correctly is approximately 15% of the maximum flow for which it is designed.

Balanced proportioning allows for a wide range of flows and pressures without manual adjustments, while placing no limitations on inlet pressure during foam operation.

2.7.2 Foam Nozzles

For the most effective and economical use, the foam solution must be properly expanded. Standard fog nozzles generally do not provide optimum expansion, and therefore, do not provide for the best, most cost effective application of the foam supply. In the case of Polar Solvent fuels, these standard fog nozzles may not deliver a foam quality that is able to extinguish the fire.

Foam nozzles are specifically designed to air aspirate (expand) the foam solution and form finished foam. There are three main types of foam nozzles.

2.7.2(a) Low Expansion. Low expansion nozzles expand foam solution up to 12:1, i.e., for every 3.8 liters (1 gallon) of foam solution that enters the base of the nozzle, approximately 45.6 liters (12 gallons) of finished foam is produced. These nozzles draw air at the base of the nozzle, the air and the solution mix travel up the foam tube (this is called residence time) and the properly-expanded foam exits the nozzle.

2.7.2(b) Medium Expansion. Medium expansion nozzles can have expansion characteristics as high as 100:1, although expansions of 50:1 are more common. They operate in much the same way as low expansion nozzles. However, the diameter of the nozzle is much larger.

2.7.2(c) High Expansion. High expansion foam nozzles can expand foam in excess of 100:1, when high expansion foam concentrates are used.

2.7.3 Foam Monitors

The foam monitors or turrets are permanently-installed foam discharge units capable of being aimed and projecting large quantities of foam substantial distances. They normally are mounted on a rotating base that allows the projection of foam in a 360-degree circle around the monitor platform. The angle of throw from the horizon can also be adjusted to facilitate flexibility in directing the foam to the fire. The foam solution is supplied to the monitor through a hard-piped foam main system that incorporates an expansion nozzle to aspirate the foam.

2.7.4 Applicators

Foam applicators are portable foam discharge devices supplied with foam solution through a hose from the hard-piped foam main. The applicators provide the flexibility to apply foam directly to specific locations or in a manner that the monitors may not be effective.

2.7.5 Valves and Piping

The foam solution is distributed from the proportioning device to the monitors or applicators through a system of pipes and valves. The piping system must be adequately designed to match the flow rates of the equipment, and a thorough understanding of the system control valves is critical for quick and effective operation of the system. A diagram of the piping system and control valves is typically posted in the foam supply room and identifies which valves are to be opened in the event the system must be activated. The diagram normally explains thoroughly and clearly all the steps necessary to put the system into operation. Color coding of the valves is also frequently used and aids in identification (e.g., all valves that are to be opened when a fire alarm is received might be painted some distinctive color). Each valve is also normally labeled as to its function, which helps in operating, restoring and maintaining the system.

2.7.6 Foam Concentrate Storage

The foam-concentrate is stored in tanks ready to supply the proportioning system. The concentrate tank should be kept filled with liquid halfway into the expansion dome to ensure prolonged storage life of the concentrate. The tank should be kept closed to the atmosphere, except for the pressure-vacuum vent. When a tank is partially empty, there is a larger liquid surface area to interact with air. This allows excessive evaporation and condensation, which degrade the foam concentrate and permit corrosion of the tank shell.

2.8 Foam Fire Fighting Application Techniques

2.8.1 Bounce-off Technique

When foam nozzles are used, particular care should be taken to apply the foam as gently as possible. For straight stream use, the foam should be bounced or banked off of a wall or other obstruction when available.

2.8.2 Bank-in Technique

Foam can also be rolled onto the fuel surface by hitting the ground in front of the spill, and allowing the foam to “pile up” in front of the spill. The velocity of the stream will roll the foam onto the fuel.

2.8.3 Rain-down Technique

The foam nozzle is directed almost straight up and the foam stream is allowed to reach its maximum height and break into small droplets. The nozzle operator must adjust the altitude of the nozzle so the fallout pattern matches that of the spill area. This technique can provide a very fast and effective knockdown. However, if the fuel has had a significant preburn and a thermal column has developed, or if the weather is severe (high winds), the Raindown method may not be practical or effective.

2.8.4 Never Plunge

Plunging the stream directly into the fire can splash the fuel causing the fire to spread. If a foam blanket exists, plunging can break the existing blanket allowing vapors to escape. This usually results in spreading the fire, reignition or flare ups. Usually, the fire will lessen in intensity or self-extinguish once the plunging stream is removed.

If the foam nozzle is equipped with a spray stream attachment, it should be used to provide the gentlest application possible and reduce the mixing of foam and fuel. Only as a last resort should a straight stream be directed into the center of a pool or spill. Under this condition, the efficiency of the foam will be $\frac{1}{3}$ or less than when applied by the recommended methods.

Conventional AFFFs may be used effectively with standard water spray nozzles under some conditions although a very unstable foam with relatively poor reignition resistance is formed from such devices.

Do not use water streams in such a way as to physically disrupt a foam blanket. Water streams may be used for cooling adjacent areas or as a fine spray to reduce flame radiant heat. However, do not direct water streams where a foam blanket has been or is being applied.

3 ABS Requirements for Foam Extinguishing Systems

The following information is provided as general guidance regarding the ABS requirements for foam fire-extinguishing systems. However, reference should always be made to the Rules applicable to the specific vessel concerned for the complete set of requirements.

3.1 General Requirements Applicable to All Foam Systems

3.1.1 Design and Certification of Piping Components

All valves, fittings and piping are to comply with the applicable requirements of SVR Sections 4-6-1 and 4-6-2. Accordingly, all valves and fittings are to be designed and constructed in accordance with a recognized standard, be suitable for the intended pressures and comply with all other requirements in SVR Section 4-6-2. These components are also to be certified in accordance with SVR 4-6-1/7 and of SVR 4-1-1/Table 6, as applicable.

3.1.2 Pipe and Pipe Joints

The design of the pipe and pipe joints is to comply with the requirements in SVR 4-6-2/5. Accordingly, compliance with the wall thickness requirements for the piping specified in SVR 4-6-2/5.1, as well as compliance of the type and design of the pipe joints with SVR 4-6-2/5.3 and SVR 4-6-2/5.5, should be verified during plan review.

3.1.3 Materials

In addition to the common requirements and limitations in SVR Section 4-6-1 and 4-6-2, the materials used in the system should not be rendered ineffective by heat. This requirement is important to ensure that the foam system will remain intact and functional even if a portion of the foam system piping is actually within the immediate vicinity of the fire. In order to be considered not “readily rendered ineffective by heat”, a component is to be certified as having passed an acceptable recognized fire test or the material is to have a melting temperature higher than the test temperature specified in an acceptable fire test.

Accordingly, the review should verify that the materials of the valves, fittings and pipe, as well as the method of joining sections of pipe, will not be rendered ineffective by heat.

3.1.4 Pumps

The pumps associated with the foam system are obviously critical to the satisfactory operation of the system, and therefore, should be tested in the presence of a Surveyor, in accordance with SVR 4-6-1/7.

3.1.5 Pressure Vessels

In some designs, the concentrate storage tank utilizes a bladder and is subjected to pump pressure to facilitate the discharge of the concentrate in water stream. Where such designs are used, the tank is to be considered a pressure vessel and is to comply with the requirements of SVR Section 4-4-1, as applicable.

3.1.6 System Component Certification

In accordance with of SVR 4-1-1/Table 4, fixed fire-extinguishing system components are to be certified. Accordingly, components such as foam system eductors, proportioners, monitors, nozzles, etc., are to comply with the certification requirements specified in SVR 4-1-1/Table 4 and details verified accordingly.

3.2 Additional Requirements for “Oil Carrier” Deck Foam Systems

3.2.1 Application

SVR 5-1-7/23.1 requires oil carriers of 20,000 tonnes deadweight and upward to be fitted with protection of the cargo rank deck area and cargo tanks by a deck foam system and requires those vessels of less than 20,000 tonnes deadweight to be fitted with a deck foam system or equivalent. Accordingly almost all oil carriers are required to be fitted with a deck foam system

Related IACS Unified Interpretation

UI SC131 re. SOLAS Chapter II-2, Regulation 55.2 (SOLAS (2000 Amendments) II-2/1.6.2) (Last Paragraph)

Liquid cargoes with a flashpoint above 60°C other than oil products or liquid cargoes subject to the Chemical Codes’ requirements are considered to constitute a low fire risk not requiring the protection of a foam extinguishing system.

The system requirements for the deck foam system are found in SVR 5-1-7/27. The following is an outline of the requirements specified in SVR 5-1-7/27.

3.2.2 General

In accordance with SVR 5-1-7/27.1, the deck foam system is to be capable of discharging foam at the required rates to the entire cargo tank deck area, as well as into any cargo tank that is open due to a rupture in the deck. This system will normally consist of fixed monitors, as well as required hand line applicators.

3.2.3 Controls

SVR 5-1-7/27.1 requires that the deck foam system is to be capable of simple and rapid operation. This requires that the controls and arrangements for the system be designed so that it can be brought into operation quickly and would preclude complicated interconnections with non-firefighting systems.

SVR 5-1-7/27.1 also requires that the main control station for the system be located outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the area being protected by the foam system. This Paragraph is considered to require the control arrangements (controls for the motors, valves, pumps, etc., required to operate the system) to be in the location described above. The deck foam system concentrate tank, proportioner unit, etc., are also normally installed in the above location but are not specifically mandated to be located at the control station, and therefore, may be in the engine room. The pump(s) supplying water are normally located down in the engine room, but the controls for the pumps, as well as all portions of the foam system not located within the space containing the foam system control station, should be operable from the foam system control station.

*Related IACS Unified Interpretation***UI SC150 re. SOLAS Chapter II-2, Regulation 61.2, (FSS Code Chapter 14/3)**

The major equipment such as the foam concentrate tank and the pumps may be located in the engine room. The controls of the system are to be located in accordance with Reg.II-2/61.2 (FSS Code Chapter 14/3)

3.2.4 Application Rate/System Flow Calculations

The minimum flow rate for the deck foam system for a typical oil carrier is determined by the criteria identified in SVR 5-1-7/27.3. This Paragraph identifies three different sets of criteria, and the minimum capacity of the system is not to be less than the largest of the coverage rates identified. These different sets of criteria are discussed in the following:

- i) SVR 5-1-7/27.3i) requires a system flow rate of not less than 0.6 L/min/m² (0.015 gpm/ft²) based upon the total cargo tank deck area. The cargo tank deck area is further defined as the maximum breadth of the vessel multiplied by the total longitudinal extent of the cargo tank spaces.
- ii) SVR 5-1-7/27.3ii) requires a system flow rate of not less than 6.0 L/min/m² (0.15 gpm/ft²) based upon the horizontal deck area of the single largest cargo tank.
- iii) SVR 5-1-7/27.3iii) requires a system flow rate of not less than 3.0 L/min/m² (0.075 gpm/ft²) of the area protected by the largest monitor, but not less than 1,250 L/min.

As indicated above, the minimum flow rate of the system is not to be less than the largest rate identified in the three sets of criteria specified in 5-1-7/27.3.

Complete detailed system flow/pressure drop calculations are required to verify that the capacity and sizing of the system pumps, piping and monitors are adequate to comply with the above requirements.

There are certain cargoes on which regular foams are not effective and certain alternative requirements, including different application rates, are applicable. For more information, refer to 6/3.2.12 of these Guidance Notes.

3.2.5 Foam Concentrate Quantity

For a vessel fitted with an inert gas system, the amount of foam concentrate carried onboard is to be sufficient to supply the system for a period of at least 20 minutes when operating at the system's maximum flow rate. For a vessel not fitted with an inert gas system, the amount of foam concentrate carried onboard is to be sufficient to supply the system for a period of at least 30 minutes when operating at the system's maximum flow rate. The above is based upon the requirements in SVR 5-1-7/27.5.

The amount of foam concentrate required to be carried should be calculated based upon the maximum rated capacity of the system for the time period specified above, and as indicated in SVR 5-1-7/27.5, the expansion ratio of the foam should not typically be greater than 12:1. However, if it is slightly greater than 12:1, the calculated amount is still to be based upon the 12:1 ratio. If a medium expansion foam (between 50:1 and 150:1) is to be used, the same would require special approval.

3.2.6 System Arrangements

Based on the requirements of SVR 5-1-7/27.7, the cargo deck foam system is to be a fixed system. Also, on tankers of 4,000 DWT and above, the system is to consist of monitors, as well as foam applicators. Tankers of less than 4,000 DWT may utilize a fixed system supplying only foam applicators with a capacity of not less than 25% of the foam supply rate required in SVR 5-1-7/27.3i) or 5-1-7/27.3ii) [6/2.4i) and 6/2.4ii) of these Guidance Notes].

3.2.7 Foam Monitors

The cargo deck foam monitors (see general discussion above for definition/description) are critical components of the deck foam system since they provide the crew with the ability to engage the fire by placing large quantities of foam where needed from a relatively safe location. SVR 5-1-7/27.7 and 5-1-7/27.9 provide specific requirements concerning the number, capacity and locations of the monitors. Details of the monitor(s), as well as the proposed locations should be checked. These requirements are summarized below:

Each monitor must have the capacity to deliver not less than 50% of the foam required in SVR 5-1-7/27.3i) and 5-1-7/27.3ii) [6/2.4i) and 6/2.4ii) of these Guidance Notes]. In addition, each monitor is to have a capacity of at least 3.0 L/min/m² (0.074 gpm/ft²) of the area protected by that monitor, but in no case less than 1,250 L/min (330 gpm). The capacity of the monitors should be verified by reviewing the monitor capacity curves produced by the manufacturer at the pressure indicated in the foam piping system pressure drop calculations. Accordingly, pressure-drop calculations for the foam piping distribution system should be requested and reviewed.

The number and position of the monitors is to be adequate to provide coverage to the entire cargo tank deck area, as well as into any cargo tank that is open due to a rupture in the deck. The coverage area of any particular monitor is to be based upon the following:

- i) Only the area forward of the monitor is to be considered to be protected by that particular monitor.
- ii) The distance to the farthest point of the coverage of a monitor is not to be more than 75% of the monitor throw in still air.
- iii) Monitors are to be provided both on the port as well as starboard sides of the vessel at the front of the accommodations space.

Compliance regarding the locations and capacities of the monitors with the above requirements should be verified by reviewing a deck foam system arrangement drawing in conjunction with the monitor capacity and throw data provided by the monitor manufacturer along with system pressure flow drop calculations determining the pressure at the inlet of the monitor.

3.2.8 Foam Applicators

The foam applicators (see general discussion above for definition/description) are also a critical component of the deck foam system as they provide the crew with the versatility and flexibility needed to combat a cargo tank fire. SVR 5-1-7/27.11 and 5-1-7/27.13 provide specific requirements concerning the number, capacity and locations of the applicators. Details of the applicators, as well as the proposed locations, should be checked. These requirements are summarized below:

Each applicator must have the capacity to deliver not less than 401 L/min (106 gpm) and a throw of at least 15 m (50 feet) in still air. Once again, the capacity and throw of the applicators should be verified by reviewing the capacity and throw curves produced by the manufacturer at the pressure indicated in the foam piping system pressure drop calculations.

Each monitor station is to be provided with a hose connection for an applicator, including the monitor stations provided at the port and starboard sides of the vessel at the front of the accommodations space.

The number and locations of the foam main outlets for hose connections to serve the foam applicators is to be sufficient to ensure that at least two (2) applicators can be directed to any part of the cargo tank deck area.

At least four (4) applicators with the appropriate hoses, connection devices, etc., are to be carried onboard.

3.2.9 Isolation Valves

The foam main is to be fitted with isolation valves immediately forward of any monitor position so as to provide the means to isolate damaged sections of the main, as required by SVR 5-1-7/15. These isolation valves should be of a type, design and material that will ensure that they will not be rendered ineffective by heat.

3.2.10 Simultaneous Operation

SVR 5-1-7/27.17 specifies that the operation of the deck foam system at its required output is to permit the simultaneous use of the minimum required number of jets of water at the required pressure from the fire main. This is especially important to note when the fire pumps are being utilized to also supply the foam system. If the fire pumps are used for this service, the combined capacity of the fire pumps must be capable of supplying the total required fire main capacity at the required pressures while simultaneously supplying the maximum capacity required by the foam system.

Related IACS Unified Interpretation

UI SC61 re. SOLAS Chapter II-2, Regulation 61.10 (FSS Code Chapter. 14/2.1.3)

A common line for fire main and deck foam line can only be accepted provided it can be demonstrated that the hose nozzles can be effectively controlled by one person when supplied from the common line at a pressure needed for operation of the monitors. Additional foam concentrate is to be provided for operation of 2 hose nozzles for the same period of time required for the foam system. The simultaneous use of the minimum required jets of water should be possible on deck over the full length of the vessel, in the accommodation, service spaces, control stations and machinery spaces.

3.2.11 Foam Concentrate Quality and Testing

As discussed above, the quality of the foam and its suitability for use in the intended application is critical. Accordingly, the International Maritime Organization (IMO) has developed performance testing criteria for foam concentrates. This testing criterion is provided in IMO Circular 582, “Guidelines for the Performance and Testing Criteria, and Surveys of Low –Expansion Foam Concentrates for Fixed Fire Extinguishing Systems”. The testing procedure covers a wide spectrum of requirements, from freezing and drain time testing to expansion ratio and fire testing. It is important to note that certain portions of the testing, such as the expansion ratio, drain time and fire tests, are dependent upon the types of mixing and expansion equipment used (proportioners, monitors, etc.). Accordingly, it should be verified that the foam concentrate has been tested in accordance with IMO Circular 582 and further, that the equipment being provided onboard is the same equipment utilized during the testing or is equipment that will produce foam which is equivalent to that tested.

3.2.12 Suitability of Foam Concentrate

In addition to the above, it is critical to recognize that the foam to be used must be suitable for the particular cargoes to be carried. While this is not normally a problem with most cargoes being carried by an “Oil Carrier”, the carriage of products such as MTBE, which is a polar solvent cargo, by “Oil Carriers” must be recognized. Accordingly, during the review of the deck foam system, clarification should be requested as to whether the vessel is to carry any polar solvent cargoes, and if so, then the suitability of the foam for such cargoes should be verified.

Related IACS Unified Interpretation**UI SC131 re. SOLAS Chapter II-2, Regulation 55.2 (SOLAS 2000 II-2/1.6.2)**

A liquid cargo with a flashpoint not exceeding 60°C for which a regular foam fire fighting system complying with Regulation 61 is not effective, is considered to be a cargo introducing additional fire hazards in the scope of Regulation II-2/55.2 (SOLAS 2000 II-2/1.6.2) The following additional measures are required: The foam should be of an alcohol resistant type.

The capacity and application rates of the foam extinguishing system should comply with Chapter 11 of the IBC Code, except that lower application rates may be accepted based on performance tests. For tankers fitted with inert gas systems a quantity of foam concentrate sufficient for 20 min. of foam generation may be accepted.

For determining which cargoes require the use of an alcohol-resistant foam, the MSC/Circular 553 may be used for guidance.

Liquid cargoes with a flashpoint above 60°C other than oil products or liquid cargoes subject to the Chemical Codes' requirements are considered to constitute a low fire risk not requiring the protection of a foam extinguishing system.

Example Calculation of the Capacity of Foam System for Oil Carrier*Ship particulars*

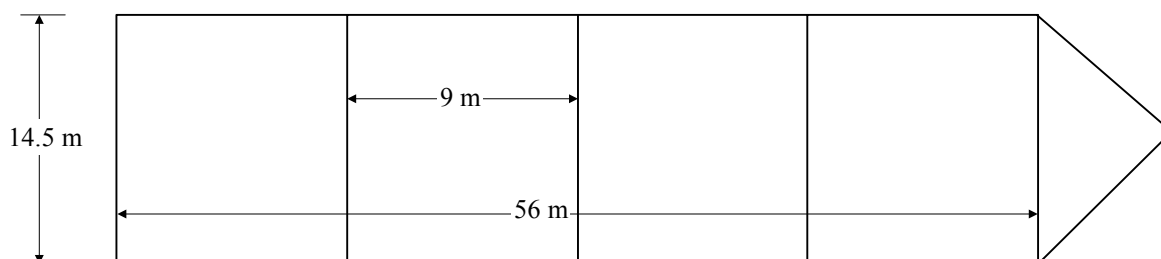
- Beam = 14.5 m
- Length of cargo area = 56 m
- Length of largest cargo tank = 9 m
- Cargo deck area = 14.5 m × 56 m = 812 m²
- Horizontal sectional area of single largest tank = 14.5 m × 9 m = 130.5 m²

(Note: For the purpose of this illustration, a single tank encompasses the entire beam of the vessel)

- Proposed monitor spacing = 9 m

Area protected by largest monitor = 9 m × 14.5 m = 130.5 m²

FIGURE 1
Calculation of Foam System Capacity – Oil Carrier



Calculations Based Upon the Above Criteria

1. Determination of foam supply rate:

The largest of:

5-1-7/27.3i): The foam supply rate based upon the entire cargo deck area.

$$0.6 \text{ L/min/m}^2 \times 812 \text{ m}^2 = 487 \text{ L/min}$$

5-1-7/27.3ii): The foam supply rate based upon the horizontal sectional area of the single largest tank:

$$6.0 \text{ L/min/m}^2 \times 130.5 \text{ m}^2 = 783 \text{ L/min}$$

5-1-7/27.3iii): The foam supply rate based upon the area protected by the largest monitor:

$$3.0 \text{ L/min/m}^2 \times 130.5 \text{ m}^2 = *392 \text{ L/min}$$

(* Must not be less than 1,250 L/min)

The foam supply rate is therefore 1,250 L/min, which is the largest of the three above calculated rates.

2. Determination of the required quantity of foam concentrate:

5-1-7/27.5: 1,250 L/min is the foam supply rate from *5-1-7/27.3iii*). This flow rate for twenty minutes will require $20 \text{ min} \times 1,250 \text{ L/min} = 25,000$ liters of foam-water solution.

If a 6% foam concentrate is used, then 6% of the 25,000 liters must be foam concentrate, or $0.06 \times 25,000 = 1500$ liters

3. Determination of the minimum monitor capacity:

5-1-7/27.7& 5-1-7/27.9: Each monitor must supply at least:

(a) 50% of the required system foam rate; or

(b) 3 L/min/m² for the area it protects; or

(c) 1,250 L/min, whichever is greater

$$50\% \text{ of the foam supply rate} = 1,250 \text{ L/min} \times 0.5 = 625 \text{ L/min}$$

$$3.0 \text{ L/min/m}^2 \text{ times the area the monitor protects} = 130.5 \text{ m}^2 \times 3.0 \text{ L/min/m}^2 \\ = 390.6 \text{ L/min}$$

Based upon (c) above, the minimum monitor capacity is therefore 1,250 L/min.

3.3 Additional Requirements for “Chemical Carrier” Deck Foam Systems**3.3.1 Application**

SVR 5-9-11/3.1 requires all chemical carriers, except those solely dedicated to the carriage of non-flammable cargoes (see SVR 5-9-11/3.1.2), to be fitted with a deck foam system complying with SVR 5-9-11/3.2 through 5-9-11/3.12.

3.3.2 General

In accordance with SVR 5-9-11/3.3, a deck foam system is to be provided which is capable of discharging foam at the required rates to the entire cargo tank deck area, as well as into any cargo that is open due to a rupture in the deck. This system will normally consist of fixed monitors, as well as required hand line applicators.

3.3.3 Controls

The deck foam system is to be capable of simple and rapid operation, as specified in SVR 5-9-11/3.4. This would require that the controls and arrangements for the system be designed so that it can be brought into operation quickly and would preclude complicated interconnections with non-fire-fighting systems.

SVR 5-9-11/3.4 also requires that the main control station for the system be located outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the area being protected by the foam system. This Paragraph is considered to require the control arrangements (controls for the motors, valves, pumps, etc., required to operate the system) to be in the location described above. The deck foam system concentrate tank, proportioner unit, etc., are also normally installed in the above location but are not specifically mandated to be located at the control station. The pump(s) supplying water are normally located down in the engine room but the controls for the pumps, as well as all portions of the foam system not located within the space containing the foam system control station, should be operable from the foam system control station.

3.3.4 Application Rate

The minimum flow rate for the deck foam system is determined by the criteria identified in SVR 5-9-11/3.5. This Paragraph identifies three different sets of criteria, and the minimum capacity of the system is not to be less than the largest of the coverage rates identified. These different sets of criteria are discussed below.

- i) SVR 5-9-11/3.5.1 requires a system flow rate of not less than 2.0 L/min/m² (0.049 gpm/ft²) based upon the total cargo tank deck area. The cargo tank deck area is further defined as the maximum breadth of the vessel multiplied by the total longitudinal extent of the cargo tank spaces.
- ii) SVR 5-9-11/3.5.2 requires a system flow rate of not less than 20.0 L/min/m² (0.49 gpm/ft²) based upon the horizontal deck area of the single largest cargo tank.
- iii) SVR 5-9-11/3.5.3 requires a system flow rate of not less than 10.0 L/min/m² (0.245 gpm/ft²) of the area protected by the largest monitor, but not less than 1,250 L/min.

As indicated above, the minimum flow rate of the system is not to be less than the largest rate identified in the three sets of criteria specified in SVR 5-9-11/3.5.1, 5-9-11/3.5.2 and 5-9-11/3.5.3.

3.3.5 Foam Concentrate Quantity

The amount of foam concentrate carried onboard is to be sufficient to supply the system for a period of at least 30 minutes when operating at the system's maximum flow rate, as determined above. The above is based upon the requirements in SVR 5-9-11/3.6.

The amount of foam concentrate required to be carried should be calculated based upon the maximum rated capacity of the system for the time period specified above.

3.3.6 System Arrangements

Based upon the requirements of SVR 5-9-11/3.7, the cargo deck foam system is to be a fixed system and is to consist of monitors as well as foam applicators.

3.3.7 Foam Monitors

The cargo deck foam monitors are a critical component of the deck foam system since they provide the crew with the ability to engage the fire by placing large quantities of foam where needed from a relatively safe location. SVR 5-9-11/3.7, 5-9-11/3.8, and 5-9-11/3.9 provide specific requirements concerning the number, capacity and locations of the monitors. Details of the monitor(s), as well as the proposed locations should be checked. The requirements of SVR 5-9-11/3.7, 5-9-11/3.8, and 5-9-11/3.9 are summarized below:

Each monitor must have the capacity to deliver not less than 50% of the foam required in SVR 5-9-11/3.5.1 or 5-9-11/3.5.2. In addition, each monitor is to have a capacity of at least 10.0 L/min/m² (0.245 gpm/ft²) of the area protected by that monitor, but in no case less than 1,250 L/min. (330 gpm). The capacity of the monitors should be verified by reviewing the monitor capacity curves produced by the manufacturer at the pressure indicated in the foam piping system pressure drop calculations. Accordingly, pressure drop calculations for the foam piping distribution system should be requested and reviewed.

The number and position of the monitors is to be adequate to provide coverage to the entire cargo tank deck area, as well as into any cargo tank that is open due to a rupture in the deck. The coverage area of any particular monitor is to be based upon the following:

- i) Only the area forward of the monitor is to be considered to be protected by that particular monitor.
- ii) The distance to the farthest point of the coverage of a monitor is not to be more than 75% of the monitor throw in still air.
- iii) Monitors are to be provided both on the port and starboard sides of the vessel at the front of the accommodations space.

Compliance regarding the locations and capacities of the monitors with the above requirements should be verified by reviewing a deck foam system arrangement drawing in conjunction with the monitor capacity and throw data provided by the monitor manufacturer.

3.3.8 Foam Applicators

The foam applicators are also a critical component of the deck foam system as they provide the crew with the versatility and flexibility needed to combat a cargo tank fire. SVR 5-9-11/3.7, 5-9-11/3.9 and 5-9-11/3.10 provide specific requirements concerning the number, capacity and locations of the applicators. Details of the applicators as well as the proposed locations should be verified. The requirements of SVR 5-9-11/3.7, 5-9-11/3.9 and 5-9-11/3.10 are summarized below:

Each applicator must have the capacity to deliver not less than 400 L/min (105.7 gpm) and a throw of at least 15 m (49.2 feet) in still air. Once again, the capacity and throw of the applicators should be verified by reviewing the capacity and throw curves produced by the manufacturer at the pressure indicated in the foam piping system pressure drop calculations.

Each monitor station is to be provided with a hose connection for an applicator, including the monitor stations provided at the port and starboard sides of the vessel at the front of the accommodations space.

The number and locations of the foam main outlets for hose connections to serve the foam applicators is to be sufficient to ensure that at least two (2) applicators can be directed to any part of the cargo tank deck area.

At least four (4) applicators with the appropriate hoses, connection devices, etc., are to be carried onboard.

3.3.9 Isolation Valves

The foam main is to be fitted with isolation valves immediately forward of any monitor position so as to provide the means to isolate damaged sections of the main, as required by SVR 5-9-11/3.11. These isolation valves should be of a type, design and material that will ensure that they will not rendered ineffective by heat.

3.3.10 Simultaneous Operation

SVR 5-9-11/3.12 specifies that the operation of the deck foam system at its required output shall permit the simultaneous use of the minimum required number of jets of water at the required pressure from the fire main. This is especially important to note when the fire pumps are being utilized to also supply the foam system. If the fire pumps are used for this service, the combined capacity of the fire pumps must be capable of supplying the total required fire main capacity at the required pressures while simultaneously supplying the maximum capacity required by the foam system.

3.3.11 Foam Concentrate Quality and Testing

It is critical to recognize that the foam to be used must be suitable for the particular cargoes to be carried. As many chemical cargoes are polar solvents, the suitability of the foam for such cargoes should be verified.

Also, it is important to recognize that the effectiveness of any particular foam concentrate may vary when used on fires from different chemicals. However, provisions of a system to supply multiple types of foam concentrates would be difficult and may introduce unwanted complications. Accordingly, SVR 5-9-11/3.2 indicates that only one type of foam concentrate should be supplied, and it should be effective for the maximum possible number of cargoes intended to be carried. However, for other cargoes for which foam is not effective or is incompatible, additional arrangements to the satisfaction of the Administration should be provided. Confirmation of the suitability of the foam concentrate with all chemicals to be carried is important.

3.3.12 Suitability of Foam Concentrate

As the quality of the foam and its suitability for use in the intended application is critical, the International Maritime Organization (IMO) has developed performance testing criteria for foam concentrates. This testing criterion is provided in IMO Circular 582, "Guidelines for the Performance and Testing Criteria, and Surveys of Low - Expansion Foam Concentrates for Fixed Fire Extinguishing Systems". The testing procedure covers a wide spectrum of requirements, from freezing and drain time testing to expansion ratio and fire testing. Certain portions of the testing, such as the expansion ratio, drain time and fire tests, are dependent upon the types of mixing and expansion equipment used (proportioners, monitors, etc.). Accordingly, it should be verified that the foam concentrate has been tested in accordance with IMO Circular 582 and further, that the equipment being provided onboard is the same equipment utilized during the testing or is equipment that will product foam which is equivalent to that tested.

Example Calculation of the Capacity of Foam System for Chemical Tankers (based upon MSC Circular 314)

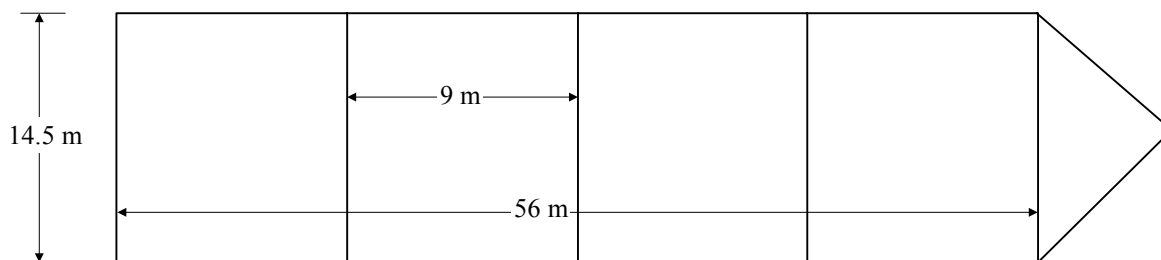
Ship particulars

- Beam = 14.5 m
- Length of cargo area = 56 m
- Length of largest cargo tank = 9 m
- Cargo deck area = $14.5 \text{ m} \times 56 \text{ m} = 812 \text{ m}^2$
- Horizontal sectional area of single largest tank = $14.5 \text{ m} \times 9 \text{ m} = 130.5 \text{ m}^2$

(Note: For the purpose of this illustration, a single tank encompasses the entire beam of the vessel)

- Proposed monitor spacing = 9 m
- Area protected by largest monitor = $9 \text{ m} \times 14.5 \text{ m} = 130.5 \text{ m}^2$

FIGURE 2
Calculation of Foam System Capacity – Chemical Tankers



Calculations Based Upon the Above Criteria

1. Determination of foam supply rate:

The largest of:

5-9-11/3.5.1: the foam supply rate based upon the entire cargo deck area.

$$2 \text{ L/min/m}^2 \times 812 \text{ m}^2 = 1,624 \text{ L/min}$$

5-9-11/3.5.2: the foam supply rate based upon the horizontal sectional area of the single largest tank

$$20 \text{ L/min/m}^2 \times 130.5 \text{ m}^2 = 2,610 \text{ L/min}$$

5-9-11/3.5.3: the foam supply rate based upon the area protected by the largest monitor

$$10 \text{ L/min/m}^2 \times 130.5 \text{ m}^2 = 1,305 \text{ L/min}$$

(* Shall not be less than 1,250 L/min)

The foam supply rate is therefore 2,610 L/min which is the largest of the three above calculated rates.

2. Determination of the required quantity of foam concentrate:

5-9-11/3.6: 2,610 L/min is the foam supply rate from 5-9-11/3.5. This flow rate for thirty minutes will require $30 \text{ min} \times 2,610 \text{ L/min} = 78,300$ liters of foam-water solution.

If a 5% foam concentrate is used, then 5% of the 78,300 liters must be foam concentrate, or $0.05 \times 78,300 = 3,915$ liters

3. Determination of the minimum monitor capacity:

5-9-11/3.7: Each monitor must supply at least:

- (a) 50% of the required foam rate; or
- (b) 10 L/min/m² for the area it protects; or
- (c) 1,250 L/min, whichever is greater

50% of the foam supply rate = 2,610 L/min × 0.5 = 1,305 L/min

10 L/min/m² times the area the monitor protects = 130.5 m² × 10 L/min/m²
= 1,305 L/min

The minimum monitor capacity is therefore 1,305 L/min.

Designer Wishes to Increase Monitor Spacing to 15 meters Between Monitors

1. Recalculate required foam supply:

5-9-11/3.5.1: same as before—1,624 L/min

5-9-11/3.5.2: same as before—2,610 L/min

5-9-11/3.5.3: larger area covered by monitor is 15 m × 14.5 = 217.5 m²

10 L/m²/min × 217.5 m² = 2,175 L/min

The required foam rate therefore remains 2,610 liters per minute.

2. Recalculate required foam concentrate supply:

5-9-11/3.6: The minimum foam supply rate has not changed therefore 3915 liters of foam concentrate are still required.

3. Recalculate minimum monitor capacity:

5-9-11/3.7: 50% of foam supply rate:

2,610 L/min × 0.5 = 1,305 L/min

10 L/min/m² of area protected by monitor = 10 L/min/m² × 217.5 m² = 2,175 L/min

The new minimum monitor capacity is therefore 2,175 L/min.

3.4 Additional Requirements for Fixed High Expansion Foam Systems in Machinery Spaces

3.4.1 Application

SVR 4-7-2/1.1.1ii) recognizes the use of a fixed high expansion foam system as an acceptable system to meet the requirement for a fixed fire extinguishing system in the machinery space. In addition to the general ABS requirements noted above, SVR 4-7-2/1.1.1ii) references SVR 4-7-3/5.1 for the specific requirements. The requirements of SVR 4-7-3/5.1 are outlined below.

3.4.2 General

SVR 4-7-3/5.1.1 requires that the high expansion foam system is to be a fixed system and capable of rapidly discharging the foam through fixed nozzles. The arrangement and distribution of the nozzles should be reviewed to ensure adequate coverage of the protected space.

3.4.3 Application Rate

The discharge rate for the high expansion foam system is to be sufficient to fill the greatest space being protected at a rate of not less than 1 meter (3.3 feet) per minute, as per SVR 4-7-3/5.1.1. Calculations, along with details of the system capacity, should be submitted to verify compliance with this requirement.

3.4.4 Foam Concentrate Quantity

The quantity of foam concentrate is to be sufficient to produce a volume of foam equal to at least five (5) times the volume of the largest space to be protected, as per SVR 4-7-3/5.1.1. The quantity of foam concentrate to be provided, in association with the particular foam's expansion ratio, should be reviewed and determined sufficient during plan review.

3.4.5 Foam Concentrate

Adequate details of the foam should be submitted to confirm its suitability for the intended service. In addition, the details should identify the expansion ratio of the foam which is not to exceed 1,000:1 as per SVR 4-7-3/5.1.1.

3.4.6 System Design

The supply ducts for delivering foam, the air intakes to the foam generator and the number of foam-producing units are to be such as to provide effective foam productions and distribution, in accordance with SVR 4-7-3/5.1.2. Accordingly, the capacities of the foam generators, designs of the ducts, etc., should be reviewed to verify their suitability for the required system capacity.

3.4.7 System Arrangements

SVR 4-7-3/5.1.3 specifies that the arrangement of the foam generator delivery ducting is to be such that a fire in the protected space will not affect the foam generating equipment. In addition, it should be noted that the location of the foam generating equipment, foam concentrate storage, source of power (as well as the power supply arrangements), ventilation, source of water, etc., are to be such that a fire in the protected space will not affect the foam generating system and the same should be verified during plan review.

In association with the above, the location of the controls, as well as the foam generating equipment, foam concentrate storage and source of power should be such that access to the spaces containing this equipment will not be cut off due to a fire in the protected space.

3.4.8 Foam Concentrate Quality and Testing

As indicated in SVR 4-7-3/5.1.4, the high expansion foam concentrate is to be approved in accordance with IMO Circular 670, "Guidelines for the Performance and Testing Criteria. And Surveys of High Expansion Foam Concentrates for Fixed Fire Extinguishing Systems".

Similar to the testing requirements of IMO Circular 582, "Guidelines for the Performance and Testing Criteria, and Surveys of Low-Expansion Foam Concentrates for Fixed Fire Extinguishing Systems" discussed above, the testing procedures of IMO Circular 670 cover a wide spectrum of requirements, from freezing and drain time testing to expansion ratio and fire testing. Also, as certain portions of the testing, such as the expansion ratio, drain time and fire tests, are dependent upon the types of mixing and expansion equipment used (proportioners, aerators, etc.), the equipment being provided onboard must be the same equipment utilized during the testing or equipment that will produce foam which is equivalent to that tested.

3.5 Additional Requirements for Supplementary Fixed Low Expansion Foam Systems in Machinery Spaces

3.5.1 General

Similar to SOLAS, SVR 4-7-3/5.3.1 indicates that the use of a fixed low expansion foam system is not considered acceptable as the required fixed fire extinguishing system in a machinery space. However, it is recognized that such systems are installed as a supplementary or additional system to fight fires in the bilge areas and will be relied on by the crew during a hazard. Accordingly, in addition to the general ABS requirements noted above, SVR 4-7-3/5.3 provides requirements for these systems. These requirements are outlined below.

3.5.2 System Arrangement

The system is to be arranged to discharge the foam through a permanent piping distribution system, fixed nozzles and adequate control valves, which will allow for the effective distribute the foam over the protected area(s).

3.5.3 System Capacity

The system is to be capable of generating sufficient foam in a five (5) minute period to cover the largest space over which oil fuel is liable to spread to a depth of 150 mm (6.0 inches).

3.5.4 Expansion Ratio

Adequate details of the foam should be submitted to confirm its suitability for the intended service. In addition, the details should identify the expansion ratio of the foam that is not to exceed 12:1, as per SVR 4-7-3/5.3.1.

3.5.5 Controls

The control arrangements for the system are to be readily accessible, in a location that will not be cut off by a fire in the area being protected and are to be easy to operate, as per SVR 4-7-3/5.3.2. These arrangements should be verified during plan review, or if such information is not provided in the submittal, a note made requesting the Surveyor to verify the arrangements.

3.5.6 Foam Concentrate Quality and Testing

As indicated in SVR 4-7-3/5.3.3, the low expansion foam concentrate is to be approved in accordance with IMO Circular 582, "Guidelines for the Performance and Testing Criteria, and Surveys of Low –Expansion Foam Concentrates for Fixed Fire Extinguishing Systems". As discussed above, it is important to ensure that the equipment being provided onboard is the same equipment utilized during the testing or is equipment that will produce foam that is equivalent to that tested.

3.6 Additional Requirements for Helicopter Landing Facilities

3.6.1 Application

In accordance with SVR 4-7-2/5.3.1, each helicopter deck onboard a vessel designated for helicopter operations must be provided with a fixed foam fire extinguishing system complying with SVR 4-7-2/5.3.2(d) and 4-7-2/5.3.3

For clarification, SVR 4-7-2/5.3.1 indicates that a helicopter deck is to be considered as the helicopter landing area on a vessel, including all structure, fire fighting appliances and other equipment necessary for the safe operation of helicopters, but does not include those areas for occasional or emergency helicopter operations (e.g., circle H marked on hatch covers for drop-off/pickup of pilot).

3.6.2 System Arrangement

In accordance with SVR 4-7-2/5.3.2(d), a fixed foam fire extinguishing system, consisting of monitors or hose streams or both, is to be installed to protect the helicopter landing area.

3.6.3 System Capacity

The system is to be capable of delivering foam solution at a discharge rate in accordance with the following table for at least five minutes and calculations verifying compliance with the same should be submitted and reviewed.

TABLE 1
System Capacity

<i>Category</i>	<i>Helicopter overall length, L_H</i>	<i>Liters/min</i>	<i>Gpm</i>
H1	$L_H < 15 \text{ m (49 ft)}$	250	66
H2	$15 \text{ m (49 ft)} \leq L_H < 24 \text{ m (79 ft)}$	500	132
H3	$24 \text{ m (79 ft)} \leq L_H < 35 \text{ m (115 ft)}$	800	211

3.6.4 Foam Concentrate

In accordance with SVR 4-7-3/5.3.2(d), the foam agent is required to meet the performance standards for Level “B” foam in the International Civil Aviation Organization’s Airport Services Manual (Part 1 Chapter 8, Paragraph 8.1.5, Table 8-1) and be suitable for use with sea water. Adequate details regarding the foam concentrate should be submitted to verify compliance with this requirement.

3.6.5 Simultaneous Operation

SVR 4-7-3/5.3.2(d) indicates that the operation of the foam system is not to interfere with the simultaneous operation of the fire main. Accordingly, where the foam system is supplied off of the fire main system, the capacity of the fire pumps is to be increased accordingly.



SECTION 7 **Gas Carrier Cargo Area Fire Extinguishing Systems**

1 Unique Hazards of Fires Onboard Gas Carriers

Gas carriers present a number of unique fire hazards. Therefore, the fire-fighting systems used must be carefully reviewed to ensure they are adequate for the dangers involved. The unique hazards associated with gas carriers include:

- Boiling Liquid Expanding Vapor Explosions (BLEVEs)
- Vapor release of cargo, leading to creation of gas clouds
- Liquid pool fires, where discharge of water would only increase the evaporation rate and intensify the fire
- Jet fires

1.1 Flammability

When a gas is released to the atmosphere, it will burn if within its flammable range or if exposed to a source of ignition. Depending upon the conditions under which combustion takes place, some degree of overpressure will also occur due to the rapid expansion of the heated gas. A liquid spill or vapor cloud burning over open water will develop little overpressure due to the unconfined nature of its surroundings. However, ignition of vapor within an enclosed space rapidly creates an overpressure sufficient to burst the boundaries.

In cases of partial confinement, such as what might occur among shore plants and equipment, ignition may produce an overpressure sufficient to cause substantial damage, thus escalating the hazard and its consequences. If a leakage of liquid or vapor occurs from a pipeline under pressure, it will burn as a jet and continue to burn as long as fuel is supplied.

1.1.1 BLEVE

A particularly destructive form of vapor burn, BLEVE is associated with the storage of liquefied gas in pressurized containers. The BLEVE is a phenomenon associated with the sudden and catastrophic failure of a pressurized containment vessel when subjected to surrounding fire. This is one of the most devastating of liquefied gas accident scenarios.

In all BLEVE incidents, the pressure vessel is subjected to flame impingement. BLEVEs occur when the fire increases internal tank pressure, and particularly at that part of the vessel not cooled by the internal liquid, the structure can be weakened to the point of failure. As a result, the tank can suddenly split, throwing pieces of the vessel's shell a considerable distance, and concave sections such as end caps, being propelled like rockets if they contain liquid. Upon rupture, the sudden decompression produces a blast and the pressure immediately drops. At this time, the liquid temperature is well above its atmospheric boiling point, which then spontaneously boils off, creates large quantities of vapor that travels upward along with the liquid droplets.

When the gas/air mixture is within its flammable limits, it will ignite from the tearing metal of the surrounding fire, creating a fireball that can reach gigantic proportions. A sudden release of gas provides further fuel for the rising fireball. The rapidly expanding vapor produces a further blast and intense heat radiation.

1.1.2 Jet Fires

Small leaks from pump glands, pipe flanges or from vent risers will initially produce vapor. This vapor will not ignite spontaneously. However, if the escape is large, then there may be a risk of the vapor cloud spreading to a source of ignition. If ignition does occur, it will almost certainly flash back to the leak. Leaks from pipelines are likely to be under pressure and, if ignited, will give rise to a jet flame. While arrangements for the emergency shutdown of the pumps and remote closure of ESD valves are required, pressure may remain in a closed pipeline until the liquid trapped within has been expelled through the leak. In such a case, the best course of action is often to allow the fire to burn out. The alternative of extinguishing the fire has a high risk of producing a vapor cloud and having a flash back from re-ignition of the vapor. While the fire is being allowed to burn itself out, the surroundings should be protected with cooling water.

1.1.3 Liquid (Pool) Fires

Significant pool fires are not likely on the vessel's decks because the amount of liquid which can be spilled in such a location is limited. The arrangement of the vessel's deck, with its camber and open scuppers, will allow liquid spillage to flow quickly and freely away over the vessel's side. Prompt initiation of ESD procedures further limits the availability of liquid cargo. However, any spillage of flammable gases in a liquefied state will result in a gas vapor cloud as the liquid evaporates. The gas generation rate will be large due to the low liquefaction storage temperature and the large amount of heat available from the surrounding structure and environment. Water should never be applied to a burning liquefied gas pool, which would provide a heat source for more rapid vaporization of the liquid and increase the rate of burning.

Any ignition of the ensuing vapor cloud would then result in a pool fire. The emissive power of a flame surface increases with pool diameter. LNG vapors burn in the initial stages with a comparatively clear flame; LPG, however, burns with a greater production of soot and, therefore, maximum surface emissive powers are lower than for LNG. Heat radiation levels from both LNG and LPG pool fires dictate that unprotected personnel must escape from the immediate vicinity as quickly as possible. Because of the damage which radiation can inflict on surrounding tanks and structure, such items are required to be protected by a water deluge system.

2 General Principles of Cargo Deck Dry Chemical Extinguishing System

Vessels carrying liquefied gases in bulk are required to be fitted with a dry chemical fire extinguisher conforming to IMO Regulations. The system is used to protect the cargo deck area and all loading-station manifolds on the vessel. A deck system is typically made up of several independent skid-mounted units. The units are self-contained fire-fighting systems that use a dry chemical-extinguishing agent propelled by a high-pressure inert gas such as nitrogen.

Dry chemical extinguishing agents are chemicals in powder form. Dry chemical powders, such as sodium bicarbonate, potassium bicarbonate and urea potassium bicarbonate can be very effective in extinguishing small LNG or LPG fires. Dry chemical powders are effective in dealing with gas fires on deck or in extinguishing jet fires from a holed pipeline. They have been used successfully in extinguishing fires at vent risers.

2.1 Extinguishing Effects of Dry Chemical

Dry chemical agents extinguish fire to the greatest extent by breaking the combustion chain. Minor amounts of cooling, smothering and shielding of radiant heat are also present.

2.1.1 Chain Breaking

As discussed in Section 1 of these Guidance Notes, chain reactions are necessary for continued combustion. In these chain reactions, fuel and oxygen molecules are broken down by heat, and they recombine into new molecules, giving off additional heat. This additional heat breaks down more molecules, which then recombine and give off still more heat. The fire thus builds, or at least sustains itself, through reactions that liberate enough heat to set off other reactions.

Dry chemical (and other agents such as the halogen) attacks this chain of reactions. It does so by reducing the ability of the molecular fragments to recombine and form additional radicals. It also combines with the fragments of fuel and oxygen molecules so that the fuel cannot be oxidized. Although the process is not completely understood, chain breaking is the most effective extinguishing action of dry chemical.

2.1.2 Cooling

No dry chemical exhibits any great capacity for cooling. However, a small amount of cooling takes place simply because the dry chemical is at a lower temperature than the burning material. Heat is transferred from the hotter fuel to the cooler dry chemical when the latter is introduced into the fire.

2.1.3 Smothering

When dry chemical reacts with the heat and burning material, some carbon dioxide and water vapor are produced. These dilute the fuel vapors and the air surrounding the fire. The result is a limited smothering effect.

2.1.4 Shielding of Radiant Heat

Dry chemical produces an opaque cloud in the combustion area. This cloud reduces the amount of heat that is radiated back to the heart of the fire, i.e., the opaque cloud absorbs some of the radiation feedback that is required to sustain the fire. Less fuel vapor is produced, and the fire becomes less intense.

3 ABS Requirements for Fire Fighting Systems Onboard Gas Carriers

The following information is provided as general guidance and instruction regarding the ABS requirements for fixed dry chemical fire extinguishing systems. However, reference should always be made to the Rules applicable to the specific vessel concerned for the complete set of requirements.

3.1 Dry Chemical Powder Fire Extinguishing Systems

Vessels intended to carry flammable products are required to be fitted with a fixed dry chemical powder type extinguishing system for the purpose of fighting fires on the deck in the cargo area and bow or stern cargo handling areas, if applicable. The ABS requirements for such systems are found in SVR 5-8-11/4.

3.1.1 Coverage Area and Arrangement

In accordance with SVR 5-8-11/4.2, the arrangement and capacity of the system is to provide the ability to deliver powder from at least two hand hose lines or combination monitor/hand hose lines to any part of the above-deck exposed cargo area including above-deck product piping. In addition, at least one hand hose line or monitor should be situated at the after end of the cargo area, as per SVR 5-8-11/4.3.

Per SVR 5-8-11/4.6, coverage considered from fixed monitors should be limited to the following:

TABLE 1
Fixed Monitor Requirements

Capacity of fixed monitor	10 kg/s	25 kg/s	45 kg/s
Maximum permitted coverage distance	10 m	30 m	40 m

Hand hose lines have a maximum effective distance of coverage that is equal to the length of hose. The location of fixed monitors and hand line stations, as well as the hose lengths, should be re-evaluated to ensure compliance with the above requirements.

3.1.2 Dry Powder Units

Per SVR 5-8-11/4.3, vessels with a cargo capacity of 1,000 m³ (35,315 ft³) or more require a dry chemical fire extinguishing system. This system must consist of at least two (2) independent and self-contained, dry chemical powder units, which include the associated controls, pressurizing medium fixed piping, monitors and/or hand hose lines.

For vessels with a cargo capacity of less than 1,000 m³ (35,315 ft³), only one (1) unit is necessary. This system must be activated by an inert gas such as nitrogen, used exclusively for this purpose and stored in pressure vessels adjacent to the powder containers. Details of the powder units should be requested and compliance with the same confirmed.

3.1.3 Pressure Vessels

All pressure vessels associated with the powder units would be required to comply with SVR Part 4, Chapter 4 and appropriate certification verified, as necessary.

3.1.4 Controls

If monitors are installed, they must be capable of actuation and discharge both locally and remotely. The monitor does not have to be aimed remotely, provided it can deliver the necessary powder (from a single position) to all necessary areas of coverage.

3.1.5 Piping Arrangements

Per SVR 5-8-11/4.4, a fire-extinguishing unit with two or more monitors, hand hose lines or a combination thereof should have independent pipes (with a manifold at the powder container), unless a suitable alternative means is provided to ensure proper performance. Where two or more pipes are attached to a unit, the arrangement should be such that any or all of the monitors and hand hose lines should be capable of simultaneous or sequential operation at their rated capacities.

Where fixed piping is provided between the powder container and a hand hose line or monitor, the length of piping should not exceed that length which is capable of maintaining the powder in a fluidized state during sustained or intermittent use, and which can be purged of powder when the system is shut down in accordance with SVR 5-8-11/4.5. This can be difficult to verify since the ability to maintain the powder in solution is dependent upon a number of issues. As a minimum, appropriate criteria from the manufacturer justifying the sizing and length of piping should be requested.

3.1.6 Monitors and Hand Lines Requirements

The capacity of a monitor should not be less than 10 kg/s (22 lb/s). Hand hose lines should be non-kinkable and be fitted with a nozzle capable of on/off operation and discharge at a rate not less than 3.5 kg/s (7.7 lbs/s). The maximum discharge rate should be such as to allow operation by one man. The length of a hand hose line should not exceed 33 m (108.3 ft). Hand hose lines and nozzles should be of weather-resistant construction or stored in weather-resistant housing or covers and be readily accessible. These requirements are found in SVR 5-8-11/4.5.

In addition, the monitors should be certified in accordance with SVR 4-1-1/Table 4.

3.1.7 System Capacity

A sufficient quantity of dry chemical powder is to be stored in each container to provide a minimum 45 seconds discharge time for all monitors and hand hose lines attached to each powder unit in accordance with SVR 5-8-11/4.6.

3.1.8 Bow/Stern Loading and Discharge Arrangements

In accordance with SVR 5-8-11/4.7, vessels fitted with bow or stern loading and discharge arrangements are to be provided with an additional dry chemical powder unit complete with at least one monitor and one hand hose line. This additional unit should be located to protect the bow or stern loading and discharge arrangements. In addition, hand hose lines are to be provided to protect the area of the cargo line forward or aft of the cargo area (see SVR 5-8-1/3.6 for definition of cargo area).

3.1.9 General Piping Requirements

In addition to the above, system piping components are to comply with the general requirements and limitations in SVR Sections 4-6-1 and 4-6-2. In addition, depending upon the pressure “Class” (see SVR 4-6-1/Table 1) of the system, the components may also be required to be certified in accordance with SVR 4-6-1/Table 2.

3.2 Cargo Area Water Spray Systems

Fixed water deluge systems are required to be provided to protect surfaces such as vessel’s structures, cargo tanks and piping, which can be exposed to liquefied gas fires. Such systems are designed to provide a layer of water over the exposed surfaces, and by this means, the radiant heat from the fire is absorbed by the water. Provided a water layer of some thickness can be maintained, the surface temperature usually will not exceed 100°C (212°F).

3.2.1 Areas to be Protected

In association with SVR 5-8-11/3.1, vessels carrying flammable or toxic products, should have a water spray system for cooling, fire prevention and crew protection equipment that can cover the following:

- Cargo tank domes and any other exposed parts of cargo tanks
- Exposed on-deck storage containers of flammable or toxic products
- Cargo liquid, vapor discharge and loading manifolds and the area surrounding the control valves or any other areas where essential control valves are situated
- Boundaries of superstructures and deckhouses that are normally manned
- Cargo compressor and pump rooms, storerooms containing high fire risk items and cargo control rooms, which all face the cargo area

Note: Boundaries of unmanned forecastle structures that do not contain high fire risk items or equipment do not require water spray protection.

3.2.2 Coverage Rate

As discussed in SVR 5-8-11/3.2, the system is to be capable of covering all areas mentioned with a uniformly distributed water spray of at least 10 L/min/m² (0.24 gpm/ft²) for horizontal projected surfaces and 4 L/min/m² (0.096 gpm/ft²) for vertical surfaces. For structures having no clearly defined horizontal or vertical surfaces, the capacity of the water spray system should be the greater of the projected horizontal surface multiplied by 10 L/min/m² (0.24 gpm/ft²) or the actual surface multiplied by 4 L/min/m² (0.096 gpm/ft²). On vertical surfaces, spacing of nozzles protecting lower areas may take into account anticipated rundown from higher areas.

3.2.3 Piping Arrangement

For isolating damaged sections, stop valves are required to be fitted in the spray system at various intervals. Alternatively, the system is permitted to be divided into two or more sections, which may be operated independently provided that the necessary controls are located together aft of the cargo area. However, a section protecting any area included in SVR 5-8-11/3.1.1 (e.g., exposed cargo tank domes and any exposed parts of cargo tanks) and SVR 5-8-11/3.1.2 (exposed on-deck storage vessels for flammable or toxic products) should cover the whole of the athwartship tank grouping which includes that area. In addition, the vertical distances between water spray nozzles for protection of vertical surfaces is not to exceed 3.7 m (12 ft).

3.2.4 Pumping Capacity

The capacity of the water spray pumps should be sufficient to deliver the required amount of water to all areas simultaneously or where the system is divided into sections, the arrangements and capacity should be such as to supply water simultaneously to any one section and to the surfaces specified above as indicated in SVR 5-8-11/3.3. Alternatively, the main fire pumps may be used for this service, provided that their total capacity is increased by the amount needed for the spray system. In either case, a connection, through a stop valve, should be made between the fire main and water spray main outside the cargo area. Water pumps normally used for other services may be arranged to supply the water spray main if specifically approved by the Administration.

3.2.5 General Piping Requirements

In addition to the requirements in SVR Sections 4-6-1 and 4-6-2; all pipes, valves, nozzles and other fittings in the water spray systems should be resistant to corrosion by seawater (for which purpose galvanized pipe, for example, may be used) and to the effect of fire, as required in SVR 5-8-11/3.5.

3.2.6 Controls

Remote starting of pumps supplying the water spray system and remote operation of any normally closed valves in the system should be arranged in suitable locations outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected. Details verifying compliance with the above should be reviewed in accordance with SVR 5-8-11/3.6.

3.3 Fire Main System

Refer to Section 3 for more information about the requirements for fire main systems installed on gas carriers.

3.4 Cargo Pump/Compressor Room Fixed CO₂ Fire Extinguishing System

Per SVR 5-8-11/5, the cargo compressor and pump rooms of any vessel must have a fixed carbon dioxide fire-extinguishing system. For more information about the requirements for this system, refer to Section 4.

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SECTION **8 Portable/Semi-portable Fire Extinguishers**

Because a fire starts small, most fires that are discovered early and attacked quickly are usually controlled and extinguished before they can grow out of control. The ready availability of suitable portable and semi-portable fire extinguishers is therefore very important. Although limited in capacity, portable extinguishers are easy to transport and can be used to engage a fire quickly. Semi-portable extinguishing systems bring larger amounts of extinguishing agent to the fire but are more difficult to transport. When used properly, both can be very effective in controlling and extinguishing a small, localized fire.

Not all extinguishers are the same. Fire extinguishers can vary in size, as well as the extinguishing medium that they use. Therefore, not all extinguishers are suitable for use on various types of fires. The usual types of extinguishing agents found in portable extinguishers onboard a vessel include:

- Water
- Foam
- Carbon-dioxide
- Dry chemical
- Dry powder

Portable extinguishers using Halon as the extinguishing agent have also been very popular. However, with the Montreal Protocol and the restrictions developed regarding the manufacture and use of Halon, such extinguishers are being phased out and will not be covered in this Section.

Within the various types of extinguishing mediums, there are differences between the specific extinguishing medium and the methods by which the medium is expelled. Extinguishers also vary significantly in size ranging from very small portables, which can be transported to the fire quickly and easily, to large semi-portable units, which the container must basically remain in place and the extinguishing medium discharged through a long hose.

Note: This Section examines portable and semi-portable fire extinguishers only. For more information about other types of portable fire-fighting appliances required by the Rules (e.g., portable foam applicators, fire axes, fireman's outfits, etc.), refer to Section 10.

1 Portable and Semi-portable Fire Extinguishers

The following Paragraphs discuss the types of portable extinguishers available and their differences within the individual categories of extinguishers. A general description of the various types of portable extinguishers (including individual comparisons, characteristics, and limitations) is provided in IMO Resolution A.602(15). For more information, refer to FSS Code Chapter 5, and Appendix C – IMO Resolution A.602(15).

1.1 Water-type Fire Extinguishers

Extinguishers that use water or water solution as the extinguishing agent are suitable only for class “A” fires (refer to Section 2 for more information about fire classifications.). There are typically three types of water extinguishers used onboard, including *soda-acid*, *cartridge-operated* and *stored pressure water extinguishers*. Manufacturing of the soda-acid and cartridge-operated extinguishers has generally been discontinued. However, since large numbers of these types of extinguishers are still in use, they will be discussed along with the currently produced type, the stored pressure water extinguishers.

Water extinguishers may be filled with either water or a water/antifreeze solution. Accordingly, water extinguishers could be subject to freezing and adherence to the manufacturer’s recommendations regarding the environmental conditions of the storage locations is important.

1.1.1 Soda-Acid Extinguishers

The soda acid extinguisher normally comes in a 9.5 liter (2½ gallon) size and weighs about 13.6 kg (30 lb) when charged. It has a typical reach of 10.7 to 12.2 meters (30 to 40 feet) and expends itself in about 55 seconds. The shell of the extinguisher is filled with a solution of 0.7 kg (1½ lb) of sodium bicarbonate in 9.5 liters (2½ gallons) of water. The screw-on cap contains a cage that holds a 0.23 kg (8-oz) bottle, half filled with sulfuric acid, in an upright position. A loose stopper in the top of the acid bottle prevents acid from splashing out before the extinguisher is to be used.

The extinguisher is carried to the fire by means of the top handle. At the fire, the extinguisher is inverted; the acid mixes with the sodium bicarbonate solution, which then forms carbon dioxide gas. The pressure of the CO₂ can then propel the water out through the nozzle.

The stream should be directed to the seat of the fire and then moved back and forth to hit as much of the fire as possible. Typically, there is no discharge control mechanism; the nozzle should be directed at the fire until the entire content of the extinguisher is discharged.

IMPORTANT! The extinguishing agent, sodium bicarbonate solution mixed with acid is *corrosive* and it should be recognized that care should be taken to avoid contact with the agent on the skin or face, as *this acid can cause burns*.

Also, *soda-acid extinguishers must be properly maintained*. This type of extinguisher is not normally under pressure. Therefore, when the extinguisher is inverted for use, a pressure of 896 kilopascals (130 psi) or more is suddenly generated. *If the extinguisher was not properly maintained*, and the container is corroded or otherwise damaged, then the *sudden pressure could be sufficient to burst the container*.

1.1.2 Cartridge-Operated Water Extinguisher

1.1.2(a) Rupture Disc-type, Cartridge-Operated Extinguisher. The cartridge-operated water extinguisher is similar in size to the soda-acid extinguisher. The most common size is 9.5 liters (2.5 gallons) and has a range of about 10.7 to 12 meters (30 to 40 feet). The container is filled with water or an antifreeze solution. The screw-on cap contains a small cylinder of CO₂, and when the CO₂ cylinder is punctured, the gas provides the pressure to propel the extinguishing agent.

For use, the extinguisher is carried to the fire, then inverted and bumped against the deck. This ruptures the CO₂ cylinder and expels the water. Once again, the stream should be directed at the seat of the fire. The nozzle should be moved back and forth to quench as much of the burning material as possible in the short time available. The discharge time is less than one minute and the entire content of the extinguisher will be discharged, since like the soda-acid extinguisher, typically the flow cannot be shut off.

As with the soda-acid extinguisher, the container is not subjected to pressure until it is put to use. Thus, any weakness in the container may not become apparent until the container fails.

1.1.2(b) Pin-Type Cartridge-Operated Extinguisher. A newer version of the cartridge-operated water extinguisher is the pin-type cartridge operated extinguisher that does not need to be inverted for use. Instead, a pin is pulled out of the cartridge, with the extinguisher upright. A lever is squeezed to discharge the extinguishing agent (water or anti-freeze solution).

1.1.3 Stored-Pressure Water Extinguishers

The stored-pressure water extinguisher typically comes in a 9.5 liter (2.5 gallon) size and weighs about 13.6 kg (30 lb). It has a horizontal range of about 10.7 to 12.2 meters (35 to 40 feet). In continuous operation, it will expend its water in about 55 seconds. However, stored pressure water extinguishers are typically fitted with means to control the discharge, and therefore, they may be used intermittently, to extend their operational time.

The container is filled with water or an antifreeze solution, to within about 15 cm (6 in.) of the top. (Most extinguishers have a fill mark stamped on the container.) The screw-on cap holds a lever-operated discharge valve, a pressure gauge, and an automobile tire-type valve. The extinguisher is pressurized through the air valve, with either air or an inert gas such as nitrogen. The normal charging pressure is about 690 kilopascals (100 psi). The gauge allows the pressure within the extinguisher to be checked at any time. Most gauges are color coded to indicate normal and abnormal pressures.

The extinguisher is carried to the fire, and the ring pin or other safety device is removed. The operator aims the nozzle with one hand and squeezes the discharge lever with the other hand. The stream should be directed at the seat of the fire and moved back and forth to ensure complete coverage of the burning material. Short bursts can be used to conserve the limited supply of water.

1.2 Foam-type Fire Extinguishers

Foam extinguishers typically have greater range of extinguishing capability than water extinguishers. The most common size is a 9.5 liter (2.5 gallon) unit and may be used on both class “A” and class “B” fires. On class “A” fires, the foam serves to cool the fire and fuel source, while on class “B” fires the foam serves to act as a barrier to exclude oxygen from the fuel surface below the ignition surface. Foam extinguishers typically have a range from 6.1 to 7.7 meters (20 to 25 feet) and a discharge duration of slightly less than one (1) minute.

There are two different types of foam extinguishers available:

- Chemical foam
- Mechanical foam

Note: Chemical foam extinguishers are being phased out, but may still be found onboard.

Like water extinguishers, foam extinguishers may also be subject to freezing and adherence to the manufacturer’s recommendations regarding the environmental conditions of the storage locations is important.

1.2.1 Chemical Foam Portable Fire Extinguishers

The chemical foam extinguisher is charged by filling it with two solutions that are kept separated (within the extinguisher) until it is to be used. These solutions are commonly called the “A” and “B” solutions, but their designations have nothing to do with fire classifications.

The foam extinguisher is carried to the fire right side up and then inverted. This mixes the two solutions, producing a liquid foam and CO₂ gas. The CO₂ acts as the propellant and also as the gas for the foam bubbles. The liquid foam expands to about 8 times its original volume, so this means that the 9.5 liter (2.5 gallon) extinguisher will produce approximately 68 to 76 liters (18 to 20 gallons) of foam.

The foam should be applied gently on burning liquids (Class “B” fires). This can be done by directing the stream in front of the fire. The stream also may be directed against the back wall of a tank or a structural member to allow the foam to run down and flow over the fire. Chemical foam is stiff and flows slowly. For this reason, the stream must usually be directed to the fire from several angles, for complete coverage of the burning materials.

For fires involving ordinary combustible materials (Class “A” fires), the foam may be applied in the same way (as a blanket) or the force of the stream may be used to get the foam into the seat of the fire.

Once activated, these extinguishers will expel their entire foam content; which should be directed onto the fire. As with other pressurized extinguishers, the containers are subject to rupture when their contents are mixed, and are a possible cause of injury to the operator.

1.2.2 Mechanical Foam Extinguishers

Mechanical foam portable extinguishers contain a pre-mixed solution of film-forming foam surfactant and water. The solution is stored under a pressurized charge of carbon dioxide or other gas which serves as the expelling force. The discharge hose is fitted with an air aspirating nozzle which expands the solution into foam as it is discharged through the nozzle. Mechanical foam extinguishers closely resemble the pressurized water extinguishers except for the air aspirating nozzle.

Like the chemical foam extinguisher, the foam should be applied gently on burning liquids. This can be done by directing the stream in front of the fire. The stream also may be directed against the back wall of a tank or a structural member to allow the foam to run down and flow over the fire.

1.3 Carbon Dioxide (CO₂) Fire Extinguishers

Carbon dioxide extinguishers are used primarily on class “B” and “C” fires. The most common size of portable extinguisher for shipboard use contains 6.8 kg (15 lb) of CO₂.

Note: This weight does not include that of the relatively heavy shell.

The CO₂ is mostly in the liquid state and is at a pressure of 5860 kPa (850 psi) at 21°C (70°F). The range of the CO₂ varies between 1.8 to 2.4 meters (3 to 8 feet), and the duration from 8 to 30 seconds.

The extinguisher is carried to the fire in an upright position. (The short range of the CO₂ extinguisher means the operator must get fairly close to the fire.) The extinguisher is placed on the deck and the locking pin is removed. The discharge is normally controlled either by opening a valve or by squeezing two handles together.

The operator must grasp the hose handle and not the discharge horn. The CO₂ expands and cools very quickly as it leaves the extinguisher. The horn gets cold enough to frost over and cause severe frostbite. When a CO₂ extinguisher is used in a confined space, the operator should guard against suffocation by wearing breathing apparatus.

For use on class “B” fires, the horn should be aimed first at the base of the fire nearest the operator. The discharge should be moved slowly back and forth across the fire. At the same time, the operator should move forward slowly. The result should be a “sweeping” of the flames off the burning surface, with some carbon dioxide “snow” left on the surface. Whenever possible, a fire on a weather deck should be attacked from the windward side. This will allow the wind to blow the heat away from the operator and to carry the CO₂ to the fire. Generally, CO₂ extinguishers do not perform well in a wind. The blanket of CO₂ gas does not remain on the fire long enough to permit the fuel to cool down.

For use on Class “C” fires, the discharge should be aimed at the source of a fire that involves electrical equipment. The equipment should be de-energized as soon as possible to eliminate the chance of shock and the source of ignition.

CO₂ extinguishers need not be protected against freezing. However, they should be stowed at temperatures below 54°C (130°F) to keep their internal pressure at a safe level. At about 57°C (135°F), the safety valves built into CO₂ extinguishers are activated at approximately 18620 kPa (2700 psi), to release excess pressure.

Note: IMO Circular 847 indicates that CO₂ extinguishers should not be placed in accommodations areas, as the inadvertent or undetected release of the CO₂ could suffocate unsuspecting personnel.

1.4 Dry Chemical-type Fire Extinguishers

Dry chemical extinguishers are available in several sizes, with any of five different extinguishing agents.

The different dry chemical agents have different extinguishing capabilities. If sodium bicarbonate is arbitrarily given an extinguishing capability of 1, then the relative capabilities of the other dry chemical agents are as follows:

- | | |
|-----------------------------------|-----|
| • Mono-ammonium phosphate (ABC) | 1.5 |
| • Potassium chloride (BC) | 1.8 |
| • Potassium bicarbonate (BC) | 2.0 |
| • Urea potassium bicarbonate (BC) | 2.5 |

Dry chemical extinguishers typically extinguish fires by inhibiting the chemical reaction of the fire process. All five dry chemicals mentioned above are suitable for extinguishing Class “B” and Class “C” fires. However, one dry chemical-extinguishing agent, mono-ammonium phosphate (ABC, multi-purpose) is also approved for use on Class “A” fires. This agent extinguishes a fire by chain breaking (as do the other dry chemical agents). As a by-product of this chemical reaction, a residue is created that coats and clings to the surfaces of burning materials. This coating deprives solid fuels of air and has therefore been found acceptable for use on Class “A” fires.

Since dry chemical extinguishers extinguish fires mainly through the breaking of the chemical chain reaction, there is little or no cooling of the flame or fuel surface. Thus, a reflash is possible if fuel continues to remain in contact with hot surfaces. Additional dry chemical extinguishers or other appropriate extinguishers should be available as backup, until all sources of ignition are eliminated. Dry chemical extinguishing agents may be used along with water and some dry chemical extinguishers are filled with an extinguishing agent that is compatible with foam.

There are basically two different types of dry chemical extinguishers: the cartridge-operated extinguisher and the stored-pressure extinguisher. The following provides a description of each:

1.4.1 Cartridge-Operated Dry Chemical Extinguisher

Portable cartridge-operated, dry chemical extinguishers range in size from 2.25 to 13.6 kg (5 to 30 lb), and semi-portable models contain up to 22.7 kg (50 lb) of agent. An extinguisher may be filled with any of the five agents, and its rating will be based on the particular agent used. A small cylinder of inert gas is used as the propellant. Cartridge-operated, dry chemical extinguishers have a range from 3 to 9.1 m (10 to 30 ft). The 2.25 kg (5 lb) extinguisher will have a discharge duration of approximately 8 to 10 seconds, while the larger extinguishers provide up to 30 seconds of discharge time.

The extinguisher is carried and used upright. The ring pin is removed and the puncturing lever is depressed. This releases the propellant gas, which forces the extinguisher agent up to the nozzle. The flow of dry chemical is controlled with the squeeze-grip On-Off nozzle at the end of the hose. The discharge is directed at the seat of the fire, starting at the near edge. The stream should be moved from side to side with rapid motions, to sweep the fire off the fuel. On a weather deck, the fire should be approached from the windward side if possible. The initial discharge should not be directed onto the burning material from close range, 0.91 to 2.4 m (3 to 8 ft), as the velocity of the stream may scatter the burning material. However, the agent may be applied in short bursts by opening and closing the nozzle with the squeeze grips.

If the propellant gas cylinder is punctured but the extinguisher is not put into use or is only partially discharged, the remaining gas may leak away in a few hours. Thus, the extinguisher must be recharged after each use or activation.

1.4.2 Stored-Pressure Dry Chemical Extinguishers

Stored-pressure dry chemical extinguishers are available in the same sizes as cartridge-operated types. They have the similar ranges and duration of discharge and are used in the same way. The only differences are that the propellant gas is mixed in with the dry chemical in the stored-pressure type and the extinguisher is controlled with a squeeze-grip trigger on the top of the container. A pressure gauge indicates the condition of the charge.

Many stored-pressure extinguishers have pressure gauges that indicate whether the internal pressure is within the operating range. The gauge is located on the bottom of some extinguishers.

1.5 Dry Powder-type Fire Extinguishers

Frequently the terms “Dry Powder” extinguisher and “Dry Chemical” extinguisher have been incorrectly considered as interchangeable. The two terms actually represent different types of medium, and it is important to understand that there is a difference between the two types of extinguishers. Dry chemical extinguishers and their mediums, as discussed above, are typically suitable for use on “B” and “C” Class fires, or in the case of mono-ammonium phosphate, suitable for use on “A”, “B” and “C” fires. However, the extinguishing medium in a “Dry Powder” extinguisher is a special type of dry chemical agent that is specifically suitable for use on combustible metal (class D) fires. Accordingly, the term “Dry Powder” extinguisher is intended to specifically refer to that extinguisher which has an extinguishing agent suitable for use on combustible metal (class D) fires. The extinguishing agent typically found in “Dry Powder” extinguishers is sodium chloride, which forms a crust on the burning metal.

1.6 Portable Fire Extinguishers

Portable extinguishers are smaller extinguishers that can easily be transported to the fire. The Rules consider a 13.5 liter (3.5 gallon) fluid extinguisher (or smaller) to be a portable extinguisher. Extinguishers utilizing other extinguishing mediums must provide an equivalent degree of portability to that of a 13.5 liter (3.5 gallon) fluid extinguisher. IMO Resolution A.602(15) defines a portable extinguisher as one which is designed to be carried and operated by hand and which in working order has a total weight of not more than 23 kg (50.6 lbs). For more information, refer to Appendix C – IMO Resolution A.602(15).

Although portable fire extinguishers provide only a limited quantity of fire extinguishing agent, their ability to be transported easily to a fire and used to quickly engage a fire before it spreads plays a vital role aboard a vessel. Many large scale fires have been avoided simply due to the availability and use of small portable fire extinguishers.

1.7 Semi-portable Fire Extinguishers

Semi-portable extinguishers provide a larger amount of extinguishing agent to a fire rapidly, which allows the operator to make a sustained attack. However, semi-portable fire extinguishers are much larger, which results in a restriction of mobility. Semi-portable units may be wheeled units or may be semi-fixed and typically utilize a discharge hose which can be run out to engage the fire. The hose must be of sufficient length to reach all portions of the protected area.

Semi-portable systems typically utilize foam, carbon dioxide dry chemical or dry powder, depending upon the requirements of the hazard to be protected. They are often required to be provided at high fire risk areas within spaces which may already be fitted with a fixed fire extinguishing system. The purpose of the semi-portable units is to provide the means to quickly engage a fire with larger volumes of extinguishing agent. If this attack controls or extinguishes the fire, then the large fixed system need not be activated. Semi-portable systems may also be used as primary extinguishing systems.

1.8 Fire Extinguisher Designations

Portable and semi-portable extinguishers are typically classified with one or more letters and with a numeral. The letter or letters indicate the classes of fires on which the extinguisher may be used. These letters correspond exactly to the four classes of fires (refer to Section 2). Thus, for example, class “A” extinguishers may be used only on class “A” fires – those involving common combustible materials. Class “AB” extinguishers may be used on fires involving wood (class “A”) or diesel oil (class “B”) or both. The numeral indicates either the relative efficiency of the extinguisher or its size. The particular size and classification ratings for a specific manufacturer’s extinguisher should be established through appropriate testing conducted by a recognized testing agency or laboratory.

In the method of designation used by the Rules, Roman numerals are used to indicate the sizes of portable extinguishers. The numeral “I” indicates the smallest size, and “V” the largest. The ratings of the different types of extinguishers are provided in the following table.

TABLE 1
Portable/Semi-portable Extinguisher Classifications

Type	Size	Water Liters (Gal.)	Foam Liters (Gal.)	Carbon Dioxide kg (lbs.)	Dry Chemical kg (lbs)
A	II	9 (2½)	9 (2½)	---	2.25 (5) (“ABC” only)
B	II	---	9 (2½)	6.8 (15)	4.5 (10)
B	III		45 (12)	15.8 (35)	9 (20)
B	IV		76 (20)	22.5 (50)	13.6 (30)
B	V		152 (40)	45 (100)	27.7 (50)
C	II		---	6.8 (15)	4.5 (10)

2 ABS Requirements for Portable/Semi-portable Fire Extinguishers

The following Paragraphs provide general guidance regarding ABS requirements for portable/semi-portable fire extinguishers. However, reference should always be made to the Rules applicable to the specific vessel concerned for the complete set of requirements.

2.1 Sizing of Portable Extinguishers

Establishment of a minimum size for portable extinguishers is important in order to ensure that adequate extinguishing medium will be provided. Accordingly, SVR 4-7-3/15.1.1 establishes a 9 liter (2.5 gallon) fluid extinguisher as a baseline for the extinguishing capability of a portable extinguisher and requires any other extinguisher to have the fire extinguishing capability of not less than that provided by a 9 liter (2.5 gallon) fluid extinguisher. Therefore, a CO₂ or dry chemical extinguisher must establish by testing that they provide a fire extinguishing capacity equivalent to that of the 9 liter (2.5 gallon) fluid extinguisher for the particular fire hazard.

Portability of an extinguisher is also critical. The Rules address the portability of a “portable” fire extinguisher in SVR 4-7-3/15.1.1 and establish a 13.5 liter (3.5 gallon) fluid extinguisher to be the upper limit to be considered a portable extinguisher. A 13.5 liter (3.6 gallon) pressurized water extinguisher weighs *approximately* 20.5 to 22.7 kg (45 to 50 lbs), depending upon the manufacturer.

IMO Resolution A.602(15) defines a portable extinguisher as one which is designed to be carried and operated by hand and which in working order has a total weight of not more than 23 kg (50.6 lbs). Accordingly, the Rule and IMO requirements are very similar in this regard. For more information, refer to IMO Resolution A.602(15).

In accordance to SVR 4-7-3/15.1.1 and FSS Code Chapter 4/3.1.1.1, the mass of portable fire extinguishers should not exceed 23 kg (50.6 lbs). Each powder or carbon dioxide extinguisher should have a capacity of at least 5 kg (11 lbs) and each foam extinguisher a capacity of at least 9 liters (2.5 gallons).

2.2 Approval of Portable and Semi-portable Extinguishers

SVR 4-7-3/15.1.1 requires all portable extinguishers to be of an approved type and design (in the context of this requirement, the term “portable extinguisher” should be considered to apply to both portable and semi-portable extinguishers). Therefore, the extinguisher is to be designed and fabricated to an appropriate “marine” portable extinguisher standard which addresses the needs and concerns associated with the marine environment (i.e., corrosion, etc.). To verify compliance, the extinguisher should have documentation confirming its approval by an appropriate agency or laboratory for “marine” service. This would be in addition to the size and classification ratings being established by an appropriate laboratory or testing agency.

In addition to the above, SVR 4-1-1/Table 4 also requires portable extinguishers to be covered under the ABS Certification Program. Accordingly, portable and semi-portable extinguishers must also meet the requirements specified in the table for either an “Individual Unit Certification” or the “ABS Type Approval Program”.

For “Individual Unit Certification”, an extinguisher is to be subject to type testing in the presence of a Surveyor unless “type approved” by the Flag Administration.

For the “ABS Type Approval Program”, an extinguisher is to be subject to prototype examination and prototype testing as discussed in SVR 4-1-1/3.5.1(b) and the manufacturer must pass a quality assurance assessment as discussed in SVR 4-1-1/3.5.2.

2.3 Spaces Containing Boilers (Main or Auxiliary), Oil-fired Equipment

SVR 4-7-2/1.1 identifies requirements for portable and semi-portable extinguishers to be provided in spaces containing oil-fired boilers. SVR 4-7-2/1.1 further indicates that the requirements for oil-fired boilers are also applicable to other types of oil-fired equipment, such as oil-fired inert gas generators and oil-fired incinerators. Accordingly, where the Rules provide fire fighting requirements for oil-fired boilers, the same requirements are also applicable to other types of oil-fired equipment.

SVR 4-7-2/1.1 also identifies requirements for the number and type of portable and semi-portable extinguishers to be provided in spaces containing oil fuel units. An oil fuel unit is defined in SVR 4-7-1/11.19 as the equipment used for the preparation of oil fuel for delivery to an oil-fired boiler (including inert gas generators, incinerators, waste disposal units, etc.) or equipment used for the preparation for delivery of heated or non-heated oil internal-combustion engines and includes any oil pressure pumps, filters and heaters dealing with oil at a pressure of more than 1.8 bar (26 psi).

The Rule requirements regarding portable and semi-portable extinguishers for spaces containing the above types of equipment are discussed below.

2.3.1 Portable Fire Extinguishers

SVR 4-7-2/1.1.3 requires at least two portable foam extinguishers or the equivalent in each of the following locations:

- i) Each firing space of a boiler room
- ii) Each firing space for oil fired equipment (inert gas generators, incinerators, etc.)
- iii) Spaces containing all or part of an oil fuel installation.

As SVR 4-7-2/1.1.3 indicates, the portable extinguishers are to be provided in each firing space. Accordingly, if there is more than one firing space in the boiler room, then each firing space is to be provided with two portable foam extinguishers. However, where the firing stations for two separate boilers share a common firing space, then a single set of portable foam extinguishers would be acceptable.

SVR 4-7-2/1.1.3 indicates that the portable extinguishers are to be foam extinguishers “or equivalent”. Therefore, other types of portable extinguishers may be provided. However, the alternative extinguisher must have an extinguishing capacity equivalent to the portable foam extinguisher when used on an oil fire. Accordingly, portable foam, CO₂ or dry chemical extinguishers with a “B-II” rating would be acceptable.

One of the portable fire extinguishers intended for use in the space should be stowed near the entrance to that space, in accordance with SOLAS 2000 Reg. II-2/10.3.2.2.

2.3.2 Semi-portable Fire Extinguisher(s)

SVR 4-7-2/1.1.3 also requires that there is to be at least one approved foam-type extinguisher of not less than 135 liters (36 gallons) capacity or the equivalent in each boiler room. SVR 4-7-2/1.1.3 also requires that this extinguisher is to be provided with a hose on a reel that is suitable for reaching any part of the room. Accordingly, at least one “B-V” rated semi-portable extinguisher is to be provided in each of the above-mentioned rooms, and more than one “B-V” portable extinguisher would be required if the hose of the single unit is not sufficient to reach all portions of the room.

In the case of an installation involving domestic boilers of less than 175 kW (500 hp) on cargo vessels, special consideration may be given to the elimination of the “B-V” semi-portable extinguisher in accordance with IACS UI SC30 and IMO MSC Circular 847.

2.3.3 Summary

Note: In the following table, references to an oil-fired, inert gas generator or oil-fired incinerator are considered the same equipment as an oil-fired boiler.

TABLE 2
Spaces Containing Boilers or Oil-fired Equipment

Category A Machinery Spaces	Type Extinguisher					
	Portable foam applicator ⁽¹⁾	Portable foam	Additional portable foam	135 l foam	45 l foam ⁽²⁾	Sand box ⁽³⁾
Boiler room:						
Oil-fired boilers	1	2N	--	1 ⁽⁴⁾	--	N
Oil-fired boilers and oil fuel units	1	2N + 2	--	1 ⁽⁴⁾	--	N
Engine room:						
Oil fuel units only	1	2	--	--	--	--

Notes: (based upon IACS UI SC30):

- 1 May be located at outside of the entrance to the room.
 - 2 May be arranged outside of the space concerned for smaller spaces on cargo vessels.
 - 3 The amount of sand is to be at least 0.1 m³ (3.5 ft³). A shovel is to be provided. Sand boxes may be substituted by approved portable fire extinguishers.
 - 4 Not required for such spaces in cargo vessels wherein all boilers contained therein are for domestic services and are less than 175 kW.
- N = number of firing spaces or stations
- 2N = two extinguishers to be located in each firing space.
- x = sufficient number (minimum 2 in each space, thus, at least 1 portable fire extinguisher is within 10 meters (33 feet) walking distance from any point).
- y = sufficient number (to enable foam to be directed onto any part of the fuel and lubricating oil pressure systems, gearing, and other fire hazards).

2.4 Category “A” Machinery Spaces Containing Internal Combustion Machinery

SVR 4-7-1/11.15 defines category “A” Machinery spaces, in part, as those spaces and trunks to such spaces that contain:

- Internal combustion machinery used for main propulsion; or
- Internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW (500 hp).

The requirements for portable and semi-portable extinguishers in category “A” machinery spaces containing internal combustion machinery are found in SVR 4-7-2/1.3.

Note: Internal combustion machinery would include *internal combustion engines*, as well as *gas turbines*.

2.4.1 Portable Fire Extinguishers

Per SVR 4-7-2/1.3iii), two or more portable foam extinguishers or the equivalent (e.g., “B-II” rated portable extinguishers) are to be provided and are to be so located that no point in the space is more than 10 meters (33 feet) walking distance from an extinguisher.

One of the portable fire extinguishers intended for use in the space should be stowed near the entrance to that space in accordance with SOLAS 2000 Reg. II-2/10.3.2.2.

2.4.2 Semi-Portable Fire Extinguisher(s)

In accordance with SVR 4-7-2/1.3iii) each such space is also to be provided with approved foam type fire extinguisher(s), each of at least 45 liters (12 gallons) capacity or the equivalent (e.g., “B-III” rated extinguishers), sufficient in number to enable foam or its equivalent to be directed on to any part of the fuel and lubricating oil pressure systems, gearing and other fire hazards.

2.5 Combined Boiler and Internal Combustion Engine Machinery Spaces

Frequently, machinery spaces may contain a combination of boilers, internal combustion engines, and oil fuel units. In order to provide clarification of the Rule requirements for portable and semi-portable fire extinguishers in such spaces the following table is provided:

Note: In the following table, references to an oil-fired, inert gas generator or oil-fired incinerator are considered the same equipment as an oil-fired boiler.

TABLE 3
Combined Boiler/Internal Combustion Engine Machinery Spaces

Category A Machinery Spaces	Type Extinguisher					
	Portable foam applicator ⁽¹⁾	Portable foam	Additional portable foam	135 l foam	45 l foam ⁽²⁾	Sand box ⁽³⁾
Engine room:						
Oil fuel units only	1	2	NA	--	--	--
Internal combustion machinery	1	x		--	y	--
Internal combustion machinery and oil fuel units	1	x		--	y	--
Combined engine/boiler room:						
Internal combustion machinery, oil fired boilers, and oil fuel units	1	(2N + 2) or x whichever is greater		1 ⁽⁴⁾	y ⁽⁵⁾	N

Notes: (based upon IACS UI SC30):

- 1 May be located at outside of the entrance to the room.
 - 2 May be arranged outside of the space concerned for smaller spaces on cargo vessels.
 - 3 The amount of sand is to be at least 0.1 m³ (3.5 ft³). A shovel is to be provided. Sand boxes may be substituted by approved portable fire extinguishers.
 - 4 Not required for such spaces in cargo vessels wherein all boilers contained therein are for domestic services and are less than 175 kW.
 - 5 Machinery spaces containing both boilers and internal combustion engines, one of the foam fire-extinguishers of at least 45 liters capacity or equivalent required by SVR 4-7-1/1.3iii) may be omitted on the condition that the 135 liter extinguisher required by SVR 4-7-2/1.1.3 can protect efficiently and readily the area covered by the 45 liter extinguisher.
- N = number of firing spaces or stations
- 2N = two extinguishers to be located in each firing space.
- x = sufficient number (minimum 2 in each space, thus, at least 1 portable fire extinguisher is within 10 meters (33 feet) walking distance from any point).
- y = sufficient number (to enable foam to be directed onto any part of the fuel and lubricating oil pressure systems, gearing, and other fire hazards).

2.6 Spaces Containing Steam Turbines or Steam Engines

In accordance with SVR 4-7-2/1.5, spaces containing steam turbines or steam engines used either for main propulsion or for other purposes when such machinery has in the aggregate a total power output of not less than 375 kW (500 hp) are to be provided with the following portable and semi-portable extinguishers:

2.6.1 Portable Fire Extinguishers

Sufficient number of portable foam extinguishers or the equivalent (e.g., “B-II” extinguishers) are to be provided and located so that no point in the space is more than 10 meters (33 feet) walking distance from an extinguisher.

As a minimum, there are at least two such extinguishers in each such space. One of the portable fire extinguishers intended for use in the space should be stowed near the entrance to that space in accordance with SOLAS 2000 Reg. II-2/10.3.2.2.

2.6.2 Semi-Portable Fire Extinguisher(s)

SVR 4-7-2/1.5i) also requires that approved foam fire extinguisher(s) each of at least 45 liters (12 gallons) capacity or equivalent (e.g., “B-III” extinguisher) be provided and are to be in sufficient number to enable foam or its equivalent to be directed to any part of the pressure lubrication system, onto any part of the casings enclosing pressure lubricated parts of the turbines, engines or associated gearing and onto other fire hazards. However, the Rules do allow the elimination of these semi-portable extinguishers if an approved fixed fire extinguishing system is installed in the space.

2.7 Portable/Semi-portable Fire Extinguishers in Other Machinery Spaces

SVR 4-7-2/1.7 requires that machinery spaces other than those discussed above, in which fire hazards exist, are to be provided with a sufficient number of portable fire extinguishers or other means of fire extinction in, or adjacent to, that space.

SVR 4-7-1/11.17 defines machinery spaces as all machinery spaces of category “A” and all other spaces containing propulsion machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces.

The requirements for Category “A” machinery spaces containing internal combustion machinery, as well as spaces containing oil fired boilers, oil fired incinerators, oil fired inert gas generators, oil fuel units, steam turbines and steam engines have been addressed above. However, there are numerous other “machinery spaces” found aboard vessels which present serious fire risks, and in accordance with 4-7-2/1.7, these other machinery spaces must be provided with appropriate portable extinguishers. The following identifies just a few of these spaces:

- i) Spaces containing internal combustion machinery of less than 375 kW (500 hp) and not used for main propulsion
- ii) Switchboard and electrical distribution rooms
- iii) HVAC equipment rooms
- iv) Dedicated pump rooms with electric motors, motor controllers, etc.
- v) Spaces containing hydraulic power units and hydraulic equipment
- vi) Oil filling stations
- vii) Oil fuel units operating at a pressure less than 1.8 bar (26 psi)

It is important to carefully review a fire control plan to understand the equipment or systems which may be located within various compartments and evaluate the particular fire risk involved to ensure that the necessary portable extinguishers are being provided and are actually suitable for the service. The above only identifies a few of the “other machinery spaces” found aboard a vessel which pose a fire risk. Any “other machinery space” which poses a fire risk must be provided with suitable portable extinguishers, in accordance with SVR 4-7-2/1.7.

2.8 Accommodations, Service Spaces and Control Stations

SVR 4-7-2/3.5 requires that *accommodation, service spaces and control stations* be provided with portable fire extinguishers suitable for their intended service. This is a very generic statement but has very far reaching effects. To properly apply this requirement, one must (1) clearly understand which spaces are included under the rather generic terms *accommodation, service spaces and control stations*, and (2) understand the fire risks typically inherent with the various spaces to ensure that the portable extinguishers being provided are actually suitable for the intended service.

2.8.1 Definitions

For the first item noted above, the Rules provide very specific definitions for these spaces and the same are provided below:

2.8.1(a) Accommodation Spaces. Accommodation spaces are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobbies rooms, barber shops, pantries containing no cooking appliances and similar spaces (See SVR 4-7-1/11.3). Further, public spaces are those portions of the accommodation which are used for halls, dining rooms, lounges and similar permanently enclosed spaces (See SVR 4-7-1/11.5).

2.8.1(b) Service Spaces. Service spaces are those spaces used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, storerooms, workshops other than those forming part of the machinery spaces, and similar spaces and trunks to such spaces (See SVR 4-7-1/11.7).

2.8.1(c) Control Stations. Control stations are those spaces in which the vessel’s radio, main navigation equipment or emergency source of power is located or where the fire recording or fire control equipment is centralized.

- i) Spaces containing, for instance, the following battery sources are to be regarded as control stations regardless of battery capacity,
- ii) Emergency batteries in separate battery room for power supply from blackout till start of emergency generator,
- iii) Emergency batteries in separate battery room as reserve source of energy to radiotelegraph installation,
- iv) Batteries for start of emergency generator; and
- v) In general, all emergency batteries required in pursuance of SVR 4-8-2/5.

(See SVR 4-7-1/11.21).

For the second portion of this requirement, it is important to consider the particular fire hazards that might be involved with the specific location. In most accommodation spaces such as cabins, offices and public spaces, the concern would be Class “A” fires. However, in service spaces, the concern may actually be Class “B” fires (liquid fuel fires) or Class “C” fires (electrical fires).

2.8.2 Accommodation Spaces

The Rules require that all corridors be provided with suitable portable fire extinguishers located not more than 45 m (150 ft) apart. For normal accommodation spaces (e.g., cabins, offices, games and hobbies rooms, barber shops, pantries containing no cooking appliances and similar spaces accommodation spaces), type “A-II” portable extinguishers provided at the above spacing on each level are considered acceptable. Typically, additional “A-II” portable extinguishers are provided in larger public spaces, such as dining rooms and lounges. However, there are certain other accommodation spaces, such as hospitals, cinemas, etc., that may warrant other types of extinguishers due the fire hazards involved.

2.8.3 Service Spaces

As noted from the definition, the term “service spaces” may include a wide variety of spaces, and a variety of fire hazards. The installation of Type “B-II” portable extinguishers would be appropriate for galleys and possibly workshops, while Type “A-II” should be provided for mail, specie and storerooms. Once again, it is very important to take into account the fire hazard involved when considering the suitability of the portable extinguisher being provided.

2.8.4 Control Station

Fire hazards associated with control stations mainly involve electrical equipment. Accordingly, Type “C-II” extinguishers should normally be provided for these spaces.

2.8.5 Conclusion

For vessels of 1000 gross tons and above, the total number of portable extinguishers for these spaces is not to be less than five. In addition, the number of portable extinguishers actually provided for a particular space should be based upon the amount and type of equipment or combustible materials within that space. And where portable extinguisher(s) are provided to protect a specific space (i.e., control station, galley, etc.) one of the portable fire extinguishers should be stowed near the entrance to that space, in accordance with SVR 4-7-2/3.5.

Per SVR 4-7-3/15.1.4, carbon dioxide fire extinguishers should not be placed in accommodation spaces. In control stations and other spaces containing electrical or electronic equipment or appliances necessary for the safety of the vessel, fire extinguishers should be provided whose extinguishing media are neither electrically conductive nor harmful to the equipment and appliances.

Per SOLAS (2000 Amendments) Reg. II-2/10.3.2.4, fire extinguishers should be situated ready for use at easily visible places, which can be reached quickly and easily at any time in the event of a fire. Furthermore, they are to be located in such a way that their serviceability is not impaired by the weather, vibration or other external factors. Portable fire extinguishers should be provided with devices that indicate whether they have been used.

2.9 Fire Protection Arrangements for Paint Lockers

Paint lockers and flammable liquid lockers can contain large quantities of paints, cleaners, solvents and other products that may have low flash points. While these products are stored in sealed containers, they can represent a sizable fire load. In addition, these areas are normally also used for mixing operations, resulting in flammable atmospheres and a very real potential for fires. In order to address the hazards associated with paint and flammable liquid lockers and to fight any fires that may develop, approved fire-extinguishing arrangements are required, in accordance with SVR 4-7-2/5.

Normally, paint lockers and flammable liquid lockers are required to be provided with a fixed fire extinguishing system. However, for paint lockers and flammable liquid lockers with a deck area less than 4 m² (43 ft²) which provide no access to accommodation spaces, portable 6.8 kg (15 lb) CO₂ extinguishers which can be discharged through a port in the boundary of the lockers may be accepted. The number of portable CO₂ extinguishers to be provided is to be sufficient to provide 40% of the gross volume of the room when considering specific volume of CO₂ to be 0.56 m³/kg (9 ft³/lb).

2.10 Fire Protection Arrangements for Helicopter Landing Areas

If the vessel is fitted with arrangements to accommodate helicopter operations, the following arrangements are to be provided in accordance with SVR 4-7-2/5.3.2(b) and 4-7-2/5.3.2(c).

2.10.1 Semi-Portable Extinguishers

The helicopter deck is to be protected by at least two (2) approved dry powder extinguishers with a total capacity of not less than 45 kg (100 lb).

2.10.2 Backup CO₂ Extinguishers

A backup fire-fighting system is to be provided, consisting of CO₂ extinguishers of a total capacity of not less than 18 kg (40 lb) or equivalent, one of these extinguishers being equipped so as to enable it to reach the engine area of any helicopter using the helicopter deck. The backup system is to be located so that the equipment would not be vulnerable to the same damage as the dry powder extinguishers.

2.11 Vessels with Automation Designation “ACCU”

Vessels being classed with the **ACCU** automation notation are required to have a “Fire Fighting Station”, as per SVR 4-9-4/21. And in accordance with SVR 4-9-4/21.7, certain additional equipment is required to be provided at the “Fire Fighting Station”. This additional equipment includes a number of portable fire extinguishers equal to the Machinery Space portable fire extinguishers required in SVR 4-7-2/1.

However, where duplicated portable extinguishers are provided to satisfy the requirement of SVR 4-7-3/15.1.2 in lieu of spare charges, these duplicated extinguishers may be considered to satisfy the above requirement, provided that they are stored at the “Fire Fighting Station”.

2.12 Additional Requirements for Ro-Ro Spaces, Ro-Ro Spaces Carrying Motor Vehicles with Fuel in Their Tanks, and Cargo Spaces Carrying Motor Vehicles with Fuel in Their Tanks (other than Ro-Ro Spaces)

In accordance with SVR 5-10-4/3.3.3, at least one portable extinguisher is to be provided at each access to any ro-ro cargo space. In addition, at each vehicle deck level where vehicles with fuel in their tanks are carried, sufficient portable extinguishers suitable for fighting oil fires (B-II extinguishers) are to be provided such that they are not more than 20 meters (65 feet) apart on both sides of the vessel. The one located at the access may be credited for this purpose.

In accordance with SVR 5-10-4/5, cargo spaces, other than ro-ro spaces, intended to carry motor vehicles with fuel in their tanks are to also comply with the above requirements for portable fire extinguishers.

It should be noted that when applying the requirements of SOLAS 2000 Reg. II-2/20.6.2.1, MSC Circular 847 provides an interpretation which specifies that the portable fire extinguishers being provided in the above-listed spaces be suitable for “A” and “B” class fires and that the extinguishers should have a capacity of 12 kg (26.5 lb) dry powder or the equivalent.

2.13 Additional Requirements for Vessels Carrying Dangerous Goods

If “Dangerous Goods” cargoes are to be carried aboard the vessel, additional portable extinguishers may be required. As indicated in of SVR 4-7-2/Table 4, vessels carrying Dangerous Goods Classes 3.1, 3.2 (flammable liquids) with a flash point less than or equal to 23°C, Class 3.3, Classes 4.1, 4.2 and 4.3; Class 5.1, Class 6.1 (toxic liquids) with a flash point equal to or less than 61°C, and Class 8.1 (corrosive liquids) with a flash point equal to or less than 61°C are required to be provided additional portable extinguishers. These additional extinguishers are to be dry powder portable extinguishers with a total capacity of at least 12 kg (26.5 lb) or the equivalent, in accordance with SVR 4-7-2/7.3.3.

2.14 Additional Requirements for Chemical Carriers

Paragraph 5-9-11/3.14 requires that chemical carriers be provided with suitable portable fire extinguishing equipment for the products to be carried.

2.15 Vessels Under 90 Meters (295 Feet)

For vessels under 90 meters, 4-5-1/9 of the *Rules for Building and Classing Steel Vessels Under 90 meters (295 feet) in Length* refers to 4-5-1/Table 1 and 4-5-1/Table 2 for guidance regarding the type, number and size of portable extinguishers required to be provided onboard. SVR(L<90m) 4-5-1/Table 1 is identical to Section 8, Table 1. A copy of SVR(L<90m) 4-5-1/Table 2 is provided below and should be applied when conducting a review of the portable extinguisher on vessels under 90 meters in length.

TABLE 4
Portable/Semi-portable Extinguishers – Vessels Under 90 meters

<i>Space</i>	<i>Classification</i>	<i>Quantity and Location ⁽⁵⁾</i>
Safety Areas:		
Communicating corridors	A-II	1 in each main corridor not more than 46 m (150 ft) apart. (May be located in stairways.)
Pilothouse	C-I	2 in vicinity of exit. See note 4.
Radio room	C-II	1 in vicinity of exit. See note 4.
Accommodations:		
Sleeping Accommodations	A-II	1 in each sleeping accommodation space. (Where occupied by more than 4 persons.)
Service Spaces:		
Galleys	B-II or C-II	1 for each 230 m ² (2500 ft ²) or fraction thereof for hazards involved.
Storerooms	A-II	1 for each 230 m ² (2500 ft ²) or fraction thereof located in vicinity of exits, either inside or outside of spaces. See note 4.
Workshops	A-II	1 outside the space in vicinity of exit. See note 4.
Machinery Spaces:		
Internal combustion or gas turbine engines	B-II and	1 for each 746 kW (1000 hp), but not less than 2 nor more than 6. See note 1.
	B-III	1 required. See note 3
Electric motors or generators of the open type	C-II	1 for each motor or generator unit. See note 2.

Notes:

- 1 When installation is on weather deck or open to atmosphere at all times, one B-II for every three engines is allowable.
- 2 Small electrical appliances, such as fans, etc., are not to be counted or used as basis for determining number of extinguishers required.
- 3 Not required on vessels of less than 500 gross tons.
- 4 Vicinity is intended to mean within 1 meter (3 feet).
- 5 For vessels of 1000 gross tons and above, at least five extinguishers are to be provided for accommodation spaces, services spaces, spaces where the vessel's radio, main navigation equipment or emergency source of power is located, and locations where the fire recording or fire control equipment is located.

2.16 Oil Carriers Under 30.5 Meters (100 Feet)

In accordance with SVR(L<90m) 4-5-3/9.3, oil carriers with a length under 30.5 meters (100 feet) may be provided with two “B-V” extinguishers for the protection of the cargo tank area in lieu of a deck foam system.

2.17 Spare Charges

In accordance with SVR 4-7-3/15.1.2, a spare charge is to be provided for 100% for the first 10 extinguishers and 50% for the remaining extinguishers, but not more than 60 total spare charges are required.

For fire extinguishers which cannot be recharged by the crew, additional portable fire extinguishers of the same quantity, type, capacity and number should be provided in lieu of spare charges.

Instructions for recharging should be carried onboard. Only refills approved for the fire extinguisher in question may be used for recharging. Partially emptied extinguishers should also be recharged.

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SECTION **9 Additional Fire Protection Requirements**

On a vessel, the close proximity of fuel sources and numerous sources of ignition present special concerns for fire safety. This Section discusses certain Rule requirements that are intended to address these concerns. However, reference should always be made to the Rules applicable to the specific vessel concerned for the complete set of requirements.

1 Segregation of Fuel Oil Purifiers for Heated Oil

Any equipment intended to handle or process oil constitutes a significant fire hazard, especially if heated oil is involved. The vapors from fuel leaks or spilled oil at elevated temperatures need only come into contact with a source of ignition to initiate a serious fire. One piece of equipment providing such concerns is the fuel oil purifier unit. In order to minimize the potential of oil escaping from a purifier and coming into contact with one of the various sources of ignition within the engine room, SVR 4-6-4/13.9.2 requires fuel oil purifiers containing heated oil to be installed in a separate room. Such fuel oil purifier rooms are to be enclosed by steel bulkheads extending from deck-to-deck and provided with self-closing doors. In addition, the Rules require these rooms to be provided with the following:

- i) Independent mechanical ventilation or ventilation arrangement that can be isolated from the machinery space ventilation, of the suction type.
- ii) Fire detection system.
- iii) Fixed fire-extinguishing system capable of activation from outside the room. The extinguishing system is to be dedicated to the room but may be a part of the fixed fire extinguishing system for the machinery space.

However, for the protection of purifiers on cargo vessels of 2000 gross tonnage and above located within a machinery space of category A above 500 m³ (17,657 ft³) in volume, the above-referenced fixed dedicated system is to be a fixed water-based or equivalent, local application fire-extinguishing system complying with the provisions of SVR 4-7-2/1.11.2. The system is to be capable of activation from outside the purifier room. In addition, protection is to be provided by the fixed fire-extinguishing system covering the Category A machinery space in which the purifier room is located, see SVR 4-7-2/1.1.1.

- iv) Means of closing ventilation openings and stopping the ventilation fans, purifiers, purifier-feed pumps, etc., from a position close to where the fire extinguishing system is activated.

The Rules incorporate a provision for “special consideration” where it can be established that it is “impracticable” to locate fuel oil purifiers in a separate room. However, any special consideration must establish that it is truly “impracticable” to locate this equipment in a separate room, and that it is not just a matter of cost or convenience. Decisions to grant any allowances must be based upon the fuel oil purifier location, containment of possible leakage, shielding and ventilation, in conjunction with the particular size of the vessel and the engine room, and documentation that must establish that it is truly not practicable to incorporate such arrangements. The application of this “special consideration” would only appear applicable to small vessels since the engine rooms of larger vessels should be able to be designed to incorporate the necessary segregation.

Therefore, if it is impracticable to locate the fuel oil purifiers in a separate room, special consideration will be given with regard to location, containment of possible leakage, shielding and ventilation. In such cases, a local fixed water-based fire-extinguishing system complying with the provisions of SVR 4-7-2/1.11.2 is to be provided. Where, due to the limited size of the category A machinery space (less than 500 m³ (17,657 ft³) in volume), a local fixed water-based fire-extinguishing system is not required to be provided, then an alternative type of local dedicated fixed fire-extinguishing system is to be provided for the protection of the purifiers. In either case, the local fire extinguishing system is to activate automatically or manually from the centralized control station or other suitable location. If automatic release is provided, additional manual release is also to be arranged.

Compliance with the above requirement should be verified during the review of the machinery room arrangement drawing.

2 Segregation of High Pressure Hydraulic Units

Hydraulic units with a working pressure above 15.5 bar (225 psi) located within a machinery space are required to be placed in a separate room. Any piping outside of this room should have as few joints as are practicable, and those joints should be shielded, as necessary, to prevent any oil or oil mist that may escape under pressure from coming into contact with hot surfaces, open electrical equipment that could ignite the oil or any other sources of ignition.

These requirements are found in SVR 4-6-7/3.7.1. Compliance with the segregation requirement should be verified during the review of a hydraulic system by consulting the machinery room arrangement drawing or other suitable arrangement drawing.

3 Requirements for Piping Systems Handling Oil

3.1 Material Requirements for Piping Systems Conveying Oil

To eliminate the potential of adding additional fuel to a fire, all fuel, lube oil and hydraulic piping, valves and fittings are to be of steel or other approved material, in accordance with SVR 4-6-4/13.7.1, 4-6-4/15.5.1 and 4-6-7/3.5.1, as well as SOLAS (2000 Amendments) Reg. II-2/4.2.2.5.1, II-2/4.2.3.1 and II-2/4.2.4. By requiring piping components of systems conveying oil to be steel or other approved materials, the piping system incorporates sufficient structural integrity to resist physical abuse or damage. Further, steel with a solidus melting point above 927°C (1700°F) is not readily harmed by heat. It is recognized that there is a need for flexibility at certain points within the fuel and lube oil systems (i.e. connection to the engines, etc.), and therefore, the use of non-metallic hoses is permitted. However, these hoses are required to be fire-resistant and pass the flame test criteria specified in SVR 4-6-2/5.7.

3.2 Remote Closure Arrangements for Valves on Oil Tanks

Fuel oil and lube oil utilized for the ship services and propulsion are stored in large capacities and typically located in the immediate vicinity of the engine room. The capacity of these tanks can be as high as 3,785 m³ (1,000,000 gallons) depending on the size of the vessel. In the event of a fire, a means is needed to ensure that the contents of the tank will not add fuel to the fire, even if the associated piping is damaged. Accordingly, SVR 4-6-4/13.5.3(a) and 4-6-4/15.3.2 require that all pipes which enter a storage, settling or daily service lube or fuel oil tank at such a level that they could be subjected to a static head of oil from the tank must be fitted with positive closing valves at the tank which are capable of being closed from outside the space concerned in the event of a fire. Further, these tank valves are required to be of steel or equivalent material and must have an elongation of at least 12% if installed outside the tank.

3.3 Fuel Oil and Lube Oil Systems on Engines

The operation of propulsion and generator engines require fuel oil and lube oil systems utilized at high pressures and temperatures and clearly in the direct vicinity of heated surfaces and other sources of ignition. Accordingly, there is the potential for serious fires if these piping systems should leak or release oil in any way. In order to address these concerns, certain requirements are identified in SVR 4-6-4/13.3, 4-6-4/15.1, 4-6-5/3.3, 4-6-5/3.5, 4-6-5/3.7 and 4-6-5/5.3.6(a). These include special limitations on the type of piping that can be used, arrangements to ensure that oil will not be released when strainers are inspected or cleaned, as well as leakage containment and other arrangements required to protect against oil coming into contact with sources of ignition.

3.4 Insulation Requirements for Heated Surfaces

The surfaces of internal combustion engines, gas turbines, boilers, and exhaust pipes reach temperatures high enough that any flammable liquid, which may come into contact with these surfaces, would cause a major fire hazard. Therefore, SVR 4-6-4/13.3.2, 4-6-4/15.5.1.4 and 4-6-5/11.3 require any surface that may be heated to a temperature in excess of 220°C (428°F) and may be exposed to a flammable liquid be insulated with non-combustible materials. If this insulation is oil absorbing and exposed to penetration of oil, then the insulation is to be encased in sheet metal or any other insulation that is not capable of being penetrated.

3.5 Remote Stopping of Fuel Oil Pumps and Thermal Fluid Circulating Pumps

To minimize the spread of a fire, it is important to eliminate any additional sources of fuel that could feed the fire. Accordingly, arrangements are required to shut off auxiliary machinery, such as oil-fuel transfer pumps, oil-fuel unit pumps and other similar fuel pumps and thermal-oil heating pumps. The shut-off arrangements for this type of equipment are required to be located outside the space concerned so that they may be stopped in the event of a fire arising in the space where they are located and include the following:

- Oil-fuel pump remote stops [see SVR 4-6-4/13.9.1].
- Remote stops for circulating pumps for thermal oil heating systems [see SVR 5-1-7/9.5.3v)].
- Purifier room remote closures and stops [see SVR 4-6-4/13.9.2iv)].

3.6 Remote Stops for Ventilation Fans and Closing Arrangements for Openings

Similar to the need to stop fuel oil and thermal heating pumps, since oxygen is vital to the propagation of fire, any fans supplying air to a space engaged in a fire should be stopped immediately. This will minimize the oxygen supply to the fire and assist in bringing a fire under control. Accordingly, SVR 4-7-2/3.7.2 and 4-7-2/3.7.3 require all ventilation fans to have a remote means of stopping. The remote stop is to be located outside of the space(s) being ventilated by the fans and arrangements to close ventilation inlets and outlets are also required.

In particular, the remote means of stopping the ventilation fans serving the machinery spaces is to be located in the passageway leading to the engine room or at the fire control station. In addition, it is important that any compartment involved in a fire can be made as airtight as possible, to keep oxygen out. This is especially important for spaces protected by a fixed gas fire extinguishing system. Accordingly, SVR 4-7-2/1.9 requires means for closing all doorways, ventilators, annular spaces around funnels and other openings to machinery rooms, pump rooms and cargo spaces.

4 Paint/Flammable Liquid Lockers

Most paints, varnishes, lacquers and enamels, as well as numerous cleaners used onboard, are oil-based, and therefore, present a high fire risk. Accordingly, these flammable liquids are stowed in designated paint or flammable liquid lockers or rooms, and because of this high fire risk, paint lockers and similar service spaces used for the storage of flammable liquids are required to be protected by an appropriate fire extinguishing arrangement, as discussed below.

4.1 Lockers of 4 m² (43 ft²) and More Floor Area

Paint lockers and flammable liquid lockers of floor area 4 m² (43 ft²) or more and also such lockers of any floor area with access to accommodation spaces are to be provided with one of the fixed fire extinguishing systems specified below:

- i)* CO₂ system, designed for 40% of the gross volume of the space.
- ii)* Dry powder system, designed for at least 0.5 kg/m³ (0.03 lb/ft³).
- iii)* Water spraying system, designed for 5 L/min/m² (0.12 gpm/ft²). The water spraying system is permitted to be connected to the vessel's fire main system, in which case the fire pump capacity is to be sufficient for simultaneous operation of the fire main system (as required in SVR 4-7-3/1.7) and the water spray system. Precautions are also required to be taken to prevent the nozzles from becoming clogged by impurities in the water or corrosion of piping, nozzles, valves and pump.
- iv)* Systems other than those mentioned above may be considered, provided they are not less effective.

4.2 Lockers of Less Than 4 m² (43 ft²) Floor Area

For paint lockers and flammable liquid lockers of floor area less than 4 m² (43 ft²) having no access to accommodation spaces, portable fire extinguisher(s) sized in accordance with 9/4.1i) of these Guidance Notes, and which can be discharged through a port in the boundary of the lockers, may be accepted. The required portable fire extinguishers are to be stowed adjacent to the port. Alternatively, a port or hose connection may be provided for this purpose to facilitate the use of water from the fire main.

SECTION **10 Fire Control Plans**

The Fire Control Plan provides vital information that is crucial for the rapid and efficient action of the vessel's crew during a fire. Accordingly, it is very important that the Fire Control Plan accurately reflects the fire-fighting arrangements installed onboard and is consistent with the arrangements approved for the vessel.

The following discussion is limited to the "active" fire-fighting arrangements and equipment for the vessel to be depicted on the Fire Control Plan. This discussion does not address requirements associated with the passive fire protection, such as structural fire protection, or any additional requirements associated with electrical systems or arrangements. However, other requirements for "passive" fire protection arrangements (e.g., structural fire protection arrangements, escape routes, etc.), as well as electrical system requirements (e.g., electrical control arrangements, emergency generator location, etc.), exist and should be shown on the Fire Control Plan.

The Fire Control Plan is frequently submitted as part of the Safety Plan, which also indicates life saving equipment, etc. While the Bureau is authorized to review the requirements associated fire control and safety plans by most Flag Administrations, the review for life saving equipment is also outside the scope of this discussion.

1 Standardized Symbols

The International Maritime Organization (IMO) has issued IMO Resolution A.654(16) which provides a standardized set of symbols to be used on a Fire Control Plan. The use of a standardized set of symbols assists the vessel's officers and crew in quickly identifying and locating equipment; and is very helpful in making the Fire Control Plan "User Friendly". However, the resolution was issued as guidance only and its use is not mandated by SOLAS. Accordingly, while there are certain Flag Administrations that require the use of the standardized symbols identified in Res. A.654(16), its use is not mandatory insofar as Classification requirements are concerned.

Related IMO MSC 847 Interpretation

SOLAS Reg. II-2/20 (SOLAS (2000 Amendments) II-2/15). Reference to Resolution A.654(16)

Reference is made to resolution A.654(16) - Graphical symbols for fire control plans and resolution A.765(18) - Guidelines on the information to be provided with fire control plans and booklets required by SOLAS regulations II-2/20 (SOLAS (2000 Amendments) II-2/15).

2 ABS Requirements for Fire Control Plans

The following information is provided as general guidance on the ABS requirements for Fire Control Plans, as required by the *Rules for Building and Classing Steel Vessels* and *Rules for Building and Classing Steel Vessels 90 Meters in Length*. However, reference should always be made to the Rules applicable to the specific vessel concerned for the complete set of requirements.

2.1 Steel Vessels 90 Meters in Length and Greater in Unrestricted Service

2.1.1 Information and Details to be Indicated

In accordance with SVR 4-7-1/9, Fire Control Plans are to be general arrangement plans that must show the following details for each deck, as applicable:

- i) Control stations
- ii) Various fire sections enclosed by “A” class divisions
- iii) Sections enclosed by “B” class divisions
- iv) Particulars of the fire detection and alarm systems
- v) Particulars of the sprinkler installation
- vi) Particulars of the fire-extinguishing appliances
- vii) Means of access to different compartments, decks, etc.
- viii) Ventilating system including particulars of the fan control positions, the position of dampers and identification numbers of the ventilating fans serving each section

As an alternative to using general arrangement plans, SVR 4-7-1/9 indicates that the aforementioned details may be set out in a booklet. If this approach is selected, a copy of the booklet is required to be supplied to each officer, and one copy must be available onboard in an accessible position at all times.

SVR 4-7-1/9 requires that the Fire Control Plan and booklet must to be kept up-to-date, any alterations being recorded thereon as soon as practicable. Descriptions in such plans and booklets are to be in the official language of the flag state, and if the language is neither English nor French, a translation into one of those languages is required. In addition, instructions concerning the maintenance and operation of all the equipment and installations onboard for the fighting and containment of fire are to be kept under one cover, readily available in an accessible position.

A copy of the Fire Control Plan or a booklet is to be permanently stored in a prominently marked weathertight enclosure outside the deckhouse for the assistance of shore-side fire-fighting personnel.

SVR 4-7-1/9 is making a reference to MSC/Circular 451 – Guidance concerning the location of Fire Control Plans for assistance of shoreside fire-fighting personnel.

From the above list of items to be shown on the Fire Control Plan, the details and arrangements that the Engineering Services Department would review include the following:

- Control stations
- Particulars of the fire detection and alarm systems
- Particulars of the sprinkler installation
- Particulars of the fire-extinguishing appliances
- Ventilating system including particulars of the fan control positions and identification numbers of the ventilating fans serving each section

2.1.2 Control Stations

SVR 4-7-1/11.21 defines control stations as those spaces in which the vessel’s radio or main navigating equipment or the emergency source of power is located or where the fire recording or fire control equipment is centralized.

In addition, spaces containing the following battery sources are to be regarded as control stations, regardless of battery capacity:

- Emergency batteries in separate battery room for power supply from blackout till start of emergency generator
- Emergency batteries in separate battery room as reserve source of energy to radiotelegraph installation
- Batteries for start of emergency generator
- In general, all emergency batteries required in accordance with SVR 4-8-2/5

The review of the Fire Control Plan should verify that the above locations are clearly identified.

2.1.3 Fire Detection and Fire Alarm Systems

Where a fire detection and alarm system is required or installed, the locations of the control panels, indicating units, manual call points and detectors are to be indicated on the Fire Control Plan. Compliance with the requirements in SVR 4-7-3/11 and consistency with the arrangements indicated on the approved fire detection and alarm system diagram should be verified during review of the Fire Control Plan.

2.1.4 Sample Smoke Detection and Alarm Systems

Where a smoke detection and alarm system is required or installed, the locations of the control panels, indicating units and detectors are to be indicated on the Fire Control Plan and compliance with the requirements in SVR 4-7-3/13 verified. Consistency with the arrangements indicated on the approved smoke detection and alarm system diagram should also be verified during review of the Fire Control Plan.

2.1.5 Particulars of Sprinkler Installation/Fire-extinguishing Appliances

A substantial number of fire-extinguishing systems and appliances would include, as a minimum, the following:

- Fire main system arrangements
- Fixed fire-extinguishing system locations and arrangements
- Sprinkler system locations and arrangements
- Provision, location and particulars of portable fire-fighting equipment and appliances
- Location of controls for fuel-oil pumps and oil tank shut off valves
- Provision, location and particulars of firefighters' outfits
- The number and locations of Emergency Escape Breathing Devices (EEBDs)

Details should be indicated on the Fire Control Plan for each of the above systems or equipment and further discussion regarding each of these items is provided below:

2.1.6 Fire Main System

- i) The number and location of the main fire pumps are to be indicated on the Fire Control Plan. The arrangements are to indicate that the location(s), as well as the separation and access arrangements, are in compliance with SVR 4-7-3/1.5 for cargo vessels.
- ii) The location and access arrangements for the emergency fire pump, if required, are to be indicated on the Fire Control Plan and comply with SVR 4-7-3/1.5.3.

- iii) While not specifically required by SVR 4-7-1/9, identification of the spaces where the fire pump isolation valves required by SVR 4-7-3/1.11.3 are located is useful to the vessel's officers and crew. The review should verify that the locations are indicated and are consistent with the locations indicated on the approved fire main system diagram.
- iv) The number and position of the hydrants are to be in compliance with SVR 4-7-3/1.9 and consistent with the arrangements indicated on the approved fire main system diagram. The locations of the hydrants should be reviewed and any questionable areas brought to the attention of the submitter and the Surveyor. Frequently, the Fire Control Plan will not indicate the maximum coverage areas from each hydrant, and therefore, accurate verification of compliance is difficult from the drawing alone. Also, actual arrangements onboard may involve certain restrictions which are not readily apparent from the drawing. Accordingly, the attending Surveyor should also be requested to verify compliance with this Rule requirement.
- v) SVR 4-7-3/1.13.2 requires that at least one fire hose be provided, each complete with couplings and nozzles, for each 30 m (100 ft) length of the vessel, as well as one additional hose with couplings and nozzles, as a spare. Further, for vessels of 1000 gross tons and above, a minimum of five (5) hoses are to be provided. The above does not include any hoses required in any engine or boiler room. The Fire Control Plan should indicate the compliance with the above requirement.
- vi) The Fire Control Plan should indicate the individual hose lengths, and the review should verify that the lengths are in accordance with SVR 4-7-3/1.13.1.
- vii) The Fire Control Plan should indicate the type of fire hose nozzles, and the review should verify that they are of the dual-purpose type and comply with SVR 4-7-3/1.15.
- viii) At least one International Shore Connection is to be shown on the Fire Control Plan, as per SVR 4-7-3/1.19. The Fire Control Plan should indicate at least two (2) locations, one (1) on either side of the vessel, where the International Shore Connection can be attached to the fire main system.

2.1.7 Fixed Fire-extinguishing Systems

The following spaces are required to be fitted with a fixed fire-extinguishing system. The Fire Control Plan should be reviewed to verify that fixed fire-extinguishing systems are indicated for these spaces. In addition, the location of the system release controls, as well as storage arrangements for the fire-extinguishing medium, as specified in SVR 4-7-3/3.1.6, 4-7-3/3.3.5, 4-7-3/3.5.5 and 4-7-3/5.3.2, as applicable, should be verified.

- i) Main or auxiliary boiler rooms as per SVR 4-7-2/1.1.1
- ii) Spaces containing internal combustion engines or gas turbines with an output greater than 375 kW (500 hp) (i.e., Category "A" machinery space) as per SVR 4-7-2/1.3
- iii) Spaces containing steam turbines or steam engines with an output greater than 375 kW (500 hp) and intended for periodic unattended operation as per SVR 4-7-2/1.5
- iv) Any space containing oil fuel units (see SVR 4-7-1/11.19 for definition), oil-fired inert gas generators and oil-fired incinerators, as per SVR 4-7-2/1.1.1
- v) Paint or flammable liquid lockers, depending upon size, as per SVR 4-7-2/5.1
- vi) Accommodation spaces of cargo vessels, depending on method of construction, as per SVR 4-7-2/3.3.2
- vii) Cargo spaces, as required by SVR 4-7-2/7

2.1.8 Portable Extinguishers

The type, size and locations of all portable extinguishers are to be indicated on the Fire Control Plan and compliance with the Rules should be verified during review of the plan. However, as a detailed discussion concerning the requirements regarding the types, designs and locations of portable fire-fighting extinguishers is provided in Section 8, the requirements are not repeated in this Section, and the Engineer should be guided by the information and instructions provided in Section 8.

2.1.9 Remote Stop of Pumps/Fans, Closure of Doors and Oil Tank Valves

The locations of the following remote stops or closure devices, as applicable, are to be shown on the Fire Control Plan and should be verified during review.

- i) All ventilator closing appliances (see SVR 4-7-2/3.7.2)
- ii) Ventilator fan remote stops (see SVR 4-7-2/3.7.3)
- iii) Oil-fuel pump remote stops (see SVR 4-6-4/13.9.1)
- iv) Remote stops for circulating pumps for thermal oil heating systems [see SVR 5-1-7/9.5.3v)]
- v) Purifier room remote closures and stops [see SVR 4-6-4/13.9.2iv)]
- vi) Oil-fuel tank and lube oil tank suction valve remote closing stations (see SVR 4-6-4/13.5.3 and 4-6-4/15.3.2)

2.1.10 Ventilation Fans

The locations and identification numbers for the ventilation fans serving the various spaces should be indicated on the Fire Control Plan, in accordance with SVR 4-7-1/9, and review of the drawing should verify the same.

2.1.11 Firefighter's Outfits

Details regarding the firefighter's outfits are required to be indicated on the Fire Control Plan. The location and type of equipment to be provided as part of the firefighter's outfits are addressed in SVR 4-7-3/15.5. The following provides a brief discussion of the required equipment and the locations of the firefighter's outfits onboard the vessel.

2.1.11(a) Number of Firefighter's Outfits. At least two firefighter's outfits consisting of the equipment identified below are to be carried onboard each vessel, as per SVR 4-7-3/15.5.2. However, certain types of vessels require additional sets of firefighter's outfits, depending upon the type of vessel involved.

2.1.11(b) Individual Firefighter's Outfit. In accordance with SVR 4-7-3/15.5.1, each firefighter's outfit is to consist of a set of personal equipment and a breathing apparatus:

- i) *Personal equipment.* Personal equipment is to consist of:
 - Protective clothing of material to protect the skin from the heat radiating from the fire and from burns and scalding by steam. The outer surface is to be water-resistant.
 - Boots of rubber or other electrically non-conducting material.
 - A rigid helmet providing effective protection against impact.
 - An electric safety lamp (hand lantern) of an approved type with a minimum burning period of three hours. Electric safety lamps on tankers and those intended to be used in hazardous areas are to be of an explosion-proof type.
 - An axe with a handle provided with high-voltage insulation.

- ii) *Breathing Apparatus.* Breathing apparatus is to be a self-contained compressed air-operated breathing apparatus, the volume of the air contained in the cylinders of which is to be at least 1,200 liters (317 gallons), or other self-contained breathing apparatus which is to be capable of functioning for at least 30 minutes. Two spare charges are to be provided for each required breathing apparatus. All air cylinders for breathing apparatus are to be interchangeable. Vessels that are equipped with suitably located means for fully recharging the air cylinders free from contamination need carry only one spare charge for each required apparatus.
- iii) *Lifeline.* For each breathing apparatus, a fireproof lifeline of at least 30 m (98.5 ft) in length is to be provided. The lifeline is to successfully pass an approval test by static load of 3.5 kN (787 lbf) for 5 minutes without failure. The lifeline is to be capable of being attached by means of a snap hook to the harness of the apparatus or to a separate belt in order to prevent the breathing apparatus becoming detached when the lifeline is operated.

2.1.11(c) Locations of Firefighter's Outfits. The firefighter's outfits and equipment are required to be stored so as to be easily accessible and ready for use and are to be stored in widely separate positions, in accordance with SVR 4-7-3/15.5.3.

The places for the storage of firefighter's outfits and personal equipment should be permanently and clearly marked.

2.1.12 Emergency Escape Breathing Devices (EEBDs)

To aid crew in escaping from smoke filled spaces, vessels are to be provided with Emergency Escape Breathing Devices. The requirements for EEBDs are outlined in SVR 4-7-3/15.5 and are summarized below:

2.1.12(a) Accommodation Spaces. All vessels are to carry at least two emergency escape breathing devices and one spare device within accommodation spaces.

2.1.12(b) Machinery Spaces. On all vessels, within the machinery spaces, emergency escape breathing devices are to be situated ready for use at easily visible places, which can be reached quickly and easily at any time in the event of fire. The location of emergency escape breathing devices is to take into account the layout of the machinery space and the number of persons normally working in the spaces. (See the Guidelines for the performance, location, use and care of emergency escape breathing devices, MSC/Circ. 849 and 1081). The number and locations of EEBDs are to be indicated in the Fire Control Plan required in SVR 4-7-1/9.

A summary of the MSC/Cir 1081 requirements is shown in Section 10, Table 1. This applies to machinery spaces where crew are normally employed or may be present on a routine basis.

TABLE 1
Minimum Number of Required EEBDs

A. In machinery spaces for category A containing internal combustion machinery used for main propulsion⁽¹⁾:
a) One (1) EEBD in the engine control room, if located within the machinery space b) One (1) EEBD in workshop areas. If there is, however, a direct access to an escape way from the workshop, an EEBD is not required; and c) One (1) EEBD on each deck or platform level near the escape ladder constituting the second means of escape from the machinery space (the other means being an enclosed escape trunk or watertight door at the lower level of the space).
B. In machinery spaces of category A other than those containing internal combustion machinery used for main propulsion,
One (1) EEBD should, as a minimum, be provided on each deck or platform level near the escape ladder constituting the second means of escape from the space (the other means being an enclosed escape trunk or watertight door at the lower level of the space).
C. In other machinery spaces
The number and location of EEBDs are to be determined by the Flag Administration.

Note:

- 1 Alternatively, a different number or location may be determined by the Flag Administration taking into consideration the layout and dimensions or the normal manning of the space.

2.1.12(c) EEBD Specification

- i) *General.* An EEBD is a supply-air or oxygen device only used for escape from a compartment that has a hazardous atmosphere and is to be of an approved type. EEBDs are not to be used for fighting fires, entering oxygen deficient voids or tanks, or worn by fire-fighters. In these events, a self-contained breathing apparatus, which is specifically suited for such applications, is to be used.
- ii) *EEBD Particulars.* The EEBD is to have a duration of service of 10 minutes. The EEBD is to include a hood or full face piece, as appropriate, to protect the eyes, nose and mouth during escape. Hoods and face pieces are to be constructed of flame resistant materials and include a clear window for viewing. An inactivated EEBD is to be capable of being carried hands-free.
- iii) *EEBD Storage.* An EEBD, when stored, is to be suitably protected from environment.
- iv) *EEBD Instructions and Markings.* Brief instructions or diagrams clearly illustrating their use are to be clearly printed on the EEBD. The donning procedures are to be quick and easy to allow for situations where there is little time to seek safety from a hazardous atmosphere. Maintenance requirements, manufacturer's trademarks and serial number, shelf life with accompanying manufacture date and name of approving authority are to be printed on each EEBD. All EEBD training units are to be clearly marked.

2.1.13 Fire Protection Arrangements for Helicopter Operations

If the vessel is fitted with a helicopter deck arranged to accommodate helicopter operations, the following fire-fighting arrangements are to be provided, in accordance with SVR 4-7-2/5.3, and the same should be indicated on the Fire Control Plan. Verification that appropriate arrangements are so indicated should be determined during review of the Fire Control Plan.

2.1.13(a) Helicopter Decks. SVR 4-7-2/5.3.1 defines a helicopter deck as a helicopter landing area on a vessel, including all structure, fire-fighting appliances and other equipment necessary for the safe operation of helicopters, but does not include those areas for occasional or emergency helicopter operations (e.g., circle H marked on hatch covers for drop-off/pickup of pilot). As indicated in SVR 4-7-2/5.3.2, helicopter decks are to be fitted with the following fire-fighting systems and portable extinguishers:

- i) *Hoses and Nozzles.* At least two approved combination solid stream and water spray nozzles and hoses sufficient in length to reach any part of the helicopter deck.
- ii) *Portable Extinguisher.* The helicopter deck is to be protected by at least two (2) approved dry powder extinguishers with a total capacity of not less than 45 kg (100 lb).
- iii) *Back-up System.* A back-up fire-fighting system is to be provided, consisting of CO₂ extinguishers of a total capacity of not less than 18 kg (40 lb) or equivalent, one of these extinguishers being equipped so as to enable it to reach the engine area of any helicopter using the helicopter deck. The back-up system is to be located so that the equipment would not be vulnerable to the same damage as the dry powder extinguishers.
- iv) *Fixed-Foam System.* A fixed-foam fire-extinguishing system, consisting of monitors or hose streams or both, is to be installed to protect the helicopter landing area. The locations of the monitors should be reviewed and compliance with the approved system drawings verified.
- v) *Firefighter's outfits.* In addition to any firefighter's outfits required elsewhere in the Rules, two additional firefighter's outfits are to be provided and stored near the helicopter deck.
- vi) *Additional Equipment.* The following equipment is to be provided near the helicopter deck, in accordance with SVR 4-7-2/5.3.2(f), and is to be stored in a manner that provides for immediate use and protection from the elements:
 - Adjustable wrench
 - Fire resistant blanket
 - Bolt cutter, with arm length of 60 cm (24 in.) or more
 - Grab hook or salving hook
 - Heavy duty hack saw, complete with six (6) spare blades
 - Ladder
 - Lifeline of 5 mm (³/₁₆ in.) diameter × 15 m (50 ft) in length
 - Side cutting pliers
 - Set of assorted screwdrivers
 - Harness knife complete with sheath.

2.1.13(b) Helicopter Facilities. Enclosed helicopter hangars, refueling and maintenance facilities are to be provided with fixed fire-extinguishing systems, as per SVR 4-7-2/5.3.3. Appropriate details, indicating the coverage of the space, as well as the locations of the controls and extinguishing medium storage should be indicated.

2.2 Vessels with Automation Designation “ACC”

In addition to other required fire detection and alarm system arrangements, for vessels which are to receive the **ACC** notation, the propulsion machinery space is required to be protected by a fixed fire detection and alarm system, in accordance with SVR 4-7-2/1.13.1. Details indicating compliance with SVR 4-7-2/1.13.1 should be indicated on the Fire Control Plan and verified during the review.

2.3 Vessels with Automation Designation “ACCU”

2.3.1 Fire-fighting Station

Vessels being classed with the **ACCU** automation notation are required to be provided with a “Fire-fighting Station”, as per SVR 4-9-4/21.1. The “Fire-fighting Station” is to be provided with certain additional controls and equipment. The location of the “Fire-fighting Station”, as well as controls and equipment associated therewith, should be indicated on the Fire Control Plan and indicate compliance with the following:

2.3.1(a) Location. The fire-fighting station is to be located outside the propulsion machinery space. However, consideration can be given to the installation of the fire-fighting control station within the room housing the centralized control station, provided that the room’s boundary common with the propulsion machinery space, including glass windows and doors, is insulated to A-60 standard and the doors opening into the propulsion machinery space are self-closing. In addition, there is to be a protected access, insulated to A-60 standard, from the room to the open deck. These details should be indicated on the Fire Control plan or verified from other drawings.

2.3.1(b) Fire-fighting Controls. The fire-fighting station is required to be provided with remote manual controls for the operations identified in the following list and the Fire Control Plan should indicate the same:

- Shutdown of ventilation fans serving the machinery space
- Shutdown of fuel-oil transfer pumps, fuel oil unit pumps and other similar fuel pumps
- Shutdown of forced draft blowers of boilers, inert gas generators and incinerators, and of auxiliary blowers of propulsion diesel engines
- Closing of propulsion machinery space fuel oil tanks suction valves. This is to include other forms of fuel supply, such as gas supply valves in LNG carriers
- Closing of propulsion machinery space skylights, openings in funnels, ventilator dampers and other openings
- Closing of propulsion machinery space watertight and fire-resistant doors. Doors normally closed and self-closing doors may be excluded
- Starting of emergency generator where it is not arranged for automatic starting
- Starting of a fire pump located outside the propulsion machinery space, including operation of all necessary valves, to pressurize the fire main. Starting of one of the main fire pumps is also to be provided on the navigation bridge (see SVR 4-9-3/15.5.2)
- Actuation of the fixed fire-extinguishing system for the propulsion machinery space
- Stopping of circulating pumps for thermal oil heating systems [see SVR 5-1-7/9.5.3]

2.3.2 Fire Detection and Alarm System

In addition to other required fire detection and alarm system arrangements, for vessels which are to receive the **ACCU** notation, the propulsion machinery space is required to be protected by a fixed fire detection and alarm system, in accordance with SVR 4-7-2/1.13.1, and is to also comply with the requirements found in SVR 4-9-4/21.5. The Fire Control Plan should provide sufficient details to indicate compliance with the following:

- Unattended propulsion machinery space is protected by a fire detection and alarm system
- Indicator panel is located at either the navigation bridge or the fire control station
- If the indicator panel is located at the fire control station, then a repeater panel is provided on the navigation bridge

2.3.3 Fire Alarm Call Points

In accordance with SVR 4-9-4/21.5.2, manually operated fire alarm call points are to be provided at the centralized control station, on the navigation bridge and in the passageways leading to the propulsion machinery space, and these items are to be indicated on the Fire Control Plan.

2.3.4 Portable Fire Extinguishers

For vessels receiving the **ACCU** notation, SVR 4-9-4/21.7 requires that the vessel be provided with additional portable fire extinguishers. The number of additional portable extinguishers is to be equal to the number of hand portable extinguishers required by SVR 4-7-2/1.1.3 for the machinery spaces. These additional extinguishers are to be provided either at the fire-fighting station or at the entrance to the propulsion machinery space and are to be indicated on the Fire Control Plan.

2.4 Additional Requirements for Vessels Carrying Dangerous Goods

In addition to the requirements discussed in 10/2.1 through 10/2.3 of these Guidance Notes, a vessel designated to carry “Dangerous Goods”, as defined in SVR 4-7-1/11.25, is required to be fitted with certain additional systems and equipment, depending on the class of Dangerous Goods to be carried. The additional safety and fire-fighting arrangements are identified in SVR 4-7-2/7.3 and SVR 4-7-2/Tables 1 through 4 and the particular requirements vary depending upon the class or classes of dangerous goods to be carried. Where any of the additional requirements from SVR 4-7-2/7.3 are applicable, due to the carriage of Dangerous Goods, such arrangements or equipment are required to be indicated on the Fire Control Plan and the review should verify compliance with the same.

2.5 Additional Requirements for Vessels Carrying Bulk Oil

In addition to the requirements discussed in 10/2.1 through 10/2.4 of these Guidance Notes, vessels carrying oil in bulk present certain additional fire hazards due to the flammability of the cargo, and therefore, certain additional requirements, as discussed below, are required. The review of the Fire Control Plan should verify the same are properly indicated and are consistent with the approved system arrangements.

2.5.1 Fixed Fire-extinguishing Systems

Vessels intended to carry oil in bulk are required to be provided with the following additional fixed fire-extinguishing systems:

- i) A deck foam system covering the cargo deck area is typically required to be fitted, in accordance with SVR 5-1-7/27. The specific arrangements required are discussed in Section 6. The Fire Control Plan should be reviewed to verify that the foam system control station, monitors, applicators, foam main isolation valves, etc., are indicated and that the locations of this equipment comply with the details of the deck foam system approved for the vessel.
- ii) The cargo pump room is required to be provided with a fixed fire-extinguishing system, as per SVR 5-1-7/29.1, and the controls and arrangements for the system should be indicated on the Fire Control Plan.

2.5.2 Fire Main System

Isolation valves are required, in accordance with SVR 4-7-3/1.5.7, to be fitted in the fire main at the poop front in a protected position and on the tank deck at intervals of not more than 40 m (131 ft). While not specifically mentioned in SVR 4-7-1/9, the arrangements indicated on the Fire Control Plan should indicate the isolation valves and the same verified during plan review.

2.5.3 Firefighter's Outfits

In addition to the two firefighter's outfits normally required for any cargo vessel, SVR 5-1-7/23.7 requires that vessels intended to carry oil in bulk be provided with two additional firefighter's outfits and the same indicated on the Fire Control Plan.

2.6 Additional Requirements for Gas Carriers

Gas carriers also present additional fire hazards due to the flammability of the cargo being transported. Accordingly, in addition to the requirements discussed in 10/2.1 through 10/2.4 of these Guidance Notes, gas carriers are also required to be provided with certain additional fire-fighting systems, as discussed below. The review of the Fire Control Plan should verify the same are properly indicated and are consistent with the approved system arrangements.

2.6.1 Additional Required Fixed Systems

In accordance with SVR 5-8-11/3, gas carriers transporting flammable or toxic products are required to be provided with a water spray system for covering:

- Exposed cargo tank domes and any exposed parts of cargo tanks.
- Exposed on-deck storage vessels for flammable or toxic products.
- Cargo liquid and vapor discharge and loading manifolds and the area of their control valves and any other areas where essential control valves are situated and which should be at least equal to the area of the drip trays provided.
- Boundaries of superstructures and deckhouses normally manned, cargo compressor rooms, cargo pump rooms, storerooms containing high fire risk items and cargo control rooms, all facing the cargo area. Boundaries of unmanned forecastle structures not containing high fire risk items or equipment do not require water spray protection.

If a water spray system is required, the indicated arrangements should be consistent with the system details approved for the vessel and review of the Fire Control Plan should verify the same.

In accordance with SVR 5-8-11/4, if a gas carrier is to transport flammable products, a fixed dry chemical powder type extinguishing systems for the deck in the cargo area and bow or stern cargo handling areas is required and the Fire Control Plan should indicate the same. If required, the indicated arrangements should be consistent with the system details approved for the vessel and review of the Fire Control Plan should verify the same.

2.6.2 Firefighter's Outfits

In accordance with SVR 5-8-11/6, every gas carrier that transports flammable products is to be provided with the following firefighter's outfits:

<i>Total cargo capacity</i>	<i>Number of outfits</i>
5,000 m ³ and below	4 Firefighter's outfits
Above 5,000 m ³	5 Firefighter's outfits

In addition, any breathing apparatus required as part of a firefighter's outfit should be a self-contained air-breathing apparatus having a capacity of at least 1,200 liters (317 gallons) of free air, in accordance with SVR 5-8-11/6.3. If these additional firefighter's outfits are required, the provisions for the same should be indicated on the Fire Control Plan and verified during plan review.

2.6.3 Gas Detection System

Depending of the cargo to be carried, a gas detection system may be required, in accordance with SVR 5-8-13/6.7. Where required, the control station and locations monitored are typically indicated on the Fire Control Plan, and if indicated, the arrangements should be reviewed to confirm that they are consistent with the arrangements approved for the vessel.

2.6.4 Personnel Protection and First Aid Equipment

While not specifically associated with fire-fighting, SVR Section 5-8-14 discusses certain protective equipment for personnel and first aid equipment required to be carried onboard, depending of the cargoes to be carried. This equipment is frequently indicated on the Safety Plan of gas carriers and compliance with the Classification requirements should be verified if indicated.

2.6.5 Fire Main System

Isolation valves are required, in accordance with SVR 4-7-3/1.5.7 and SVR 5-8-11/2.3, to be fitted in the fire main at the poop front in a protected position and on the tank deck at intervals of not more than 40 m (131 ft). While not specifically mentioned in SVR 4-7-1/9, the arrangements indicated on the Fire Control Plan should indicate the isolation valves and the same verified during plan review.

2.7 Additional Requirements for Chemical Carriers

Chemical carriers may present additional hazards depending upon the cargoes to be transported. Accordingly, in addition to the requirements discussed in items 10/2.1 through 10/2.4 of these Guidance Notes, chemical carriers are also required to be provided with certain additional fire and safety systems, as discussed below. The review of the Fire Control Plan should verify the same are properly indicated and are consistent with the approved system arrangements.

2.7.1 Fixed Fire-extinguishing Systems

In addition to the fixed fire-extinguishing systems discussed above, vessels intended to carry chemicals in bulk are to be provided with the following additional fixed fire-extinguishing systems:

- Vessels intended to carry chemicals in bulk are typically required to be fitted with a deck foam system covering the cargo deck area, as well as any bow or stern loading areas, in accordance with SVR 5-9-11/3. The specific requirements and arrangements required are discussed in Section 6. The Fire Control Plan should be reviewed to verify that the foam system control station, monitors, applicators, foam main isolation valves, etc., are indicated and that the locations of this equipment comply with the details of the deck foam system approved for the vessel, as necessary.
- The cargo pump room is required to be provided with a fixed fire-extinguishing system, as per SVR 5-9-11/2, and the controls and arrangements for the system should be indicated on the Fire Control Plan.

2.7.2 Vapor Detection System

Depending of the cargo to be carried, means for flammable and/or toxic vapor detection, in accordance with SVR 5-9-13/2 and 5-9-13/3, may be required. Where required, such equipment is typically indicated on the Safety Plan, and if portable devices are to be used, the Safety Plan may be the only place where such equipment is indicated. Accordingly, if required for the vessel, the arrangements should be reviewed to confirm with the Rules.

2.7.3 Personnel Protection and Safety Equipment

While not specifically associated with fire-fighting, SVR Section 5-9-14 discusses certain protective and safety equipment for personnel, depending of the cargoes to be carried. This equipment is frequently indicated on the Fire Control Plan or Safety Plan of chemical carriers and compliance with the Classification requirements should be verified, if indicated.

2.7.4 Fire Main System

Isolation valves are required, in accordance with SVR 4-7-3/1.5.7, to be fitted in the fire main at the poop front in a protected position and on the tank deck at intervals of not more than 40 m (131 ft). While not specifically mentioned in SVR 4-7-1/9, the arrangements indicated on the Fire Control Plan should indicate the isolation valves and the same verified during plan review.

2.8 Additional Requirements for Passenger Vessels

Passenger vessels present unique dangers and safety concerns. This is due to the large number of untrained people onboard who will not be familiar with emergency procedures and may in certain cases have reduced agility and mobility. Accordingly, there are certain fire and safety requirements that are uniquely applicable to passenger vessels. These requirements are in addition to or in lieu of the requirements discussed in 10/2.1 through 10/2.4 of these Guidance Notes and should be verified during review of the Fire Control Plan.

2.8.1 Fire Main System

The number and location of the main fire pumps are to be indicated on the Fire Control Plan and indicate that the location(s), as well as the separation and access arrangements, are in compliance with PVG 6/5.1.2.

The number and position of the hydrants are to be in compliance with PVG 6/5.1.7 and consistent with the arrangements indicated on the approved fire main system diagram. In this regard, if the Fire Control Plan does not indicate the maximum coverage areas possible from each hydrant, verification of compliance will to be left to the attending Surveyor. However, the locations of the hydrants should still be reviewed and any questionable area brought to the attention of the submitter and the Surveyor.

PVG 6/5.1.8(b) requires that at least one fire hose is to be provided for each required hydrant. For vessels carrying more than 36 passengers, each interior hydrant is to have a hose attached.

Category “A” machinery spaces on passenger vessels are to be provided with at least two water fog applicators, as per PVG 6/5.1.9(e).

2.8.2 Additional Fixed Fire-extinguishing Systems Required on Passenger Vessels

Depending upon the construction methods utilized, vessels carrying 36 passengers or less may be required to be provided with an automatic sprinkler system (or equivalent) for accommodations, controls and service spaces, in accordance with PVG 6/5.5.1(a). And all passenger vessels carrying more than 36 passengers are required to have automatic sprinkler system for such spaces, as per PVG 6/5.5.1(b). The Fire Control Plan should indicate the spaces being protected and review of the Fire Control Plan should verify consistency with the approved details of the sprinkler system plans and ensure that all required spaces are being protected.

2.8.3 Fire Detection and Fire Alarm Systems

In addition to any previously discussed fire detection and alarm system component location requirements, the location of the fire detectors, fire alarms, manual call points, indicating stations and control stations required by PVG 6/5.7, are to be shown on the Fire Control Plan and verified during review.

2.8.4 Firefighter's Outfits

PVG 6/5.15.3(b) requires that in addition to the two firefighter's outfits required by PVG 6/5.15.3(a), every passenger vessel be provided with two additional firefighter's outfits and two additional sets of personal equipment at every 80 m (263 ft), or part thereof, of the aggregate of the lengths of all passenger spaces and service spaces, or if there is more than one such deck, on the deck which has the largest aggregate of such lengths. Each set of personal equipment is to comprise non-conducting boots and gloves, a rigid helmet and protective clothing.

2.8.4(a) Vessel Carrying More than 36 Passengers. In accordance with PVG 6/5.15.3(c), two additional firefighter's outfits are to be provided for each main vertical zone. No additional firefighter's outfits are required, however, for stairway enclosures which constitute individual main vertical zones and for the main vertical zones in the fore or aft end of a vessel that do not contain spaces of the following categories, as defined in Regulation II-2/9.2.2.3.2.2 of SOLAS 2000:

- i) Accommodation spaces of minor fire risk
- ii) Accommodation spaces of moderate fire risk system
- iii) Accommodation spaces of greater fire risk
- iv) Machinery spaces and main galleys

There is also to be provided for each pair of breathing apparatus one water fog applicator which is to be stored adjacent to such apparatus.

2.8.4(b) Storage Arrangements. PVG 6/5.15.5 specifies that the firefighter's outfits are to be stored so as to be easily accessible and ready for use. They are also to be stored in widely separate locations, but at least two firefighter's outfits and one set of personal equipment is to be available at any one position.

For vessels carrying more than 36 passengers, at least two firefighter's outfits are to be stored in each main vertical zone. Also, vessels carrying more than 36 passengers are to carry at least two spare charges for each breathing apparatus in lieu of the one spare charge required by SVR 4-7-3/15.5.1(b), and all air cylinders for breathing apparatus are to be interchangeable, as per PVG 6/5.15.7.

2.8.5 Additional Marking Requirements

In conducting the review of the Fire Control Plan, the Engineer should note that SOLAS Regulation II-2/13.3.2.5.1 requires all fire equipment location markings to be of photoluminescent material or marked by lighting. Compliance with this requirement should be verified during plan review as a classification requirement.

2.9 Additional Requirements for Ro-Ro Spaces

Vessels intended to carry vehicles present certain additional hazards due to the low flash point fuels normally used and the increased amount of class "A" combustibles. Accordingly, SVR Section 5-10-4 provides certain requirements for cargo spaces intended for the carriage of vehicles that should be verified in addition to those specified in 10/2.1 through 10/2.4 of these Guidance Notes. In addition, the requirements outlined in 10/2.8 of these Guidance Notes would also be applicable if the ro-ro spaces are on a passenger vessel.

2.9.1 Fire Detection

In accordance with SVR 5-10-4/3.1, ro-ro spaces are required to be provided with a fixed fire detection and fire alarm system complying with the requirements of SVR 4-7-3/11. The locations of the fire detection and alarm system components, including the locations of the fire detectors, fire alarms, manual call points, indicating stations and control stations should be shown on the Fire Control Plan and verified during review.

2.9.2 Fixed Fire-extinguishing Systems

In addition, the location of the system release controls, as well as storage arrangements for the fire-extinguishing medium, as specified in SVR 4-7-3/3.1.6, 4-7-3/3.3.5, 4-7-3/3.5.5 and 4-7-3/5.3.2, as applicable, should be verified.

2.9.2(a) Ro-Ro Spaces Capable of Being Sealed. In accordance with SVR 5-10-4/3.3.1(a), ro-ro cargo spaces capable of being sealed are to be fitted with a fixed gas fire-extinguishing system. As an alternative, SVR 5-10-4/3.3.1(b) allows the installation of a fixed pressure water-spray system for such spaces. Indication that such systems are provided and appropriate details regarding the locations of the control valves and actuating station(s) should be indicated on the Fire Control Plan and their compliance with the appropriate requirements verified during plan review.

2.9.2(b) Ro-Ro Spaces Not Capable of Being Sealed. In accordance with SVR 5-10-4/3.3.2, ro-ro cargo spaces not capable of being sealed are to be fitted with a fixed pressure water-spray system. Indication that such systems are provided and appropriate details regarding the locations of the control valves and actuating station(s) should be indicated on the Fire Control Plan and their compliance with the appropriate requirements verified during plan review.

2.9.3 Fire Hydrants

In accordance with SVR 4-7-3/1.9, any ro-ro cargo space or any vehicle spaces are to be provided with sufficient hydrants to ensure that at least two jets of water, each from a single length of hose are capable of reaching any part of the space and that hydrants are to be positioned near the accesses to the spaces.

2.9.4 Portable Extinguishers

SVR 5-10-4/3.3.3 requires at least one portable extinguisher is to be provided at each access to any ro-ro cargo space. In addition, at each vehicle deck level where vehicles with fuel in their tanks are carried, sufficient portable extinguishers suitable for fighting oil fires are to be provided such that they are not more than 20 m (65 ft) apart on both sides of the vessel. The one located at the access may be credited for this purpose. These extinguishers should be indicated on the Fire Control Plan and verified during plan review.

2.9.5 Water Fog and Foam Applicators

SVR 5-10-4/3.3.4 requires that each ro-ro cargo space intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion is to be provided with the following:

- At least three (3) water fog applicators
- One (1) portable foam applicator unit complying with SVR 4-7-3/15.3 (provided that at least two such units are available in the vessel for use in such ro-ro cargo spaces)

These items should be indicated on the Fire Control Plan and verified during plan review.

2.10 Additional Requirements for Cargo Spaces, Other Than Ro-Ro Cargo Spaces, Intended to Carry Vehicles with Fuel in Their Tanks

SVR 5-10-4/5 indicates that cargo spaces, other than ro-ro cargo spaces, intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion are to comply with the provisions of SVR 5-10-4/3, except that in lieu of SVR 5-10-4/3.1 a sample extraction smoke detection system complying with the provisions of SVR 4-7-3/13 may be permitted and SVR 5-10-4/3.3.4 may be omitted. Accordingly, items 10/2.9.1, 10/2.9.2 and 10/2.9.4 of these Guidance Notes would be applicable with the exception that a sample extraction smoke detection system may be installed in lieu of the fire detection system. Details verifying that the appropriate systems and equipment are provided for such spaces should be indicated on the Fire Control Plan and verified during plan review in association with the review of requirements outlined in items 10/2.1 through 10/2.4 of these Guidance Notes.

2.11 Vessels Under 500 Gross Tons

For vessels under 500 gross tons, certain alternative arrangements are permitted, as discussed in SVR(L<90m) 4-5-3/1 through 4-5-3/9. Where the Fire Control Plans for such vessels are being reviewed, the alternative requirements SVR(L<90m) 4-5-3/1 through 4-5-3/9, as discussed below, should be considered in association with the requirements stated in 10/2.1 through 10/2.10 of these Guidance Notes, as applicable.

2.11.1 Fire Pumps

SVR(L<90m) 4-5-3/1 addresses the number and type of fire pumps required. Separation arrangements for the fire pumps as referenced in 10/2.1 of these Guidance Notes are not applicable.

2.11.2 Machinery Space Fixed Fire-extinguishing Systems

Fixed fire-extinguishing systems are not required for machinery spaces of vessels below 500 gross tons, unless a space contains an oil fuel unit, as per SVR(L<90m) 4-5-3/3.

2.11.3 Carbon Dioxide Systems

Alternative storage arrangements for the CO₂ system, as discussed in SVR(L<90m) 4-5-3/5.1, are permitted.

2.11.4 Fire Axe

A fire axe is required to be carried on all such vessels over 20 meters (65 feet) in length. Firefighter's outfits are not required.

2.11.5 Oil Carriers

The cargo tank protection for oil carriers less than 30.5 meters (100 feet) in length may be provided with two "B-V" extinguishers.

2.12 Barges

Where Fire Control Plans for a barge is submitted, it is to be reviewed to verify compliance with Sections 14, 17 and 19 of the *Rules of Building and Classing Steel Barges*, as applicable.



APPENDIX **1** References

The following have been referenced in or have been utilized as sources of information in the development of these Guidance Notes:

- *ABS Rules for Building and Classing Steel Vessels* (2005)
- *ABS Rules for Building and Classing Steel Vessels Under 90 meters (295 feet) in Length* (2001)
- *ABS Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways* (1997)
- *ABS Guide for Building and Classing High Speed Craft* (2001)
- *ABS Guide for Building and Classing Motor Pleasure Yachts* (2000)
- *ABS Guide for Building and Classing Passenger Vessels* (2001).
- *ABS Rules for Building and Classing Steel Barges* (2003)
- *ABS Rules for Building and Classing Accommodation Barges and Hotel Barges* (1989)
- Applicable ABS Fire Fighting Systems Process Instructions (effective date 1 September 2004)
- “A Firefighter’s Guide to Foam,” National Foam Company
- Ansul Marine Foam Systems Design, Installation and Maintenance Manual
- “Fire Protection Handbook,” 19th Edition, National Fire Protection Association
- International Maritime Organization (IMO) Safety of Life at Sea (SOLAS), Amendments 2000, Published in 2001
- International Maritime Organization (IMO) International Code for Fire Safety Systems (FSS Code), Published in 2001
- IMO MSC Circular 847, Interpretations of Vague Expressions and Other Vague Wording in SOLAS Chapter II-2, Consolidated Edition 1997
- IMO Resolution A.602(15), Revised Guidelines for Marine Portable Fire Extinguishers
- International Association of Classification Societies (IACS) Unified Interpretations (1 September 2004)
- “Marine Fire Prevention, Firefighting and Fire Safety,” Marine Training Advisory Board, U.S. Department of Transportation
- The SFPE Handbook of Fire Protection Engineering, 3rd Edition, National Fire Protection Association
- U.S. Coast Guard NVIC 6-72, Guide to Fixed Fire-Fighting Equipment Aboard Merchant Vessels

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